A MINERALOGRAPHIC REPORT ON ORE
FROM THE HIGHLAND BELL MINE
BEAVERDELL BRITISH COLUMBIA

AN ESSAY SUBMITTED IN PARTIAL
FULFILMENT OF THE COURSE IN
FOURTH YEAR APPLIED SCIENCE
GEOLOGICAL ENGINEERING

by

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THE UNIVERSITY OF BRITISH COLUMBIA

April, 1952

Fort Camp,
University of British Columbia,
Vancouver, British Columbia.
April 16, 1952.

Dr. H.V.Warren,
Professor of Mineralogy,
Department of Geology & Geography,
University of British Columbia.

Dear Sir:

I herewith submit this essay, "A Mineralo-

graphic Report on Ore from the Highland Bell Mine,

Beaverdell, British Columbia," in partial fulfilment

of the course in mineralography, Geology 409, at the
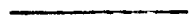
University of British Columbia.

Yours sincerely,

R.H.Beaton

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PREFACE

This essay is based on a study of specimens
of ore from the Highland Bell Mine, British Columbia.
The writer has not visited the property consequently
much of the material is purely reference. Particular
acknowledgment is made to Dr.R.M.Thompson, Assistant
Professor of Geology, who supervised the laboratory
work. Recognition is also due Mr.J.Donnan who directed
the preparation of the polished sections, and Mr.J.Mc
Dougall who assisted in the laboratory. The examination,
largely microscopic, was made in the mineralogical labora-
tories of the University of British Columbia.

INTRODUCTION

The Highland Bell silver mine is situated on Wallace Mountain four miles east by road from the village of Beaverdell, British Columbia, where the main camp is located. Beaverdell is on a spur of the Kettle Valley line, the southern route of the Canadian Pacific Railway, about fifty-one miles north of Greenwood.

A fifty-ton mill was opened for operation at Beaverdell on September 20, 1950 to concentrate the ore from the Highland Bell Mine. During the fifty years prior to this time, commencing with earliest mining operations, the ore was shipped to Trail for treatment.

Numerous mining and exploration companies have worked the silver ores of Wallace Mountain, major production being from the Bell and Highland Lass properties. These mines were amalgamated in 1930 into the Beaverdell property, separate production being recorded until 1936 when the purchase was completed. Renamed as Highland Bell, Ltd., the company gained control of the Beaver property in the same year. In 1946 Leitch Gold Mines Ltd. acquired control of Highland Bell Ltd. and the Sally property, but continued operations as Highland Bell Ltd.

The productive zone is at present confined to an area $1\frac{1}{2}$ miles by 1/2 mile. According to the 1950 Annual Report of the Minister of Mines, a total of 18,000,000 ounces of silver have been produced from the camp.

Production figures quoted for 1950 are:

Ore mineral	8,383 tons
Ore milled	4,107 tons
Recovery	
Gold	237 oz.
Silver	696,561 oz.
Lead	377,113 lbs.
Zinc	495,990 lbs.
Cadmium	1,325 lbs.

Fifty seven men were employed, twenty working underground, and ten, in the mill. Some surface exploration, stimulated by rising metal prices, was done by other mining groups on adjoining claims.

Total production from the Beaver, Bell, Highland Lass, Sally, Rob Roy, and Wellington properties up to and including 1949 is as follows:

Metal	Production	Average grade
Gold	3,630 oz.	.03 oz./ton
Silver	16,697,010 oz.	159.84 oz./ton
Lead	9,940,037 lbs.	4.75%
Zinc	12,145,766 lbs.	7.16%

GENERAL GEOLOGY

An examination of the geology of Wallace Mountain and vicinity, both on the surface and underground, was made by Dr.W.H.White, Associate Professor of Geology at the University of British Columbia, in June of 1949, his report being published in the Annual Report of the Minister of Mines for British Columbia of that year. A brief condensation of the report follows.

The mineral veins occur just west of the summit of Wallace Mountain, the western half of which is an intrusive mass related to the Westkettle batholith described by L.Reinecke in Memoir 79 of the Geological Survey of Canada. The eastern half is composed of metamorphised sedimentary and volcanic rocks of the Wallace formation partly covering the batholith. A stock, one mile in diameter, named by Reinecke as the "Beaverdell Batholith" intrudes the Westkettle batholith but is largely concealed by valley fill. Productive veins lie in rock of granodiorite composition in the Westkettle batholith.

