A MINERAGRAPHIC STUDY

OF ORE FROM

THE HIGHLAND BELL MINE

Yale District, British Columbia.

by

Charles B. Newmarch

The University of British Columbia

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ILLUSTRATIONS

ACKNOWLEDGMENTS

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LOCATION

The Highland Bell Mine is in the Boundary District of Southern British Columbia between Okanagan and Kootenay Lakes. The mine is located on the west slope of Wallace Mountain approximately one mile due east of the town of Beaverdell on the Kettle Valley Railway.

HISTORICAL SKETCH[1]

In 1936 the Bell and the Highland Lass Mines passed under a single ownership through the amalgamation of the two operating companies, the new organization taking the name of Highland Bell Ltd.. N.M. Mattson, who directed the operations at both mines was appointed manager.

The small veins of high grade silver-lead ore are intersected and displaced by numerous faults, in the vicinity of which the ground is often blocky and somewhat treacherous. The method of mining followed is by overhand stoping with waste filling, there being an abundance of stowing material at all times. The number of men employed varies from 32 to 38.

The mine, which has the reputation of being the most profitable operation on Wallace Mountain, has produced (up till the end of 1939) 530 ounces of gold, 2,610,319 ounces of silver, 1,678,636 pounds of lead, and 2,290,411 pounds of zinc.

The company, which has a capital of 1,500,000 shares of one dollar par value, has its main office at Penticton B.C. and the mine office at Beaverdell. F.V. Staples is the president, Miss A.H.Doyle is secretary treasurer, and R.B. Staples is the managing director.

GENERAL GEOLOGY

The geology of the district has been described by by Reinecke[2]. The oldest rocks in the area are the Wallace group, which occupy about one-third of it and generally outcrop on the upland. They consist of limestone, argillites, andesites, tuffs, schists, and basic plutonic rocks; the andesites and tuffs forming perhaps 80 percent in bulk of the whole. The sediments, andesites, and tuffs are bedded and in some cases have been thrown into open folds. The andesites and tuffs occur also in irregular masses in which bedding planes are not apparent. The coarser igneous rocks are in dykes, sheets or irregular masses. The group is provisionally classed as of Triassic-Jurassic age.

Into this group there is intruded an extremely irregular batholith, the West Fork (Westkettle) quartz diorite, which is thought to be of Jurassic age. In the Eocene another batholith, the Beaverdell quartz monzonite came into place.

The oldest group, the Wallace, has been very extensively faulted, brecciated, and metamorphosed; but only locally foliated. The metamorphism varies in character and intensity from place to place, and is largely the result of later, batholithic intrusion. The West Fork batholith is also faulted, brécciated, and locally foliated but in less degree than the Wallace group. The Beaverdell batholith of the

Eocene is nowhere foliated, seldom brecciated, and, except very locally, is unmetamorphosed.

McKinstry[3] concludes that the similarity in composition of the two intrusives suggests that they are differentiates from the same magma, the later differentiate being the more siliceous.

Thus a small stock intrudes a batholith which has already intruded earlier sediments and volcanics. The veins occur about the stock but in the batholith and where they pass upward into the Wallace formation they become non-productive.

ORE DEPOSITS

The veins strike east and west, and most of them dip southward, although a few are vertical or dip northerly. They vary in width from a few inches to six or eight feet though the individual ore-bearing streaks are seldom more than a foot or so in width. In places the vein or "shear zone" consists of a number of parallel ore streaks. The veinlets forming the lodes undergo intricate branching and in places almost form a breccia of the country rock. Large vugs and coarse comb-structure occur, but are rare. Tiny vugs in the quartz are common.

The gangue is mainly quartz but this is minor in amount. The vein filling consists of pyrite with some arsenopyrite, sphalerite, galena, tetrahedrite, and pyrargyrite. The proportion of the minerals varies. In some veins pyrite predominates, in others sphalerite, and in still others galena. Usually all the other minerals mentioned are present.

An entirely later type of mineralization consists of veins carrying calcite, argentite, and native silver. They are later than the earliest faulting, as the faults themselves show mineralization of this type and bear delicate unshattered calcite crystals. In the Highland Bell Mine veins of this type yield native silver in association with green fluorite.

Ore from other mines near the valley bottom, which is at 2500 feet elevation, consists of coarse-grained sphalerite and galena with decidedly lower silver content and higher gold.

