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LABORATORY EXAMINATION
OF SPECIMENS OF ORE FROM THE
HIGHLAND BELL MINE,
BEAVERDELL, BRITISH COLUMBIA.

-by-

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April, 1942.

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INTRODUCTION

The examination of this ore was undertaken at the University of British Columbia as an elective in one of the Geology courses (Geology 9), under the direction of Dr. H.V. Warren. The work centered around the inspection of polished sections of the ore, and micro-chemical tests were relied upon for elemental determinations.

ACKNOWLEDGMENT

The writer has been greatly aided in this work by the kindly interest, experience, and suggestions of Dr. H.V. Warren and Mr. Bob Thompson.

LOCATION

The Highland Bell Mine is situated on Wallace Mountain about five miles east of Beaverdell in the Boundary District of Southern British Columbia. The Highland Bell, with other mines on Wallace Mountain, overlooks the valley of the Westkettle River and the town of Beaverdell on the Kettle Valley Railway.

GENERAL GEOLOGY OF THE BEAVERDELL DISTRICT

The description of the geology of the district by Reinecke¹ is summarised by McKinstry² as follows:

"The relatively flat-lying Mesozoic sediments of the Wallace group (metamorphosed lavas and tuffs overlying limestone and hornfels) occupy the uplands. They are intruded first by the quartz diorite of the Westkettle Batholith (Jurassic) and this in turn by the quartz-monzonite of the Beaverdell Batholith (Eocene) (which is really little more than a stock).

Westkettle Quartz Diorite.--The batholith occupies an area of at least 200 square miles though exposed only in the valleys which cut through the overlying Wallace group. The rock is grano-diorite characterized by low iron, high calcium, and moderate content in alkalis. The minerals are orthoclase and labradorite with quartz, biotite, and hornblende. It is correlated by Reinecke with the Okanagan composite batholith.

Beaverdell Quartz Monzonite.--The stock as exposed in the bottom of the valley is about two miles in diameter. The rock is more siliceous than the quartz diorite but resembles it in containing low iron, high ratio of calcium to magnesium, and unit ratio of sodium to potassium. The rock is characterized by large pink feldspar phenocrysts, usually Carlsbad twins, which are microperthite composed of anorthoclase or soda-orthoclase intergrown with albite in the proportions of five to one. Quartz composes about 14 percent. of the rock, biotite about 5 per cent. with smaller amounts of hornblende and titanite.

... The similarity in composition of the two intrusives suggests that they are differentiates of 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."

¹ Reinecke, L., "Ore deposits of the Beaverdell Map-Area," Canada Geol. Survey, Mem. 79, No. 65 Geol. Series, 1915.

² McKinstry, H. E., "Silver mineralization at Beaverdell, B. C.," Econ. Geol., vol. 23, pp. 434 and 435, 1928.

ORE DEPOSITS

The ore lies in nearly vertical, east-west striking, veins which vary in width from a few inches to six or eight feet; however, the individual ore-bearing streaks are rarely more than a foot or so in width. 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.³ Some of the veins are traceable for over 1,000 feet and have been shown to be quite persistent; the ore shoots are interrupted by faults rather than by pinching of the vein. Vertically, the upper limit of ore-bearing ground is determined by the overlying Wallace group which forms the roof of the quartz diorite stock.

With regard to the minerals and gangue in the veins, McKinstry states:⁴

"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 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

³ Annual Report of the Minister of Mines of the Province of B. C., Part D, 1936.

⁴ McKinstry, H. E., op. cit., p.436.

unshattered calcite crystals. In the ... Bell mine, veins of this type yield native silver in association with green fluorite.

...Ore from other mines approximately 900 feet lower near the valley bottom ... consists of coarse grained sphalerite and galena with decidedly lower silver content and higher gold.

MICROSCOPIC DETERMINATION OF MINERALS

For the most part the writer used the methods described by Short⁵ to identify the minerals in the polished sections. However, other distinguishing features were noted, particularly among the silver-antimony-sulfur minerals, and these features will be mentioned under the respective mineral headings.

The minerals identified in the polished sections were: Pyrite, Galena, Sphalerite, Chalcopyrite, Arsenopyrite, Tetrahedrite, Pyrargyrite, Polybasite, Stephanite (?), Quartz, and Calcite(?).