Multiple faults, divisible into at least five types are recognized. These are further diversified by division into pre-mineral and post-mineral groups, most of which have received later movement. Most prominent of the complex system are those faults, related to mineralization, which strike easterly and north-easterly, dipping moderately south and south-easterly respectively.

Veins averaging twelve inches in width have mineralized faults in zones of altered granodiorite immediately underlying the Wallace formation. The granodiorite, often discolored by purple blotches, contains such alteration minerals as sericite, chlorite, calcite, epidote, and hematite. Banding of sulphides and vugs lined with hackly masses of native silver in proximity to crystals of calcite, flourite, and argentite are characteristic in the Beaverdell ore.

In general, numerous offsets have complicated the structure, but careful study of displacements has permitted systematic exploitation of the faulted ore bodies. As yet, no indication of termination of the ore zone, either structurally or mineralogically, is in sight.

Reinecke, in his memoir, classifies the deposits as late Eocene or early Oligocene. He states that the Wallace andesites and tuffs of Mesozoic Age have acted as a barrier to upward infiltration of mineralizing solutions, and relates them to a late phase of intrusion of the Beaverdell batholith. The Westkettle batholith is believed by him to be Jurassic in age.

MINERALOGY

The study of the Highland Bell ore was largely confined to eight polished sections prepared in the grinding laboratory of the geological department at the University of British Columbia. Many hand specimens were available including those in the collection of Dr.R.M.Thompson, who directed this assignment.

Although other studies have been made of the ore, including that of L.Reinecke, none has been so exhaustive as the work of Dr.H.V. Warren, Professor of Mineralogy at the University of British Columbia, and A.B.Staples, Director and Mine Manager of the Highland Bell Mine, published in the May and June issues of the Western Miner for 1946. Their report includes detailed physical, crystallographic, analytic, and microscopic examinations of carefully prepared and selected specimens.

A further brief examination of a few polished sections by the writer cannot hope to add much of significance to the mineralogic knowledge of the ore, but can attempt to describe some textural relationships that seem pertinent to the paragenetic sequence of deposition.

A rather general description of each mineral observed together with a few words on its appearance in the hand specimen follows this paragraph.

Galena

Galena occurs in plentiful amounts in practically all specimens. Megascopically it is easily detected by its "block" cleavage and characteristic tendency to form coarsely-crystalline aggregates in preference to fine-grained masses or bands. Microscopically it can be identified by isotropism, gelena-white color, hardness of B, and triangular pitting on its polished surface.

Sphalerite

This mineral is probably more abundant than galena (see introduction) occurring as crystalline masses, bands, and disseminations. Its rather dark color supports the value by analysis of seven percent iron.

Mineralographic properties to be noted are isotropism, slate-grey color, hardness of C, equidimensional pitting on surface, and a general negative reaction to etch reagents.

Pyrite

Pyrite is found in generous amounts in practically all specimens largely as fine grained crystalline masses or disseminations and to a lesser degree as coarse crystals in vugs. Banding and shearing or fracturing are easily recognized by its presence. Microscopic properties are isotropism, pale yellow color, isometric grain shape, hardness of F, and poor polished surface. Notable pseudo-anisotropism was observed in some sections.

Arsenopyrite

Although not so common as pyrite, arsenopyrite was persistent in all specimens examined. Arsenopyrite seems to be closely associated with pyrite. Sections examined revealed arsenopyrite as granular aggregations, seldom massive, with numerous typical diamond and lath shapes indicating well developed crystallinity. Its anisotropic colors (greenish yellow to brownish violet), hardness of F, white color with pebbled surface, and typical crystal form served to simplify identification.

Tetrahedrite (Freibergite)

Tetrahedrite is a common constituent, occurring as massive, blackish, fine-grained areas throughout the ore. Its metallic-to-splendent lustre causes it to appear almost light grey in proper light. Those properties, together with its black streak, separate it from all other minerals present save polybasite. Under the microscope it appears flat grey

in color, although considerably lighter than sphalerite, with a rather smooth monotonous surface. Its hardness of D, anisotropism, and general lack of response to etches aid in identification. Microchemical tests for silver vary from positive to doubtful; however, Dr.Warren has stated in his report that the silver content has been found by analysis to be as much as 25% of the total. The name Freibergite is therefore justifiable.

