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GEOLOGY 409

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Introduction

The Mineral King Mine, 28 miles southwest of Invermere, B.C., is a relatively new mine of modest stature. Though the zinc-lead ore showing had been intermittently prospected since 1898 the property never came into production until 1954, when the Sheep Creek Mining Company, Nelson, B.C., established a 625 ton per day concentrator. Average mill-head assays in 1958 were:

Zn	5.57 %
Pb	2.20 %
Ag	0.58 oz./ton

Two groups of specimens were studied: Group A - a suite sent to the university by Mr. Daryl McSpadden and Group B - a suite from an earlier collection. The A group consists of six unweathered hand specimens from which four polished sections were made, and twelve 4"-6" sections of 7/8" core from which four thin sections and two polished sections were made. The core specimens have been numbered from 1 to 12 inclusive; the hand specimens from 13 to 18 inclusive. The B group has not been numbered.

This academic report includes macroscopic and microscopic description of the specimens, textural and paragenetic descriptions and classification of the ore deposit. Eleven illustrations are appended. Conclusions presented are those of the author and not necessarily those of the Geology Department of the University of British Columbia.

Macroscopic Description

Hand specimens of the A group have medium grained replacement mineralization, both massive and disseminated, in a gangue of limestone (in part dolomitic), barite and quartz. Sulphide minerals present are sphalerite (50%), galena 20% and pyrite (10%); associated sulphosalts are bournonite (15%) and tetrahedrite (5%).

Sphalerite varies from a brownish-green, translucent variety disseminated in silicified limestone (specimen A15) to a dark brown, nearly opaque, massive variety accompanied by quartz (A16). A brecciated layer in A16 has inequigranular pyrite ranging in size from a fraction of a millimeter to 3mm. Specimen A14 is composed of medium grained sphalerite, galena and pyrite in brecciated limestone. Specimens A13 and A17 have distinct forms of bournonite: A13 has aggregates of short prismatic crystals, no longer than 3mm., and granular masses of bournonite in a gangue of quartz and deformed, tabular barite; A17, a small specimen about an inch long, is composed of sub-parallel aggregates of deformed, striated crystals up to 1cm. long. Specimen A18 is composed of irregular veinlets of tetrahedrite and bournonite in crushed barite. In places a soft, black, sooty material, presumed to be an alteration product of tetrahedrite because of positive microchemical tests for Cu and Sb and negative tests for Pb and Ag, occurs in the barite. This specimen has been stained brown by iron, and pink by an unknown material which is likely the product of the decomposition of the tetrahedrite. An uncrushed portion of the specimen is not mineralized, nor is it stained.

Core specimens of the A group are only slightly mineralized, the minerals being pyrite and, in some specimens, bournonite, but they show a variety of interesting textural features.

Specimen A1 is composed of a very finely bedded, light gray limestone, in part brecciated and in part replaced by medium grained calcite. Thin dark rims outline the crystalline calcite (see fig. 9) A thin section of this specimen shows palisade calcite crystals fringing the darker rims which bound the limestone. Some rounded remnants of the impure limestone are similarly outlined. Presumably hydrothermal fluids replaced and recrystallized the limestone, the insoluble impurities being concentrated in the dark rims.

Specimen A2 shows replacement of brecciated limestone by calcite and the dark rims form irregular suture-like lines throughout the core. Replacement has progressed selectively along the fragments of limestone. In A3 the replacement has followed the bedding.

Specimen A4 is composed of an aphanitic, limy, brown matrix with the appearance of mudstone. Angular inclusions of calcite, some of which are stained to a buff colour by iron, occur in the brown matrix. Granular aggregates and fine specks of pyrite are irregularly distributed in the rock. Lenticular masses of a translucent green mineral, which reacted doubtfully to the chromium bead test and negatively to the copper microchemical test, are oriented into a sub-parallel arrangement. At the "head" end of many of these lenticular masses a small grain of a dark gray, isotropic mineral occurs. The polished section depicted in figure 11 shows a "streamlined" textural feature, the streamlining occuring around an aggregate of coarse and fine pyrite grains. The cause of this texture is attributed to the results of the flow of some fluid through the rock, the green mineral (chrome mica?) forming in the lee of an undetermined metallic mineral and the fine pyrite specks being slowly carried along through the

