600228

Geology 409

Mineralographic Report of the Invermay Annex and Canam Suites.

Submitted by:

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Part A. Invermay Annex Suite

The suite examined consisted of 16 polished sections. Ten of the sections were of argillaceous and cherty breccia, with the ore minerals occuring in the spaces between the rock fragments. The remaining six sections were devoid of breccia and consisted of ore minerals plus included gangue of quartz, tourmaline, and carbonate.

Microscopic Description:

The ore minerals were identified by means of optical properties, microchemical analysis, etch tests, and X-ray analysis. They are listed below.

Mineral No. 1

-Good polish, yellow color, H:C, isotropic. Identified as Chalcopyrite.

-Occurs massively, showing occasional twinning under crossed nicols, and as rounded, unoriented exsolution blebs in sphalerite (Fig.3), and pyrrhotite (diameter 4μ). Contains exsolution stars and blebs of sphalerite and cubanite (Fig.4). The chalcopyrite had replacement textures with the following:-

a) replacing: i.) arsenopyrite and pyrite by corrosion of the grains and by extending tongues (Fig.1).

ii.) sphalerite and molybdenite by extending tongues.

b) replaced by: galena, tetrahedrite and jamesonite. The textures are described with the respective mineral.

Chalcopyrite had a mutual boundary relationship with gold.

Mineral No.2

-Good polish, brownish cream color, H:D, anisotropic in red-brown and blue-gray. Identified as Pyrrhotite.

-Occurs as irregular massive grains containing blebs of pentlandite and chalcopyrite. Replaces arsenopyrite (Fig.2) by corrosion of the latter's crystals. Replaced by chalcopyrite and sphalerite tongues; altering to marcasite and to pyrite displaying a bird's eye texture. Pyrrhotite had a mutual boundary texture with molybdenite.

Mineral No.3

-Poor polish, H>needle, brass yellow color, isotropic. Identified as Pyrite.

-Occurs as angular and rounded grains. Replaced by chalcopyrite and has replaced pyrrhotite with a bird's eye texture. Pyrite replaces arsenopyrite by corrosion of the latter's grains.

