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MINERALOGRAPHIC STUDY OF A SUITE OF ORE FROM MAID OF ERIN CLAIM

Geology 409

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The following report on a suite of ore from the Maid of Erin claim is submitted in partial fulfillment of the course in Mineralography (Geology 409) given at the University of British Columbia during the 1948-49 term.

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ABSTRACT

A suite of ore from the Maid of Erin claim, situated in the Atlin Mining division, was studied megascopically and microscopically. The ore minerals were identified and their paragenesis discovered.

The deposit is a replacement body in skarn lenses in limestone.

The important ore minerals are hypogene in origin.

Minor minerals included linnaeite and wittichenite.

INTRODUCTION

Purpose

a) To identify the minerals present in the Maid of Erin suite of ore.

b) To determine the paragenesis of the ore minerals.

c) To determine the occurrence of silver which assays from forty to sixty ounces per ton.

d) To study the nature of the chalcocite (i.e.) supergene vs. hypogene.

Location and Accessibility

The Maid of Erin claim is in the Squaw Creek-Rainy Hollow area of the Atlin Mining Division.

The claim lies on the south-western slope of Mineral Mountain; latitude 50°34' and longitude 136°36' [1].

The Haines Road which connects Haines on the Chilkoot Inlet with the Alaska Highway runs through the central part of the Squaw Creek-Rainy Hollow Area. An old tractor road 3 1/2 miles long connects the Maid of Erin Claim with a marked hairpin turn in the Haines Road along Inspector Creek.

Acknowledgements

The writer wishes to acknowledge the helpful assistance and guidance of Dr. R.M. Thompson, Professor of

1 Refer to the Squaw Creek-Rainy Hollow map that accompanies Bulletin 25, B.C. Department of Mines.

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Minerology at the University of British Columbia. An x-ray powder photograph taken by Dr. Thompson was ultimately used to identify linnaeite.

Bulletin No. 25 of the B.C. Department of Mines (1948) written by Dr. K. DeP. Watson on "The Squaw Creek-Rainy Hollow Area" was used extensively in the first sections of this report. Specifically the sections on location, accessibility and geology are largely a synopsis of this bulletin.

Geology [2]

In the area immediate to the Maid of Erin claim Permo-Carboniferous sediments are cut by Mesozoic granitic intrusives. The sedimentary rocks consist of quartzites, marbles, and argillites. Part of a quartz diorite batholith lies close to the claim as do two small bodies of diorite and gabbro.

The general structure on Mineral Mountain suggests a northward plunging syncline with a gently dipping western limb and a steeply dipping eastern limb. Some faults and minor folds cut this structure.

Skarn replacement bodies occur locally in the marble. It should be noted that these skarn bodies are not along the contact between the marble and the granitic body, but rather they lie where the marble is in contact with argillite, quartzite, schist or gneiss. A period of mineralization subsequent to the formation of the skarn formed fairly

2 Watson, K. DeP., "The Squaw Creek-Rainy Hollow Area (Northern British Columbia) - Bulletin No. 25 - B.C. Dept. of Mines, p. 40-44, (1948)

massive sulphide bodies in the skarn lenses.

Thus, the suite of ore from the Maid of Erin claim represents fairly massive replacement bodies in skarn which forms lenses in Permo-Carboniferous limestone.

MEGASCOPIC MINERALIZATION

The ore minerals are usually massive but in places they appear disseminated. The granular nature of the gangue has allowed the ore minerals access to the inter-grain areas. In places a replacement of the gangue by the more minerals is indicated.

The following minerals, which are listed below in apparent decreasing order of abundance, were noted in the hand specimens.

1. Bornite
2. Sphalerite
3. Malachite
4. Chalcocite
5. Chalcopyrite

Garnet is an important gangue mineral. The majority of garnets are brownish in colour; however a clear lemon-yellow variety was seen. Calcite in minor amounts was observed following small veinlets.

The bornite and chalcocite are so intermixed that it is difficult to separate these two minerals in the hand specimen.

The sphalerite is dark in color and is distinctly crystalline in character. It appears at times to cut through the bornite-chalcocite in vein fashion.

Only minute blebs of chalcopyrite were noted scattered throughout the bornite-chalcocite masses.

The malachite shows the same intimate relationship with the gangue as does the bornite and chalcocite.

MICROSCOPIC MINERALIZATION

The following minerals were found in six polished sections made from the Maid of Erin suite.