matrix until trapped by the coarse pyrite fragments.
A5 is composed of nearly pure, fine grained calcite. A6 is light gray limestone in which small fractures have been healed by calcite. A small amount (≈ 1%$_v$) of galena and splendent black tetrahedrite occurs in one of these fractures.
Specimen A7 is a light brown ferruginous limestone containing abundant irregular fragments of gray limestone and numerous light green patches (chrome mica?) associated with a small grain of a metallic mineral as in A4. Trace amounts of black sulphide minerals are present in 1mm. to 3mm. layers of darker carbonate. A thin section shows limonite, pseudomorphous after pyrite, distributed throughout the rock. The texture is comparable to that of A4.
Specimen A8 contains granular pyrite distributed throughout a brecciated limestone which contains fragments of phyllite. Calcite has replaced the limestone along the contacts of the dark green phyllite. A10 is similar. A11 is composed of fragments of limestone and phyllite as well, but is unique inasmuch as it contains some limestone fragments which are very finely but irregularly layered by very fine pyrite. As many as 25 distinct pyrite layers occur in a thickness of 1/2". A12 is predominantly black phyllite but layers of calcite separate the phyllite in places. Shearing is indicated by augen-shaped fragments of limestone within the irregular dark layers.

The following table lists the estimated composition of the twelve core specimens.

TABLE OF
ESTIMATED COMPOSITION OF CORE SPECIMENS

SPECIMEN NUMBER	HOLE No.	DEPTH (ft)	PYRITE %	OTHER SULPHIDE %	LIMESTONE %	CALCITE %	PHYLLITE %	CR. MICA(?) %
3	531	226	Tr	–	85	15	–	–
1	531	227	Tr	–	80	20	–	–
2	531	243	<1%	–	40	60	–	–
4	533	94	20	1	–	5	–	2
5	533	112	–	–	5	95	–	–
6	534	4	Tr	1	95	4	–	–
8	541	51	15	–	35	5	45	–
7	541	55	5 (limonite)	Tr	84	10	–	1
9	541	72	2	Tr	90	8	–	–
10	397	15	3	–	80	2	15	–
12	397	47	–	–	10	20	70	–
11	473	189	2	–	80	15	3	–

The B group consists of seven unweathered hand specimens and seven polished sections. Lenticular masses of medium grained, equigranular sphalerite accompanied by galena, bournonite, tetrahedrite and pyrite replace the limestone host rock along the bedding. Gangue minerals are pyrite, quartz and barite.

As in the A group, the sphalerite occurs in two distinct forms - a light brown variety and a dark chocolate brown variety. The polished section depicted in figure 10 shows a contact of the two sphalerites. The readily apparent contact follows a straight line across the specimen. Corroded grains of pyrite occur in the lighter sphalerite; in the darker sphalerite pyrite and galena occur but only at the contacts with quartz. The darker mineral takes a poorer polish because of a greater amount of fine irregular fractures. This specimen suggests that the two sphalerites belong to a different stage of mineralization. Other specimens show the lighter sphalerite usually associated with barite and fine grains of quartz; the darker sphalerite, probably the earliest of the two, occurs with larger masses of quartz and less barite.

Polished sections show varying amounts of of metallic minerals in gangue, some are predominantly sphalerite, others are composed of intergrowths of galena and sulphosalts.

Microscopic

Microscopic study revealed no other minerals than those already discussed.

Sphalerite occurs in medium to coarse grained masses, which, because of pitting and fracturing, takes a poor polish. The lighter coloured variety has a brilliant amber internal reflection; the darker material is nearly opaque but in places shows dark brown internal reflection. This variation in the two varieties is probably due to different iron contents. Sphalerite replaces pyrite, the contact between the two being of the caries type (fig. 3 and 4). Small tongues of sphalerite protrude into pyrite (fig 4) but are not common. Rounded remnants of sphalerite occur in the sulphosalts.