Mineral No.4

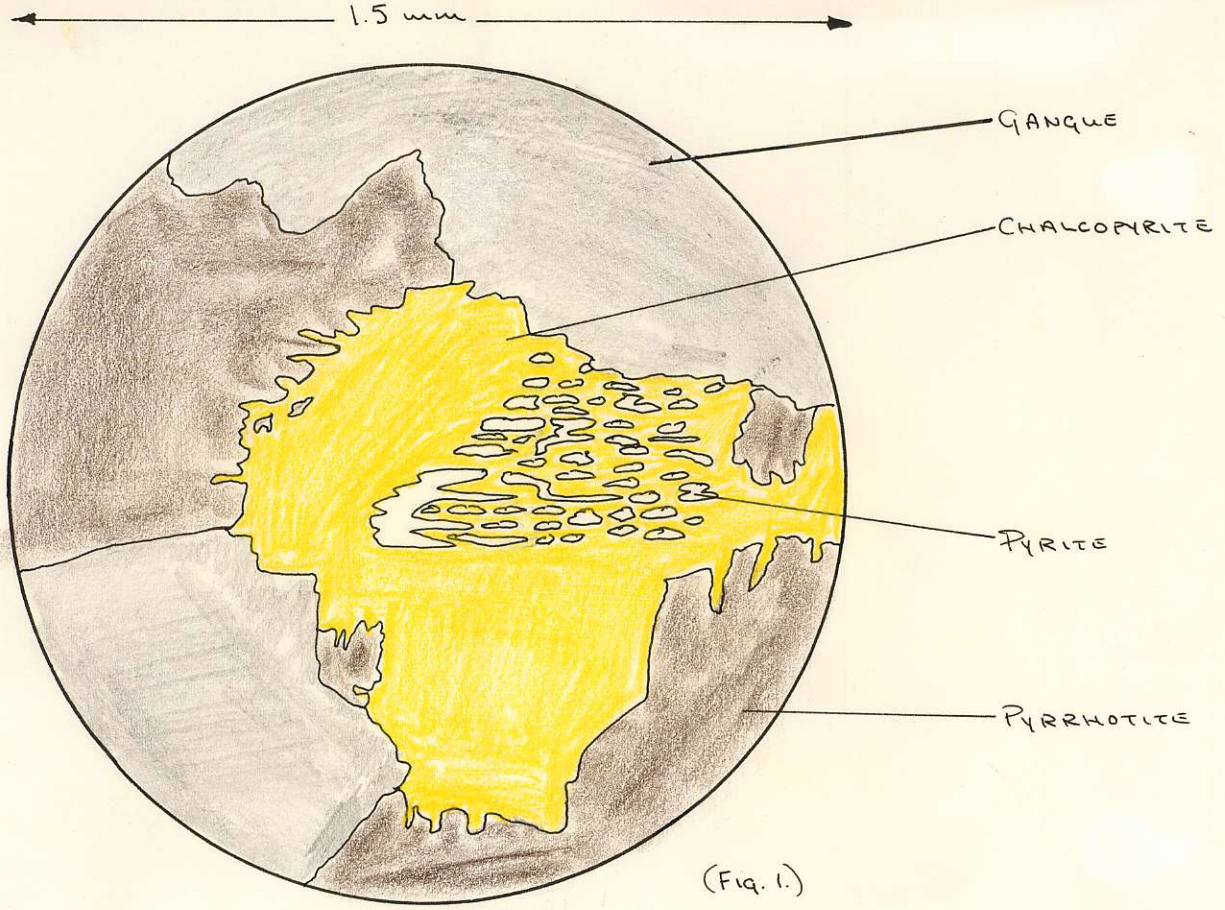
-Good polish, H>needle, pale brass color, strongly anisotropic in blue-green, blue, reddish brown. HNO_3 effervesces, tarnishes iridescent and develops zoning, fumes stain iridescent. Identified as Arsenopyrite.

-Occurs as well formed rhombs and highly fractured angular grains. Replaced by pyrrhotite (Fig.2), chalcopyrite, sphalerite, and pyrite by corrosion of grains and extending tongues (Fig.3).