1. Bornite
2. Chalcocite
3. Sphalerite
4. Chalcopyrite
5. Magnetite
6. Wittichenite
7. Linnaeite
8. Malachite
9. Covellite

Bornite Cu_5FeS_4

The diagnostic pinkish-buff color of bornite made identification of this mineral relatively easy. The bornite is massive in character though here and there throughout the section, especially where oxidized, fine minute fissures run through it. These fissures have sometimes served as channels through which carbonated waters have percolated and thereby altered the bornite to malachite.

The bornite shows anomalous anistropism in some places under crossed-nicols.

Another interesting behaviour of the bornite is that it shows different colors when etched by KCN. Normally this reagent etches the bornite a pale tan color but where the bornite is intergrown with chalcocite it etches purple to blue. A higher content of dissolved covellite (CuS) in the bornite-chalcocite might account for this etch color anomally. This might also serve as an explanation for the anomalous anistropism of the bornite.

Chalcocite Cu_2S

Chalcocite was identified by its light blue-gray color, its "B" hardness, and its diagnostic etch reactions. This mineral was massive in character and showed numerous graphic and sub-graphic textures where intergrown with bornite. These structures will be discussed in a later section.

The chalcocite showed only weak anisotropism and some appeared to be isotropic. The writer found it quite difficult to come to a conclusion regarding this mineral's behaviour under crossed-nicols.

The color of the chalcocite differed throughout the sections. Sometimes a quite bluish tinge was observed. This was noted particularly in areas where only chalcocite covered the microscopic field. Where bornite was observed on the field along with the chalcocite the chalcocite appeared quite silver-grey in color. This phenomena possibly was caused by the writer's inability to observe the color of the mineral in its own right but rather unconsciously judged the mineral color by comparison. In this case the chalcocite might look silvery-white when compared with the pinkish-buff color of bornite while, when it was viewed beside gangue, it would appear to have a bluish tinge.

In spite of these difficulties, it is felt that within some of the massive chalcocite there is "blue" chalcocite (digenite) in very minor amounts. The behaviour beneath crossed-nicols adds some weight to this conclusion.

The chalcocite shows an excellent etch cleavage after KCN reagent is left on the surface for a short time. The pattern thus produced showed relatively large rectangles which were parallel to sub-parallel in orientation. Some triangular forms were also noted. Stephens [3] has observed that supergene chalcocite gives a granular etch pattern in which there is no orientation but rather a confused mass of etch lines.

Thus the chalcocite observed is considered hypogene. This is based upon the following:

- presence of what appears to be small amounts of digenite.
- coarse grained rectangular and triangular etch patterns produced by KCN.

<u>Wittichenite</u> $3Cu_2 \cdot Bi_2S_3$

This mineral is relatively hard to see because it not only superficially looks like chalcocite but also it shows the same intergrowth relation with the bornite as does the chalcocite. There is, however, a slight color difference between wittichenite and chalcocite. While the chalcocite is bluish-gray the wittichenite is buff to pink grayish-white.

3 Stephens, M.M., "The Identification of Types of Chalcocite by Use of the Carbon Arc", Econ. Geol, 30: pp. 604-629 (1935).

The following etch reactions were obtained:

$HgCl_2$ - negative

KOH - negative

KCN - negative

HCl - negative

$FeCl_3$ - brownish stain (difficult to obtain)

HNO_3 - irridescent stain

Comparison with a standard wittichenite section was ultimately used for identification.

This mineral is found throughout the chalcocite. A relatively large area of pure wittichenite can be seen on section six.

Sphalerite ZnS

The sphalerite in this ore shows little internal reflection. As was observed megascopically this is the dark variety of sphalerite with a high iron content. The color under vertically reflected light is dark gray.

The following etch tests were observed:

$HgCl_2$ - negative

KOH - negative

KCN - negative

HCl - negative

$FeCl_3$ - negative

HNO_3 - negative (sometimes slow efferves-cence)

Aqua Regia - stains brown

These tests plus the hardness of "C" and some internal reflection lend to the identification of sphalerite.

Sphalerite can be seen surrounding subhedral grains of chalcopyrite and cutting through the bornite-chalcocite bodies with their associated minerals. It intimately surrounds the skarn minerals.

Magnetite Fe_3O_4

The negativeness of the etch reactions (except for the yellowish tinge that comes to Aqua Regia) plus the bending of the surface beneath the needle and the magnetic properties of small particles led to the identification of this mineral.

