

*Very neat work
macroscopic description
could be better. 80%*

600104

Mineralization and Paragenetic
Sequence at the Highland Bell
Mine, Beaverdell B.C.

A report written in partial
fulfillment of requirements
for Geology 409.

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INTRODUCTION

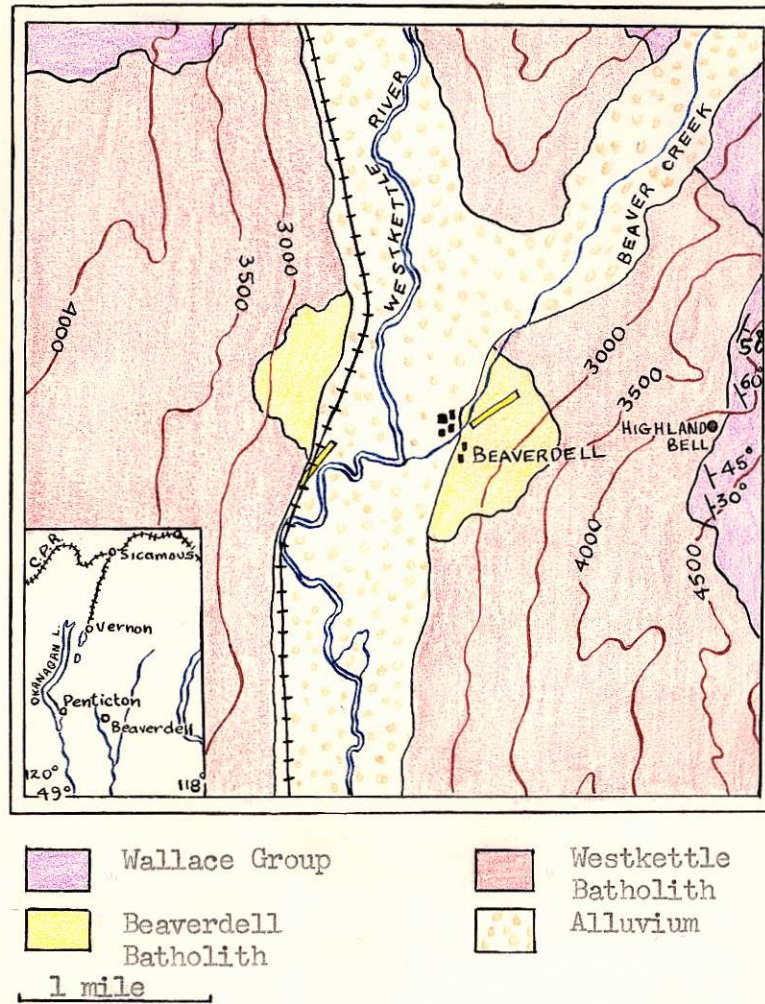
Object The object of the work was to determine the mineral assemblage and the paragenetic sequence at the Highland Bell Mine, Beaverdell B.C., as shown by ore from the fourth, sixth, and eighth levels. Nine polished sections and two thin sections were made in attempts to study most of the phases and types of mineral deposition represented in the specimens. Microscopic work was supplemented by megascopic examination and microchemical tests.

Considering the completeness of previous work, in covering the deposits in question, this report could only confirm earlier investigations, or supplement them to a very small extent.

Previous Work The geology of the Beaverdell area was quite fully described by L. Reinecke, working with the G.S.C., in 1915. In 1928 H. McKinstry did comprehensive work on the paragenesis of ore and gangue minerals of the Beaverdell deposits. A.B. Staples and H.V. Warren, in 1945-1946, made a megascopic and microscopic determination of the ore minerals present in the veins of the Highland Bell Mine. In 1949, W. White, working with the B.C. Dept. of Mines, studied some of the aspects of the structural geology of the Bell property.

LOCATION Figure 1

Sketch map of the Beaverdell area and (inset) its general geographic location in south-central B.C.



The mining camp of Beaverdell is situated on the Westkettle River some twenty-five miles east, and slightly south of Penticton.

GENERAL GEOLOGY

Stratigraphy The oldest rocks of the area are those of the Wallace Group. This series is largely igneous and consists of hornblende andesite tuffs, andesitic lavas and dykes of hornblende diorite. Parts of this series have been correlated with the Triassic, Jurassic Nicola Series.

The Westkettle quartz diorite batholith, probably Jurassic in age, intrudes the Wallace Group.

The Beaverdell quartz monzonite batholith intrudes the older rocks. It is of Eocene age.

The Curry Creek series of sediments, (not seen on map- Fig. 1) carrying Oligocene plant fossils, unconformably overlies the Wallace Group and Westkettle batholith.

Ore Bearing Veins The ore bearing veins of the Highland Bell Mine lie in the Westkettle quartz diorite, around the younger Beaverdell quartz monzonite. The veins are derived, mainly, by fissure-filling in well defined shear zones. In places, the ore has been displaced by closely-spaced faults.

The ore bodies were formed by hot ascending solutions, issuing from the magma of the Beaverdell batholith. Structural control of deposition was prominent, the ore being deposited in shear fractures which allowed ready entrance of solutions.

The ores are probably Eocene in age.

MINERALOGY

Mineral Assemblage The minerals identified, with a good degree of assurance were; Native Silver, Acanthite (Argentite?), Polybasite, Pyrargyrite, Tetrahedrite, Galena, Sphalerite, Chalcopyrite, Arsenopyrite, Pyrite, Quartz, Carbonate and a greenish alteration which is probably chlorite.

Identification of Minerals using Etch and Microchemical Tests, etc.

* Native Silver (seen in hand specimen only)

Megascopeic - The ball-like, wiry form is very distinctive. The color was silvery white, tarnished brown on the outer surface, and the hardness was about one. Grains were very sectile.