Galena, because of its' characteristic triangular pitting, was identified without difficulty. Except for this pitting the isotropic mineral takes a good polish. The galena occurs occurs in medium to coarse grained, equigranular masses with sphalerite, and as irregular rounded blebs remnants in bournonite and tetrahedrite. Tongues of galena protrude into pyrite (fig. 4) and indicate replacement of the latter. Contacts of galena and sphalerite are of the mutual boundaries type suggesting that sphalerite and galena were deposited contemporaneously. In places rounded inclusions of galena are present in sphalerite; triangular inclusions of galena are present in sphalerite as well. Contacts of galena and sulphosalts are of the caries type (fig. 5 and 8) suggesting replacement of galena. Very fine irregular veinlets of galena replace limestone

Bournonite ($Cu_2S \cdot 2PbS \cdot Sb_2S_3$) is a soft (C-), light gray, orthorhombic mineral that takes a good polish. Anisotropism is strong in shades of gray, brown and blue. Pleochroism in very faint shades of gray can be detected. Deformed polysynthetic and broad lamellar twinning is common in the prismatic crystals which may reach lengths of 1cm. Cross sectional dimensions of individual grains are usually less than 1mm.

Etch reactions for bournonite are as follows:

$HgCl_2$ - negative
KOH - negative
KCN - negative
HCl - negative
$FeCl_3$ - negative
HNO_3 - slow brown tarnish

Microchemical tests confirm the presence of Pb, Cu and Sb.

A peculiar texture in one specimen (A 23) shows remnants or inclusions of a harder mineral in twinned bournonite (fig. 6). This mineral is anisotropic in shades of tan and gray, has a hardness of C, and otherwise is similar to bournonite. Microchemical tests are comparable to those for bournonite. This mineral was concluded to be bournonite, the distinctive properties being attributed to anisotropism of oriented crystals. Though the caries texture cannot be considered conclusive this bournonite appears to be replaced by the twinned bournonite. Bournonite replaces galena and perhaps sphalerite (fig 5). In places it exhibits mutual boundaries texture with tetrahedrite, in other places the bournonite is definitely later than the tetrahedrite (fig. 8).

Pyrite occurs as granular masses, discontinuous crustiform masses associated with dark brown sphalerite, and as equant corroded grains in sphalerite (fig. 3) Specimens A 14 and A16 show pyrite concentrated in layers in the host rock. Pyrite in the ore takes a poor, pitted polish, in the core specimens the pyrite takes a good polish. Where in contact with the other metallic minerals pyrite is always the one replaced, hence it is considered to be the first deposited.

Tetrahedrite is a fairly soft (D), light gray, isotropic mineral that takes a good polish. It occurs in rounded masses varying in size from ½ cm. to rounded microscopic blebs. Caries contacts with galena (fig. 8) suggest replacement of galena but mutual boundaries with bournonite suggests contemporaneous deposition of the two sulphosalts. In places atoll texture is well developed (fig. 7) indicating replacement by bournonite. A second lighter coloured mineral with the same properties and etch reactions as tetrahedrite is associated, usually centrally, with the "atolls". This mineral is concluded to be a tetrahedrite of a second stage of deposition. Tetrahedrite does not show evidence of replacing pyrite nor sphalerite. As no silver minerals were found in any of the specimens the silver values realized from the ore are probably contained in the tetrahedrite.

Two specimens from the B group show small amounts of secondary minerals. Siderite and limonite have formed in a cavity of one specimen. A gun-steel blue mineral, possibly covellite, partially coats bournonite and tetrahedrite in a small specimen, but polished section study of the same specimen does not confirm the presence of any covellite.

The microscope study shows a small proportion of mineralization with grain size less than 74 microns. It is estimated that 95% of the sphalerite and galena would be released in a 200 mesh grind. The same grind would probably release 90% of all minerals present. Rough estimation of the metallic mineral proportions in the specimens studied is as follows: sphalerite-45, galena-25, bournonite-15, pyrite-10 and tetrahedrite-5.

The paragenetic sequence of the described specimens is illustrated in figures 1 and 2.

Presence of sphalerite, galena and tetrahedrite, common mesothermal minerals, indicate that the Mineral King deposit is of the mesothermal type.