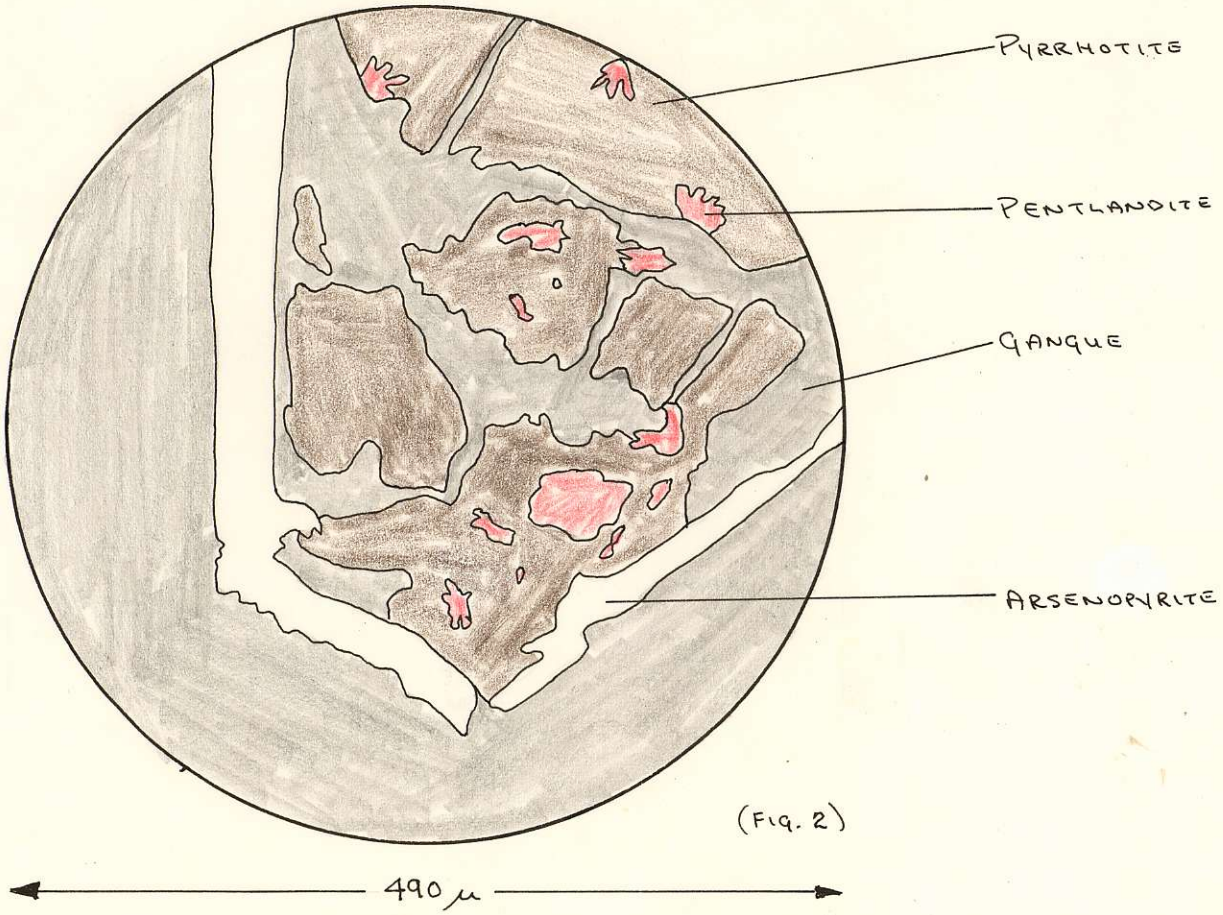
Mineral No.5

-Good polish, low reflectivity, dark gray color, H:D, slight internal reflection -red, isotropic. Identified as Sphalerite.

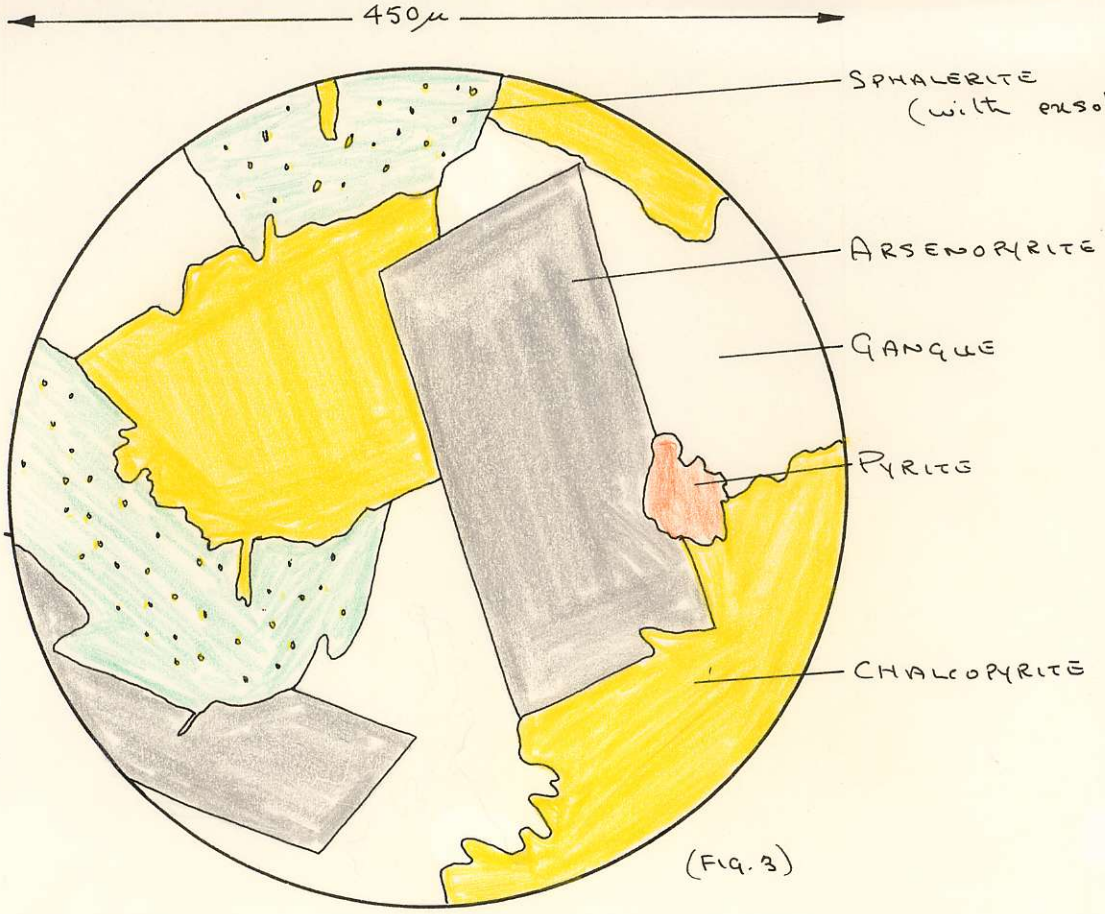
-Occurs as irregular grains and as exsolution bodies in


