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A Microscopic Examination of

Invermay Annex Ores

by

Oskar Friesen

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Illustrations and Maps

A Microscopic Examination of Invermay Annex Ores

Abstract

The object of detailed examination of the Invermay Annex ore has been to determine the minerals present, their modes of occurrence, and the possible order of deposition. Specimens available for this study consisted of five hand-picked samples of ore and wall rock representing several types of mineralization at the camp.

The samples were collected by Mr. D. Burns, geologist for Invermay Annex Mining Company, and submitted to the Department of Geology, University of British Columbia, for mineralographic study.

Introduction

The Invermay Annex Camp is situated about 25 miles southeast of Hope in the Skagit River Area of British Columbia. The property lies near the headwater of Silver Daisy Creek, a tributary of the Skagit River. Appendix I is a map[1] of the Skagit River drainage area in British Columbia. Access to the area is by road from Hope along the new Hope-Princeton highway which crosses the Skagit River headwaters.

A number of other properties, several of which are situated on Silver Daisy Creek, are located throughout the area. The main values are in gold, silver, copper, lead, and zinc. Production from the area, however, has been negligible.

According to the British Columbia Department of Mines Bulletins, shipments from the Invermay Annex have been limited to 21.227 tons of ore in 1936 and four tons in 1947. Both shipments were made to the Trail smelter.

Acknowledgements

The writer wishes to acknowledge the assistance and advice given by Dr. R.M. Thompson, Dr H.V. Warren, and Mr. J.P. Donnan in the preparation and examination of polished and thin sections.

[1] Adapted from the British Columbia Department of Mines Bulletin (1938) and the Geological Survey of Canada Map No. 932 A.

General Geology

The Skagit River in British Columbia lies within the Cascade Mountain System. Camsell[1] describes the area as an uplifted plateau, which stream erosion and glaciation have carved into rugged mountains.

According to Cairnes'[2] and Camsell's maps, the area is principally underlain by two series of rocks with some later acidic intrusives. These series are the Hozameen of Upper Paleozoic and the Dewdney of Jurassic or possibly Lower Cretaceous age.

A body of quartz diorite of Cretaceous[3] age two miles long and one mile wide at its maximum width at the north end, lies north of Silver Daisy Creek and is surrounded by rocks of the Dewdney Series. The Invermay Annex camp is situated on the southern contact of this intrusive.

The ore mineralization is associated with a shear zone striking north of east and dipping steeply to the south.

Mineralogy

General

The specimens available for this study consist of primary sulphides, wall rock, and alteration products. Five samples, representative of the more highly tourmalinized type of mineralization, have been examined. Since the writer

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[1] Summary report of the Geological Survey of Canada (1911)
[2] Summary report of the Geological Survey of Canada 1922 Part A, 1923 Part A.
[3] Br. Col. Dept. of Mines Bull. (1938) Dr.H. Sargent.

has not visited the property, the extent of this type of mineralization is not known.

Megascopic Examination

The primary ore consists of rather coarse-grained sulphides mainly arsenopyrite, chalcopyrite, sphalerite, pyrite, marcasite in a gangue of euhedral black tourmaline and clear to milky quartz crystals. The tourmaline occurs in prismatic crystals and in radiating columnar aggregates.

Because of their difference in mineralization, the five specimens will be described separately.

Sample one consists of coarse, euhedral tourmaline, quartz, and arsenopyrite crystals with fracture filling and replacement by chalcopyrite and marcasite. The dominant mineral is arsenopyrite. The specimen is well consolidated.

Sample two is largely chalcopyrite surrounding grains of arsenopyrite, quartz, tourmaline, and pyrite. The specimen is poorly consolidated and may be described as granular. It is obviously high grade copper ore.

Sample three is dominantly finely-crystalline tourmaline with disseminated sulphides. Recognizable sulphides are arsenopyrite,pyrite, and chalcopyrite. The specimen is loosely consolidated and almost friable.

Sample four is a tourmalinized "gneissic" wall rock. It consists of alternating bands of loosely consolidated black tourmaline crystals and milky quartz. The irregularity of the banding suggests gneissic or flow structure rather than altered bedding planes. The rock weathers rusty and even the freshly broken quartz surfaces appear somewhat weathered.

Sample five is an interesting example of tourmalinization. Highly weathered acidic or granitic wall rock is covered by a layer of milky quartz crystals. The quartz layer is covered by a layer of crystalline tourmaline. The basal sections of the tourmaline crystals are imbedded in the quartz and the long axes are perpendicular to the wall rock. This is obviously cavity filling by quartz and tourmaline. A few crystals of sulphide are disseminated through the tourmaline.