Metallic Minerals

Pyrite: Pyrite was identified by its peculiar pale brass yellow color and its great degree of hardness. It was usually fractured and veined by quartz, calcite, sphalerite, galena, and a "mixture" of tetrahedrite with the "ruby silvers". (Note; In this paper, "ruby silver" will be taken to mean any one ^{of a mixture} of the silver-antimony-sulphur minerals

⁵ Short, M. N., "Microscopic determination of the ore minerals", U. S. Geol. Survey Bull. 914, 2nd ed., 1940.

(Pyrargyrite, Miargyrite, Polybasite, Stephanite, or others) that may be present; chiefly because in all the assemblages in the polished sections, these could not be satisfactorily identified by the writer as individual minerals.) Generally the pyrite appeared to be earlier than any of the ore minerals.

Galena: Galena was identified by its bright, "galena-white" color, its softness, characteristic triangular pits, and by reactions to HCl and HNO₃. It occurs as irregular masses in the sections and appears to replace and fill fractures in sphalerite and pyrite (see Fig. 1). Galena is a common associate of the "ruby silvers", and an apparent host to polybasite and pyrargyrite (see Figs. 3, 5, and 6). The association and contact relations shown in Fig. 3 are very typical.

Sphalerite: This mineral was identified by its dull gray color, its intermediate hardness, brownish resin-colored internal reflection, and its apparent indifference to reaction with microchemical reagents. The sphalerite occurs in bands, surrounding quartz crystals locally, and in one place apparently filled a cavity in arsenopyrite (Fig. 2). (See also Figs. 1 and 8). In some sections the sphalerite contains uniformly scattered, very small specks of chalcopyrite, in others it is clean (Figs. 7 and 8).

Chalcopyrite: Chalco~~x~~pyrite was identified by its brass-yellow color, hardness, and lack of reaction with the micro-

chemical (etch) reagents. Quantitatively it constitutes a very small part of the mineralization in the specimens examined. The chalcopyrite most commonly occurs "disseminated" in the sphalerite, but small irregular specks of it were seen in pyrargyrite (see Figs. 7A and 7B).

Arsenopyrite: This mineral was identified by its tin-white color, hardness, and diamond and needle shaped occurrence. Although found sparingly it is very persistent. Arsenopyrite crystals and euhedral masses are found in, and often replaced by, everything ^{but} chalcopyrite (see Figs. 2, 6, and 8).

Tetrahedrite: Tetrahedrite was identified by its light gray color and hardness, particularly when in contact with galena, and by its lack of reaction with the etching reagents. Its occurrence is widespread, most commonly as a replacement in galena. It is often associated with pyrargyrite which appears to replace it, but was also found apparently veining pyrargyrite along a sphalerite-pyrargyrite contact (see Fig.4).

Assays of tetrahedrite running 7500 oz. of silver indicate the presence of the argentiferous variety, Freibergite, but etch tests were not satisfactory in distinguishing that mineral. Microchemical tests showed the presence of copper and silver, but the silver may have been present in one of the ruby silvers which are almost invariably associated and often intimately mixed with the tetrahedrite.

Pyrargyrite: This mineral was identified by its bluish gray color, hardness (slightly harder than galena and apparent

when the two are in contact), its red internal reflection, purplish gray to greenish and brownish yellow polarization colors, and etch tests. After once identifying the mineral it is quite easily recognized by its bluish gray color. In at least one polished section pyrargyrite is replaced by polybasite (Fig. 6), and although the presence of miargyrite was not satisfactorily established, it is strongly suspected. A deficiency of arsenic pretty well eliminates the possibility of the presence of proustite.

Pyrargyrite most commonly occurs replacing galena with no apparent relation to crystal structure, and associated with tetrahedrite. It is found in considerable quantities replacing and inclosing arsenopyrite and, in one case, chalcocopyrite (see Figs. 2, 3, 4, 6, and 7A)

Polybasite: This mineral was at first mistaken for tetrahedrite, but was satisfactorily distinguished by its anisotropism (giving a yellowish green polarization color) and a suggestion of red internal reflection. It was spotted with galena, pyrargyrite, and tetrahedrite on a super-polished section in which the tetrahedrite was just a little different shade of gray and pitted. Thereafter polybasite was recognized at several places in the section by its greenish-tinted gray color as opposed to the "blackish" gray of tetrahedrite. It is found associated with tetrahedrite and replacing pyrargyrite and probably galena (see Fig. 6).