Polybasite

This mineral was not distinguished from tetrahedrite in most hand specimens. Excellent specimens collected by Dr.Thompson showed it both as masses tarnished a sooty black, and as euhedral tabular crystals lining vugs. Microscopically it can be easily identified by its distinctive anisotropism (violet shades to yellowish greens), and light-grey color with a slight buff tint. A hardness of C, light-red internal reflection under crossed nicols without benefit of carbon arc, and positive reaction to most etch reagents were useful also.

Pyrargyrite

Pyrargyrite is easily recognized in both the hand specimen and polished section. Its black color, metallic to adamantine lustre with a somewhat reddish sheen, blood-red streak, distinct cleavage, and hardness of from two to three are advantageous in megascopic determination. It occurs as irregular masses and disseminations closely allied with galena, tetrahedrite, and polybasite. Distinctive microscopic properties were grey-to-brown anisotropism, bluish grey color, and strong ruby-red internal reflection tending to obscure anisotropism. Etch reactions were similar to polybasite, but were not needed for distinction.

Chalcopyrite

The specimens of ore examined did not show chalcopyrite to be present in any great amount. Polished section examination revealed only occasional blebs and veinlets identified by butter-yellow color, brittleness, hardness of C, indifference to etches, and copper reaction microchemically.

Native Silver

Prize specimens of silver from Beaverdell show it to occur as wires, sheets, and irregular masses in fractures and vugs, and generally tarnished gradationally from straw to black. Most ore specimens, however, do not manifest such obvious amounts, but instead, include the silver as minute, highly irregular filigrees, filaments, and blebs, generally surrounded by galena or the sulpho-salts. Silver is distinguished in the section by its sectility, hardness of B, and pale straw color which darkens or mottles if allowed to tarnish.

Acanthite

Acanthite, the low temperature (-180° C) form of Argentite was not detected in the sections examined. Although not common, particularly good specimens have been found occurring as vug crystals exhibiting herringbone texture remarkably well. Wire silver is a common associate. The mineral, aside from its sectility, does not reveal any distinctive property under the microscope. It is medium grey in color, isotropic, has a hardness of A, and a surface unmarred save by fine scratches.

Quartz

Quartz, the principle gangue mineral is found both crystalline and massive as an intimate associate of the metallic minerals. Megascopi-

cally it is milky white, brittle, and unoxidized. Microscopically it can be divided into two varieties, one occurring as crystals or crystalline aggregates, the other as non-crystalline veinlets or irregular masses generally darker in color. Superior hardness, internal reflection, and imperviousness to acids aided in the identification of doubtful material.

Carbonate

This mineral was found sparingly, generally as minute veinlets or irregular patches about the grain boundaries of other minerals. Its ready response to dilute HCl suggests calcite.

Flourite

No flourite was detected in the sections examined, but it is common in vugs in crystal form. One specimen examined showed it as stubby, pale green crystals, about one quarter of an inch in greatest dimension, beside crystals of galena.

PARAGENESIS

The following list constitutes the order or approximate order in which the assemblage of minerals formed. Although individual minerals may be open for re-arrangement within the groups, the groups themselves cannot be moved. The list agrees closely with that given by Dr.Warren except that a later generation of quartz has been added, and that chalco-pyrite is placed before, instead of after, the sulpho-salts. This latter placement is based on rather weak evidence, from studying scant amounts in only two or three sections.

I   (Pyrite
    (Arsenopyrite
    (Quartz (crystalline)

II   Sphalerite
     Galena

III Chalcopyrite
     (Polybasite
     (Pyrargyrite
     Tetrahedrite)
     Native Silver)

IV   Quartz (non crystalline)
     Calcite

The pyrite, arsenopyrite, and crystalline quartz are definitely the earliest minerals to form in the factures and vugs of the Highland Bell vein system. Pyrite and arsenopyrite show no relationship which suggests other than simultaneous deposition. The quartz, however, shows evidence of having been introduced prior to, during, and after the two sulphides. Possibly deposition of the metallic minerals took place more rapidly than quartz permitting them to replace to some extent the earlier quartz and in turn be surrounded by a later phase of crystalline quartz development. The microscopic relationship sketched in diagram I supports a pre-quartz sequence, while the relationship in diagram 2 suggests a post-quartz sequence.