Preparation of Sections

Because of the wide variation in hardness of the different minerals in the samples, the poor consolidation, and the presence of vugs; the specimens were mounted in bakelite so that polishing could be done by the super-polisher. The tourmaline plucked readily, however, and it was found that less scratching of the surface resulted by hand polishing. Six polished sections were made; two each from samples one and two which carried the main sulphides, one from sample three, and one from the "gneissic" wall rock. A thin section of the "gneissic" rock was prepared by Mr. J.P. Donnan. In addition tourmaline crystals from samples three and five were mounted in Canada balsam for petrographic study.

The specimen prepared from the "gneissic" rock of sample four was impregnated with dental cement and the vugs filled with the same material before mounting. This treatment reduced plucking of the tourmaline crystals considerably.

Microscopic Examination

Eleven hypogene minerals were identified by microscopic examination of the six polished sections and the thin sections. These minerals in order of abundance, as judged from sections and hand specimens are:

1. Tourmaline
2. Quartz
3. Arsenopyrite
4. Chalcopyrite
5. Marcasite
6. Sphalerite
7. Pyrite
8. Pyrrhotite
9. Jamesonite
10. Tetrahedrite
11. Molybdenite

The mode of occurrence and the relationships of these minerals are described below.

Tourmaline

A black variety of tourmaline is the most important gangue mineral in all the sections examined. It was identified as the iron tourmaline, schorlite, from examination of thin sections. In thin section the colors were olive, brown, and dark green. Zonal structure, common to schorlite[1], was marked. In general, the central portion was of the olive-colored variety grading into darker green at the edges. Cress sections showed the usual spherical triangle as well as hexagons. The schorlite occurs in prismatic, euhedral crystals and in radiating aggregates. It is not commonly replaced by other minerals although it is the earliest mineral deposited. This is shown by fracture filling in tourmaline by later sulphides. See plates I to III. The main sulphide replacement seems to be by chalcopyrite as suggested by plate III.

[1] Rogers, A.F. and Kerr, P.F. Optical Mineralogy, p. 315

Plate I. Fracture filling in tourmaline (T) by arsenopyrite (As) and chalcopyrite (Cp). Note also the replacement of the arsenopyrite by the calcopyrite. sp Remnants of arsenopyrite are evident just below the main tourmaline crystal. (X 55)

Plate II. Fracture filling in tourmaline (T) by arsenopyrite (As) and lamellar marcasite (Mc) as well as chalcopyrite (Cp). (X 55)

The diameters of the tourmaline crystals range up to three mm. or larger. In places the long crystals are badly fractured.

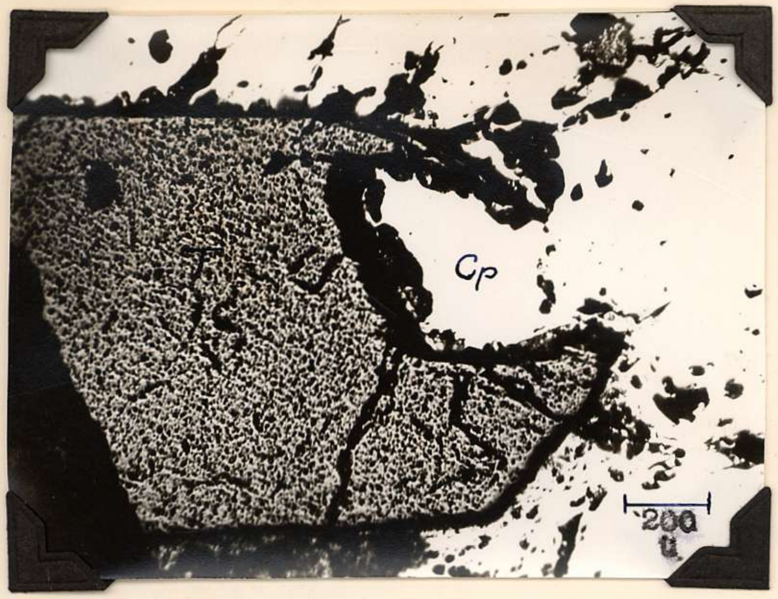

Plate III. Replacement of tourmaline(T) by chalcopyrite (Cp) (X55)

Quartz

A clear to milky variety of quartz is the second gangue mineral. It is later than tourmaline and arsenopyrite in the vein section, as shown by crystal outline of the tourmaline and arsenopyrite in contact with it. It seems to have formed as fracture filling, mainly in the arsenopyrite.