Microchemical test - A 1% HNO₃ solution of the decomposed mineral, with Ammonium Bichromate, gave red crystals - AG

* Acanthite (Argentite?) (seen in hand specimen only)

Megascopeic - Dark grey color with a dark black tarnish, soft and sectile. No good crystals were seen.

Microchemical test - A 1% HNO₃ solution of the decomposed mineral gave red crystals with Ammonium Bichromate.

* Pyrargyrite

Megascopeic - soft, dark silvery white, splintery and bright red on freshly broken surfaces.

Microscopic - The color is pale greenish-blue, hardness-B
Anisotropic- pale grey to dark grey and showing reddish internal reflection (very strongly in carbon arc light.)

<u>ETCH TESTS</u>	HgCl ₂ - positive	PbCl ₂ - positive
	KCn - "	KOH - "

HCl- positive HNO₃- positive

* Polybasite

Megascopeic - dark silvery color, high metallic lustre, soft. Some flat faces with triangular striations were seen.

Microscopic - Color- greyish white, with a greenish tint where in contact with pyrargyrite and tetrahedrite. Soft, B-C. Anisotropic, light yellowish brown to dark blue, with slight internal reflection.

<u>ETCH TESTS</u>	HgCl ₂ - positive	FeCl ₃ - negative
	KCn - "	KOh - "
	HCl - negative	HNO ₃ - positive

Microchemical test - A 1:7 HNO₃ solution of the decomposed mineral, with K₂Hg(CNS)₄, gave a white cloudy precipitate. - AG

A 1% HNO₃ solution of the decomposed mineral, with K₂Hg(CNS)₄, gave greenish yellow prisms and black feathery clumps. - AG, CU

A 1:5 HCl solution of the decomposed mineral, with CsCl₂, gave no precipitate. When KI was added, a precipitate of reddish stars and orange hexagons was obtained. - AS

* Tetrahedrite

Megascopeic - Fine grained, dark, dull grey, harder than pyrargyrite, polybasite.

Microscopic - Color- pale greyish green, hardness-D (comparatively high relief), Isotropic, may show slight internal reflection.

<u>ETCH TESTS</u>	HgCl ₂ - negative	FeCl ₃ - negative
	KCn - positive	KOH - "
	HCl - "	HNO ₃ - positive

Microchemical test - A 1% HNO₃ solution of the decomposed mineral, with KHg(CNS)₄, gave yellow prisms and black feathery clumps. - AG, CU

A 1:5 HCl solution of the decomposed mineral, with KI, gave an amorphous yellow precipitate. When CsCl₂ was added, the solution turns red and orange hexagons form. - SB

* Galena

Megascopeic - Color, silvery white metallic, hardness of three, cubic cleavage.

Microscopic - Bright white color, hardness-B, triangular cleavage pits, Isotropic.

<u>ETCH TESTS</u>	HgCl ₂ - negative	FeCl ₃ - positive
	KCn - "	KOH - negative
	HCl - positive	HNO ₃ - positive

* Sphalerite

Megascopeic - Dark reddish brown color, resinous lustre, hardness about three.

Microscopic - Dark grey color, hardness-C, Isotropic. Strong, dull red internal reflection in carbon arc light.

ETCH TESTS All reagents are negative.

* Chalcopyrite

Megascopeic and Microscopic - Brassy yellow color, hardness-C

ETCH TESTS HNO₃ and Aqua Regia were slightly positive, all other reagents were negative.

* Arsenopyrite

Megascopeic - Silvery white color, hardness about six.

Microscopic - Silvery white color, hardness-F. Anisotropic, light brown to light bluish grey. Often occurs in euhedral prisms or diamond-shaped cross sections.

ETCH TESTS HNO_3 effervesces, staining brown to blue. Aqua Regia is positive, all other reagents are negative.

Microchemical test - A 1:7 HNO_3 solution of the decomposed mineral, with Ammonium Molybdate, gave yellow isometric crystals. - AS

$\text{KHg}(\text{CNS})_4$, added to the filtrate of the above solution gave a reddish color. - FE

* Pyrite

Megascopeic and Microscopic - Pale brass yellow color, hardness-F, Isotropic. (Poor polish)

ETCH TESTS Negative to all reagents.

* Quartz, Carbonate (effervesces with dilute HCl)

CONCLUSIONS

Megascopeic and Thin Section- Description of Specimens

There is little or no conspicuous mineralogical difference, in one type of ore, in its occurrence on both the fourth and eighth levels. This ore consists of wire, native silver and massive acanthite, which form small blebs in vugs of coarsely crystalline quartz. Small amounts of disseminated pyrite arsenopyrite, sphalerite, galena, tetrahedrite? and chalcopyrite, are also present. A finely crystalline greenish alter-

ation is also associated with the quartz.

Two thin sections of this vuggy quartz, one of the fourth level and one of the eighth, were made with the idea of determining the relationship of the mineralization (especially native silver) to the vuggy quartz. It was thought some indication of either hypogene or supergene origin of the silver might be found. This did not prove to be the case, since no silver was present in the sections. Figures 2,3 and 4 show portions of thin sections of vuggy quartz from the two levels. The greenish alteration is colorless in thin section and slightly pleochroic. Individual grains are roughly prismatic, have low birefringence and straight extinction. They form parallel masses of feathery grains or small radiate bundles. This material is probably a chlorite. It corrodes the quartz grains. A few high relief, high birefringence grains are present which may be Sphene. The latter are also corroded by chlorite. Metallic grains, mainly pyrite and arsenopyrite, are closely associated with the alteration, in many places, and appear to be contemporaneous in age with the chlorite. The quartz grains are broken and crushed adjacent to veinlets of sulphides, and the latter have been replaced by fissure filling, with minor replacement of quartz along the contacts.