Stephanite (?): In one section a galena white mineral

yielding no internal reflection, and at first suspected of being galena, had the same etch reactions as those of stephanite. The observed etch reactions follow: KCN, brown stain. KOH, irridescent stain which does not wash off. HgCl_2 , brown stain, FeCl_3 , darkens. HCl, fumes tarnish irridescent - washes off. HNO_3 , slight irridescent stain.

Miargyrite has similar etch reactions, but according to Short, shows red internal reflection.

The hand polished specimen was badly broken in removing it from the demar and therefore it could not be superpolished for further study. Other specimens cut from the same small piece of ore showed no signs of stephanite, but contained polybasite.

MEGASCOPIC DETERMINATION OF MINERALS

Native Silver and Argentite: These minerals were not observed in polished sections, but were recognized in hand specimens. Wires of native silver appear to have crystallized on the surface of the argentite. Both are associated with calcite, which sometimes encloses the wires of native silver. The calcite appears, not only here, but also in the polished sections, to be the last mineral to crystallize.

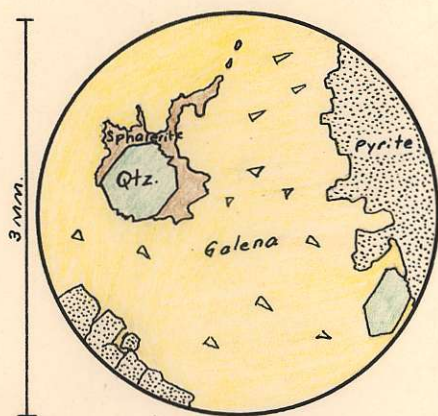


Fig. 1

Section 1. Galena fills a cavity in early pyrite and engulfs the quartz crystal and sphalerite. The sphalerite is apparently being replaced by the galena.

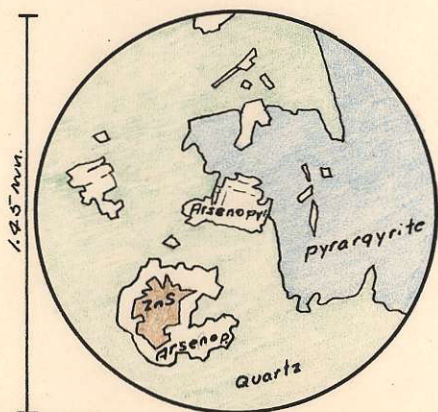


Fig. 2

Section 3. Arsenopyrite in quartz and pyrrargyrite. The pyrrargyrite is attacking arsenopyrite, but has little effect on the quartz needles. Sphalerite fills the center of a patch of arsenopyrite.

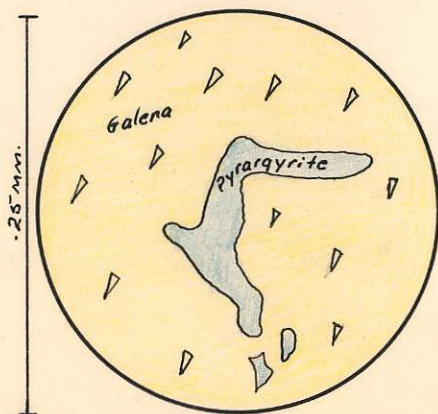


Fig. 3

Section 3. Pyrrargyrite replacing galena with no apparent relation to the crystal structure or cleavage in the galena.

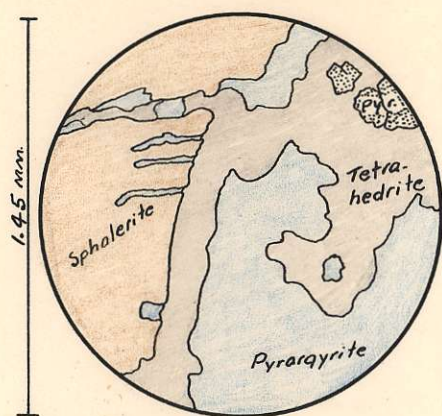


Fig. 4

Section 2. Tetrahedrite veining pyrrargyrite along a sphalerite pyrrargyrite contact. The small "inlets" of pyrrargyrite have trapped in the sphalerite.