A milky variety of quartz may have been deposited earlier than the tourmaline in some of the wall rock as shown by the hand specimen labelled sample five and described on page five.

In the "gneissic" rock the quartz also seems to have preceded the tourmaline. In thin section two distinct sizes of quartz were recognized. The smaller, even-grained variety had an average diameter of approximately 100 microns. The larger variety consisted of irregular grains up to 400 and 500 microns. Apparently the coarse-grained variety is due to recrystallization of the finer grains, probably during a later period of increased temperatures. The fine-grained quartz crystals showed irregular or wavy extinction under crossed nicols which was attributed to strain[1].

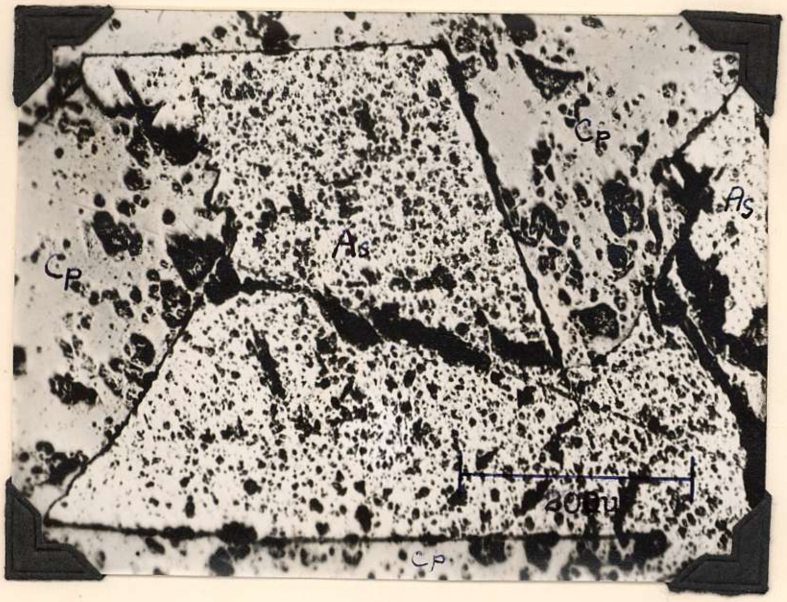

Plate IV. Fracture filling and replacment of arsenopyrite (As) crystal by Chalcopyrite (Cp). (X150)

Arsenopyrite

Arsenopyrite is the most common sulphide in the sections examined. It commonly occurs in euhedral crystals showing diamond-shaped cross sections.(See Plates IV and X.) It is one of the earliest sulphides; probably contemporaneous with pyrite. It seems readily replaced by later chalcopyrite but fairly resistant to replacement by other sulphides. Dis-

[1]Rogers, A.F. and Kerr, P.F.-Optical Mineralogy. Page 186.
White, W.H. - Economic Geology #6, 1943, Page 512.

semination of arsenopyrite throughout tourmalinized sections of wall rock was also noted.

The arsenopyrite does not seem to be a carrier of free gold in visible sizes. The association of the gold shown in assays with arsenopyrite is not indicated. Microchemical tests for cobalt proved negative.

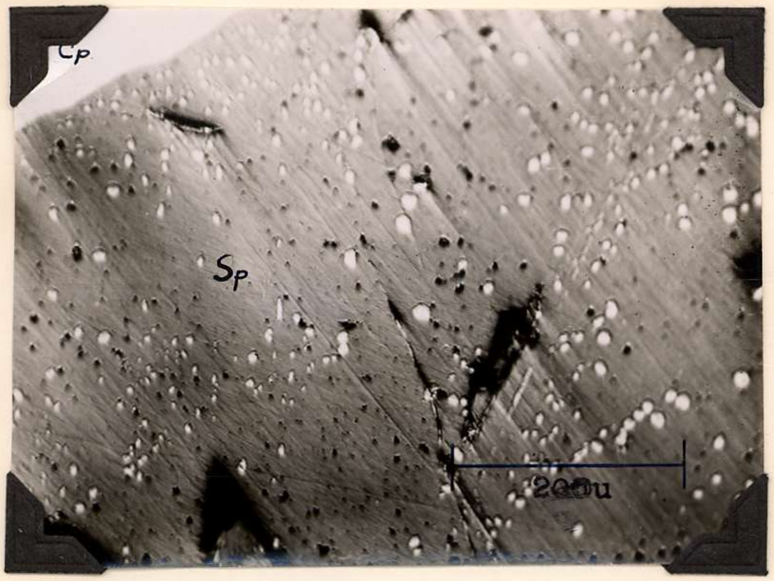

Plate V. "Mottled" texture of chalcopyrite(Cp) ex-solution bodies (white) in sphalerite (Sp) (grey). (X 150)

