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A MINERALOGICAL STUDY OF ORE FROM
THE ROBSON GROUP

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Preface

This report is respectfully submitted in fulfillment of the second term requirements of Geology 23, combined with those of Geology 9. The problem investigated concerned the identity of a mineral which has been determined as tetrahedrite. The securing of pure material (200 mg.) for assaying was the chief labor. In addition, a number of polished sections and polished specimens were prepared. Microchemistry and mineralography were used in this problem, as well as in determining the occurrence and paragenesis of the ore minerals. Previous reports have determined the mineralogy and the association of gold and silver values in these ores.

The writer here wishes to express appreciation of help and advice received from Dr. H. V. Warren. This also applies to the help of Mr. Howatson and Mr. DeLeen, who carried out the spectrographic analyses.

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THE ROBSON GROUP

PART I

Introduction

Location of the Claims

The Robson Group claims are situated in the Bonanza Basin, about 15 miles north-west of the Pioneer mine. This locality is in the Lillooet mining division, and is accessible only by pack trail from Bridge River.

Discovery

The first staking of gold-bearing arsenopyrite showings in the Bonanza Basin was in 1912 (2). The veins along Hughes Creek (3) were exposed in 1933. A five-inch arsenopyrite section of a vein assayed 2.40 oz per ton of gold, and 20.9 oz per ton of silver. The remaining 29 inches of vein width was nearly barren of gold and silver values, and consists of dark sulphide minerals.

In 1940 the J. G. Mining Company began to develop the main claims of the Robson Group, by means of adits, open cuts, and diamond drilling around the principal showing.

PART II

Geology and StructureTable of Formations(1)

- Minor Intrusives: (a) Feldspar porphyry
(b) Altered felsitic intrusives
(c) Hornblende diorite and hornblende porphyrite
(d) Feldspar-biotite porphyry
(e) Biotite syenite or quartz syenite porphyry
- Coast Range Intrusives: (a) Coarse gabbro, some of it anorthositic
(b) Quartz diorite and granodiorite.
- Cretaceous: Leckie Group:- Varicolored pyroclastic rocks interbedded with grey to mauve lavas and some shale and conglomerate.
- Lower Cretaceous and Upper Jurassic: Eldorado Group:-
(2) Lower Cretaceous:- Grey and green sandstone, shale, conglomerate, and tuffaceous beds.
(1) Upper Jurassic:- Massive to thin bedded argillites and tuffs.
- Jurassic: Taylor Group:- Much conglomerate with great thicknesses of fine-grained clastic rocks and occasional thin volcanic layers.
- Middle Jurassic:- Interbedded argillites and tuffs intruded by feldspar porphyry dykes.
- Lower Jurassic:- Limey shales with bands of fossiliferous limestone, sandstone, and conglomerate.
- Triassic and Jurassic(T): Tyaughton Group:- Grey, green, and reddish sandstone, shale, grit, conglomerate, limestone, and thick beds of light grey limestone. Probably all Triassic.
- Triassic: Hurley Group:- Mainly sedimentary. Thin-bedded limey, argillaceous, tuffaceous conglomerate and limestone.
- Pioneer Formation:- Volcanic, green, fine-grained andesites, occasionally porphyritic.
- Noel Formation:- Argillaceous and tuffaceous sediments with occasionally interbedded volcanics.
- Fergusson Group: Alternation of:

(next page)

Fergusson Group: (Cont'd.)

- (a) Ribbon-cherty argillite, and
- (b) Greenstones - fine-grained altered schistose basic lavas.

Distribution and Structure
of the Ore Veins

The mineralization is found in an upwarped fault block of Upper Triassic sediments of the Hurley Group (Fig. 1). The Bonanza Basin phase of this group is different from the limey sediments elsewhere. It consists of grey to black cherty or dense argillaceous or siliceous beds. Since this section has an obscure relation with other Hurley sediments, it may belong to the underlying Noel formation.