DETERMINATION OF MINERALS

The following minerals were identified in the sections Quartz, Pyrite, Arsenopyrite, Sphalerite, Galena, Tetrahedrite, Pyrargyrite, Chalcopyrite, Stephanite, Argentite, Native Silver, Calcite, and Fluorite. Worthy of comment are

Tetrahedrite

In contact with galena or pyrargyrite this mineral appears to be tannish grey. It is harder than the galena and tetrahedrite so that by drawing a needle across the boundary between these minerals the scratch produced is noticeably wider in the galena and pyrargyrite than it is in the tetrahedrite. The mineral gave microchemical tests for Cu, Sb, S, and Ag. Unfortunately the tetrahedrite has been almost universally strongly attacked by pyrargyrite so that it is extremely difficult to extract a clean piece of mineral. Although it is possible that the argentiferous variety, freibergite, may be present, it is more probable that the silver test was positive due to admixed ruby silver in the specimen tested. For convenience the mineral will be referred to as "tetrahedrite" in the following pages.

Pyrargyrite

This mineral in contact with galena or tetrahedrite shows a noticeable bluish tinge. It gives a deep red internal reflection at the edges of grains or in scratches or pits when the surface is illuminated with inclined light, such as the arc light or strong daylight. This internal reflection is also prominent with crossed nicols. Short describes the interference colors as "light grey, steel grey, brown". The colors noted were bluish violet and yellowish green, the mineral being rather strongly anisotropic.

A crystal of the mineral was selected and two small clean fragments broken off under the binoculars. The specific gravity of the fragments was found to be 5.85, which is the value given by Dana for pure pyrargyrite.

One edge of the crystal was polished flat on the polishing lap, the crystal was mounted in plasticine and examined with crossed nicols. The interference colors mentioned above (violet and green) were noted. Hence it is reasonable to suppose that the mineral in the sections yielding violet and green interference colors is pyrargyrite of G= 5.85

The shape of the crystals was approximately thus:

(Dana p.451)

The crystals are sometimes striated and twinned. In contrast with the stephanite (described later) the crystals are elongated. The pyrargyrite is also darker in color than the stephanite.

<u>Stephanite</u>

The specific gravity of clean fragments of this mineral was determined as 6.28. This is the value given by Dana for pure stephanite. The crystals are flat and pseudohexagonal with angular striations on the prism faces. The shape is approximately thus:

(Dana, p.455)

Microchemical tests on the mineral gave silver, antimony, sulphur, and a trace of copper. The copper was probably due to an adhering particle of chalcopyrite. The above evidence points rather strongly to the presence of stephanite but for positive identification an assay should be undertaken.

Since no stephanite was detected in the polished sections and since abundant crystals of what appear to be stephanite are found associated with the argentite and native silver, it is tentatively suggested that further work will show that stephanite and not pyrargyrite is associated with the argentite and native silver.

The following minerals were determined megascopically

<u>Argentite</u> and <u>Native Silver</u>

This mineral occurs in massive or dendritic form in close association with native silver in rather loosely aggregated vein material. The mineral may well be acanthite but will be referred to as "argentite" for convenience.

Growing on top of a dendritic specimen of argentite are small poorly formed crystals of chalcopyrite. As noticed in the polished sections the chalcopyrite is definitely minor in amount.

Wires of native silver appear to grow out of the argentite; close inspection, however, reveals that the native silver has crystallized on the surface of the argentite. Native silver wires are also found growing on the surface of stephanite crystals.

The argentite appears to be molded around the crystals of stephanite. When a crystal of the stephanite is pried out of the argentite a cast of the stephanite crystal is left. It is quite possible that the stephanite grew and replaced the argentite but it seems more reasonable to suppose that the argentite enclosed the stephanite.

Fluorite

In some of the specimens cavities are filled with crystals of green translucent crystals of fluorite with well developed octahedral cleavage. In places this fluorite is moulded on the argentite and would appear to be later.