Chalcopyrite

Chalcopyrite occurs as the main mineral in sample two and is an important mineral in sample one. Plate IV is taken from a section of sample one and shows arsenopyrite replaced by chalcopyrite. Plates V and VI show sections of the main copper ore of sample two. Two modes of occurrence are evident. The first is by ex-solution of chalcopyrite from sphalerite as shown by plate V, giving the "mottled" texture described by Edwards[1] The second type of occurrence is later than sphalerite with replacement of sphalerite by the chalcopyrite. Plate VI shows a good example of age relationships of chalcopyrite and sphalerite. Fractures in sphalerite do not continue into the chalcopyrite and minor fissure filling of chalcopyrite in sphalerite is in evidence.

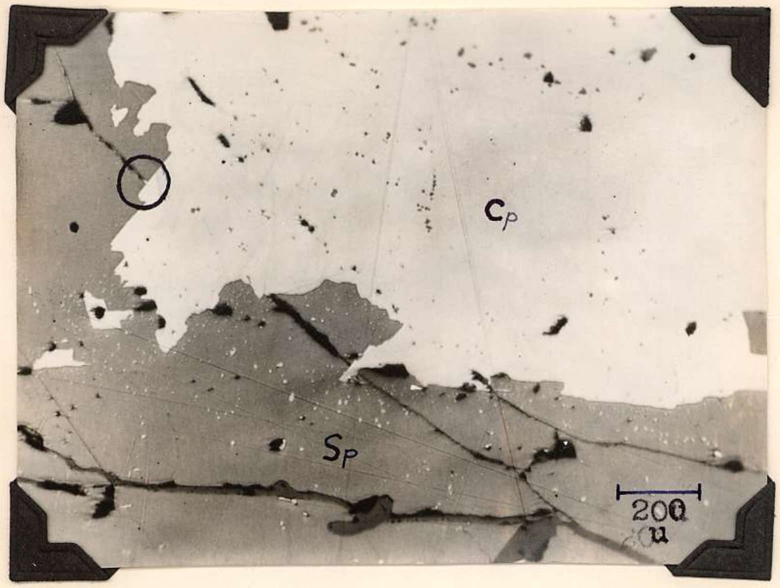

Plate VI. Chalcopyrite (Cp) replacing sphalerite (Sp). Note discontinuance of fractures through chalcopyrite and minor filling in circle. (X 55)

Under crossed nicols the massive chalcopyrite shows twinning and moderate to strong anisotropism. Sphalerite bodies may be due to ex-solution or they may be replacement remnants of earlier sphalerite deposition.

Marcasite

Most of the sulphide tentatively identified as pyrite in the hand specimen was found to be marcasite after

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[1]Edwards, A.B. Textures of the Ore Minerals, pp 79 - 82.

microscopic examination. Two modes of occurrence of marcasite were observed. One was a fine-grained variety with colloform texture. The other was a lamellar intergrowth of marcasite and probably a carbonate. See plates VII and VIII.

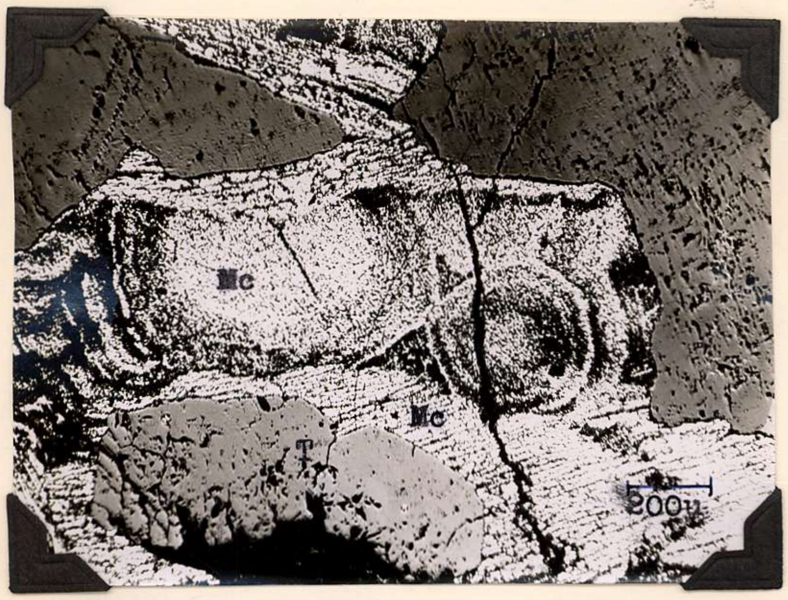


Plate VII. Colloform and banded or lamellar marcasite (Mc). (X 55)