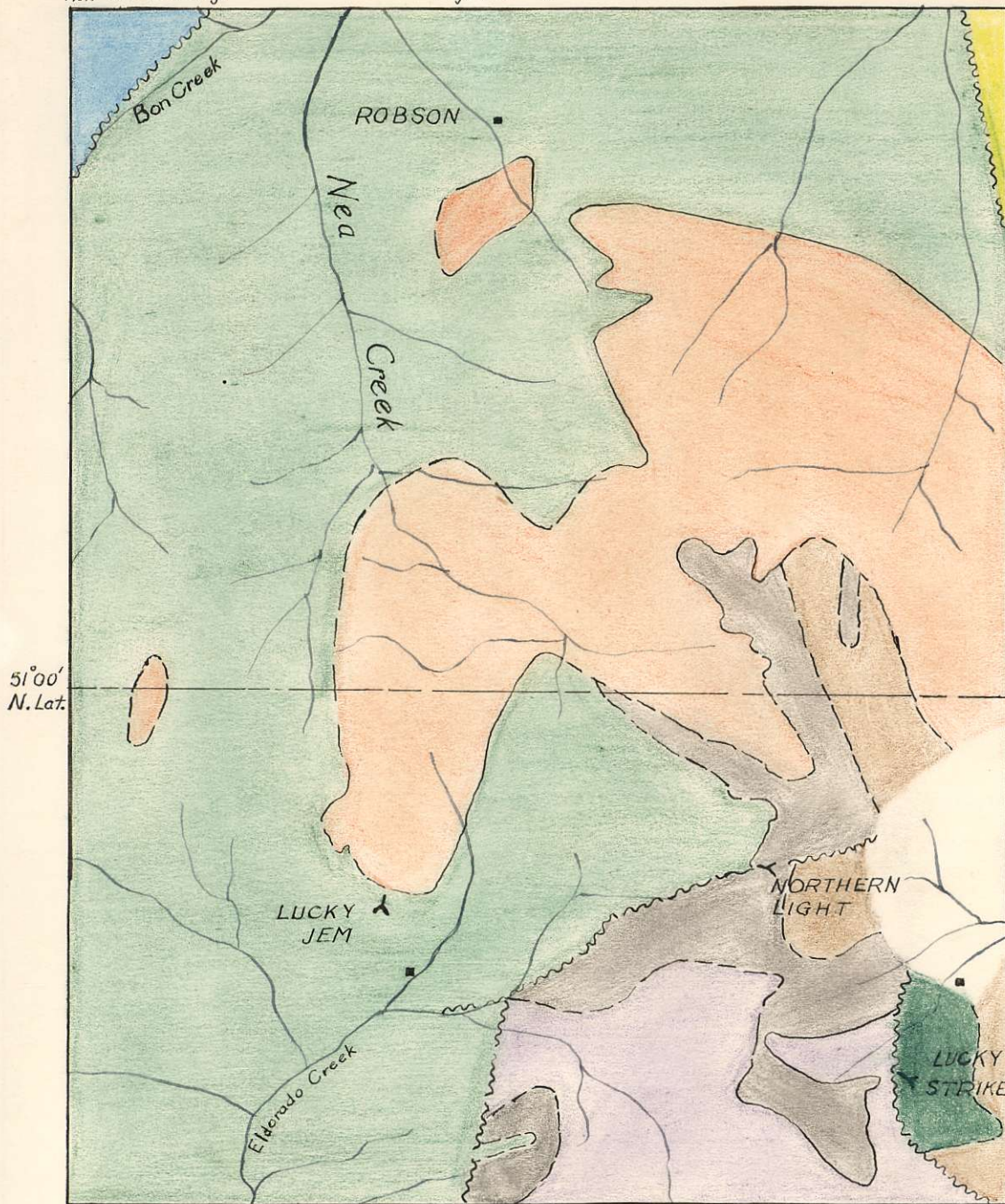
A broad shear zone is mineralized adjacent to a quartz diorite intrusive of Coast Range age. Broad, dyke-like apophyses radiate from this intrusive. One of them parallels the shear zone veins.

These "dykes" are highly feldspathic and commonly contain arsenopyrite and pyrite.