In addition to the rather sparsely mineralized (except for silver) vuggy quartz ore, massive ore, some of which is distinctly banded, occurs on the eighth level, and even more notably on the sixth. This latter ore may contain little or no quartz gangue and show alternating bands of sphalerite,

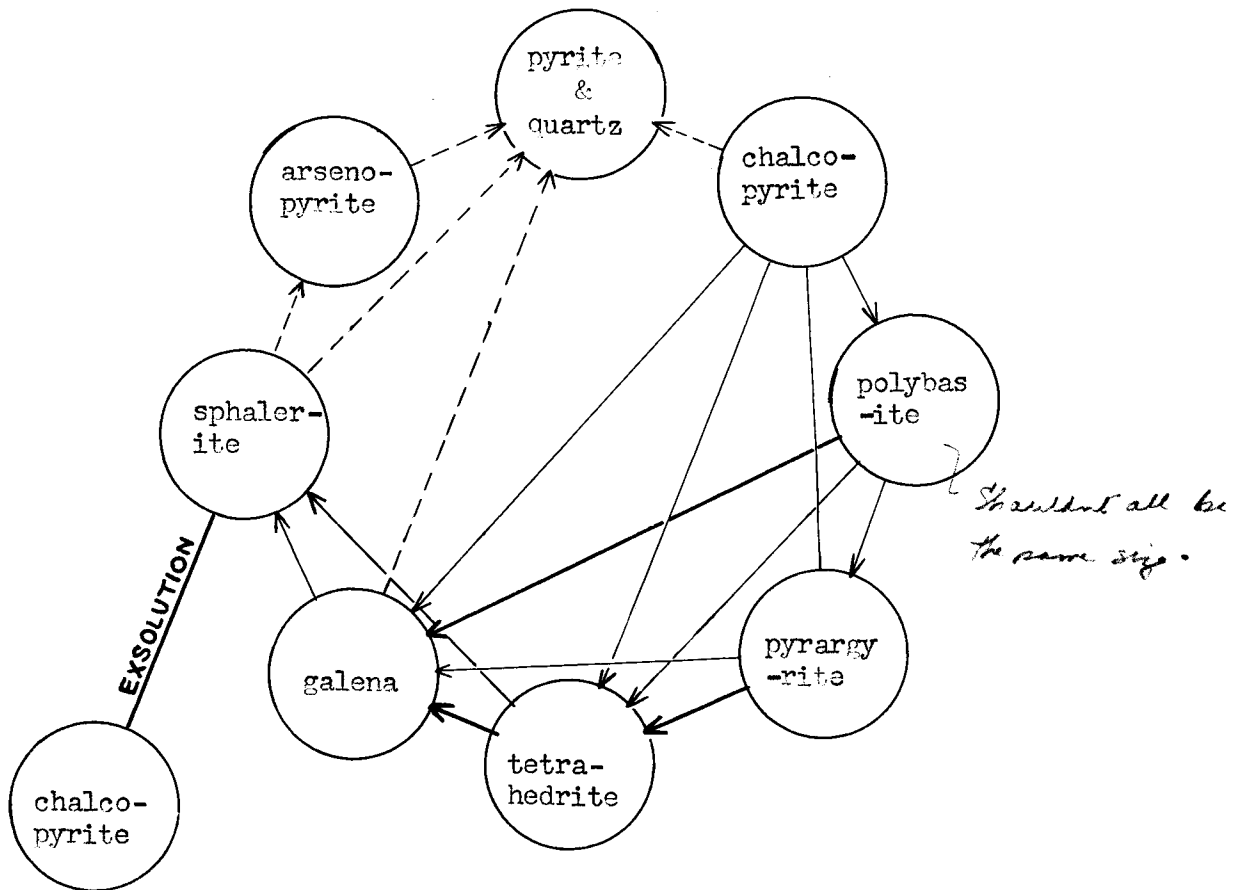
pyrite, galena and arsenopyrite. Disseminated through the bands, or forming discontinuous veinlets themselves, are variable amounts of chalcopyrite, pyrargyrite and tetrahedrite. The banded sequences are cut at right angles by stringers of polybasite, in places.

Microscopic Description- Paragenesis, from Polished Sections

Paragenetic Diagram (Native Silver and Acanthite- not seen in polished section)

Mainly fissure filling ----->

Fissure filling in part, ———> Strong replacement
 replacement important. ———> Weaker "



The general succession, as seen in polished section, is relatively clear, but it is probably much more complex than is pictured, and overlaps a good deal.

The dominant process in the early stages was fissure filling, while a replacement mechanism, of deposition, later became important or dominant.

Vuggy quartz was the first mineral to crystallize. Massive pyrite may have crystallized simultaneously, with quartz, or followed closely after it, filling interstices. Deposition of arsenopyrite followed that of pyrite. In banded sequences, arsenopyrite often coats the earlier sulphide. A second generation of quartz probably accompanied arsenopyrite, and during, or just prior to the deposition of these two minerals, some brecciation or small movement took place. Arsenopyrite crystallized in open fissures, mainly, with some replacement along contacts with quartz. (Figure 5)

Parts of this early fissure-filling process may have been repeated. More than one generation of pyrite and quartz is almost certainly involved.

Sphalerite was the next mineral to be deposited, mainly by the infilling of brecciated quartz, pyrite and arsenopyrite. Galena appears to corrode sphalerite, surround it and cross-cut it in veinlets, in places. Like sphalerite, galena has been deposited in open spaces, to some extent, around earlier constituents. (Figure 6, Figure 10)

Tetrahedrite was introduced next, mainly by replacement but with some filling of spaces around pyrite and quartz.

Tetrahedrite has replaced galena strongly (Figure 8) and sphalerite to a lesser extent.(Figures 6, 6a, 9).