1.5 mm
GANGUE
CHALCOPYRITE
PYRITE
PYRRHOTITE

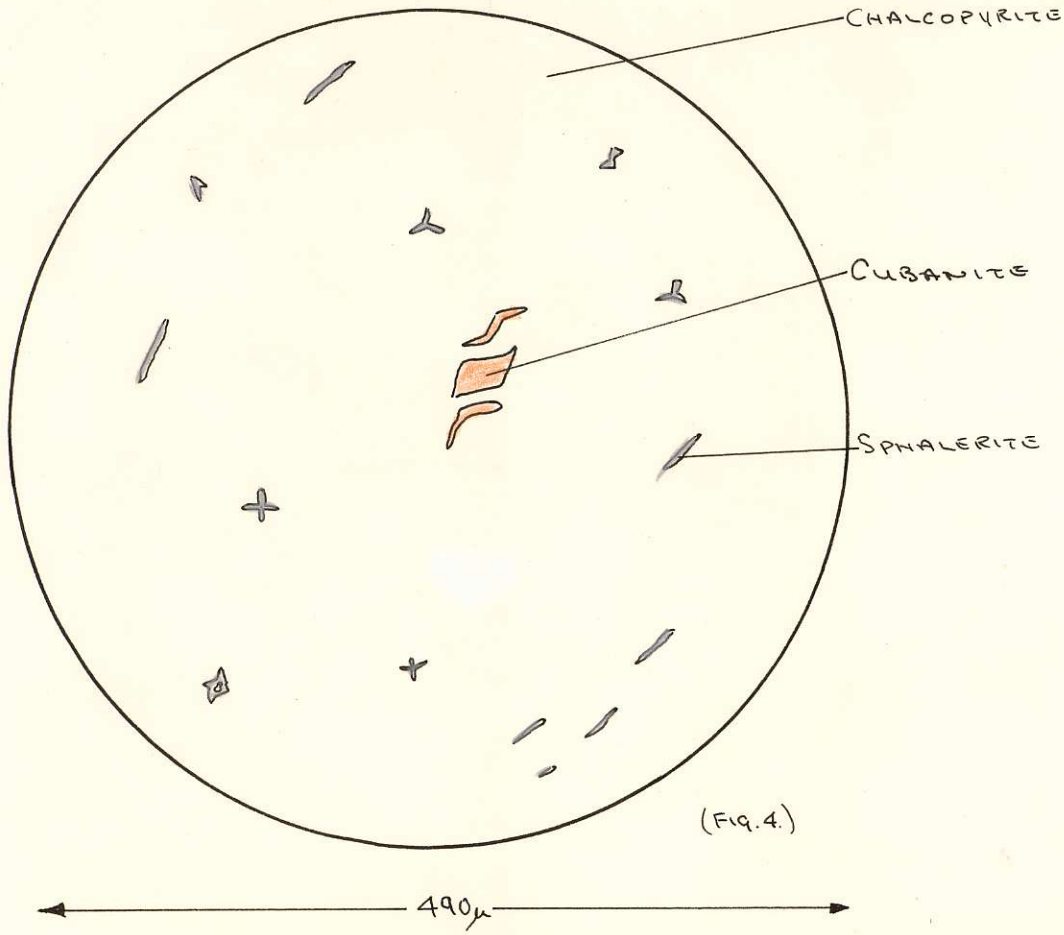
(Fig. 1.)