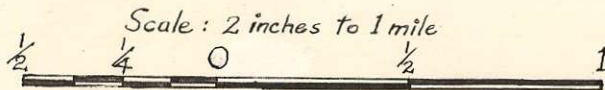
At the principal showing, the shear zone, from which the problem samples came, is 18 inches wide, and dips 30 degrees north-west.

122° 55' E. Long.





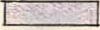



Figure 1



Traced From Preliminary Map 43-15A



GEOLOGICAL MAP SHOWING GOLD-ANTIMONY PROPERTIES

- | | | | |
|---|-------------------------------|--|-----------------------|
|  | Pioneer Formation |  | Coast Range Intrusive |
|  | Noel Formation |  | Taylor Group |
|  | Fergusson Group |  | Tyughton Group |
|  | Ultrabasics (Altered in part) |  | Hurley Group |

PART III

Mineralogy

Macroscopic Description of the Ore Vein

In general, no definite vein boundaries may be seen. The middle of the vein is formed by a 15 to 30 mm. layer of arsenopyrite and quartz in a comb-like structure, which also encrusts brecciated fragments. Inward, up to 10 cm., arsenopyrite gives place to zinckenite with some jamesonite, and quartz decreases in amount. Inwards two to 10 cm. from the arsenopyrite crust, sphalerite is found in a zone of rounded or eight-sided metacrysts, or in an uneven layer.

Tetrahedrite in rounded, squarish, or irregular patches is thinly scattered in variable zones between the sphalerite and the arsenopyrite.

Large open fractures are filled with crystals of milky quartz and pyrite. Pyrite has replaced arsenopyrite in a few places. Although the character of the quartz varied somewhat, there was no evidence of two distinct intrusions of quartz.

Microscopic Description of Minerals Found in Polished Sections

Arsenopyrite:

Found as perfect orthorhombic crystals (up to 4 mm.

broad and 15 mm. long) and massive aggregates. Crystal aggregates show extensive replacement by zinkenite and brecciation, with infilling by the quartz (Plates I and VI).

Gold:

Broken fragments are attached to the borders of coarser arsenopyrite crystals. This was not previously seen in polished sections (Plate I).

Pyrite:

In massive form, it replaces arsenopyrite. As cubic crystals, it is found in vuggy quartz veins, common to the feldspathic apophyses (Polished Specimens No. 15 and 17).

Pyrrhotite:

In grains up to 0.2 mm. diam., and as rims and lacy disseminations, it is found in massive zinkenite and jamesonite. (Plates III and IV).

Sphalerite:

As rounded or eight-sided forms (dodecahedral), it is found up to 15 mm diam. It forms irregular layers in tuffaceous material. Zinkenite has replaced the sphalerite. The usual chalcopyrite is found along cleavage lines. The sphalerite is occasionally brecciated and infilled by quartz (Plate X).

Tetrahedrite:

In irregular, rounded or squarish masses, showing yellowish tarnish and complete isotropism. Jamesonite extensively replaces it in laths and diamond-shaped inclusions. A minor amount of zinkenite may also replace it. (Plates II, V, VIII).

Zinkenite:

Massive, usually showing prismatic form or reticulate form; it fills the interstices of the quartz arsenopyrite comb.

It replaces the arsenopyrite extensively, also sphalerite. (Plates I, IV, VI, VIII).

Jamesonite:

Prismatic, sometimes brecciate. Where a prism parallels the polished surface, the basal cleavage may be seen. The whole fabric of the quartz and prismatic metallic minerals is transverse to the vein. Unless a section is exactly longitudinal to this fabric, the basal cleavage of jamesonite cannot be surely seen (Plates II, III, V, X).

Calcite:

This fills late fractures in the vein. Zinkenite and jamesonite are replaced by a carbonate.

Quartz:

In a comb with arsenopyrite, it forms hexagonal crystals, which comb extends unbroken into vein and breccia

fillings.

Dyscrasite(?):

An intensely bright silver white mineral of strongly anisotropic character, it occurs in grains less than 20 μ across which are inclusions in the tetrahedrite. Only two grains were seen in over 40 polished areas of tetrahedrite (Plate VII).

From the etch tests and optical character of the mineral, it was taken to be dyscrasite. It was not possible to confirm this by microchemistry.