FIG. 1

ILLUSTRATION OF THE PARAGENETIC SEQUENCE

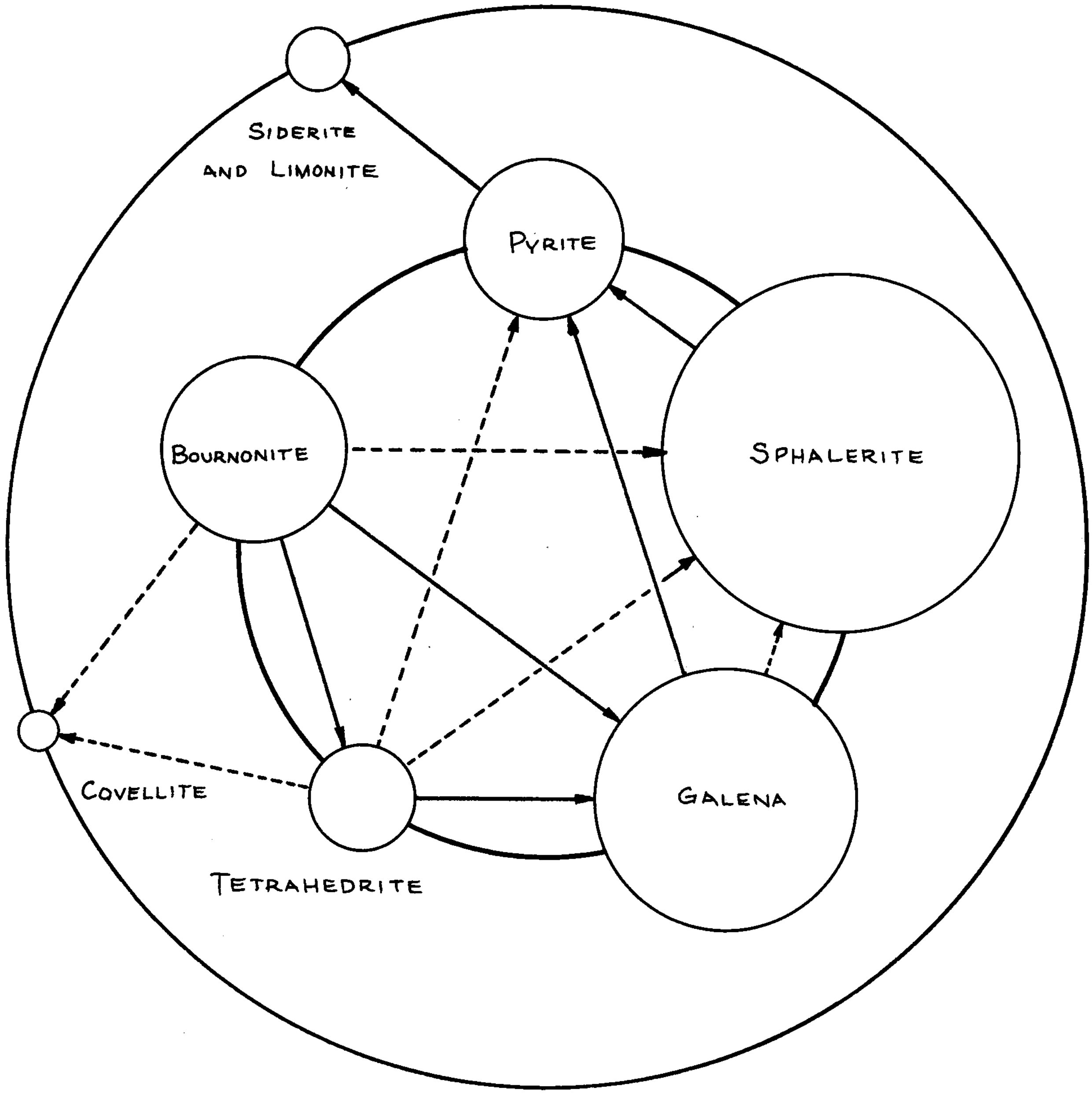
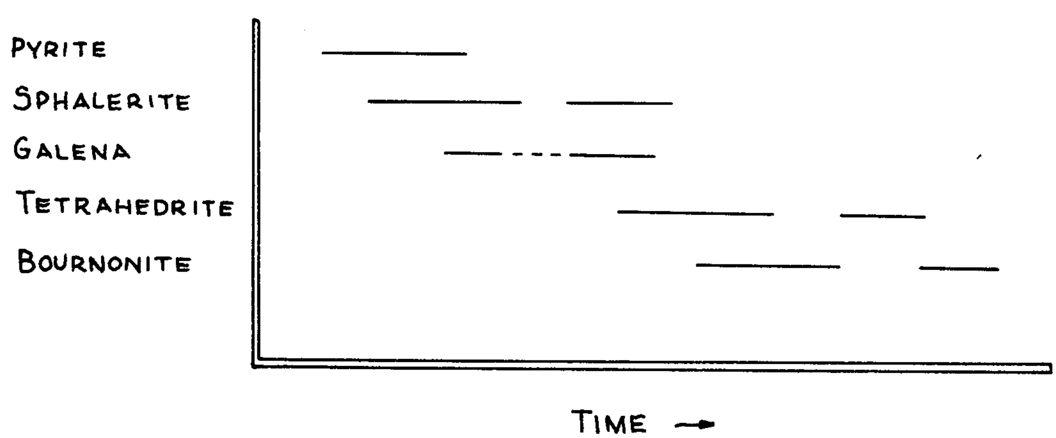


