Geology 409

Microscopic Determination of Ore Minerals
from the
Grotto Mine, near Usk River, British Columbia.

Report No. 4.
March 30, 1962.
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Introduction

Specimens examined came from the Grotto Mine, near Usk, British Columbia. The collection of specimens was contributed by Joseph T. Mandy (1953), Joe Bell (1960), and D. Silversides (1960).

One specimen from a prospect about 500 feet vertically above the Grotto mine was donated by A. Davidson (1959).

Megascopic Examination of the Hand Specimens

One distinction is immediately apparent in the hand specimens. The specimen from 500 feet vertically above the Grotto mine is massive galena with some pyrite, sphalerite, and chalcopyrite. It bears little resemblance to the specimens from the Grotto mine.

The available specimens from the Grotto may be conveniently divided into the three groups below.

✓ 1. Specimens are predominantly white quartz with some chalcopyrite and pyrite.

✓ 2. Specimens are predominantly white quartz and micaceous hematite.

✓ 3. Specimens are predominantly grey quartz, with some pyrite, and some small patchy areas with dusty disseminations of tellurides.

In the first group, ore minerals are apparently controlled by fractures in the quartz which are up to 8 m.m. wide. Some massive concentrations of ore minerals also occur.

In the second group, the hematite irregularly replaces the quartz.

Chuck

The third group contains native tellurium which is readily identified by its pure white colour. Tellurides are indestinguishable from each other in the hand specimen because they occur as extremely fine disseminations. In one specimen sectile grey hessite (?) with a sooty black coating was found.

A powdery greenish yellow alteration, which is probably a hydrous iron alteration, coats parts of many of the specimens. Limonite and several specs of malachite and azurite occur. Thin slabs of greenstone country rock up to 1/4 inch thick occur in many of the hand specimens. Except for pyrite the greenstone does not contain any metallic minerals

The specimens were not flourescent or radioactive.

Examination of the Specimens from the Grotto Mine.

The following minerals have been identified by optical properties, etch tests, microchemical tests, other physical data, and with the aid of previous x-ray results.* †

Mineral #1:
Good polish; galena white colour; isotropic; hardness B. HNO_3 stains dark grey; $FeCl_3$ tarnishes irridescent; KOH, $HgCl_2$, KCN, HCl, negative.

Probably petzite.

Mineral #2:
Good polish; very slightly anisotropic; brass yellow colour; hardness C; black streak. $HgCl_2$, KOH, KCN, HCl, $FeCl_3$, and HNO_3, negative; aqua regia was not tested.

✓ Identified as chalcopyrite.

Mineral #3:
Poor polish; brownish yellow; hardness F (cannot scratch with a needle); isotropic. HNO_3 fumes tarnish; HCl, KCN, $FeCl_3$, KOH, $HgCl_2$, negative.

✓ Identified as pyrite.

* Short, N.M. Microscopic Determination of the Ore Minerals, Geological Survey Bulletin 914 (1940).

† Uytenbogaardt, W. Microscopic Identification of Ore Minerals (1951).

Mineral #4:

Fair polish; isotropic; colour grey; hardness C. HNO_3 fumes tarnish; $HgCl_2$, KOH, KCN, HCl, $FeCl_3$, negative.

✓ Identified as sphalerite.

Mineral #5:

Good polish; silvery white colour; hardness B; strongly anisotropic, polarization colours light to dark grey. HNO_3 effervescent; $FeCl_3$ positive; $HgCl_2$, KOH, KCN, HCl, negative. Previously identified by x-ray techniques.

✓ Identified as tellurium.

Mineral #6:

Good polish; creamy white; intense anisotropism in white to brown; solid, coarse grained mosaic. $FeCl_3$, HNO_3. positive; $HgCl_2$, KOH, KCN, HCl, negative. Previously identified by x-ray techniques.

✓ Identified as empressite.

Mineral #7:

Not destinguishable from empressite in the polished section. Previously identified by x-ray techniques.

✓ Identified as paraempressite

Mineral #8:

Polish fair; blue colour; hardness B; strong anisotropism in firey orange. Borders chalcopyrite (see Figures 1&5).

Identified as covellite.