In appearance magnetite resembles sphalerite but has a somewhat higher relief and a smoother surface.

Magnetite appears in places to replace the skarn and shows intimate relations with it.

Linnaeite Co_3S_4

This mineral is pinker in color than the wittichenite and shows a high relief. It is scattered throughout the sections always showing diamond shapes and is usually attached to the gangue along one of its edges. This suggests that parts of the gangue may have acted as centres for the crystallization of the linnaeite.

The following etch reactions were obtained:

$HgCl_2$ - irridescent coating

KOH - negative

KCN - negative

HCl - negative

$FeCl_3$ - negative

HNO_3 - slight tarnish (obtained with difficulty).

These tests narrowed the diagnosis to four nickel and cobalt sulphide minerals. These were carrollite ($(Co,Cu)_3 S_4$), linnaeite (Co_3S_4), polydymite (Ni_3S_4) and siegenite ($(Ni,Co)_3S_4$).

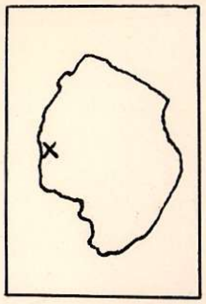
Quite naturally it was assumed that the copper bearing mineral of this group, namely carrollite, would be the final answer. However, an x-ray powder photograph made by Dr. R.M.Thompson showed the mineral to be linnaeite.

Noting the great abundance of copper in the suite and also the almost identical crystal structure of carrollite and linnaeite as seen from x-ray powder photographs, it was assumed that the period of mineralization that emplaced the linnaeite must have been distinct from the one that brought in the copper minerals. Relationships observed on the polished section proved this to be true - see diagram I.

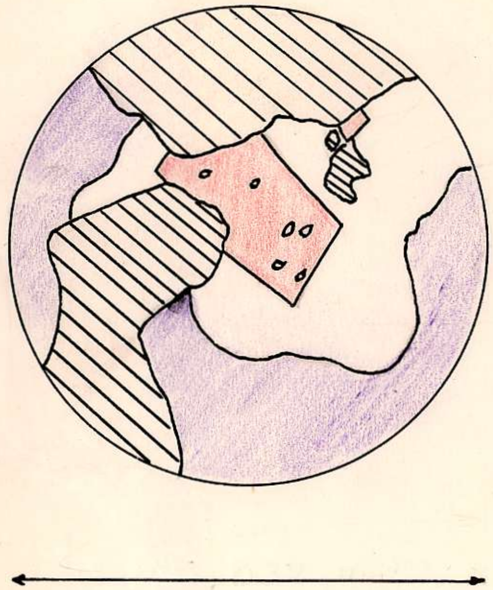
Secondary Minerals

Covellite and malachite were seen replacing out from small fractures in the bornite-chalcocite - see diagram II.

Diagram I



section 6



0.32 mm

Linnaeite

Bornite

Chalcocite

Gangue

Note: subhedral form of linnaeite

size of largest linnaeite crystal 0.1 mm

Paragenesis:

1. Gangue
2. Linnaeite
3. Bornite, chalcocite

PARAGENESIS

Bornite - Chalcocite Relations

Before proceeding with a discussion of the bornite-chalcocite relations it is well to consider the state of knowledge that exists among the mineralogists. To be brief, a great variance of opinion is exhibited in the writings about the interpretation of bornite-chalcocite textures. At this point, the writer would like to quote two passages written in "Economic Geology" by G.M. Schwartz.[4]