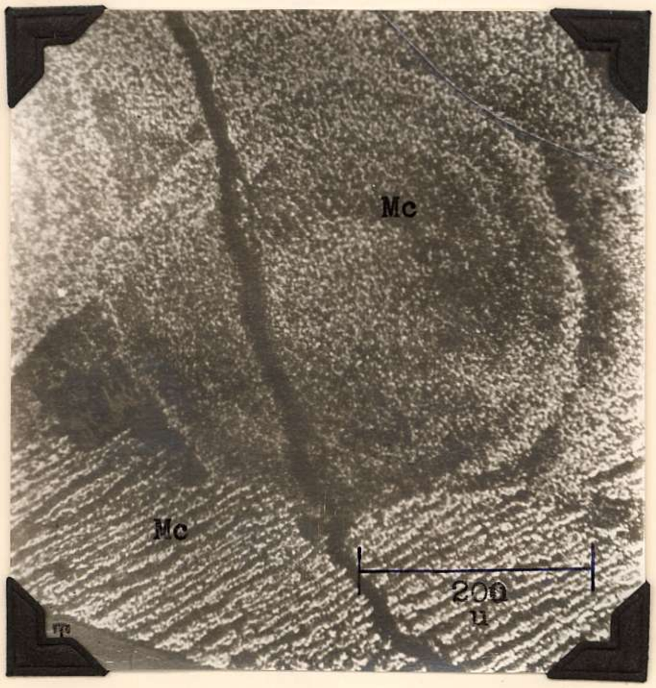


Plate VIII. The same. (X 150)

The fine-grained variety of marcasite seems to be a replacement of pyrrhotite. Plates IX and X show fine-grained marcasite replacing grains of pyrrhotite. Remnants of pyrrhotite, extinguishing at the same time, enclose areas of fine-grained marcasite. The lamellar marcasite may be due to recrystallization of the finer marcasite or may be a later stage of mineralization. Evidence for contemporaneous deposition is in the continuation of fractures through both types of marcasite.

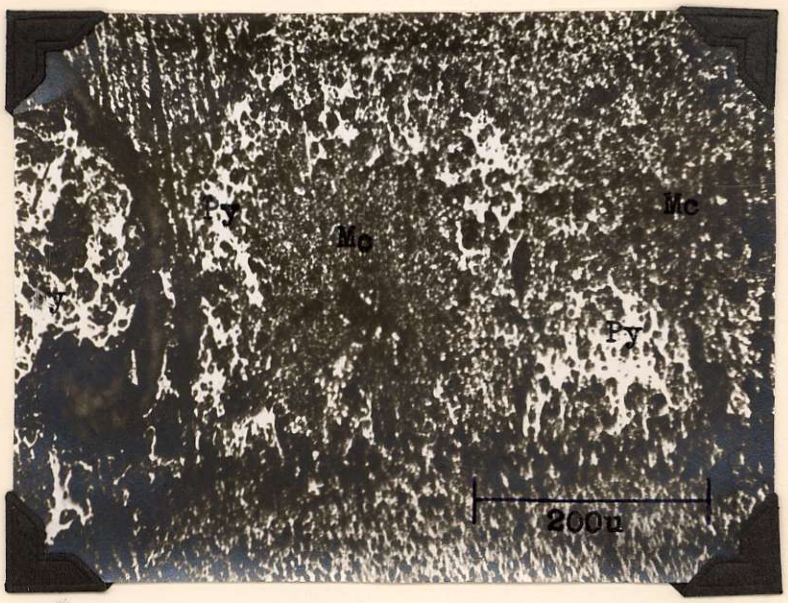


Plate IX. Fine grained marcasite replacing core of pyrrhotite(Py) grain. Crossed nicols. (X 150)

Sphalerite

Sphalerite is a common associate of chalcopyrite in all the sections examined. It is of the iron-rich metallic variety, has resin-colored internal reflection, and has triangular pits due to dodecahedral cleavage. Tetrahedrite also appears to be in rather close association with some areas of sphalerite. Chalcopyrite ex-solution blebs are common although the main sphalerite mineralization seems to have preceded the chalcopyrite. See plates V and VI.