FIG. 2

ILLUSTRATION OF THE TIME SEQUENCE



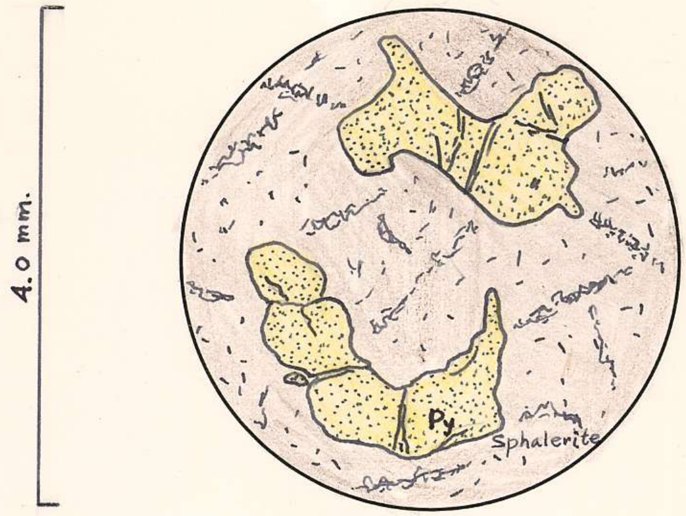


FIG. 3

CORRODED PYRITE IN SPHALERITE SHOWING PITTED POLISH OF BOTH MINERALS

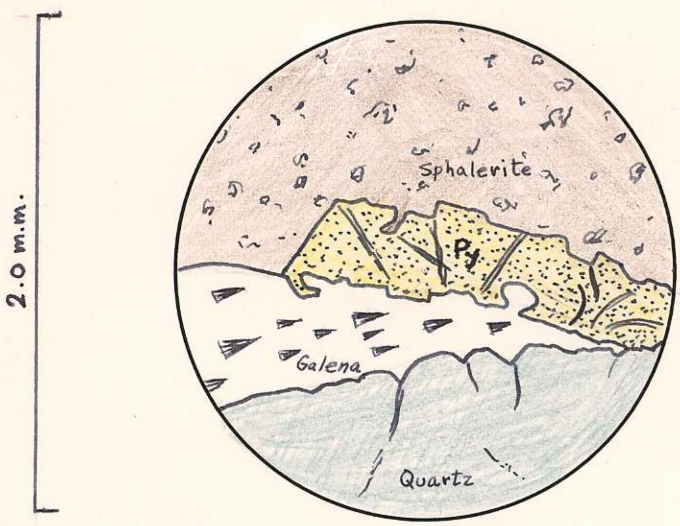


FIG. 4

PYRITE REPLACED BY SPHALERITE AND GALENA. PITTED POLISH OF GALENA.