Next, in order of deposition, are sphalerite and galena. These may be contemporaneous because boundaries generally show no significant texture. One section, as an exception, showed veining of sphalerite by
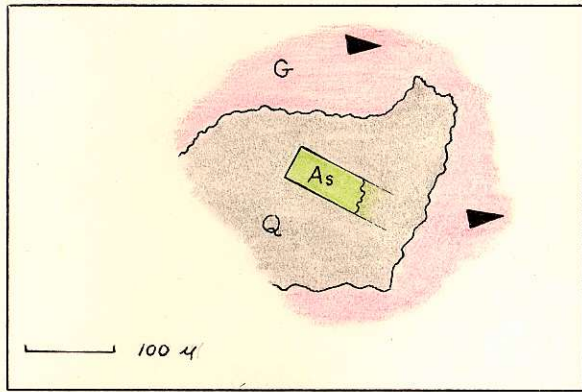
Diagram 1
Quartz surrounding crystal
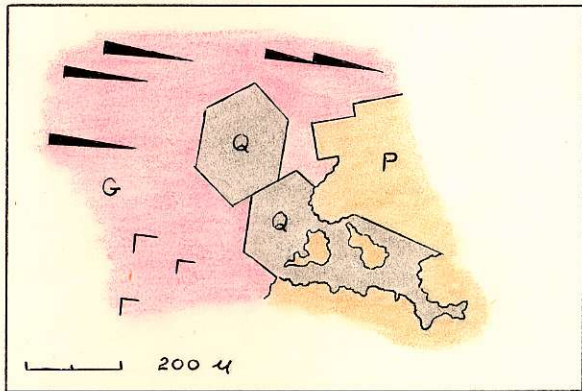of Arsenopyrite

Diagram 2
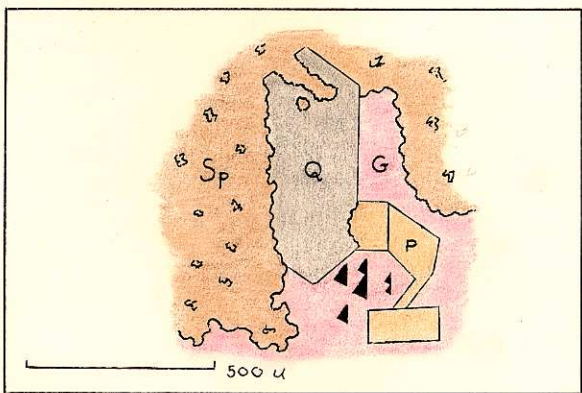Pyrite corroding crystalline
quartz

Diagram 3
Quartz crystal corroded by
Sphalerite and Pyrite

Q   Quartz
G   Galena
P   Pyrite
Sp   Sphalerite
As   Arsenopyrite

galena. Since no reverse relationship was detected the sphalerite is given priority.

Sphalerite appears to have had some tendency to replace quartz as indicated in diagram 3. This diagram also supports the idea of early replacement of quartz by pyrite. The galena does not show any similar relationship, but instead, shows considerable distortion and warping. Flexures in cleavage lines display this texture admirably, particularly in coarse-grained material. The pseudo-isotropism in pyrite may be a further indication of warping. Often the pyrite and arsenopyrite are strongly fractured and granulated expressing, perhaps, evidence of shear or crushing after deposition. Such movement seems to have continued after galena had been introduced. What appears to be small drag folds in sulphides can be detected in some hand specimens. It is quite possible that this movement, if it existed, created fresh openings and channels for mineral deposition. Diagrams 4A and 4B show galena to be paragenetically post pyrite and arsenopyrite.

Closely following deposition of the galena or perhaps during a later phase of its deposition are the chalcopyrite, sulpho-salts, and native silver. Generally there can be little reason to break these down into a more precise relationship especially when all evidence points more or less to a period of mutual formation. Some relationships have been found, however, which may suffice to establish a rough sequence although it is more than likely that considerable overlap prevailed.