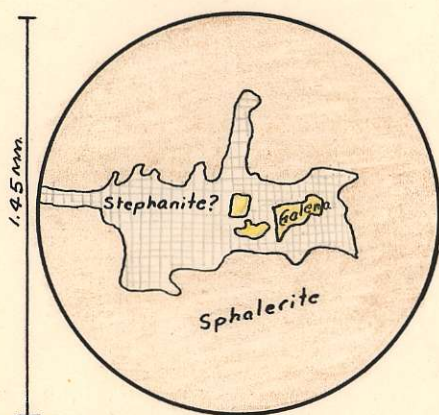


Fig. 5

Section 2. Stephanite (?) replacing galena and filling cavity in sphalerite.

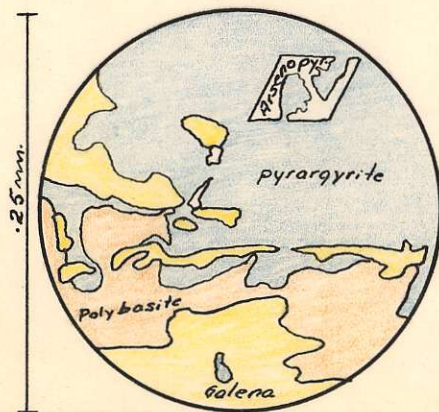
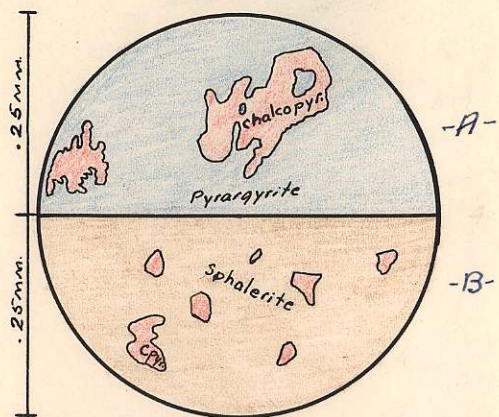


Fig. 6

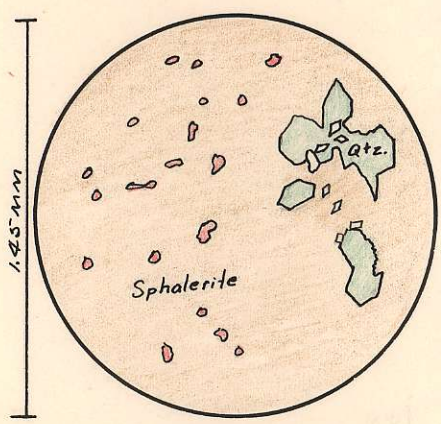
Section 10. Polybasite replacing galena and more particularly pyrrargyrite. The pyrrargyrite in turn also replaces the galena and arsenopyrite.



Section 9. Chalcopyrite in pyrrargyrite.

Section 4. Chalcopyrite in sphalerite.

Fig. 7



Section 4. Arsenopyrite in early quartz crystals and in sphalerite. Chalcopyrite "disseminated" through sphalerite.

Fig. 8

ORDER OF DEPOSITION

The earliest minerals present are pyrite, arsenopyrite, and quartz. These are sometimes fractured, veined, replaced, or surrounded by later minerals. Euhedral crystals of quartz containing diamond shaped arsenopyrite crystals probably represent an early stage of mineralization. Chalcopyrite is found scattered through sphalerite, an early mineral, and whether it is contemporaneous with the sphalerite or not is a question. This writer is inclined to believe that the chalcopyrite is a fairly late mineral and possibly a product of the reaction between tetrahedrite, pyrite, and the "ruby silvers". Its composition and occurrence, with these minerals, would suggest such a hypothesis. The galena has been attacked by tetrahedrite; both of which in turn have been attacked by the "ruby silvers". However the relations between pyrargyrite and tetrahedrite is not too obvious. Some tetrahedrite appears to definitely cut pyrargyrite, while in places the pyrargyrite occurs as "islands" apparently replacing the tetrahedrite. Polybasite replaces galena but more particularly pyrargyrite. In the polished sections a very fine quartz crystal lattice surrounded by calcite and found veining pyrargyrite represented a late quartz and calcite mineralization. The lattice structure of the quartz was not observed until the calcite, which also veined a fractured large quartz crystal of earlier age, had been dissolved by HCl.