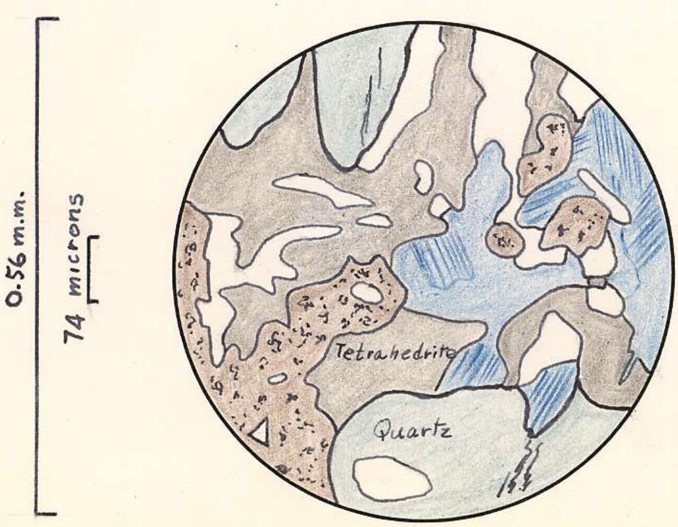


FIG. 5

GALENA REPLACED BY TETRAHEDRITE AND BOURNONITE. ROUNDED AND ANGULAR INCLUSIONS OF GALENA IN SPHALERITE. POLY-SYNTHETIC TWINNING IN BOURNONITE.

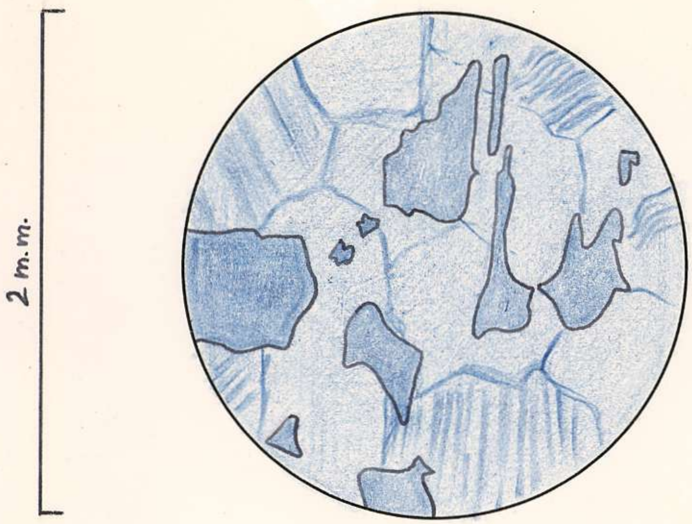


FIG. 6

REMNANTS OF AN EARLIER BOURNONITE IN TWINNED BOURNONITE. LAMELLAR AND DEFORMED POLY-SYNTHETIC TWINNING IN THE LATER BOURNONITE.

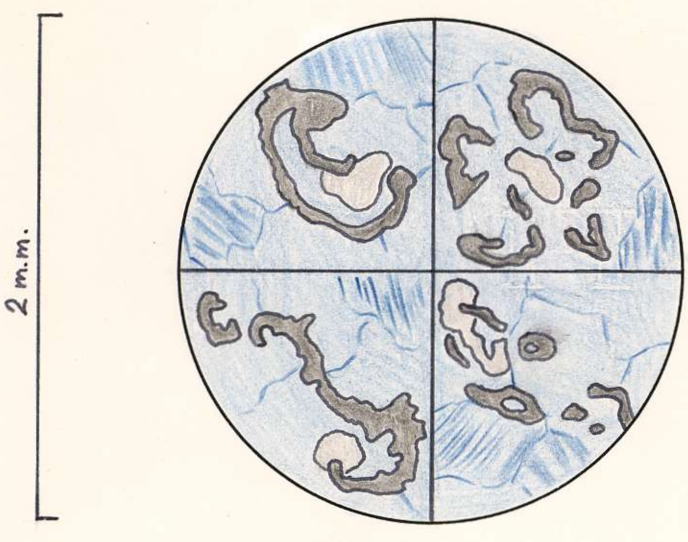


FIG. 7

ATOLL TEXTURE OF TETRAHEDRITE IN TWINNED BOURNONITE. LATE TETRAHEDRITE (LIGHT GRAY) WITHIN "ATOLLS".