Calcite

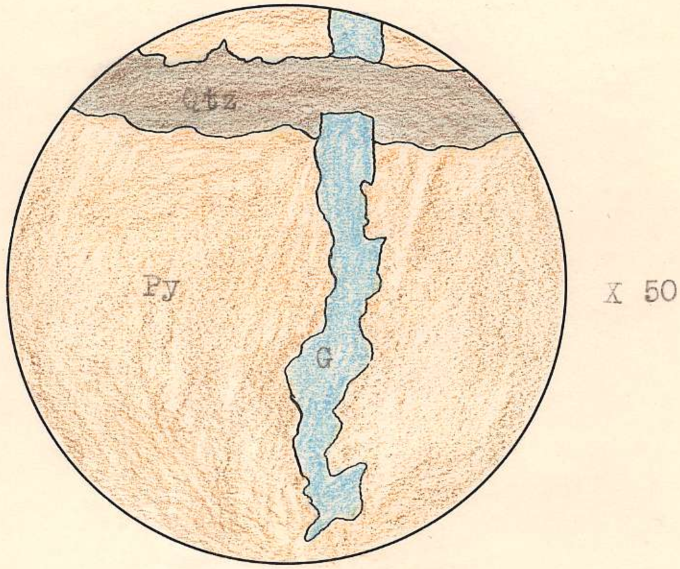
Calcite is found generally as acute rhomboheral or thin tabular crystals, or in the massive form. Crystals of calcite often enclose wires of native silver, and this fact coupled with the observation that calcite is found replacing all the minerals in the polished sections, is strongly suggestive that calcite is the last mineral to crystallize.

ORDER OF DEPOSITION

McKinstry[3] in describing the area states "the mineralization is of three distinct generations, the first two being closely connected" and he presents field evidence as well as microscopic observations to bear out his conclusions. A study of polished sections alone of the ore did not yield sufficient evidence to postulate three generations of mineralization, although the sequence of mineralization could be worked out.

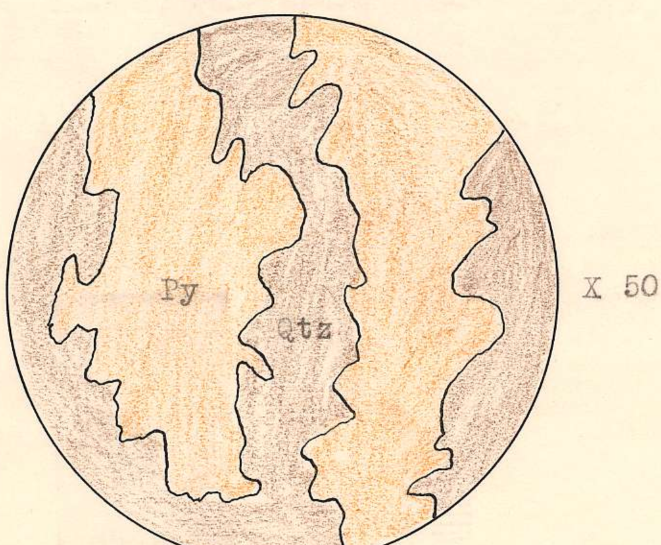
The following pages of drawings and photomicrographs have been arranged, insofar as it was possible, in the order of crystallization. For the most part discussion accompanies each illustration. Thus, the order of deposition as well as the reasons for assuming such an order are presented simultaneously. Further discussion follows the illustrated pages.

Section No. 8



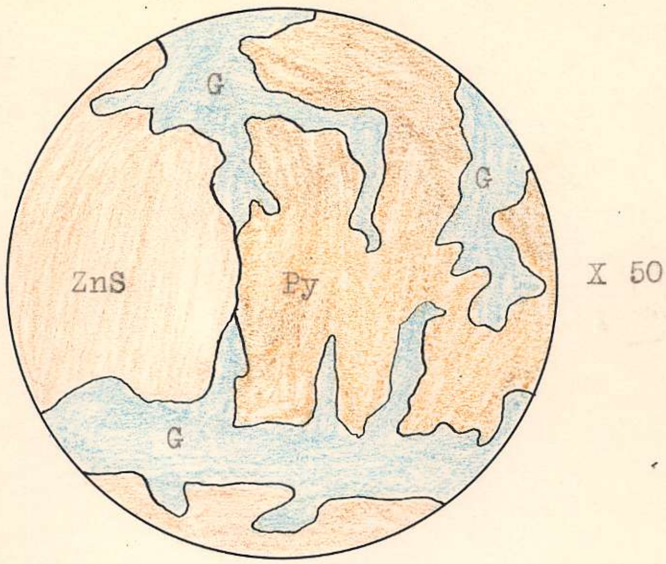
In which galena transects pyrite. Late quartz cuts the galena veinlet.