The hardness is about B-. Results of etch tests were: HNO_3 quickly stains iridescent, and dissolves the material, leaving a white deposit; HCl stains brown or may be negative; KCN stains brown; KOH negative; HgCl_2 stains faintly iridescent; FeCl_3 quickly stains iridescent.

Distinguishing Jamesonite from Zinkenite in Polished Sections

In his manual⁽⁴⁾ Short describes different etch tests for zinkenite and jamesonite, using nitric acid. All other reagents give similar results for both minerals.

The nitric acid was washed off, in applying this test, as soon as a brown cloud began to spread through the drop of reagent. Many tests were made on jamesonite with marked basal cleavage (Plate III) and numerous areas of zinkenite. Zinkenite immediately turns brown (Plate VIII), and may show a scarcely perceptible iridescence at the

edge of the drop. The nitric acid does not affect jamesonite at once, and turns it strongly iridescent, usually in bright blues and reddish tints. This will identify jamesonite where basal cleavage is not visible.

There is no visual difference between the two minerals in any respect other than cleavage. Jamesonite replaces tetrahedrite (Plate V) and commonly occurs in a carbonate gangue as broken prisms and fragments.

PART IV

The Determination of Tetrahedrite

Obtaining Pure Samples

Cairnes(1) mentions the presence of "a black, cupriferous mineral of doubtful identity." X-ray analysis and assay results have proved this mineral to be tetrahedrite.

The project was assigned as follows:

- (1) To pick and sort out 200 mg. of this mineral of uniform specific gravity.
- (2) To analyse it microchemically, and spectrographically, and have an assay made.

A 100-pound sack of ore was used. The first picking of 23 samples averaged as follows:

(a)	Sp. Gr. 4.58-4.63	.....	101.4 mg.
(b)	Sp. Gr. 4.68-4.73	.....	52.4 mg.
(c)	Sp. Gr. 4.78-4.79	.....	37.3 mg.
	Total ..		<u>191.1 mg.</u>

Material of a higher or lower specific gravity was found to contain fine impurities, mainly quartz and arsenopyrite (Plate II). Jamesonite, zinkenite, and calcite were completely removed by soaking the samples in 1:2 HCl and then 1:2 HNO₃ until bubbles ceased to appear (under binoculars). Tetrahedrite was completely unaffected.

Two samples of specific gravity 4.79 were mounted in demar and polished (Section 3). They contained dyscrasite(?) (Plate VII), and chalcopyrite (Plate IX).

More material was picked and weighed. Eighteen samples gave scattered results, and only a few milligrams were free of quartz, etc. From a calcite vein 125.1 mg. of material, specific gravity 4.54, was taken.

The final result of some 50 specific gravity determinations was:

(1)	4.54	.....	125.1 mg.
(2)	4.58-4.65	.....	103.1 mg.
(3)	4.67-4.70	.....	85.3 mg.
(4)	4.75-4.86	.....	65.9 mg.

Groups (3) and (4) were not used. Their microchemical and spectrographic analyses were similar to those of lower specific gravity. By both methods copper, zinc, silver, antimony, arsenic, and sometimes iron and lead were found to be present. The ratio of copper to zinc was constant in all samples, as seen in the $K_2Hg(CNS)_4$ microchemical test.

In making a spectrographic analysis of groups (1), (2), and (4), the analysts considered the proportions of the

principal elements to be the same in each.

X-ray Analyses

These were carried out at the University of Toronto mineralogical laboratory. Samples of groups (1) and (2) were submitted and determined to be tetrahedrite. Sample (1), of specific gravity 4.54, contained quartz, although visually pure.

Assay Results

Separate samples of group (1) (Sp. Gr. 4.54), and group (2) (Sp. Gr. 4.58-4.65) were submitted to Mr. J. R. Williams for complete analysis. The two samples, totalling 220 mg., were mixed and analysed together. Following is the result:

Insoluble	5.61
Copper	30.50
Silver	1.80
Lead	1.10
Zinc	4.50
Iron	5.73
Arsenic	7.26
Antimony	20.40
Sulphur	<u>23.06</u>
	<u>99.96</u>

Etch Tests on Tetrahedrite

Most of the tetrahedrite examined in polished

sections was tested with etch reagents. All etch reagents except KCN and aqua regia were negative to this mineral. After one to three minutes, KCN produces a visible enlargement of pits and scratches. Aqua regia stains some areas purple, the fumes producing a yellowish-buff tarnish. The etch reactions were constant in all tests.