PYRRHOTITE
PENTLANDITE
GANGUE
ARSENOPYRITE
490 μ

(Fig. 2)


450μ
SPHALERITE
(with exsolv'n Chalcopy.)
ARSENOPYRITE
GANGUE
PYRITE
CHALCOPYRITE

(FIG. 3)


CHALCOPYRITE
CUBANITE
SPHALERITE
490μ

(FIG. 4.)

chalcopyrite. The bodies are elongated blebs (20-30μ in length) and three, four pointed stars (4μ diameter) (Fig.4). Replaces arsenopyrite and chalcopyrite by extending tongues. Replaced by tetrahedrite, galena, and jamesonite - all of which extend into the sphalerite (Fig.5).

Mineral No.6

-Good polish, H:B, purplish white color, strongly anisotropic in pink to black with four extinctions per revolution . Identified as Molybdenite.

-Occurs as angular, elongated grains .15mm in length; having a position on the outside edges of the mineralized spaces. In one instance the molybdenite was observed to have been replaced by a chalcopyrite tongue. It had a mutual boundary texture with pyrrhotite, being enclosed by the latter.

Mineral No.7

-Deep yellow color, H:B, isotropic. Identified as Gold.

-Occurs as roughly cubic grains (4μ in diameter) in chalcopyrite.

Mineral No.8

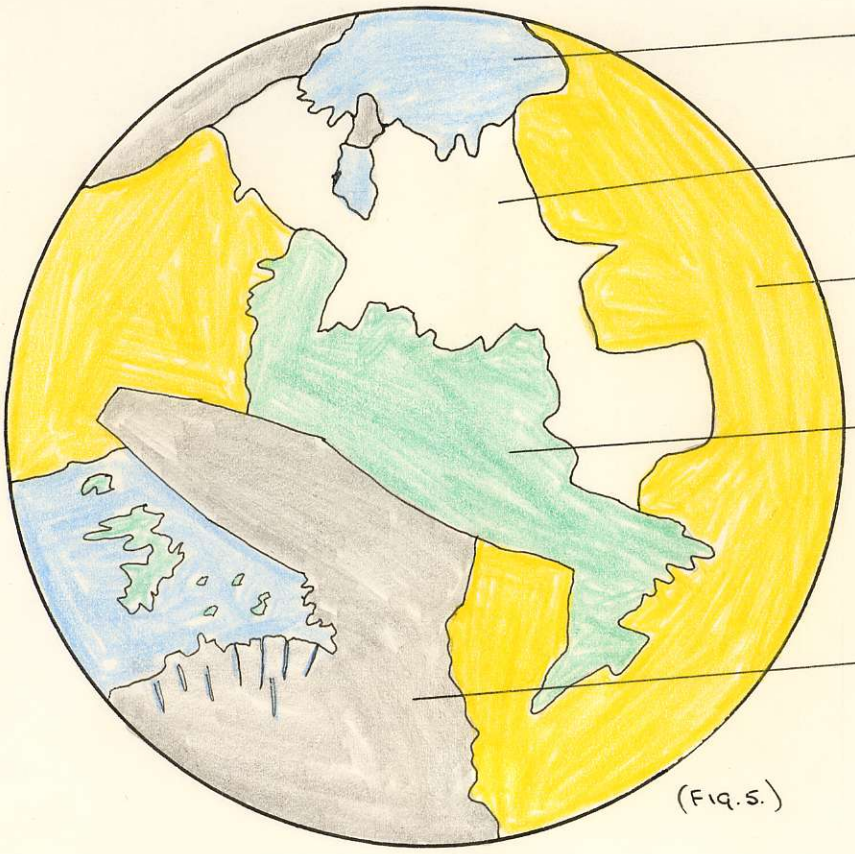
-Good polish, white, H:B, isotropic, triangular cleavage pits, two cleavages at right angles. Quickly stains dark brown with HCl. Identified as Galena.