Plate X. Fine grained marcasite (Mc) replacing pyrrhotite (Py). Lamellar marcasite on left of center and arsenopyrite (As) crystals on lower left. (X 150)

Pyrite

Pyrite was observed in most sections. It occurs as disseminated grains associated with the higher temperature minerals, tourmaline, arsenopyrite, and quartz. Cubic outline of crystals is frequently evident but crystals are generally highly corroded. The mineral association suggests an early stage of deposition. Highest concentration of pyrite is in tourmalinized wall rock.

Pyrrhotite

Pyrrhotite is a widely distributed vein mineral in the sections examined. Due to replacement by marcasite however, only remnants of pyrrhotite remain. As seen in plate

IX, groups of remnants belong to the same original crystal since they extinguish together under crossed nicols. Replacement of pyrrhotite by fine-grained marcasite by core replacement seems indicated.

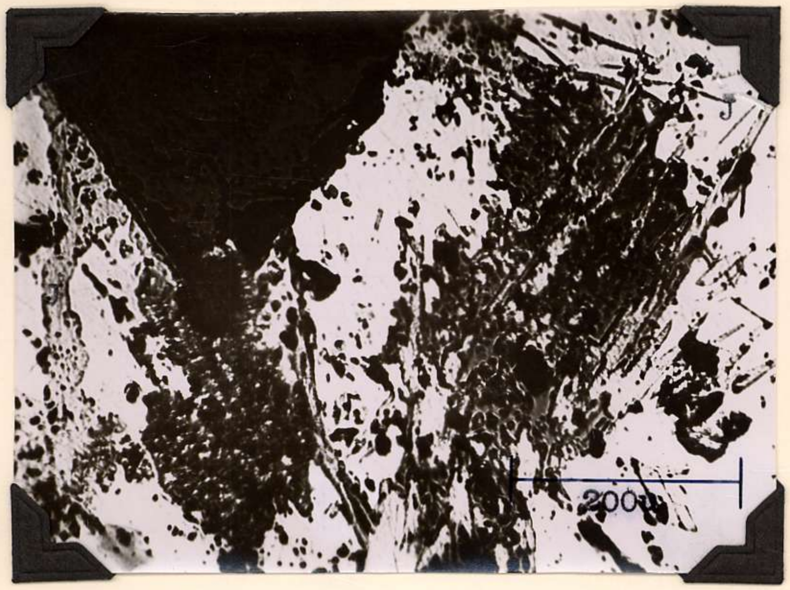


Plate XI. Jamesonite (J) crystals in chalcopyrite. (x 150)

Jamesonite

Jamesonite commonly occurs as needlelike crystals in chalcopyrite in the sections examined. It seems to be deposited around tourmaline crystals with a radiating pattern into the chalcopyrite. Identification was made by anisotropic colors and etch reactions. Confirmation by X-ray was made by Dr. R.M. Thompson. Plate XI shows the needlelike crystals as well as the massive variety. The jamesonite appears to have formed before the chalcopyrite since it occurs as euhedral crystals.

Tetrahedrite

Tetrahedrite was identified in one section from the ore consisting mainly of chalcopyrite described under sample two,page four. It occurred as irregular blebs in a tourmaline area. Closest sulphide associate seemed to be sphalerite. The tetrahedrite blebs were about 100 microns in diameter.

Identification was made on the basis of isotropism, microchemical tests for copper and antimony, and etch reactions. No microchemical reaction for silver was obtained. Confirmation of mineral was made by X-ray by Dr. R.M. Thompson. The X-ray result was suggestive of silver-bearing tetrahedrite.

Molybdenite

Molybdenite was observed in one section taken from the "gneissic" rock described under sample four on page four. It occurred as small euhedral crystals 10 to 20 microns in size. It was recognized by color, anisotropism, and four extinctions per revolution.

Shape?

Carbonate

Carbonate fractune filling appears to be the last stage in mineralization in the veins. Fractures filled with carbonates cut through all the earlier mineralization. The lamellar marcasite is believed to be intergrown with carbonates.