PART V

Deposition of the Ores

Paragenesis (See Figure 2)

Some of the less obvious features which were used to establish the order of paragenesis are:

Quartz heals fractures and has infilled brecciated portions of both arsenopyrite and sphalerite (Plates VI and X).

Pyrite replaces arsenopyrite (Polished Specimen No. 15).

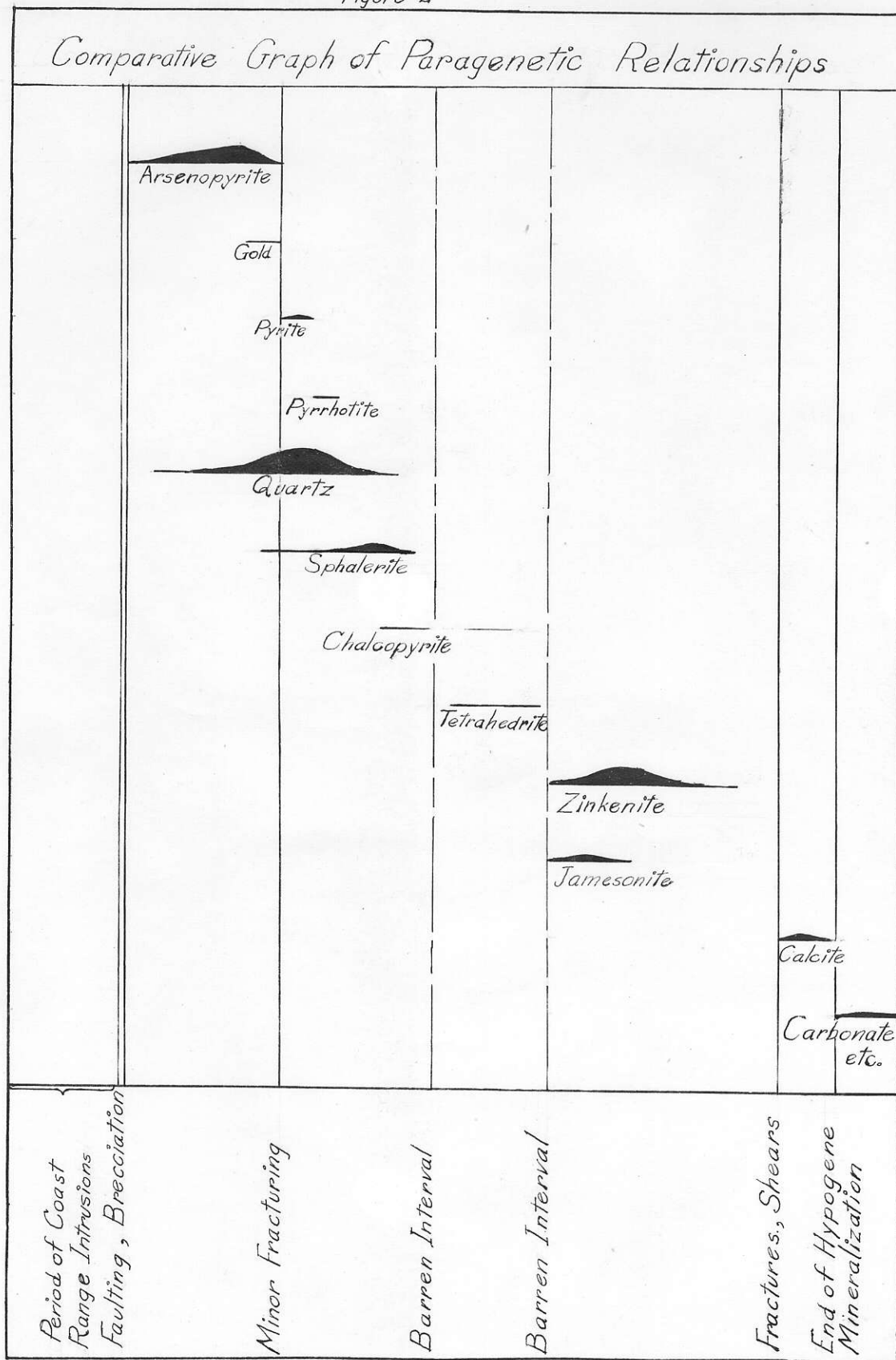
Pyrrhotite and zinkenite vein pyrite (Polished Specimen No. 14).