-Occurs as roughly cubic grains averaging 0.15mm diameter and up to 1.05mm. Replaces chalcopyrite and sphalerite. Intergrown and replaced by jamesonite (Fig.6).

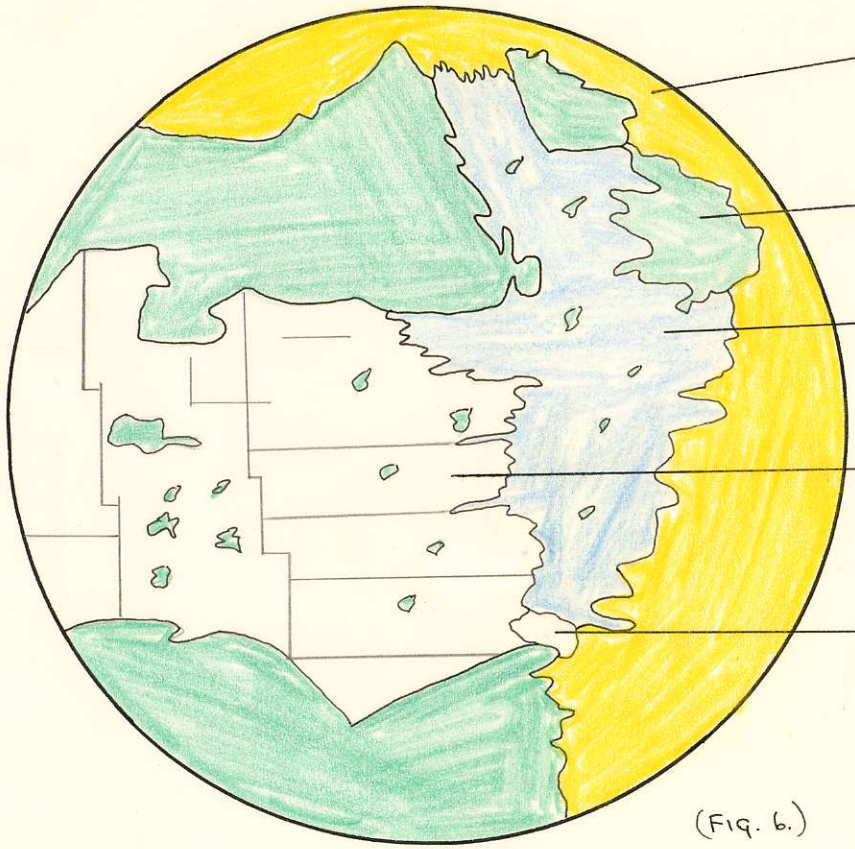
Mineral No.9

-Good polish, H:B, lighter brown than pyrrhotite, occuring as irregular flame-like bodies in pyrrhotite and having a size range 4-20μ. Believed to be Pentlandite exsolution bodies.

1.5 mm



(FIG. 5.)



(FIG. 6.)

1.5 mm

Mineral No.10

-Very pale yellow color, "isotropic", H- chalcopyrite. Occurs as blebs (45μ diameter) in chalcopyrite, showing no relief against the latter. Believed to be exsolution bodies of Cubanite.

Mineral No.11

Good polish, light gray color,,H:C. $HgCl_2$,KOH,$FeCl_3$,HCl negative. KCN stains iridescent and washes off, HNO_3 slowly tarnishes iridescent, fumes stain. Copper and Antimony tests were positive. Identified as Tetrahedrite. (X-rays indicate Argentiferous)

-Occurs as irregular grains replacing chalcopyrite and sphalerite by sharp tongues (Fig.5). