# The
# MINERALS and PARAGENESIS
# of some
# HIGHLAND BELLE ORE

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# INDEX

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## Introduction

This report represents work done at the University of British Columbia in the Geology 9 laboratory course in microchemistry and polished section microscopy. Specimans from the Highland Belle mine at Beaverdell, B.C., were prepared and studied with the object of determining the minerals present and their paragenesis.

The author would like to express his appreciation to Dr. H.V.Warren, under whose direction the work was carried out, for his helpful suggestions and enthusiastic cooperation. The author is indebted also to Messrs. J Donnan and R.M. Thompson for assistance in the preparation and examination of the sections.

**Method and Scope of the Work** Polished sections were made of four samples of Beaverdell ore. Each was rich in either galena, sphalerite, tetrahedrite, or ruby silver. Hand polished sections of each were made; super-polished sections were made of each, including two each of the sphalerite and rubysilver specimans, making a total of 10 polished sections.

The work was carried out using the methods recommended by Short[1]. Etch tests were used extensively, and were found, after some practice, to be very reliable.

**General Geology of the Beaverdell Area** The general geology is summarized in the following chart[2].

| | | |
|---|---|---|
| Quaternary | | River alluvium, glacial deposits. |
| Miocene | Nipple Mountain Series | Flows, basalt, trachyte. |
| Oligocene | Curry Creek Series | Agglomerate, tuffs, sandstone, conglomerate. |
| Eocene | Beaverdell Batholith | Quartz Diorite. |
| Jurassic | Westkettle Quartz Diorite | |
| Mesozoic | Wallace Group | Lavas, tuffs, limestone, hornfels. |

In this study, interest is confined to the three lower members of the table of formations. Middle and late Tertiary formations are of no significance in connection with the mineral deposits.

[1] Short, Microscopic Determination of the Ore Minerals, U.S.G.S. Bulletin 914, 1940.

[2] Reinecke, L , Ore Deposits of the Beaverdell Map-Area, Can. Geol Surv Mem 79, p 32, 1915.

The Wallace Group is a complex composed mostly of andesites, andesitic tuffs, and stocks and dykes of basic intrusives. Irregular patches of crystalline limestone and hornfels are found among these igneous rocks. Most of the formation has been highly metamorphosed. Relatively flat-lying, the rocks of the Wallace Group have been intruded by the Westkettle quartz diorite.

The Westkettle quartz diorite is of particular interest because it contains the silver and gold ores of the district. The batholith, which contains fragments of the rocks of the Wallace Group, has been only slightly metamorphosed, although it is gneissic in some places. Faulting is intense through the whole mass; three systems of faulting have been recognized, the oldest of which contains the ore.

The Beaverdell Batholith, which is little more than a stock, is believed to have been the source of the hydrothermal solutions which deposited the main ore bodies of the Beaverdell mines. The rock is a quartz monzonite; it is characterized in places by large pink orthoclases, which are nearly always Carlsbad twins. In total composition, the quartz monzonite resembles the Westkettle intrusive, except that the former is slightly more siliceous; McKinstry[1] believes them to be differentiates of the same magma. This stock, intruding the earlier batholith, sediments, and volcanics, is surrounded by the productive veins, which, passing upward into the older Wallace Group, lose their values.

[1] McKinstry, H.E., Silver Mineralization at Beaverdell, B.C., Economic Geology, Vol XXIII, number 4, p 435, 1928.

Veins The veins, which range from a few inches to 6 or 8 feet in width, strike east and west and dip, with few exceptions, steeply to the south. The veinlets forming the lodes are so intricately branched that the country rock often appears to be brecciated. Small vugs in quartz are common.

McKinstry[1] states that there are three generations of minerals, the first two being closely associated in the same veins, and the third being found in later veins. In the first formed veins the gangue is quartz, and the metallic minerals, pyrite, arsenopyrite, sphalerite, galena, tetrahedrite, and pyrargyrite. The second type of vein filling, which is later than the earliest faulting, since the faults themselves carry minor amounts of the same sort of mineralization, contain calcite, argentite, and native silver.

Mineralogy The following minerals were seen and identified: quartz, pyrite, arsenopyrite, sphalerite, galena, tetrahedrite, pyrargyrite, polybasite, chalcopyrite, native silver, and calcite. Molybdenite, hematite, argentite, stephanite, and gold, reported by other workers, were not identified by the writer.

Quartz, determined by its hardness and color, appears in two distinct forms. The first is ordinary massive vein quartz; the second, probably a later generation, is euhedral in form, and is scattered through the sulfides as minute

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McKinstry, H.E., loc. cit. p 436.

crystals.

Pyrite, characterized by its hardness, form, and color, is commonly euhedral, occurring as cubes. At least two generations of pyrite were seen, as proved by the replacement of one cube by another.

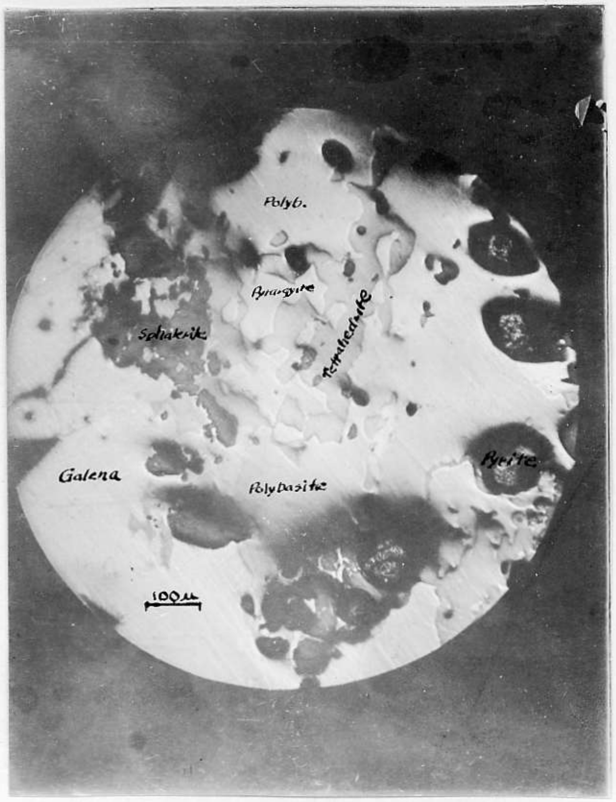
Arsenopyrite is easily identified by its hardness, and characteristic narrow rhombs. The majority of the crystals are small and perfect. It occurs in cracks in the quartz, and also with sphalerite and tetrahedrite, but commonly not with galena.

Sphalerite, identified by its color, hardness, and amber-colored internal reflection, occurs in most of the sections examined. It is usually accompanied by rods or dots of exsolved chalcopyrite.

Galena is easily spotted by its brightness, color, triangular pits, and hardness. Crystals are often curved and twisted, as indicated by the curving cleavage lines of the individual crystals.

Tetrahedrite, identified by its color, hardness, isotropism, and lack of reaction with the etch reagents, was never observed to occur without one or both of the ruby silvers. Very commonly tetrahedrite, which is, in the Highland Belle mine, very rich in silver, occurs with the ruby silvers, the whole forming an area of roughly equidimensional patches of three distinct colors, suggesting more or less contemporaneity of the three minerals.

Pyrargyrite was recognized by its etch reactions, its blue-grey color, its brilliant red reflection in polarized

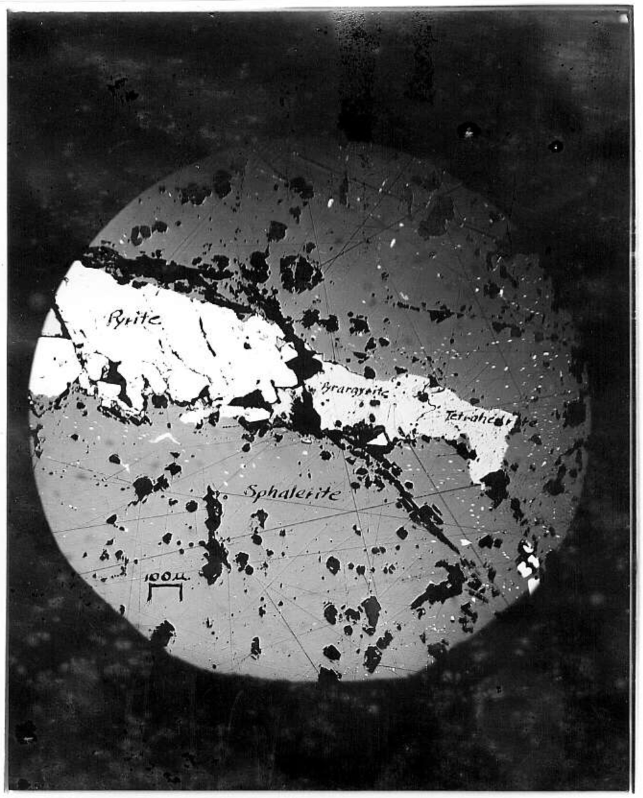


Ruby silvers,
tetrahedrite,
sphalerite, and
galena relations.

light, and its hardness. It is bluer and softer than polybasite. It often replaces galena, as shown by the fillings of triangular pits in the galena by pyrargyrite, and the occurrence of rods of pyrargyrite in the galena, parallel to the galena cleavage. It is usually associated with other silver sulfo-salts, and often with native silver.