Zinkenite replaces sphalerite and arsenopyrite, often as metacrysts (Plate VI).

Jamesonite replaces tetrahedrite (Plate V).

Gold borders arsenopyrite crystals (Plate I).

Figure 2



Chalcopyrite occurs in blebs in sphalerite and tetrahedrite (Plate IX).

Calcite fills late fractures, and carbonates have replaced jamesonite, zinkenite, and tetrahedrite.

Associations of Gold and Silver Values

Earlier in the report were noted assay values of gold and silver. In W. J. Lynott's report⁽⁵⁾, he shows similar assays on this ore. In discussing milling concentrates he notes that the antimonial-lead concentrate contained 83 per cent of the silver and four per cent of the gold, while the arsenide concentrate contained 14 per cent of the silver and 93 per cent of the gold.

The gold occurs free with arsenopyrite (Plate I). To account for all the silver values as tetrahedrite would require four per cent of this mineral (containing 1.8 per cent silver) in the ore. It is likely that much of the silver is carried by jamesonite and zinkenite.

Nature of the Ore-Forming Conditions

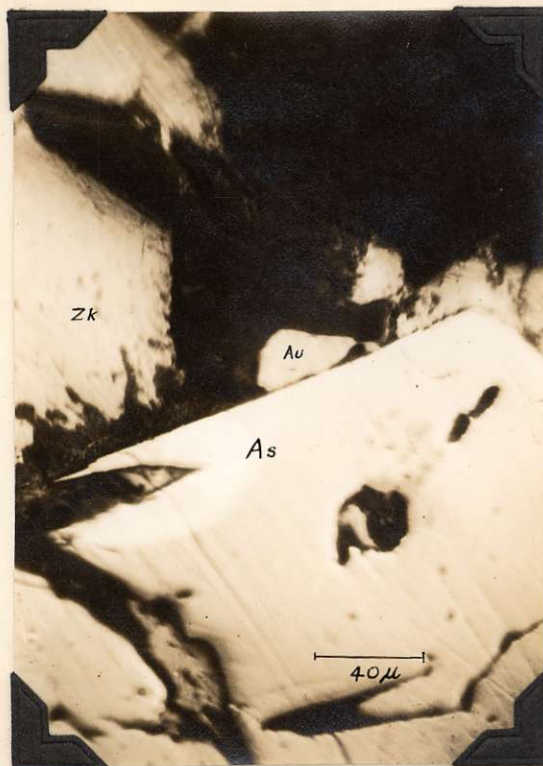
The unusual feature of this ore is the lack of vein boundaries, together with coarse idiomorphic crystallization. It is suggested that the deposit was formed by solutions which retained their volatiles in an impermeable country rock, thereby giving rise to coarse crystallization and extensive replacement. The earlier formed sulphides and

sulpharsenides are in the mesothermal temperature range. Later solutions in the epithermal range appear to have caused extensive replacement of earlier minerals and wall rock by sulpho-salts.

List of References

- (1) Can. Geol. Survey Paper 43-15, "Geology and Mineral Resources of Tyaughton Lake Map Area," C. E. Cairnes, 1943.
- (2) Ann. Rept., Minister of Mines, B. C., 1933, p. 269.
- (3) Ann. Rept., Minister of Mines, B. C., 1940, p. 59.
- (4) U. S. Geol. Survey Bull. 914, "The Microscopic Determination of Ore Minerals," M. N. Short.
- (5) "Geology and Mineralogy of the Robson Group," Geology 9 Report, University of B. C., W. J. Lynott.