Assay Interpretations

Trail Smelter assay results of the Invermay Annex ore shipped were as follows:

In 1936:21.227 tons shipped

Gold	0.01 oz/T
Silver	175.3 oz/T
Lead	13.6 %
Zinc	19.8 %

In 1947: 4 tons shipped

Net Contents:	Silver	156 oz.	(39 oz/T)
	Lead	281 lb.	(3.5 %)
	Zinc	592 lb.	(7.4 %)

Assays of samples taken by Dr. H. Sargent in 1937 ranged as follows:

Gold- Trace to 0.14 oz/T
Silver- 1.2 oz/T to 92.4 oz/T(Silver in all samples)
Copper-Nil to 0.4 %
Lead- Two samples with lead
Highest assay 15.6 %.
Zinc- 0.5% to 24.0 % (Some zinc in all samples)

From the foregoing assay results it is evident that the samples examined for this report are of different characteristics than ore previously shipped and assayed.

Dr. H. Sargent states in his report that gold values appear to be associated with pyrite and arsenopyrite. If this is the case,values of gold might be expected from the ore examined. Since no free gold was seen, solid solution of gold in pyrite and arsenopyrite may be expected. Further assays of the ore examined will have to be made to verify this possibility.

The most probable silver bearing mineral in the sections examined is tetrahedrite. X-ray examination suggested the silver bearing variety. Jamesonite might be a less probable source of the silver values indicated by assays.

The relatively high assays of lead in the ores shipped to the Trail smelter cannot be accounted for in the specimens examined. Galena was not noticed in any of the sections, nor was it seen in hand specimens. Minor lead values might be due to jamesonite but would not constitute lead ore.

The vein ore examined might be expected to run high in zinc and conform to the higher assay values. The zinc mineral, of course, is sphalerite.

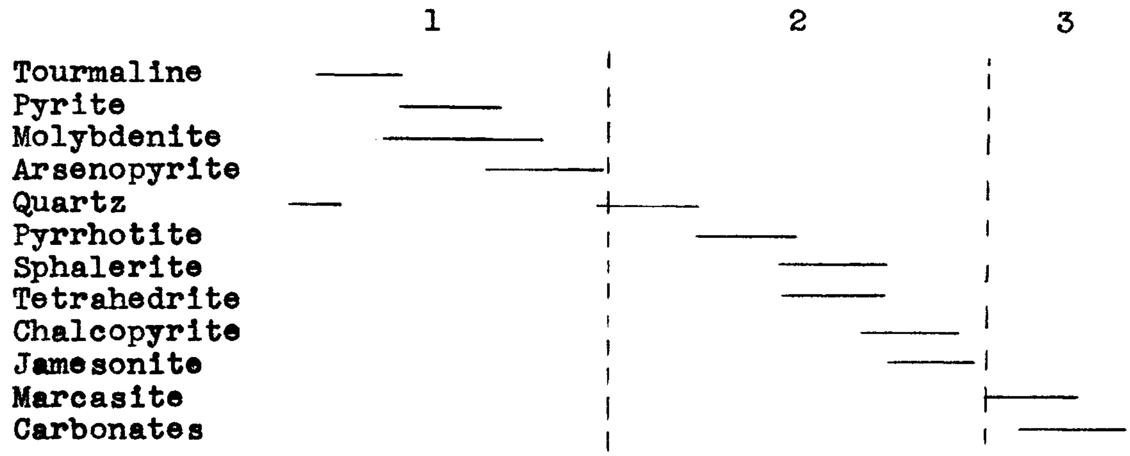
Assay results above are low or deficient in copper. Since one of the specimens is dominantly chalcopyrite high copper values are to be expected.

Paragenesis

Three groupings or stages of deposition are proposed as follows:

1. Tourmaline, pyrite,molybdenite, arsenopyrite, quartz.
2. Pyrrhotite, Sphalerite, tetrahedrite, chalcopyrite, jamesonite.
3. Marcasite and carbonates.

This interpretation probably oversimplifies the sequence of events but presents a general outline. A graphical illustration of events is as follows:



Conclusions

The two main minerals liable to carry silver are tetrahedrite and jamesonite with emphasis on the former. No silver minerals were noted.

Gold, if present, is either distributed in small amounts as free gold, or submicroscopically in either pyrite or arsenopyrite. No free gold was seen by microscopic examination.

Galena is absent in the specimens examined and only negligible lead values can be expected from the jamesonite.

The two sulphide samples examined are relatively high in sphalerite and should constitute zinc ore.

Chalcopyrite is the dominant mineral in one of the sulphide samples and relatively abundant in the other. Good values in copper may therefore be expected.

The high arsenopyrite, pyrrhotite, and marcasite content will probably prevent recovery of possible gold by cyanidation.