Polybasite was determined by its etch reactions, lack of internal reflection, and its polarization colors. Its color, a dull grey, is often difficult to distinguish from the slightly brownish grey of tetrahedrite, but differences in hardness and polarization separate the two. Polybasite is less common, in the sections examined, than pyrargyrite. It commonly replaces galena, and particularly galena in narrow veinlets which have replaced sphalerite.

Chalcopyrite, recognized by its color, hardness, and etch reactions, occurs in two ways. It is found in sphalerite as random dots and oriented lines. These appear to be the result of unmixing in the sphalerite, and resembles in part, the typical mottled type of exsolution, and in part, the bladed type. Chalcopyrite occurs also associated with tetrahedrite and the ruby silvers, and seems to have been deposited independantly of the sphalerite.



Pyrargyrite and tetrahedrite; chalcopyrite exsolved from sphalerite.

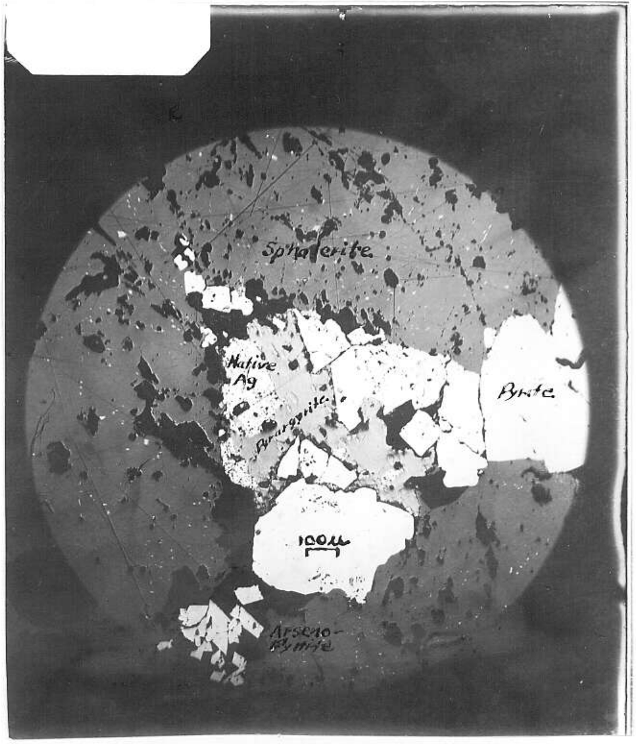
Native silver is distinguished by its isotropism and its etch tests. It was found only in sections composed mostly of sphalerite, where it is associated with pyrargyrite and terahedrite, or with pyrite. It tarnishes very quickly upon exposure to the air, and is then apt to be confused with other minerals, particularly with chalcopyrite.

Calcite, identified by its color in oblique light, hardness, and strong effervescence with hydrochloric acid, occus fairly abundantly, cutting most other minerals.

**Paragenesis** The order of deposition seems to have been as follows: quartz; pyrite; arsenopyrite; sphalerite, and galena; tetrahedrite, pyrargyrite, and polybasite; chalcopyrite; native silver; and calcite.

The relationships of quartz, pyrite, and arsenopyrite, are fairly easily seen in polished section. Evidences of replacement of one by the other clearly established the above order. The position of the second generation of pyrite, with respect to the other minerals, is obscure; evidence for such a generation is found only in one place, and was of little use in establishing its position relative to the other minerals.

Sphalerite and galena are seen to replace one another in many sections. Galena replacing sphalerite is perhaps more common than sphalerite replacing galena, so it is believed that there was overlap, with the galena more or less overlapping the sphalerite.



Native silver,
pyrargyrite, pyrite,
arsenopyrite,
sphalerite, and
chalcopyrite.

Much of the tetrahedrite, pyrargyrite, and polybasite, seem to have been deposited nearly simultaneously. There is a suggestion, however, that there was some overlap, and that they were deposited in order of increasing proportion of silver content, i.e., tetrahedrite, pyrargyrite and polybasite. Mixtures of all of these minerals form large areas which replace the earlier minerals, particularly galena and sphalerite.

An apparent exception to the above order is found in one of the sphalerite sections, where sphalerite replaces, or appears to replace, pyrargyrite, leaving concave, bitten-into, residuals of the latter. This relation is not common in the sections examined, and may be explained in several ways. It is perhaps due to pyrargyrite replacing galena which was a replacement residual of galena which had previously been replaced by sphalerite.