APPENDIX

Photomicrographs of Polished SectionsPlate I

(X350)

Gold (Au) adheres to the border of an Arsenopyrite (As) crystal. Other minerals are Zinkenite (Zk) and Quartz (Qz).



Plate II

(X70)

Tetrahedrite (Tet) growing
around crystals of arsenopyrite (As)
and quartz (Qz). Jamesonite (Ja)
and carbonate (Ca) replace it.



Plate III

(X250)

Jamesonite (Ja) shows
basal cleavage and replaces (?)
pyrrhotite (Po).

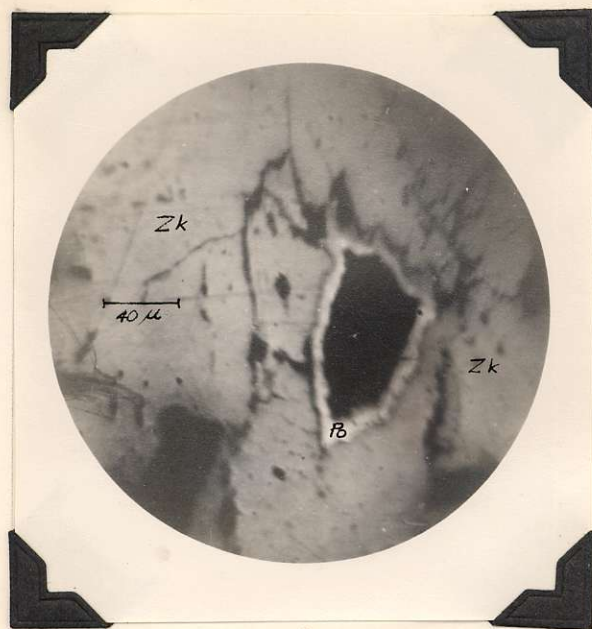


Plate IV

(X250)

Pyrrhotite (Po)

rimming a cavity, surrounded
by zinkenite (Zk.).

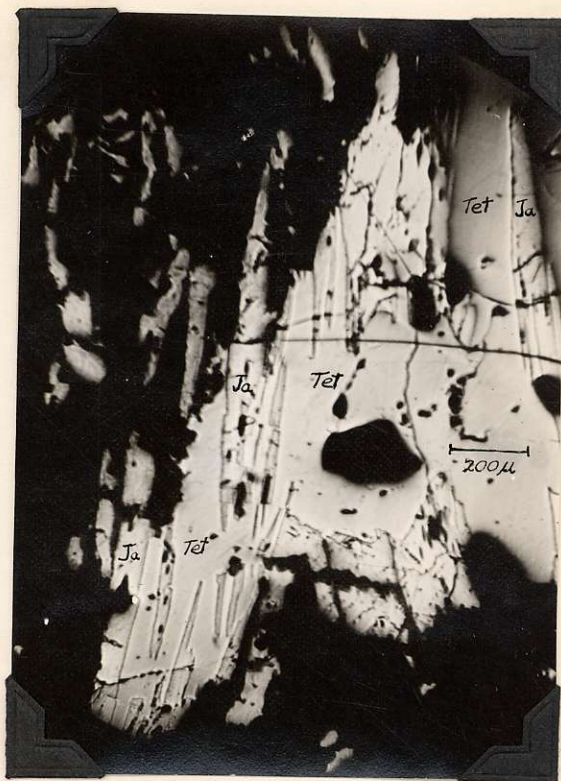


Plate V

(X50)

Jamesonite (Ja)
replacing tetrahedrite (Tet).