Mineral #9:

Very poor polish; colour grey; numberous pits as very flakey, brittle and hard; red powder when scratched; locally shows internal reflection.

✓ Identified as micaceous hematite

Mineral #10:

Fair polish; pinchbeck brown colour; tarnished purple; hardness B; isotropic. HNO_3 eff., KCN, $FeCl_3$ positive. HOH, $HgCl_2$, HCl, negative. Closely associated with chalcopyrite.

✓ Identified as bornite.

Mineral #11:

Not identified in the polished sections.

Black sooty tarnish; sectile; grey colour.

Positive microchemical tests for copper and tellurium.

✓ Probably hessite .

Mineral #12:

Not identified in the polished sections.

Red irridescent tarnish on native tellurium (or other tellurides?). Previously identified by x-ray technique.

✓ Identified as rickardite.

Mineral Percentages.

Because of the diversity of the hand specimens previously described, it is impossible to accurately estimate mineral percentages. The order of abundance decreasing downward is probably as follows:

Hematite (Fe_2O_3).
Pyrite (FeS_2)
Chalcopyrite ($CuFeS_2$)
Minor native tellurium (Te), hessite (Ag_2Te), and sphalerite ($(Fe,Zn)S$).
Trace amounts of petzite (Ag_3AuTe), empressite (Ag_5Te_3), rikardite ($Cu_{3-x}Te_2$), covellite (CuS), and bornite (Cu_5FeS_4).

Textures and Paragenesis.

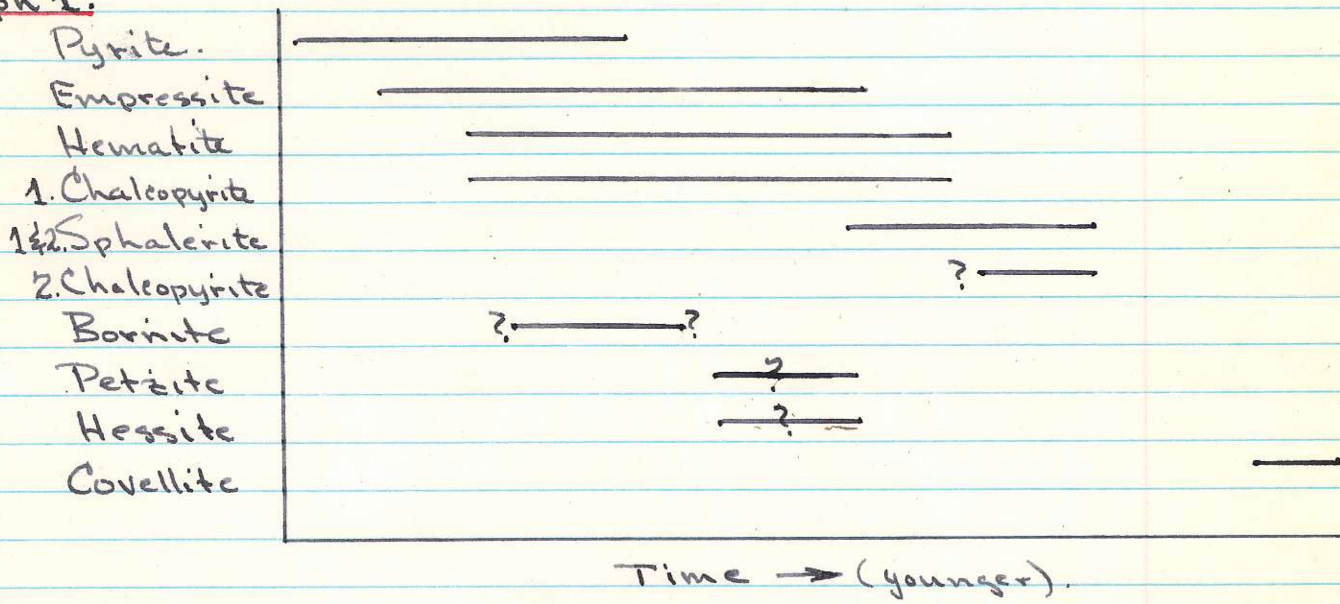
The polished sections do not show any particularly significant textures. Tellurides generally occur as fine disseminations which show few time relationships.