Section No. 1



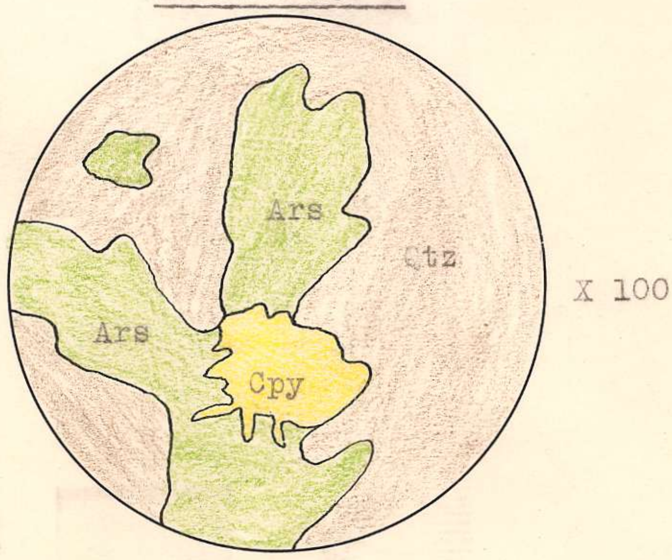
In which late quartz replaces early pyrite.

Section No. 6



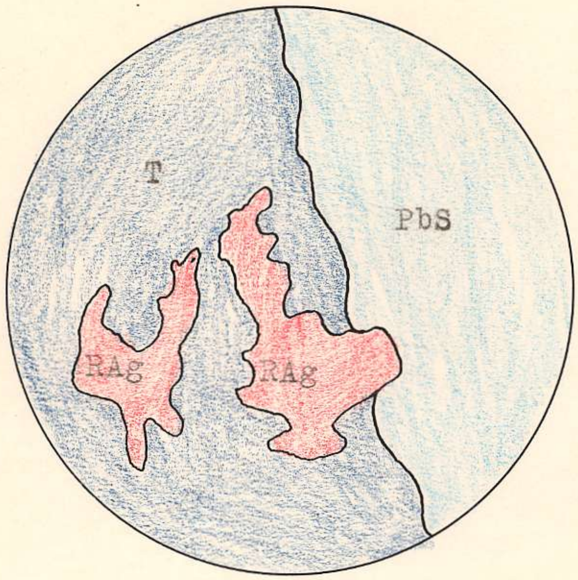
Galena replaces early pyrite and sphalerite. The smooth boundaries between the pyrite and the sphalerite suggest contemporaneity.

Section No. 2



Smooth boundaries between the arsenopyrite and the quartz indicate contemporaneous deposition. The chalcopyrite replaces the arsenopyrite selectively. Arsenopyrite is common in the wall rock but is not found with the massive sulphides in the veins.

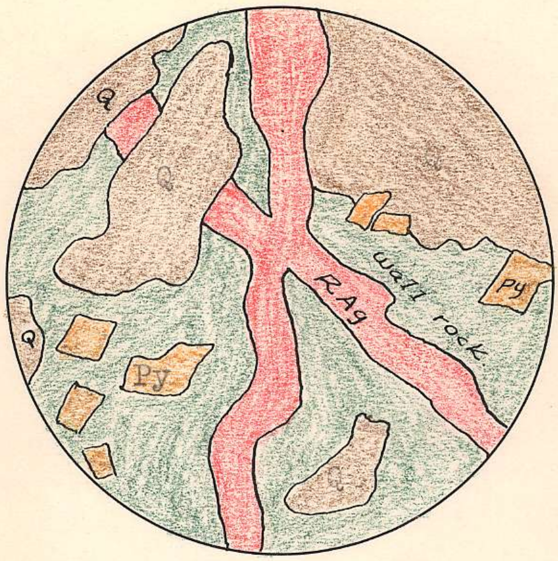
Section No. 1



X 100

Pyrargyrite transecting the boundary between the tetrahedrite and the galena, a relationship quite frequently noted in the sections. It would appear that the pyrargyrite finds the tetrahedrite much easier to replace than the galena, hence it spreads widely through the tetrahedrite but penetrates but a short distance into the galena. It is quite possible that the terahedrite could be later than the pyrargyrite but the above relationship is most easily explained by assuming that the pyrargyrite is later.