Chalcopyrite presents a problem in placement, largely because good relationsl contacts were sparse. Although it seems to show some preference to sphalerite, it is also found with quartz, galena, or sulpho-
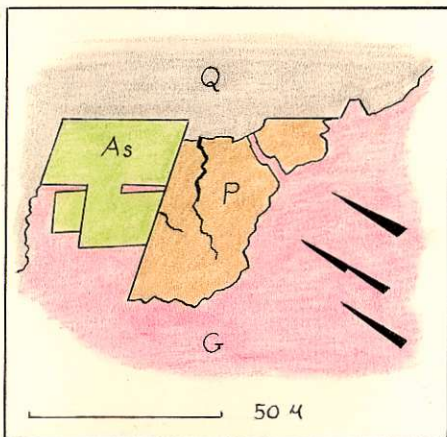
Diagram 4 A
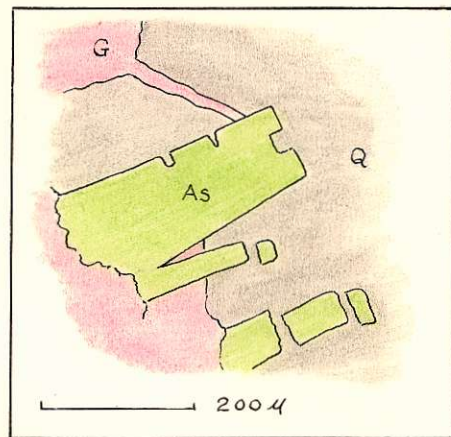Galena invading fracture
in crystalline pyrite

Diagram 4 B
Galena and Quartz
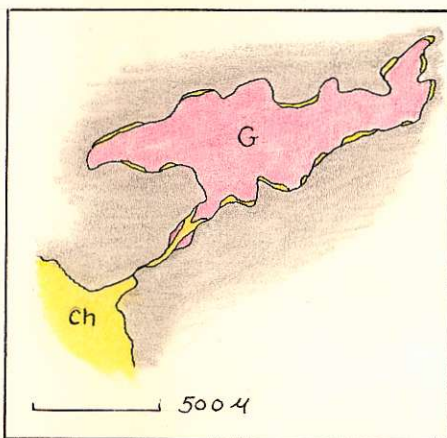surrounding fractured
Arsenopyrite

Diagram 5 A
Chalcopyrite rims about
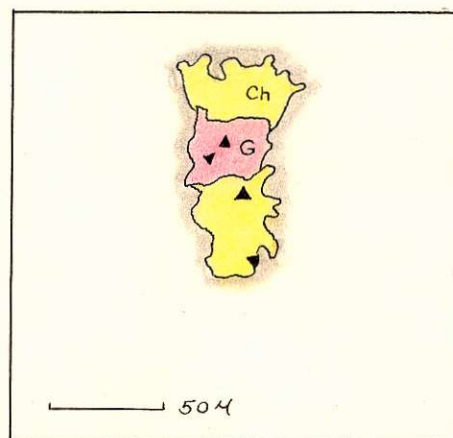Galena bleb in Quartz.

Diagram 5 B
Relic Galena pits?
in Chalcopyrite.

Q   Quartz
As   Arsenopyrite
P   Pyrite
G   Galena
Ch   Chalcopyrite

salts as its only neighbours. The sphalerite contains rather widely disseminated specks of chalcopyrite often arranged in the manner of a string of beads to suggest exsolution. Like the rest of its gnetic group, the chalcopyrite has probably replaced galena to some extent in addition to filling cleavage openings in the galena. These openings, so typical of that mineral, are probably responsible for much of the mineral solution migration.

In diagram 5A chalcopyrite is sketched as a discontinuous rim about a bleb of galena in quartz. Obviously the chalcopyrite is post galena. A relic texture (galena pitting) is shown in diagram 5B to support that sequence. In places, fine veining by chalcopyrite in galena is found to be duplicated by polybasite in a manner to suggest contemporaneous deposition. Diagram 6, on the other hand, seems to suggest initial replacement of chalcopyrite by polybasite.

Polybasite and pyrargyrite are undoubtedly mutually related since smooth curving boundaries are invariable. Both occur in equal amounts in the specimens examined, and are both common and persistent. Polybasite on only one occasion was observed to exhibit an emulsion texture with pyrargyrite. Both replace and fill galena crystographically. Often they can be seen invading galena in zones, apparently advancing in wave-like fashion and preserving relic textures of the host. Crystallographic filling and replacement is shown for polybasite in diagram 7.