Pyrargyrite replaces tetrahedrite strongly, while rims of the latter mineral seem to protect galena from any large scale replacement by pyrargyrite, (Figure 11- sea and island texture) . The latter mineral does replace galena to some extent, (Figure 7)

Polybasite is seen to replace pyrargyrite and tetrahedrite, to some extent, and galena very strongly. Polybasite attacks the latter mineral even in veinlets, where galena crosscuts earlier banded minerals. (Figures 12, 12a, 13)

Chalcopyrite occurs only as small grains, disseminated in various minerals. Its relations are therefore rather obscure. Its most notable occurrence is as tiny blebs in sphalerite. The blebs are very abundant, in this case, and they have a semi-aligned appearance. The chalcopyrite has probably been exsolved from the sphalerite. Other, sparsely scattered grains of chalcopyrite in galena, tetrahedrite, pyrargyrite and polybasite, must have formed as replacement of these minerals. (Figures 9, 12a, 13 etc.) Chalcopyrite replacement grains formed late in the sequence.

The latest stages in deposition consisted of introduction of carbonate and quartz gangue. In places the latter is seen to cut across polybasite veinlets. (Figure 14) Carbonate gangue corrodes polybasite in some sections.(Fig. 15)

In a generalized manner, the sequence can be stated as:

Pyrite and Quartz
 Arsenopyrite
 Sphalerite
 Galena
 Tetrahedrite
 Pyrargyrite
 Polybasite
 Chalcopyrite
 Quartz and Carbonate.

All these minerals are hypogene. McKinstry, discussing the origin of argentite and native silver, which are late in the paragenetic sequence, says, "Native silver may well be secondary and a replacement of easily altered argentite." "The presence of well crystallized barite and fluorite suggests hypogene mineralization. " "Secondary enrichment has not been important." Staples and Warren also state that, "acanthite is found from the top to the bottom of the mine and is not supergene." "Native silver is more conspicuous in upper levels but is found down to the lowest level." "Occurrences of it are related to the present surface.....but the native silver is apparently hypogene."

Temperature of Deposition - In his work, McKinstry states, that "there seems to be a steep thermal gradient," in the Beaverdell deposits. " Ore of the mesothermal zone (followed by later epithermal mineralization) formed within 2000' of surface, ruby silver disappears 600' lower and tetrahedrite about 1000' lower."

Acanthite is said to form only at temperatures below 179 degrees centigrade. This mineral occurs on both the fourth and eighth levels. The temperature of chalcopyrite exsolution

in sphalerite is placed at 350-400 degrees, or 550 degrees by another investigator. The melting point of pyrargyrite is 483 degrees, of galena, 1120 degrees.

Some general correlation between paragenetic sequence and falling temperatures is apparent. The wide range of temperature of formation, of associated minerals, suggests telescoping in deposition.

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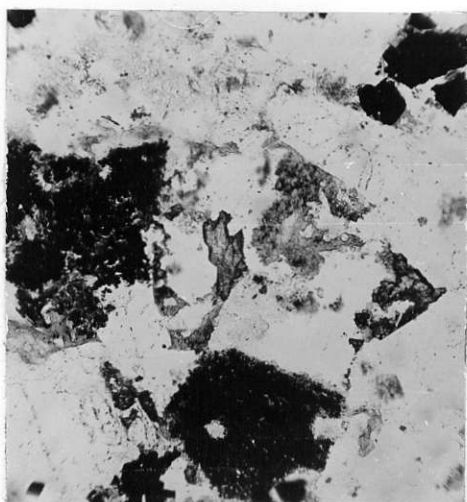


Figure 2

Vuggy quartz from the eighth level. (Ordinary light)

Black- pyrite, arsenopyrite.
 Light grey- quartz.
 Dark grey, low relief- chlorite
 Dark grey, high relief- ?

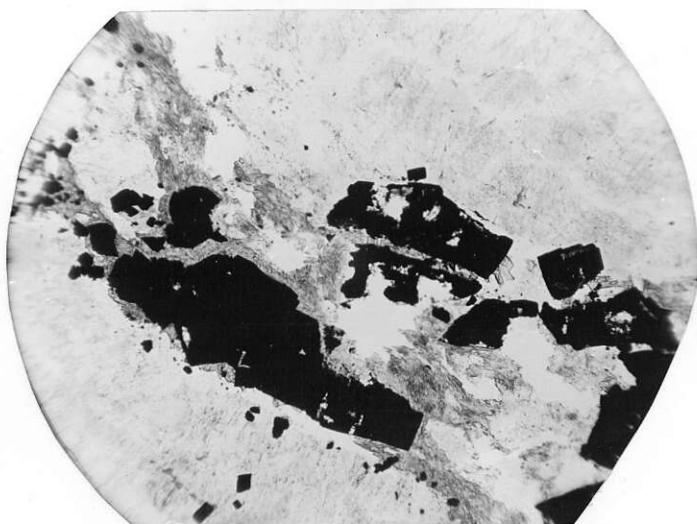


Figure 3

Vuggy quartz from the fourth level (Ordinary light)

Black- arsenopyrite.
 Light grey- quartz.
 Dark grey- chlorite.

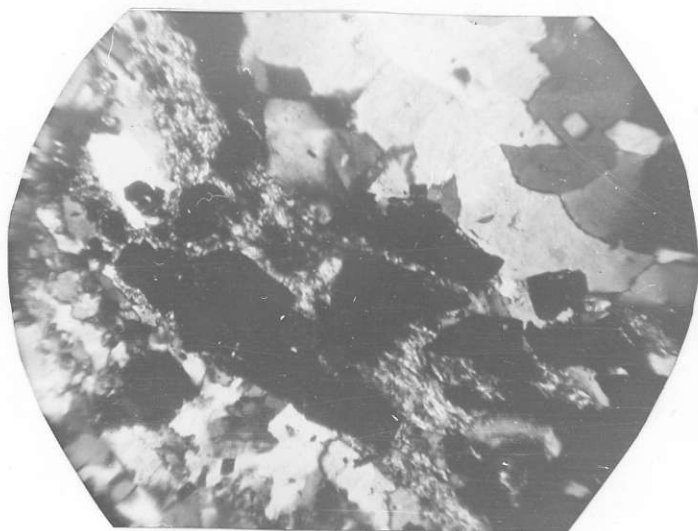
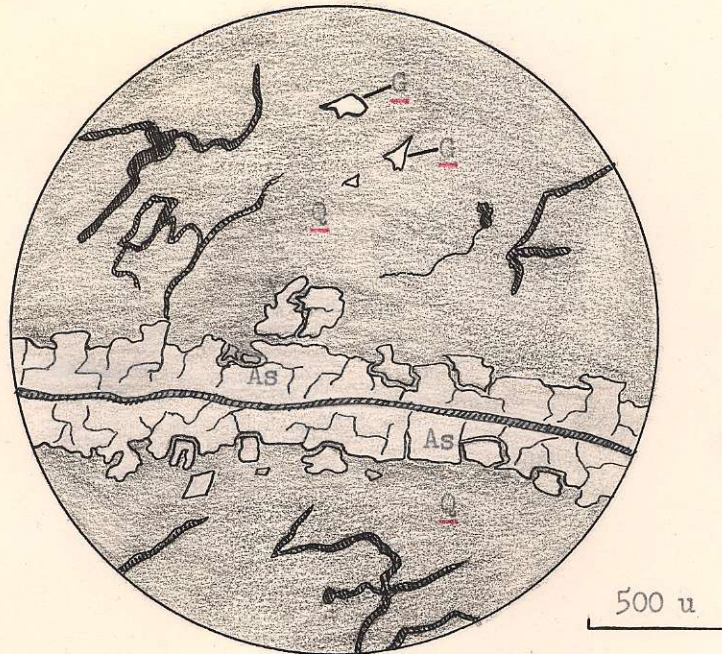


Figure 4

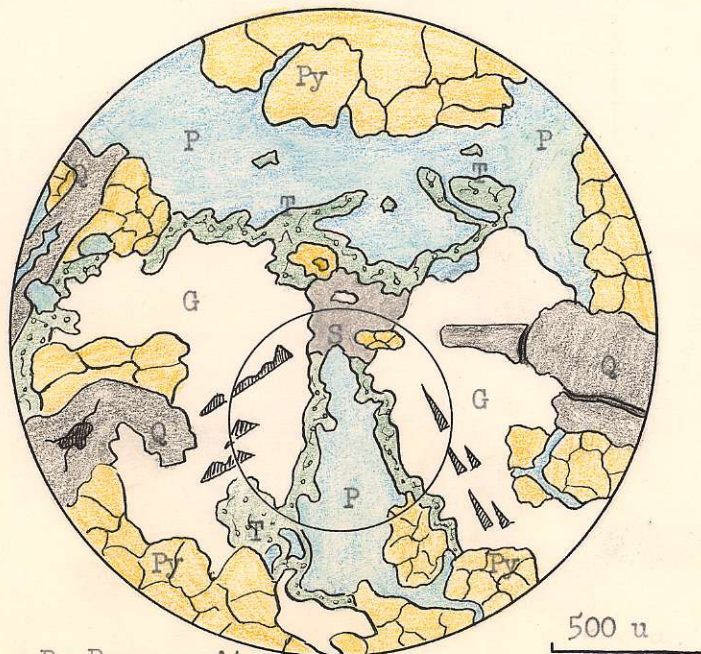
As in Fig. 3 (X-nicols)

Figure 5 (low power)



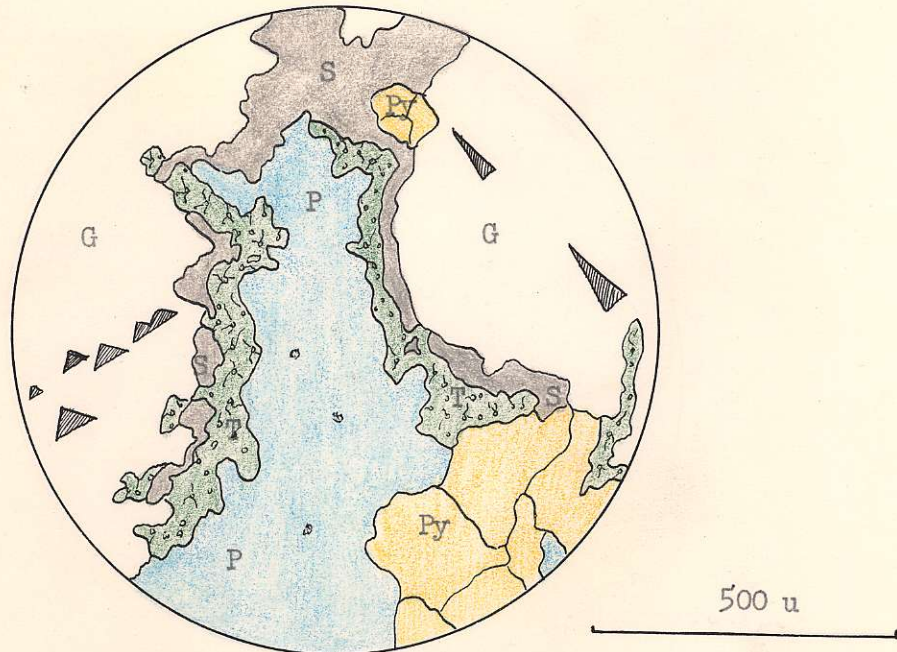
As- Arsenopyrite veinlet in Q- Quartz
G- Galena

Figure 6 (low power)



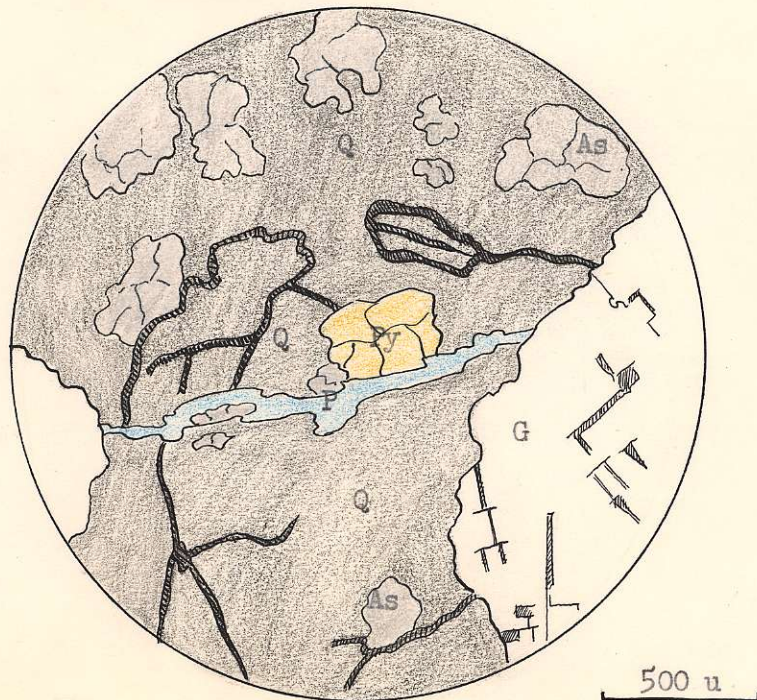
P- Pyrrangryrite
Py- Pyrite G- Galena T- Tetrahedrite
Q- Quartz S- Sphalerite

Figure 6a (medium power)



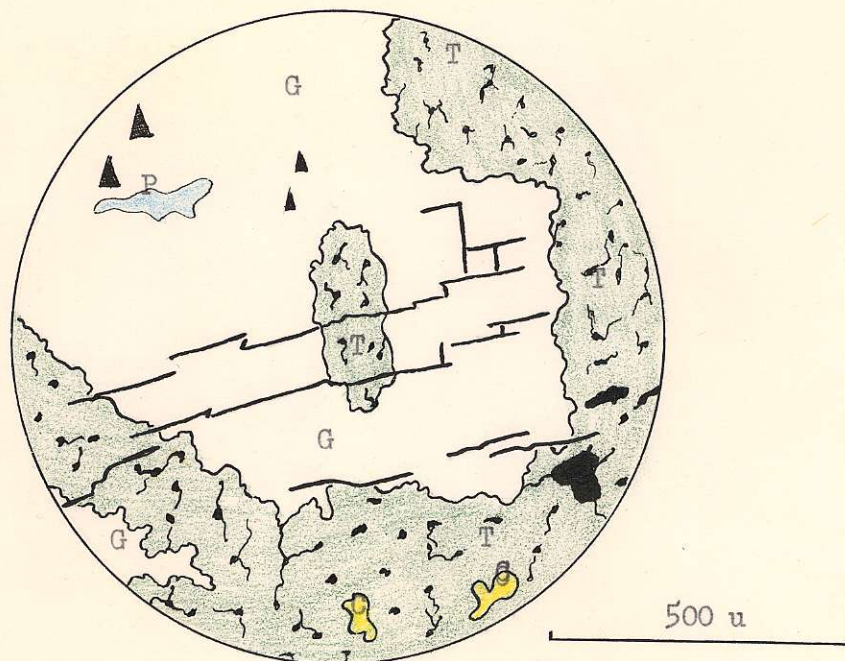
Circled area in Fig. 6
 G- Galena P- Pyrargyrite
 S- Sphalerite Py- Pyrite
 T- Tetrahedrite

Figure 7 (low power)



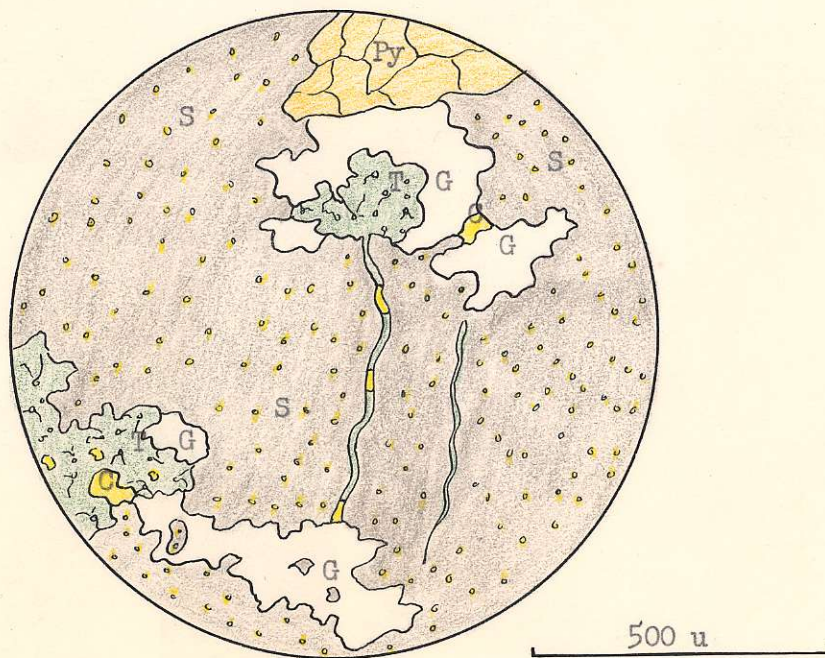
P- Pyrargyrite Py- Pyrite
 Q- Quartz G- Galena As- Arsenopyrite

Figure 8 (medium power)



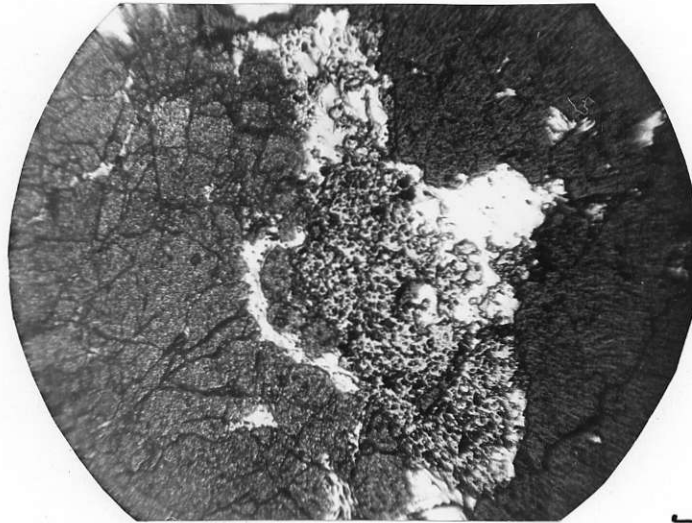
P- Pyrargyrite G- Galena
T- Tetrahedrite C- Chalcopyrite

Figure 9 (medium power)



C- Chalcopyrite G- Galena
Py- Pyrite S- Sphalerite (with Chalcopyrite blebs)
T- Tetrahedrite

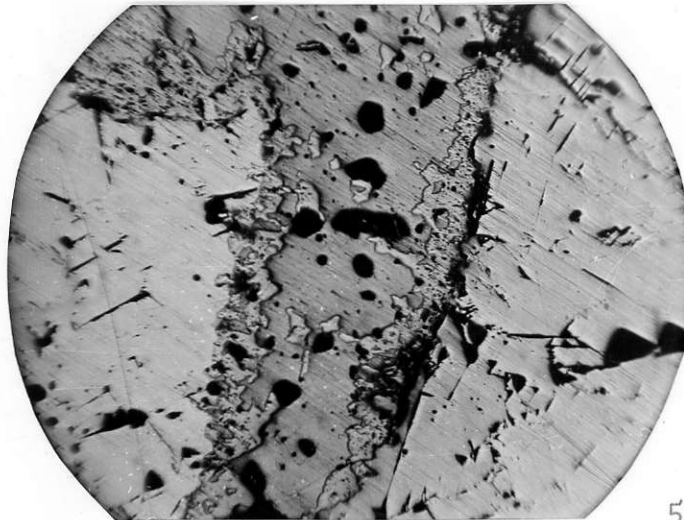
Figure 10 (low power)



500 u

Roughly banded sequence of pyrite (medium grey) quartz (dark grey- right side), sphalerite (pitted light grey) and galena (white, also encloses some tetrahedrite and pyrargyrite not visible).

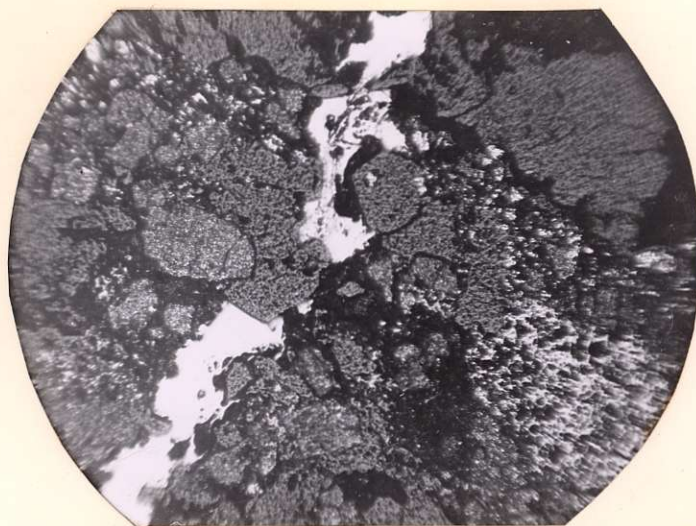
Figure 11 (low power)



500 u

Tetrahedrite (medium grey, pitted) bordering Pyrargyrite (darker grey) in Galena (white).

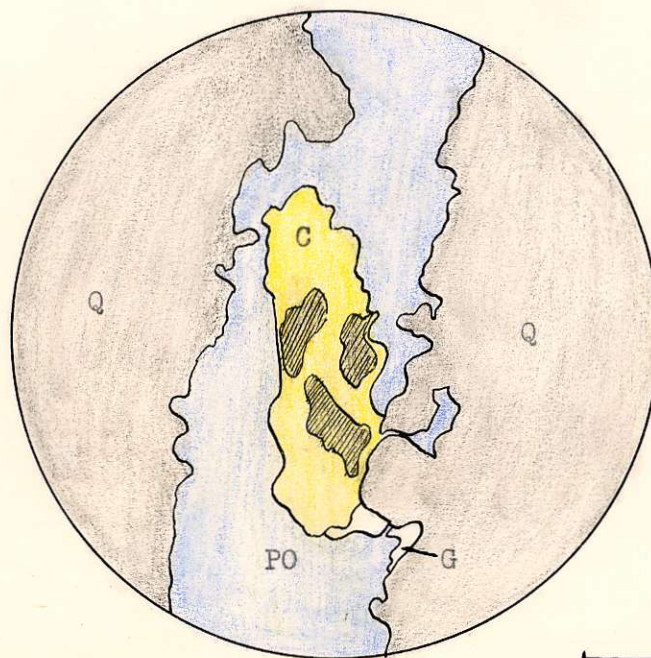
Figure 12 (low power)



500 u

Polybasite (white) veinlet crosscutting quartz (dark grey), pyrite, (lighter grey), sphalerite (pitted light grey) and arsenopyrite (whitish blebs) which are rather brecciated, and roughly banded. Small white blebs in vein are chalcopyrite.

Figure 12a (medium power)

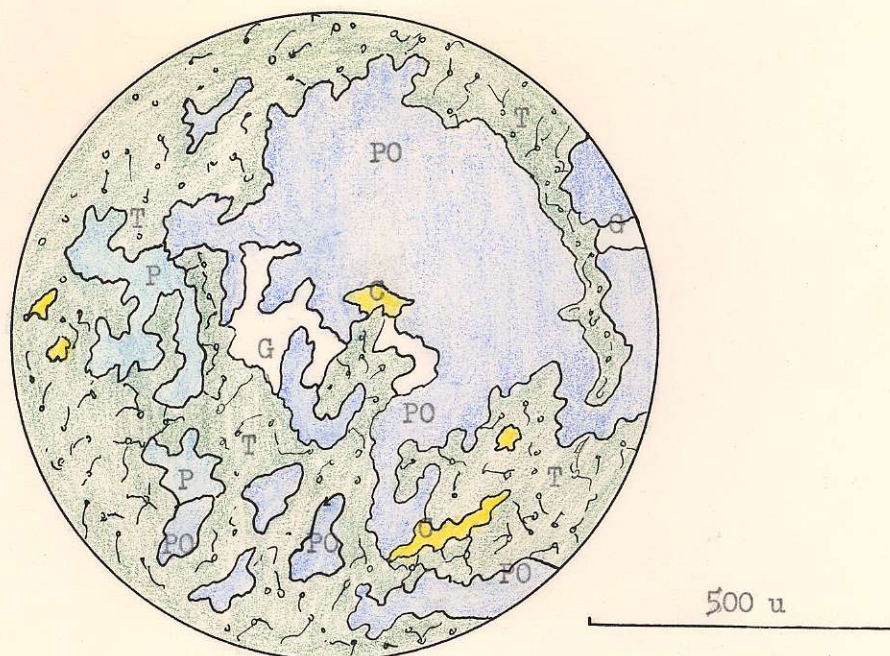


500 u

Enlargement of portion of Fig. 12

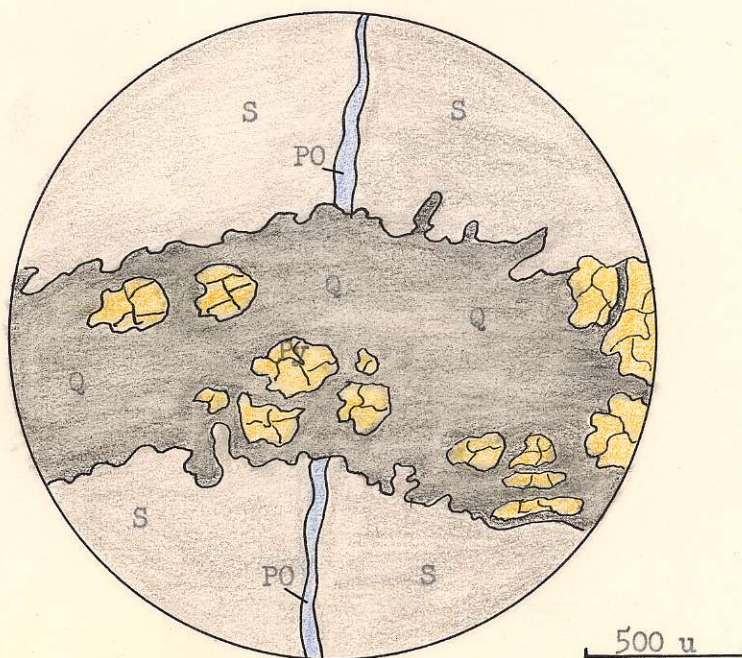
Q-Quartz G-Galena
PO-Polybasite C-Chalcopyrite

Figure 13 (medium power)



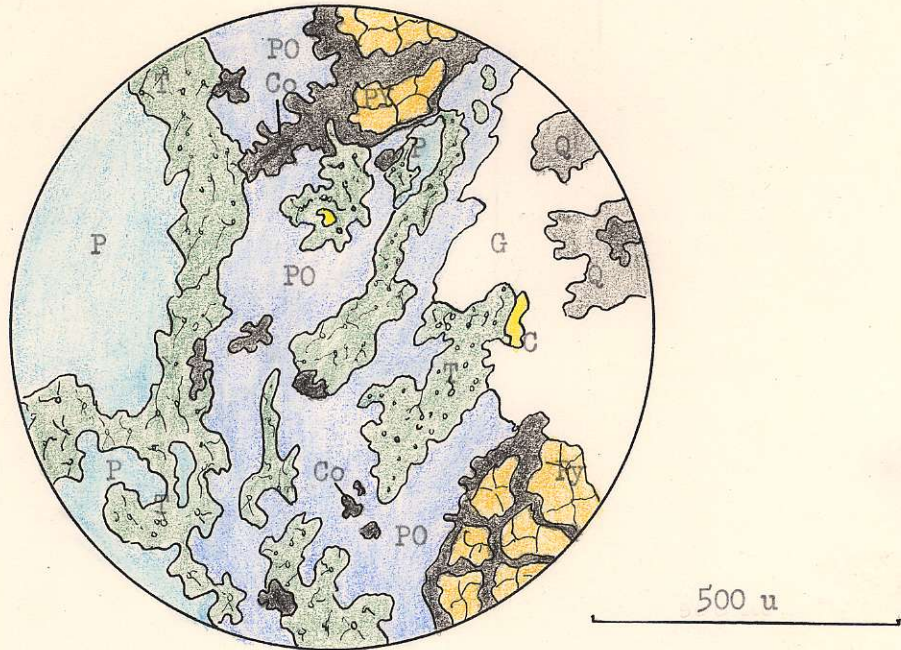
P- Pyrargyrite PO- Polybasite
 G- Galena T- Tetrahedrite
 C- Chalcopyrite

Figure 14 (low power)



S- Sphalerite PO- Polybasite
 Q- Quartz Py- Pyrite

Figure 15 (medium power)



PO- Polybasite Co- Carbonate
 P- Pyrargyrite T- Tetrahedrite
 Q- Quartz C- Chalcopyrite
 Py- Pyrite G- Galena