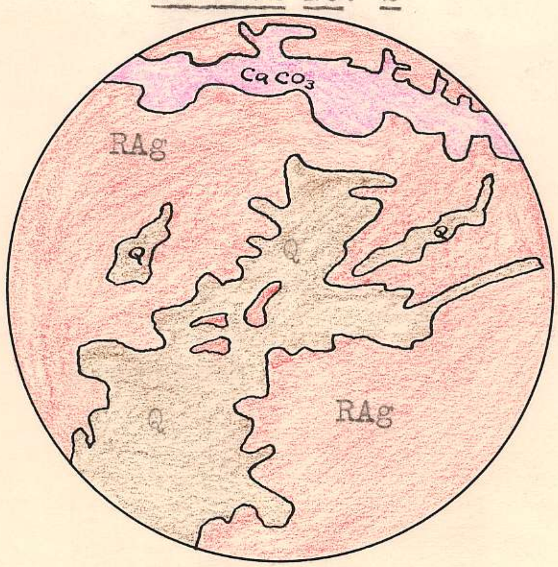
Section No. 0



X 50

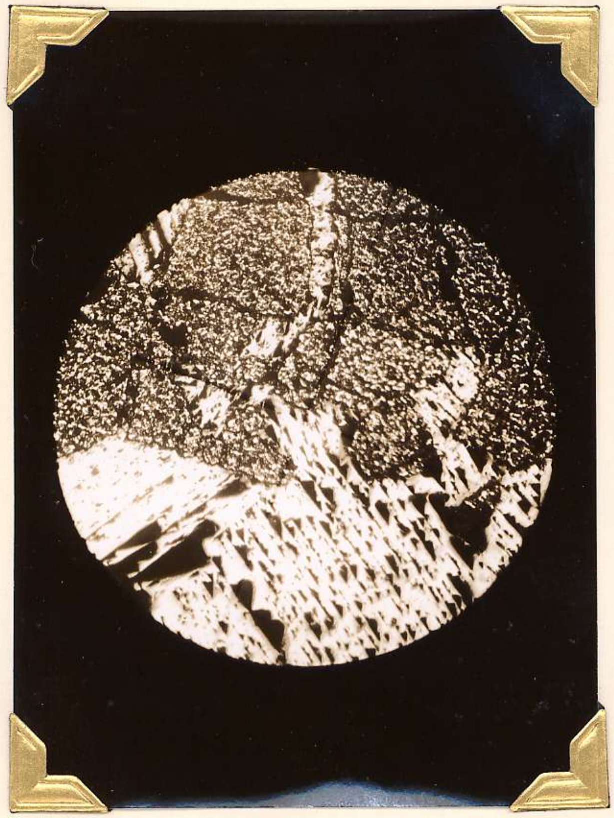
Intersecting veinlet of pyrargyrite transected by late quartz. The quartz also replaces the greenish chloritized wall rock.

Section No. 2



X 50

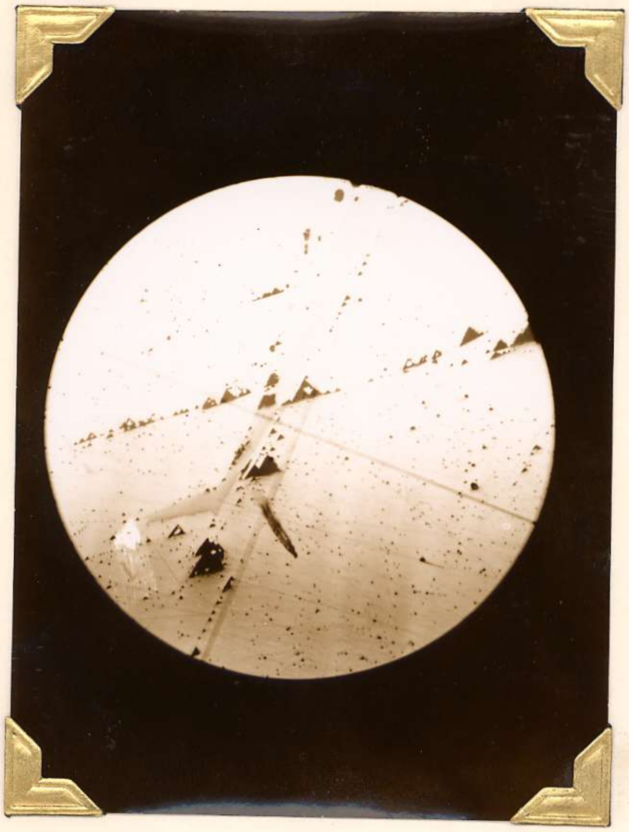
Pyrargyrite replaces early quartz. Calcite replaces the pyrargyrite. In the hand specimens calcite encloses wires of native silver, it is definitely the last mineral to come in.