Tetrahedrite and silver have been found so closely associated in most sections examined that no attempt has been made to give either priority in deposition. In some sections the silver is not found without an irregular envelope of tetrahedrite. Generally both occur as small
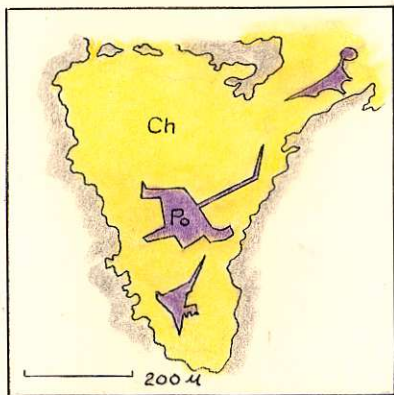
Diagram 6
Polybasite replacing Chalco-
pyrite along cleavage
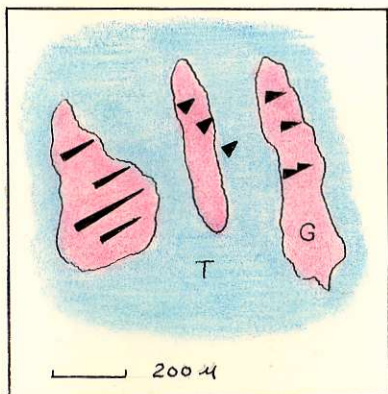boundaries. Possible intergrowth.

Diagram 7
Polybasite filling cleavage
openings in, and replacing,
Galena

Diagram 8
Tetrahedrite replacing
Galena. Note relic pit.

Ch   Chalcopyrite
Po   Polybasite
G   Galena
T   Tetrahedrite

highly irregular or mossy zones within galena, polybasite, or pyrargyrite, but may be found also as minute blebs. Strangely enough, large areas of tetrahedrite seem to have little or no associated silver and give the weakest reaction chemically for that metal.

If not in tetrahedrite, the native silver can be found in poly-basite and pyrargyrite, and to a lesser extent in galena. Bince it is unlikely that silver can exsolve from all these minerals, and since it occurs in them all in manners strongly suggestive of replacement, and also since the tetrahedrite has been proven to be exceptionally rich in silver, it seems natural to infer that, in the absence of Acanthite, exsolution of silver from tetrahedrite is plausible.

Diagrams 9 to 11 inclusive have been selected to illustrate only a few relationships between silver and the sulpho-salts. The ex-solution of silver from tetrahedrite is merely included here as a possi-bility. If exsolution is not acceptable, then a pronounced selective re-placement by silver is suggested as an alternative. Explanatory notes on the remaining diagrams are as follows: Diagram 8 shows replacement of galena by tetrahedrite; diagram 9 shows replacement of galena by tetrahedrite with possible exsolution of silver from tetrahedrite; dia-gram 10 shows preference of tetrahedrite (exsolving silver?) for polybasite over galena; and diagram 11 shows preference of silver for polybasite and pyrargyrite over galena in selective replacement.

The non-crystalline quartz and calcite have been found as ir-regular masses and veinlets cutting earlier minerals. One section exam-ined showed the two minerals to occur as dendritic networks veining all other minerals except native silver. The veinlets appear black against
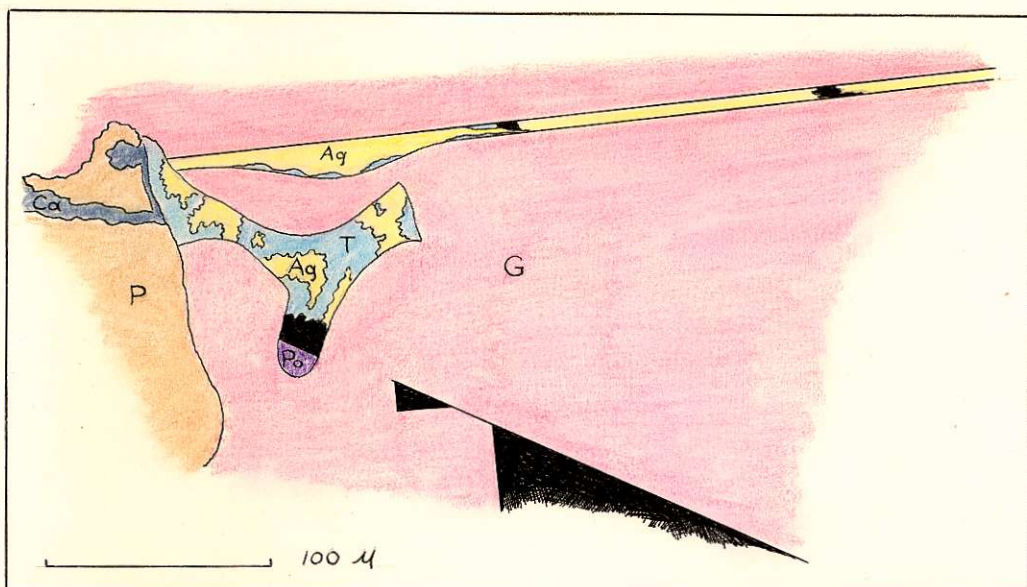
Diagram 9
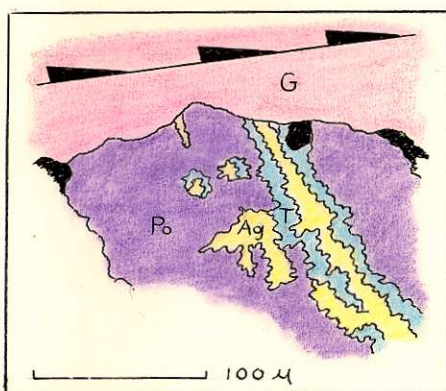Tetrahedrite replacing Galena and exsolving? Native Silver