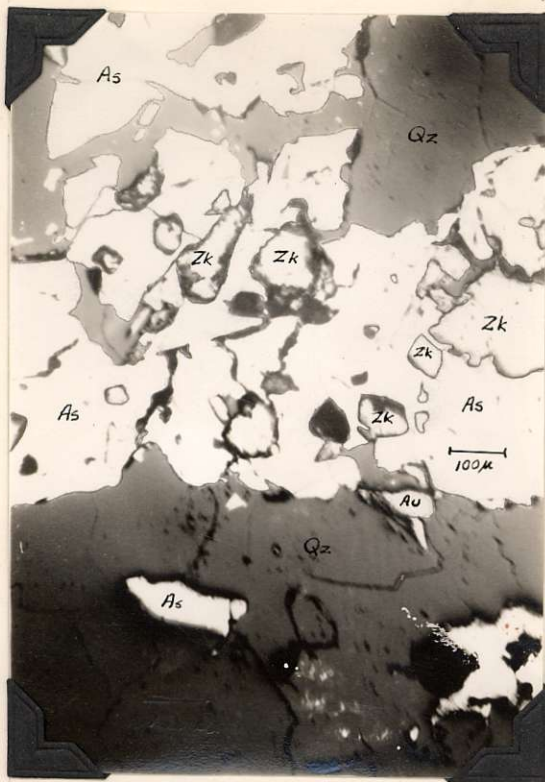


Plate VI

(X70)

Arsenopyrite (As)
bordered by Gold (Au) and
strongly replaced by zinkenite
(Zk). The gangue is quartz
(Qz).



Plate VII

(X500)

Dyscrasite(?)

(Dy) in tetrahedrite (Tet).

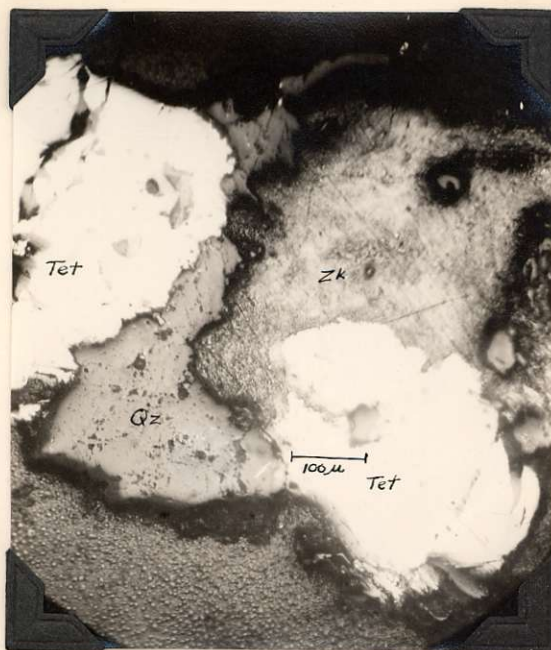


Plate VIII

(X90)

Tetrahedrite (Tet)
bordering quartz (Qz) replaced
by zinkenite (Zk) which has
been etched with HNO_3 .

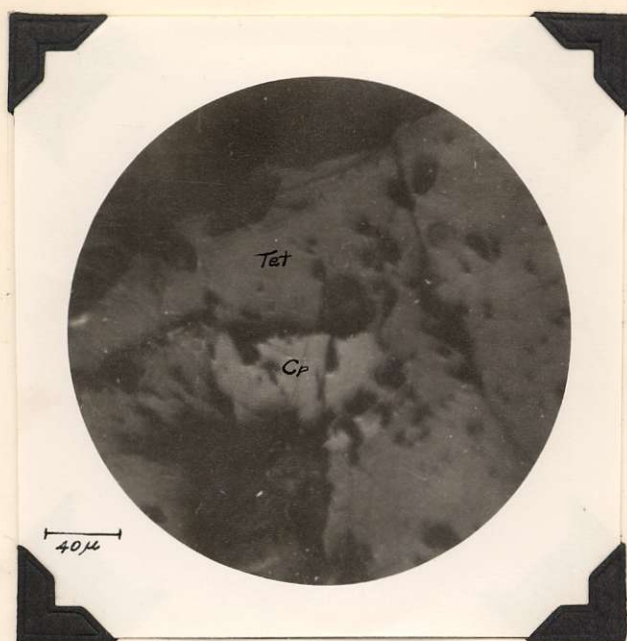


Plate IX

(X250)

Chalcopyrite (Cp)

in tetrahedrite (Tet).



Plate X

(X100)

Sphalerite (Sph)
brecciated and infilled
by quartz (Qz) which is also
in prismatic form. Also shows
jamesonite (Ja) and carbonate
(Ca).