X 100

PLATE NO. 1

Galena replaces early pyrite along the grain boundaries.



X 110

PLATE NO. 4

Pyrargyrite replacing galena along crystallographic directions. Note the thin straight band of pyrargyrite on the northeast-southwest cross hair. As explained in the original copy of the report the oblique angle in the pyrargyrite could be produced by cutting the polished section obliquely to two planes of pyrargyrite that follow the galena cleavage.

X 110

PLATE NO. 5

Tetrahedrite (white) replacing quartz. It can be seen how the tetrahedrite follows along the grain boundaries of the quartz and then spreads out. Pyrargyrite (medium grey) has replaced the tetrahedrite though this fact is not brought out in the photograph. The pyrargyrite has replaced the galena (grey with pits) and small remnants of the galena can be seen in the pyrargyrite.

X 300

PLATE NO. 6

Chalcopyrite (white) in sphalerite. Chalcopyrite in the sphalerite is very rare in the sections, most of the sphalerite being absolutely clean. It is very noticeable that the chalcopyrite is found almost entirely with the pyrargyrite or the tetrahedrite in the sections. The above photograph was taken of a section in which no pyrargyrite or tetrahedrite occurred. The inference is, then, that the chalcopyrite replaces the pyrargyrite selectively.

ORDER OF DEPOSITION (cont.)

Early quartz is found for the most part in the wall rock along with pyrite and sphalerite. This early quartz mineralization is in places well crystallized and later quartz may be seen surrounding the early crystals. As shown in section number O (page 13) later quartz cuts pyrargyrite. Whether this quartz which cuts the pyrargyrite is the same age as that which surrounds the early quartz crystals in the wall rock, or whether it is a still later "third generation" of quartz could not be ascertained. Well crystallized pyrite accompanies both the early and the late quartz mineralization, and late quartz replaces the early pyrite.

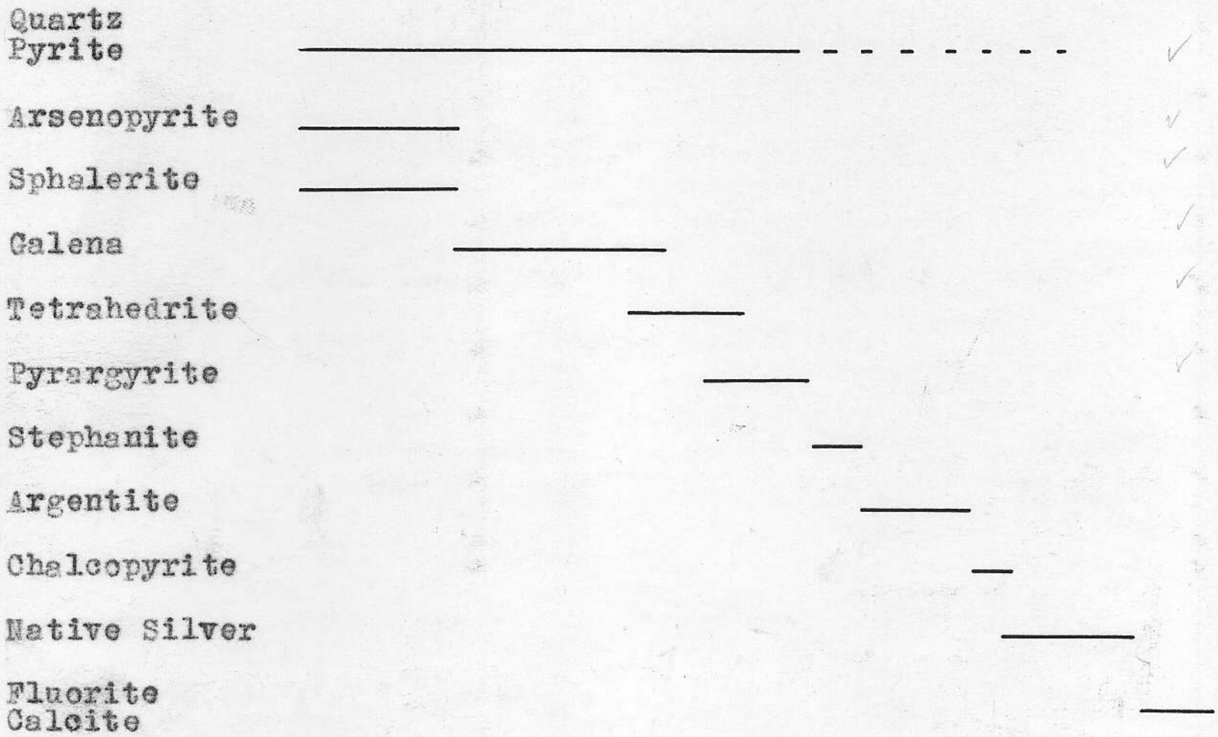
Arsenopyrite is found almost entirely in the wall rock and accompanies the early quartz and pyrite. Since it exhibits smooth boundaries with these two minerals it is assumed to be contemporaneous with them.