The higher temperature minerals are obviously due to contact metamorphism by the quartz diorite intrusion. Tourmaline and molybdenite are the main high temperature mineral indicators. The vuggy nature indicates relatively low pressure and therefore shallow overlying rock at time of deposition. The intermediate to low temperature minerals are mainly due to fracture filling and replacement. Control of mineralization is probably the main fracture system, rather than replacement of any particular horizon.

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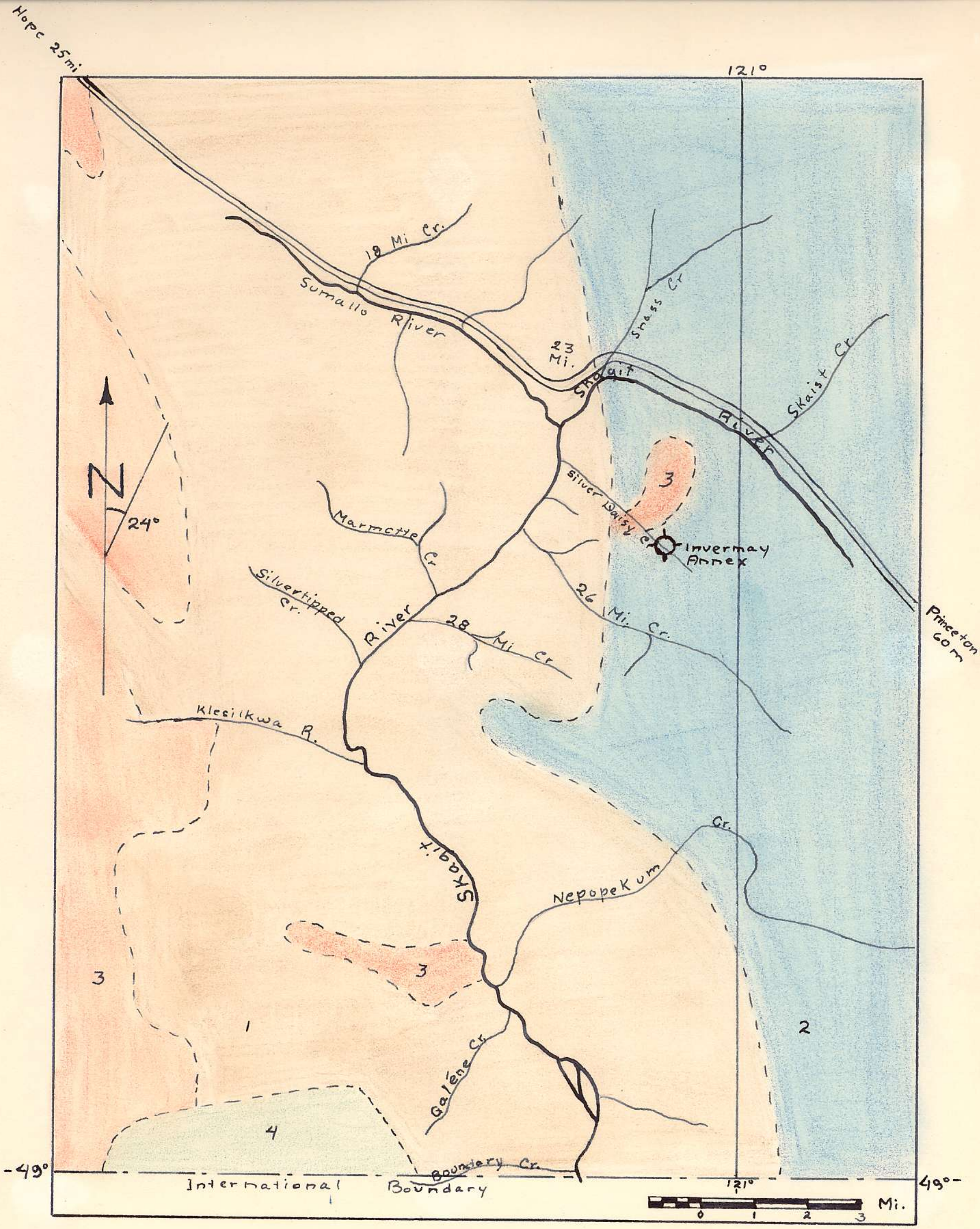

Skagit River Area

1 Hozameen Series (U. Paleozo) — 3 Acidic Intrusives (Mesozoic)

2 Dewdney Series (Jurassic) — 4 Skagit Volcanics (L.Cret.)

Appendix I