The paragenetic sequence has been tentatively established on a very few boundary conditions which are illustrated in figures 1 to 7. The sequence is illustrated with two graphs. Graph one is an interpretation of the relative time of formation of the ore minerals. Graph two is a Robertson—Van der Veer diagram which, although incomplete, shows the boundary relationships observed.

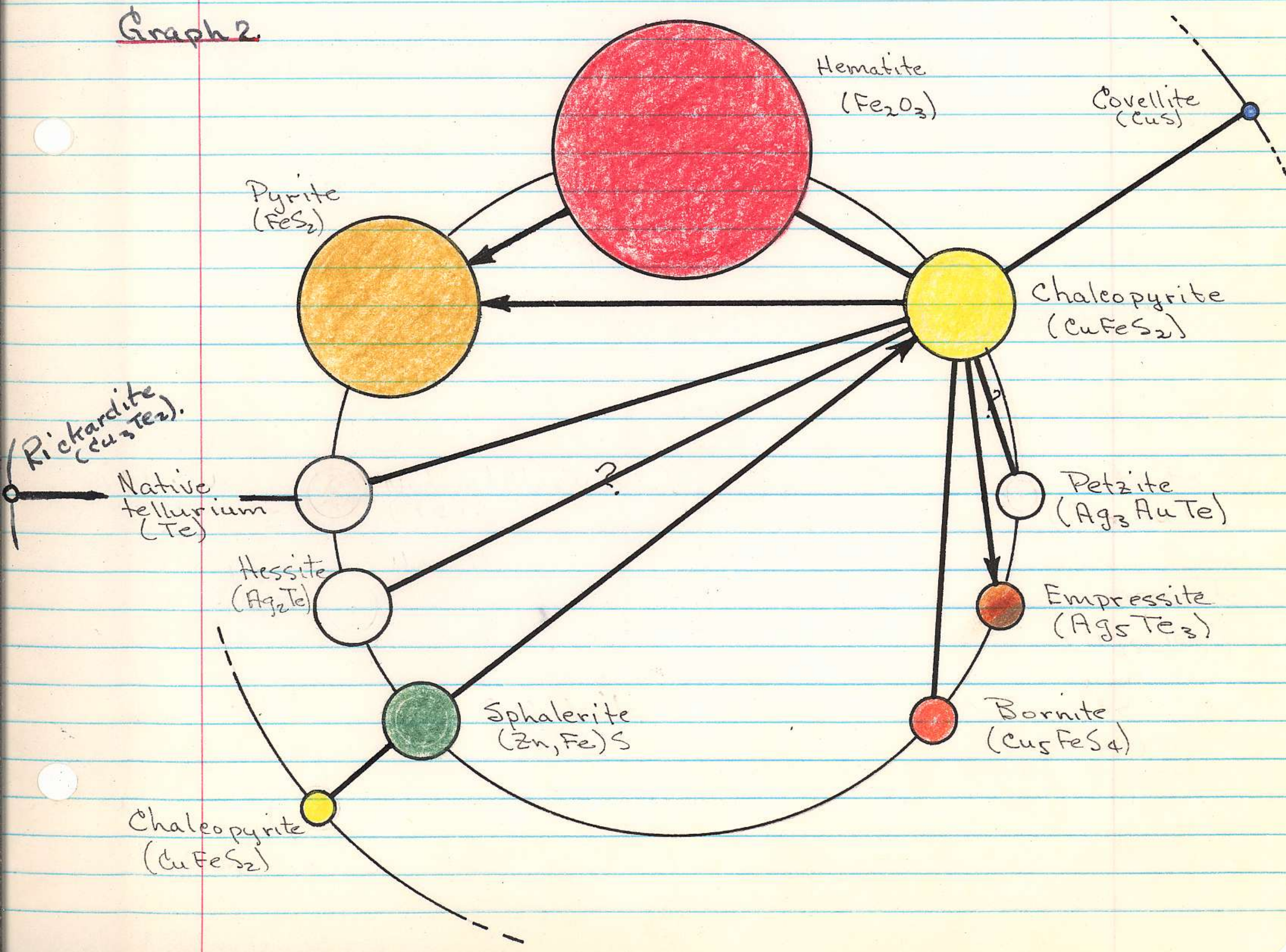
Tellurium is in abundance (suggested by the presence of native tellurium). Consequently, tellurides have been formed excluding native gold and common silver minerals such as

Paragenetic Graphs.

Graph 1.



Graph 2.



argentite and tetradedrite.

Figures four and five are apparently contradictory. In Figure four the chalcopyrite has exsolved from the sphalerite, but in Figure five the sphalerite corrodes the borders of the chalcopyrite. Consequently two origins of the chalcopyrite are suggested (see Graphs one and two).

The presence of tellurides and the fracture filling nature of the quartz suggests an epithermal deposit which would have been emplaced at a depth of less than 5,000 feet and at a temperature of 50 to 200 degrees centigrade.

Milling

Petzite contains the gold values. Milling to obtain all of the telluride particles would have to be down to 50 microns (see Figure 2).

Amalgamation to obtain the gold would not be possible because amalgam develops a contaminated surface ("sickens") in the presence of tellurides+.

+ Edwards, A.B. <u>Texture of the Ore Minerals</u> (1960).

Microscopic Examination of the Specimen from Above the Grotto Mine

The following minerals were recognized by their optical properties, and by other physical tests*

Mineral #1:

Poor polish; brownish yellow colour; isotropic; hardness F (not scratched by the needle).

Generally occurs with irregular boundaries resulting from replacement by galena. When it occurs in sphalerite, some crystal outlines are apparent but other edges are corroded (see Figure 8).

Identified as pyrite.

Mineral #2:

Good polish; galena white colour; isotropic; hardness B; abundant triangular pits.

Cleavage is crumpled indicating that the mineral has been strained after crystallization.

The mineral is likely the last formed in the paragenetic sequence because it extensively corrodes the borders of the other minerals.

Identified as galena.

Mineral #3:

Fair polish; isotropic; hardness C; grey colour; brown streak.

Replaces the pyrite and is replaced by the galena and chalcopyrite (see Figure 8).

Identified as sphalerite.

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* Short, N.M. Microscopic Determination of the Ore Minerals. Geological Survey Bulletin 914 (1940).

Mineral #4: Yellow colour;

Fair polish; hardness c; anisotropic; black streak.

Occurs mainly as unsupported neucleii in the galena.

Identified as chalcopyrite.

Mineral Percentages.

The mineral percentages of the one specimen are approximately as follows:

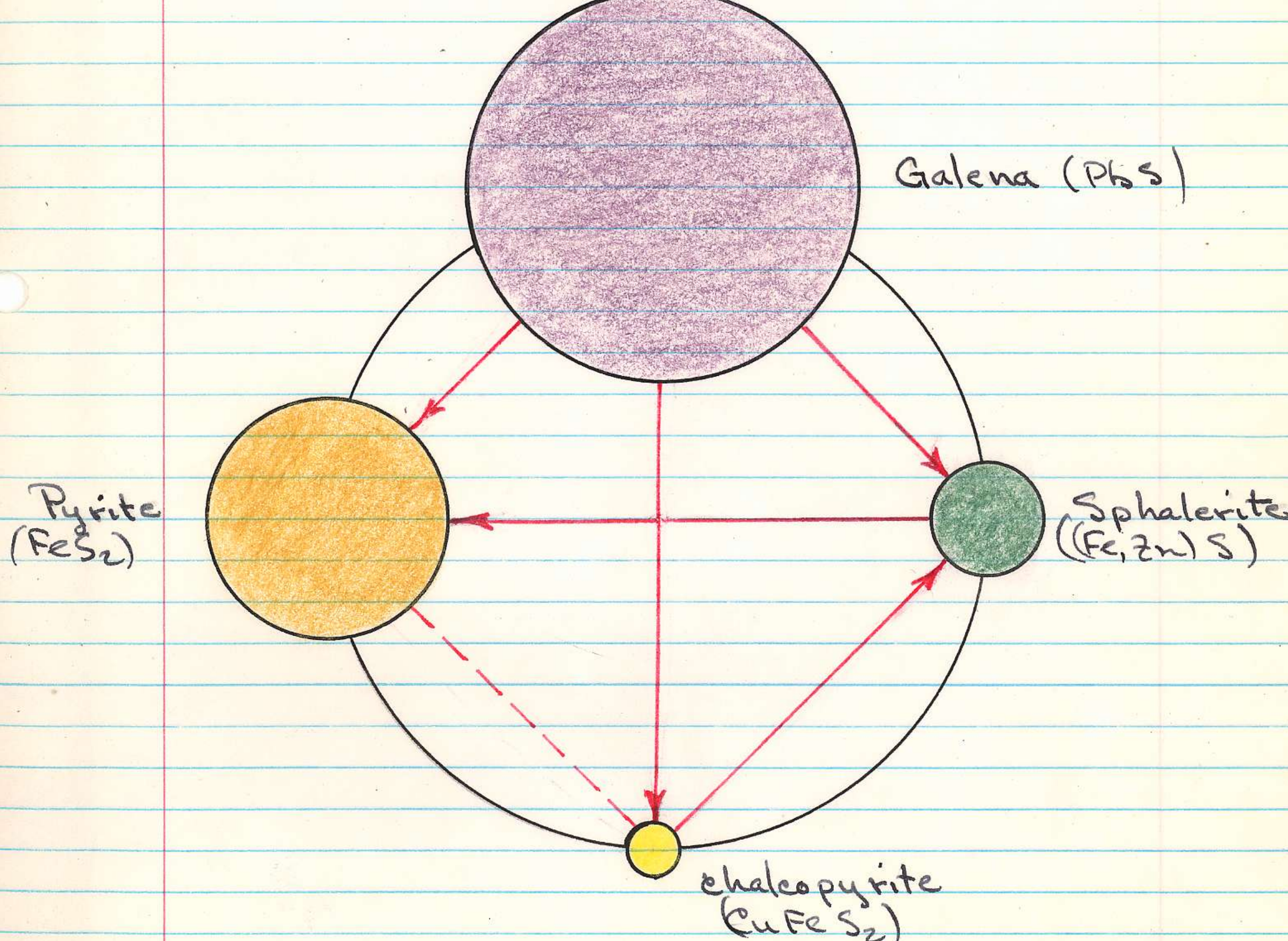
Galena (PbS)	60 percent.
Pyrite (FeS_2)	20
Sphalerite ($(Fe,Zn)S$)	15
Chalcopyrite ($CuFeS_2$)	5

Chemical analysis (data not available) from the locality of this specimen indicated the presence of Pb, Zn, Cu, Au, and Ag (up to 10 oz./ton). The silver in most galena analyses is presumably due to admixed silver minerals such as argentite or tetrahedrite.# These minerals were not found in the polished section because of the very low silver content (10 oz/ton).

Palache, Berman, Frondel, Dana's System of Mineralogy. Vol. 1., Seventh Edition, Wiley. Pp. 202.

Texture and Paragenesis.

The polished section does not illustrate any particularly significant structures. Boundary relationships which have been described and which are illustrated in Figure suggest the paragenetic sequence: pyrite, sphalerite, chalcopyrite, galena. This sequence is illustrated in the Robertson Van de Veer diagram below:



The one specimen suggests that the deposit would be best classified as a mesothermal deposit. These deposits are thought to be emplaced at a depth of 5,000 to 10,000 feet and at a temperature between 200 to 300 °C.

Milling

No particular problems in milling are apparent in the specimen. If all the chalcopyrite had to be extracted, the ore would have to be ground to about 700 microns (see Figure 8).

Conclusions

The following are main points brought out by the study:

1. Gold values in the Grotto mine are due to petzite.

2. The Grotto mine contains the very rare minerals, native tellurium and empressite.

3. Native gold and silver are probably nonexistent because of the excess tellurium available.

4. The paragenetic sequence cannot be well determined because of the lack of contact relationships.

5. The specimen from above the Grotto mine is unrelated to the specimens from the Grotto mine from the points of view of:
   (a) minerology.
   (b) environment of emplacement.

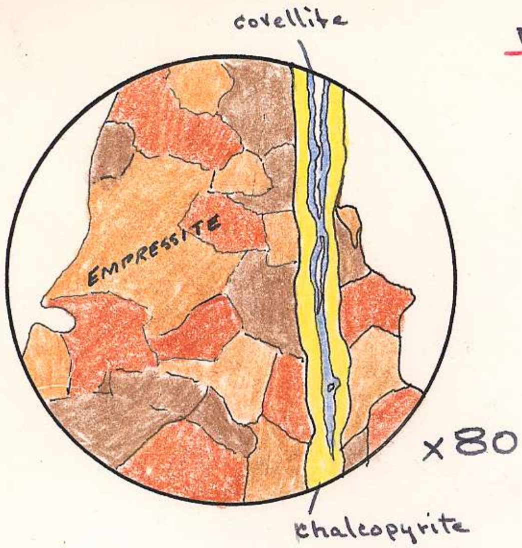


Figure 1:
Chalcopyrite replaces the empressite. Covellite is a secondary alteration of the chalcopyrite.
Note the striking mosaic and anisotropism colours the empressite (apparent under crossed nicols).

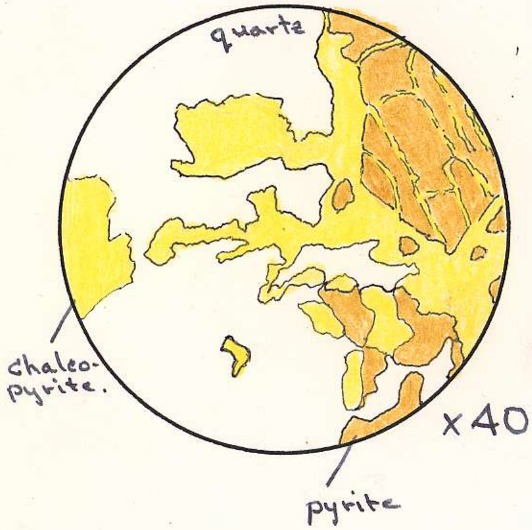


Figure 2:
Chalcopyrite replaces the pyrite in a rectangular network fashion (possibly along the indistinct (001) cleavage of pyrite).

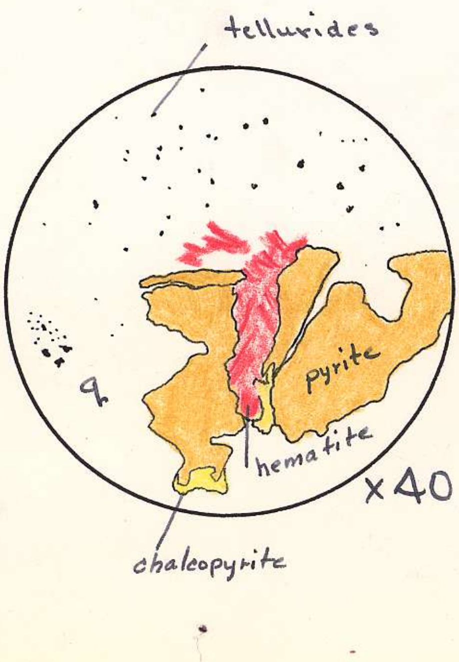


Figure 3:
Hematite and chalcopyrite appear to replace the pyrite.
Note the dusty texture of the tellurides (principally petzite) in the quartz. Smaller telluride particles are about 50 microns across.

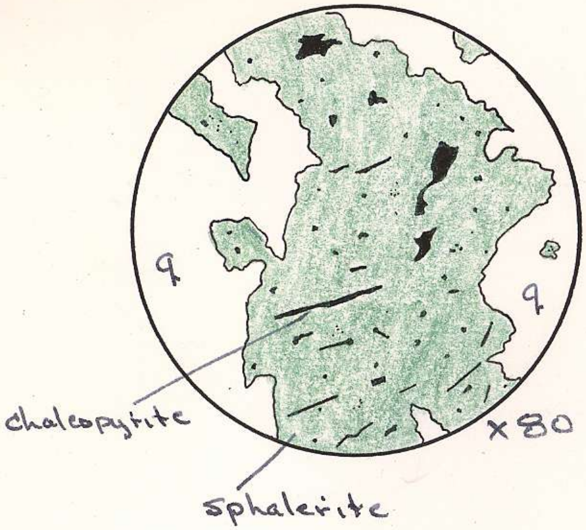


Figure 4.

Exsolution of chalcopyrite in sphalerite. Compare with Figure 5.

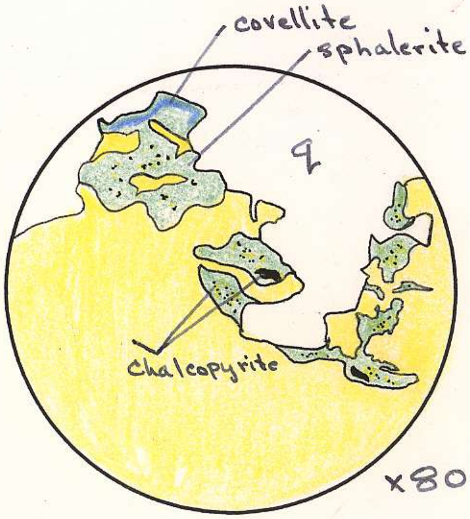


Figure 5.

Sphalerite replaces the borders of the chalcopyrite. Fine chalcopyrite unsupported neucleii are often clustered toward the centre of sphalerite grains. Compare with Figure 4.

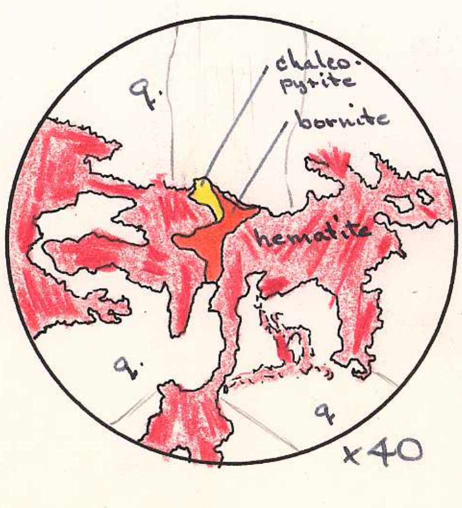


Figure 6.

Note the radiating clusters of hematite replacing the quartz. The border between the quartz and the hematite is very irregular.

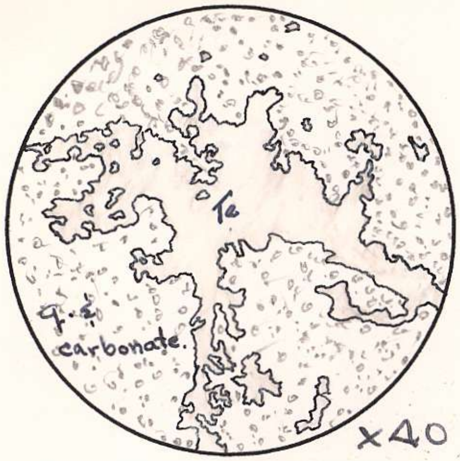


Figure 7:

Note the irregular borders of the native tellurium. The tellurium is replacing a fine grained, granular textured, mixture of quartz and carbonate.

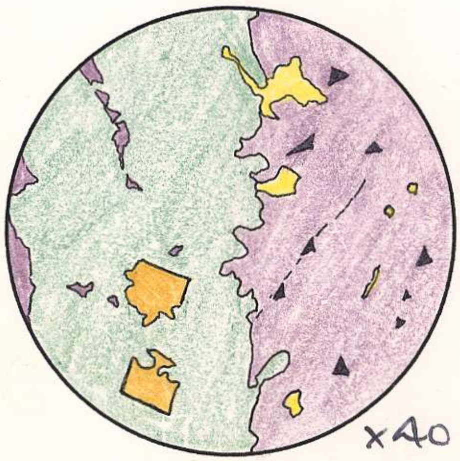


Figure 8:

Specimen from above the Grotto mine. Pyrite is replaced by sphalerite. Sphalerite is replaced by chalcopyrite. Galena replaces both the chalcopyrite and the sphalerite. Note the triangular pits in the galena, and the partial automorphic outline of the pyrite. Small particles of chalcopyrite are approximately 700 microns across.