Sphalerite exhibits smooth boundaries with the early quartz, pyrite and arsenopyrite. It is replaced by galena and hence may be placed in the early age group.

The relationships between the pyrargyrite, tetrahedrite and galena are a little more difficult to ascertain. Probably the most important point in this regard is that remnants of galena in tetrahedrite are common at the contact between these two minerals, whereas remnants of tetrahedrite in galena are seldom found. Similarly remnants of tetrahedrite in pyrargyrite are more plentiful than what could be considered remnants of pyrargyrite in tetrahedrite. In some of the veinlets of tetrahedrite in galena the pyrargyrite appears to replace the tetrahedrite from the centre outwards to within a skin surface of the contact with the galena. Such a thin skin could be produced if the tetrahedrite came in after the galena and pyrargyrite had solidified. However Plate No. 5 illustrates the fact that the pyrargyrite is later than the galena, so such a condition could not occur.

The relations that indicate an order stephanite, argentite, chalcopyrite, native silver, fluorite and calcite, were dealt with under "megascopic examination of the ore". The position of the chalcopyrite is doubtful. Since crystals of it are found on the surface of the argentite it seems logical to assume it is later than the argentite; but whether it replaces the pyrargyrite and tetrahedrite in the sections or is contemporaneous with them is still a question. Assuming the native silver to be the last metallic mineral to crystallize, you would expect to find it deposited on top of the stephanite and argentite, which is indeed the case.

The order of crystallization may be represented by the following diagram.



PRIMARY AND SECONDARY MINERALS

There is no reason for considering all of the minerals up to and including the tetrahedrite other than primary. Warren[10] in discussing the pyrargyrite at the Highland Bell Mine points out that the boundaries between the pyrargyrite and the minerals assumed to be primary are mutually rounded and that no secondary copper minerals, unless the chalcopyrite and tetrahedrite be considered such, are associated with the argentite. "The ruby silver occurs in shoots which do not and have not reached the surface; that is the pyrargyrite has played out not only in depth, but also in elevation." This last field observation is certainly strongly suggestive of a primary origin for the ruby silver.

By the same token the other later metallic minerals would appear to be primary. The copper minerals that are often supergene, such as chalcocite, bornite and covellite are notably absent. The paragenesis of the silver minerals is strongly suggestive of hypogene solutions.

	Sulphur	Antimony	Silver
Pyrargyrite	17.8 %	22.3 %	59.9%
Stephanite	16.3	15.2	68.5
Argentite	12.9		87.1
Native Silver			100.0

The inference is that as time went on the solutions became poorer in sulphur and antimony and richer in silver, the native silver being the end product.

However it is quite possible that the native silver may be a product of the easily alterable argentite, though the bulk of the evidence would suggest a primary origin.

ORIGIN OF THE ORE

The obvious source of the ore appears to be the Beaverdell batholith. During its intrusion and cooling fractures probably formed in the intruded Westkettle batholith, and disappeared in the overlying Wallace formation. The ore-bearing solutions ascended along these fractures depositing the richer silver minerals at the higher levels.

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