Diagram 10
Tetrahedrite replacing Poly-
basite in preference to
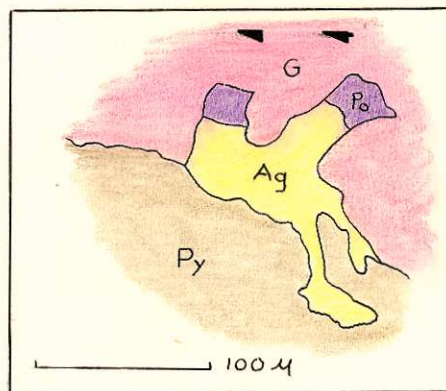Galena, and exsolving? Silver.

Diagram 11
Silver replacing Polybasite
and Pyrargyrite in preference
to Galena.

Ag	Native Silver
G	Galena
Po	Polybasite
Py	Pyrargyrite
P	Pyrite
Ca	Calcite

the dark grey of early quartz. They do not appear to be associated with mineralization so must be associated with post-ore movements. Quartz seems to predominate over calcite or at least the carbonate.

TEMPERATURE AND MODE OF ORE DEPOSITION

L.Reinecke has described the Beaverdell deposits as being cavities and fissures filled by hot ascending aqueous solutions, possibly related to the "Beaverdell Batholith". Some replacement of wall rock is recorded. With information and knowledge available at that time, he placed their temperature of formation as being between 175° C and 300° C at pressures between 140 and 400 atmospheres, but added that their mineralogy and mode of occurrence were similar to deposits found at depths of from 4,000 to 12,000 feet. He felt that the deposits would change within 1300 feet of vertical range to types low in silver and galena, and possibly higher in gold. This opinion was only natural after examining a nearby deposit, the Carmi, which was at a lower elevation and which was being mined for gold.

The presence of sulpho-salts has influenced early workers to suspect a supergene origin. However these same minerals are now found to occur in deposits that must be classed as hypogene. Dr.Warren states definitely that the Beaverdell ore is of this type. No better proof can be given that such is the case than the direct evidence offered by mining. Ore being taken from the bottom of the Highland Bell mine, nearly 1000 feet below the portal, is comparable in mineralogy and value with that found in the upper levels.

If the chalcopyrite be exsolved in part from the sphalerite, then a temperature of solidification of from 350° C to 400° C is indicated according to Edwards. Exsolution of silver from tetrahedrite is not listed by him; however, unmixing of sulpho-salt minerals capable of stable solid solution is believed possible at elevated temperatures, possibly 400° C to 600° C.

The assemblage of minerals found in the material examined indicates a formation temperature below 500° C. No alteration minerals were observed in the ore to suggest any but a primary origin. Lacking other information, it is only fair to state that the deposit is, as already stated by Dr.Warren, of hypogene origin. There is nothing to suggest other than a low to mediate temperature of formation.

Perhaps the damming of mineralizing solutions by the Wallace sediments, as described by Reinecke, has made it possible for mining to be carried out commencing with the "top" of an epithermal deposit. Thus the full vertical range of epithermal-mesothermal mineralization might exist at Beaverdell, permitting mining to continue to depths considerably beyond 1000 feet.

CONCLUSION

This study of the Highland Bell ore adds little to the mineralogy already known. Any statements that may disagree with previous work, particularly that of Dr.Warren, have been made on the evidence of only a few polished sections. Further time spent on preparation and examination of additional sections would, in all probability, bring about complete

agreement especially since no part of the mineralogy, described in the previous and more lengthy report, has given rise to contradiction.

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