The argentite and native silver apparently represent the last stages of metallic mineralization. Some calcite is known to be later than the native silver, but whether the calcite surrounding the quartz lattice is a pre-argentite or the post argentite mineralization is not known.

The fact that certain sets of minerals are fractured and the openings are filled with later minerals would suggest intermittent deposition or several generations of mineralization. However, insufficient evidence does not warrant such a grouping here. The minerals in order of deposition follow:

Pyrite,
 Arsenopyrite,
 Quartz.

Sphalerite.

Galena.

Tetrahedrite.
 or
 Pyrargyrite.

Chalcopyrite ?

Stephanite,
 Polybasite.

Quartz, Calcite ?

Argentite.

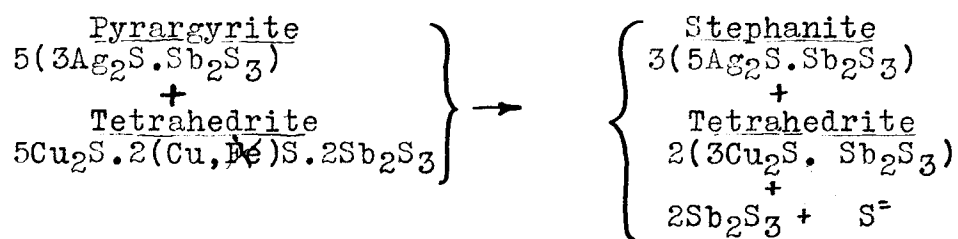
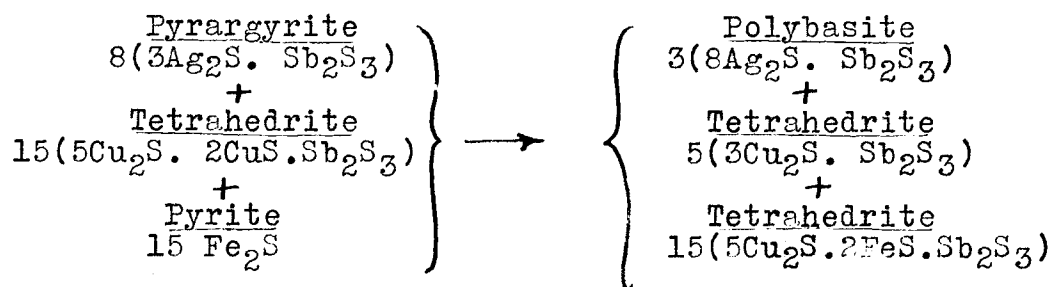
Native silver.

Calcite.

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CONCLUSIONS:

The pyrite, arsenopyrite, ^{and} sphalerite are unquestionably primary. Galena and tetrahedrite are usually hypogene minerals and there is not the evidence here to consider them otherwise. The fact that the "ruby silvers" are closely associated with, and fail to follow cleavages and fractures in galena and tetrahedrite suggests they were closely associated with these minerals in time of depositinn. This writer suggests a reaction between the tetrahedrite and pyrargyrite (or miargyrite, if present) ^{to} form the "higher" silver sulphantimonites. Quantitatively this might be expressed by equations:

or better

A little chalcopyrite could be formed and its presence in the "ruby silver" assemblage would thereby be explained. Deposition and solution along the veins would vary the concentration and some of the excess Sb_2S_3 with $(\text{Cu, Fe})\text{S}$

could pick up $(\text{Cu,Ag})_2\text{S}$ to form the argentiferous variety of tetrahedrite, Freibergite $5(\text{Cu,Ag})_2\text{S} \cdot 2(\text{Cu,Fe})\text{S} \cdot 2\text{Sb}_2\text{S}_3$. Under such circumstances tetrahedrite of "ranging" composition could be found being replaced by pyrargyrite at one point and veining pyrargyrite at another.

This writer is well aware that the whole situation cannot be pictured as simply as this, but does suggest that it offers a rather quantitative means of explaining the occurrence of the tetrahedrite, chalcopyrite, "ruby silver" assemblage.

The native silver may well be secondary and a replacement of the easily altered argentite.

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