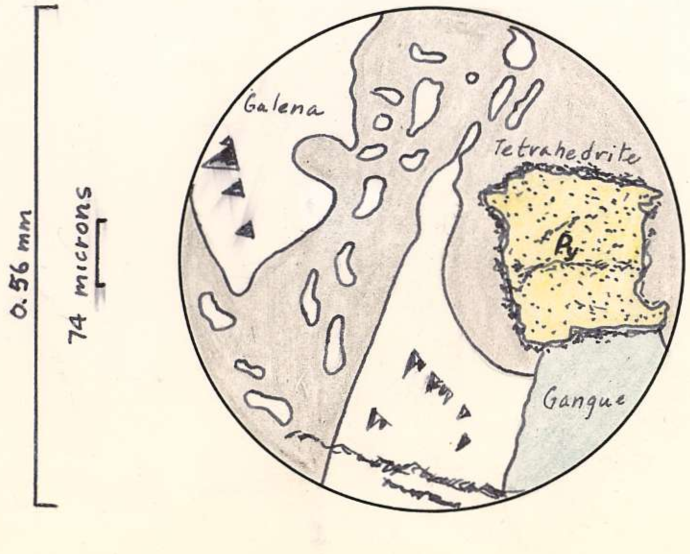


FIG. 8

GALENA REPLACED BY TETRAHEDRITE. CORRODED AND PITTED GRAIN OF PYRITE.

FIG. 9 (x2)
FINE GRAINED LIMESTONE REPLACED BY CALCITE. DARK MARGINS OF INSOLUBLE MATERIAL

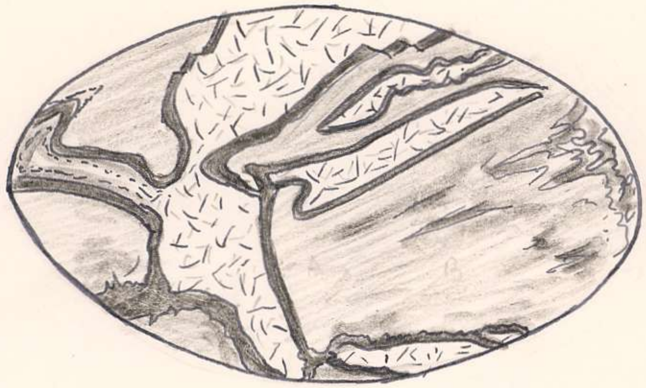


FIG. 10 (x1)
MEDIUM GRAINED SPHALERITE WITH QUARTZ GANGUE. CORRODED PYRITE GRAINS. DIFFERENCE IN SPHALERITE DENOTED BY SHADES OF BROWN.

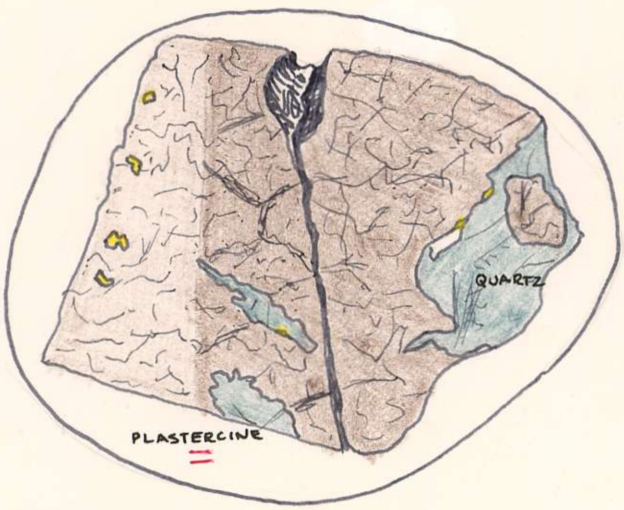


FIG. 11 (x 3.2)
CORE CROSS SECTION WITH GRAINS AND SPECKS OF PYRITE AND PORTION OF CALCITE FRAGMENT (WHITE). SMALL LENTICULAR MASSES OF CHROME MICA(?) (GREEN). STREAM LINED FLOW TEXTURE DEPICTED BY SHADING OF CALCAREOUS MATRIX.

SHEEP CREEK MINES LIMITED
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Mine Office:
TOBY CREEK, B. C.

July 5th, 1962

Dr. R. M. Thompson,
c/o, Dept. of Geology,
University of B.C.
Vancouver 8, B.C.

Dear Sir,

Thank you very much for the Minerological Report done by Roy Lammle. Please extend my thanks to him.

If this suite is again studied by another man, I would appreciate the opportunity to read the report. If stibnite is present I would also like to know. If my requests are too demanding, please feel free to tell me.

As for sending you some bournonite samples - darn rights - but it will take a little time.

My congratulations to you and your colleagues on the discovery of those new minerals.

You shouldn't tell me about your visits to many of the Eastern mineral localities - it makes me envious.

Wishing you the best of health and success.

I remain.

Yours truly,

Daryl McFadden