Native silver is apparently the last metallic mineral to be deposited. Whether the native silver of the Highland Belle mine is supergene or hypogene is a matter of some debate. The absence of typical supergene minerals, such as covellite, chalcocite, or limonitic iron, has been cited as evidence for a hypogene origin. Since only the present position of the water table is known, the theory that supergene minerals are deposited only a short distance below the water table provides no solution to the problem.

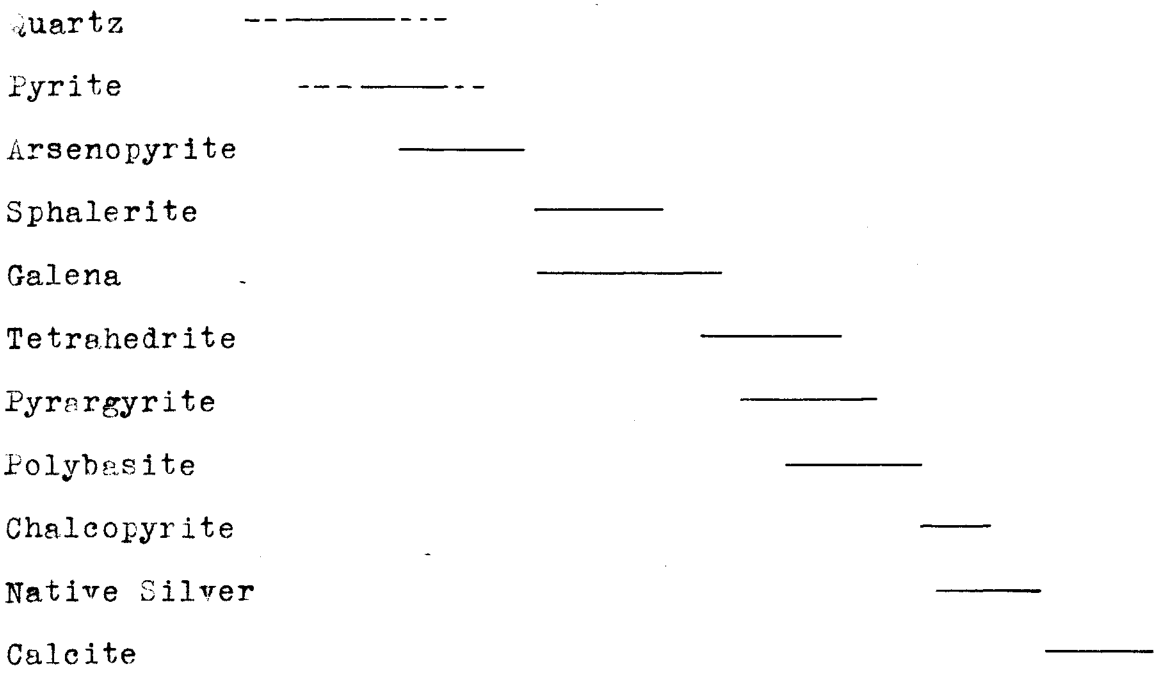
The native silver found in the sections in the present study does not resemble in its physical relationships to the preceding sulpho-salts the relationsships among those sulfo-salts, which, as is pointed out above, are thought to have been deposited with some overlap, but very closely together, almost simultaneously. It appears that the silver is distinctly later than the silver sulfo-salts, and did not overlap any of them.

No evidence for a supergene origin of the silver has come to light as a result of this work. On the contrary, the silver appears to be hypogene, with the rest of the silver minerals.

Native silver
replacing
pyrargyrite.

It has been pointed out that native silver was found only in the predominately sphalerite sections. It is interesting to note that the most silver-rich ruby-silver, polybasite, also occurs,as mentioned above, in sphalerite, suggesting that sphalerite might have exerted some control over the deposition of the rich silver minerals. This may be only a fortuitous circumstance, however, since specimans from the whole mine were not examined.

Diagram Illustrating Paragenesis



As can be seen from the above diagram, the iron and antimony seem to decrease, and the silver increase, as the mineralization progressed.

<u>Conclusions</u> The bulk of the mineralization at the Highland Belle Mine is clearly hypogene; no evidence of supergene mineralization has been found in the present study.

If the native silver is hypogene, these deposits differ from many typical bonanza silver deposits, where the silver has been proved to be supergene. Otherwise, the

Highland Belle mineralization resembles fairly closely that of many of the Nevada and Mexico silver deposits.

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