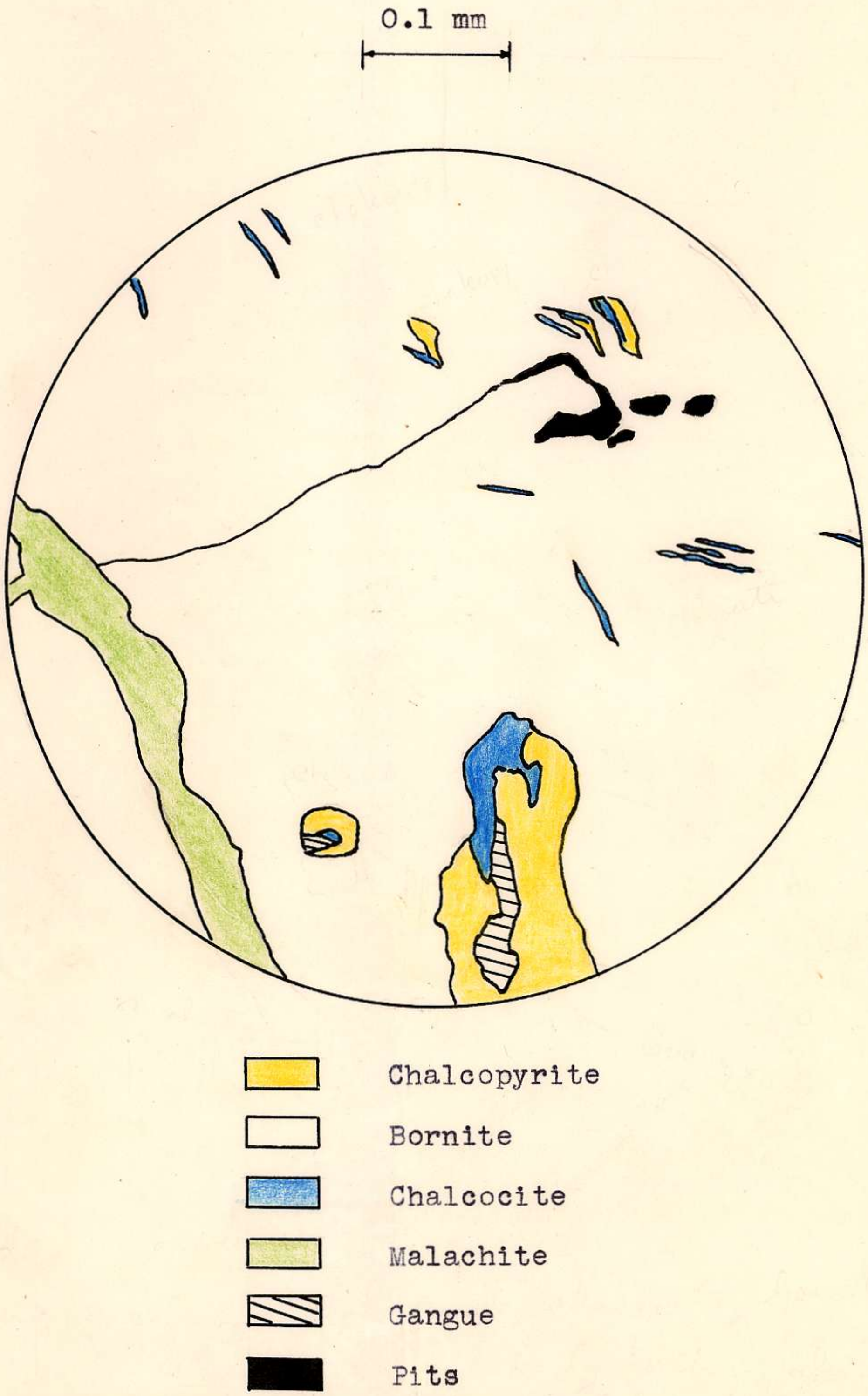
> " ... much controversey has risen regarding the origin and interpretation that it cannot be used with confidence as a criterion for any particular origin."
>
> The problem of interpretation is not only complicated by similar textures forming in different ways but by the fact that more than one generation of each mineral may be present in a specimen or even within a single field of the microscope."

Therefore, these ideas set forth below give only an interpretation of the textures based upon the one hypothesis of origin, ex-solution. This means that the writer considers contemporaneous deposition of bornite and chalcocite to be the most probable. However, some relationships seen in these sections would be used as arguments for replacement.

Diagram II shows parallel spindles of chalcocite in bornite oriented in two directions. This type of texture is considered good evidence for ex-solution which is taking

4 Schwartz, G.M., "Significance of Bornite-Chalcocite Microtextures", Econ. Geol., 34, pp. 417-419, (1939).

Section 5 (oxidized) Diagram II



Shows exsolution of chalcopyrite, chalcocite and bornite with secondary malachite replacing out from a fissure. Note alinement of chalcocite veinlets.

place along the cleavages of the bornite. Thus the chalcocite is primary, being deposited directly from ascending solutions above the eutectoid temperature of the bornite-chalcocite system as a solid solution with the bornite.

The spindles become increasingly numerous so that one may see them grading into sub-graphic and graphic textures. Some of the textures are so fine that they are practically sub-microscopic.

In areas where large masses of chalcocite and bornite are visible confliciting age relationships are observed if one is using the replacement theory of origin.

The overall picture of the relationships between bornite-chalcocite indicates contemporaneous deposition and ex-solution of these two minerals.

Minerals Contemporaneous with bornite-chalcocite

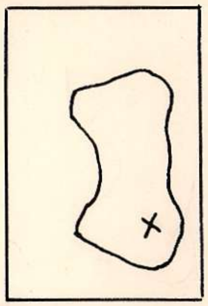
Wittichenite and chalcopyrite are both considered contemporaneous with the bornite-chalcocite system.

Diagram II shows blebs of chalcopyrite in bornite associated with chalcocite. These blebs are sub-parallel with the chalcocite spindles. Some chalcopyrite appears to be later than the bornite-chalcocite because it is seen in veins replacing the bornite.

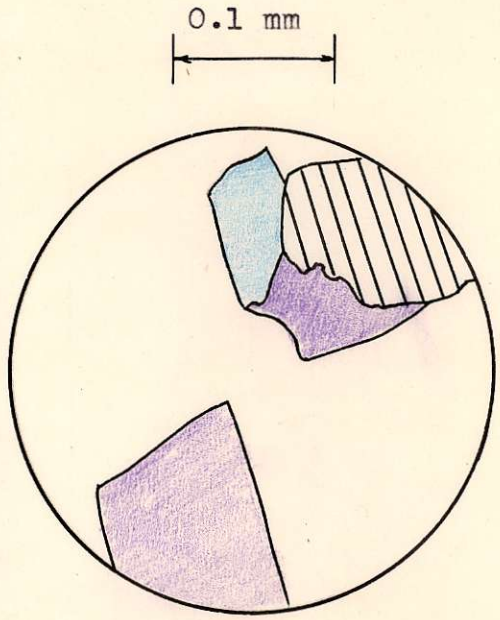
The wittichenite shows the same relationships and textures to the bornite as does the chalcocite. Gaudin and Gunther [5] in experimenting with the Copper-Bismuth-Sulphur

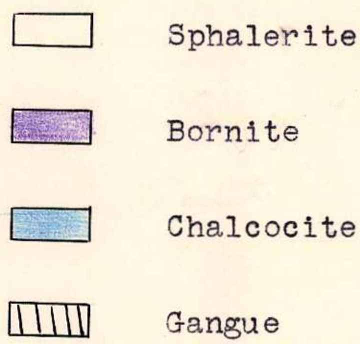
5 Gauding, A.M. and Dicke Gunther, "The Pyrosynthesis, Microscopic study and Irridescent filming of Sulphide compounds of Copper with Arsenic, Antimony and Bismuth," Econ. Geol., 34, 45-81 and 214-232 (1939).

Diagram III



section 4





Sphalerite replacing bornite and chalcocite. Minute crystals of chalcopyrite in the sphalerite (not shown).

System noted a considerable tendency for wittichenite to form solid solutions and that chalcocite was capable of dissolving large quantities of bismuth.

Relationships indicate that as the bornite cooled the chalcocite with wittichenite in it in solid solution exsolved from the system. Then, on further cooling the wittichenite came out of the chalcocite.

However, it is certain that bornite, chalcocite, wittichenite and most of the chalcopyrite are all contemporaneous.

Minerals earlier than the bornite-chalcocite

Minerals in this group are magnetite and linnaeite. No direct relationship was observed between these two.

Linnaeite - see diagram I - shows its crystal form and is usually seen surrounded by chalcocite. Some was observed in section four surrounded by sphalerite. Thus, linnaeite is older than the bornite-chalcocite et al and the sphalerite.

The magnetite is very closely associated with the gangue and in places it appears to replace the gangue.

Minerals subsequent to Bornite-Chalcocite

Sphalerite is seen cutting through the other minerals both megascopically and microscopically. Diagram III shows the relationship between bornite-chalcocite and sphalerite.

Secondary malachite can be seen replacing bornite in diagram II. Covellite is also present as a secondary mineral.

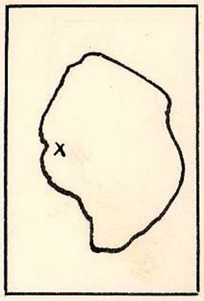
Conclusion

The following is a summarized list of the order of deposition:

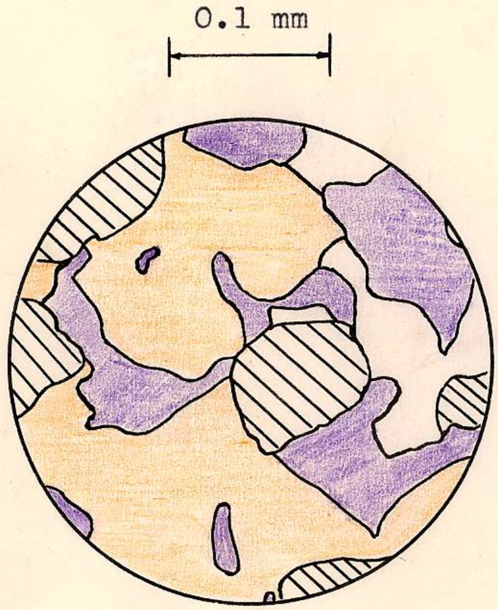
1st generation	Magnetite Linnaeite
2nd generation	Bornite, chalcocite, wittichenite, chalcopyrite Chalcopyrite (some carried on)
3rd generation	Sphalerite
4th generation	Covellite, malachite

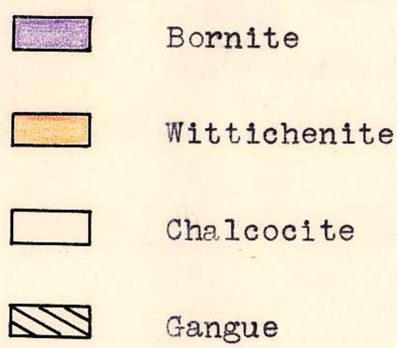
NOTE: No silver minerals were observed in the six polished sections studied.

Diagram IV



section 6

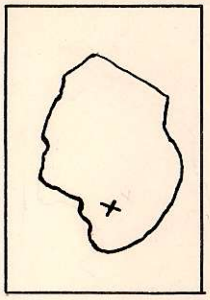




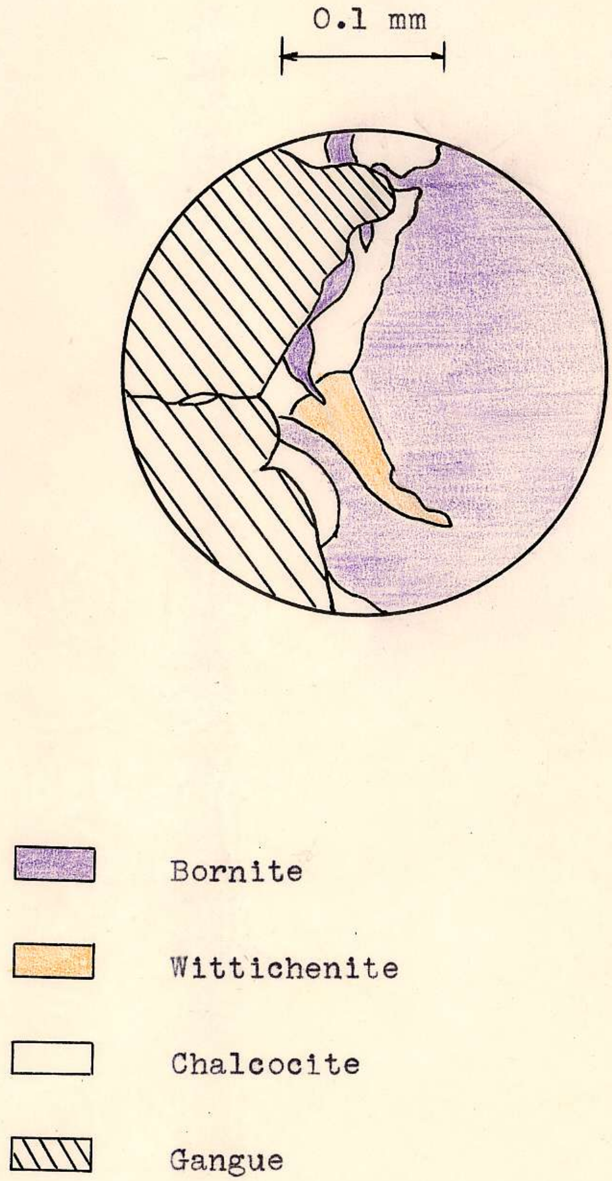
Typical of the conflicting relationships between wittichenite, chalcocite, and bornite. Relationships such that contemporaneous deposition is indicated.

Note - straight line contact between wittichenite and chalcocite in N.W. quadrant.

Diagram V



section 6



Another example wherein the relationships indicate contemporaneous deposition of wittichenite, chalcocite and bornite.

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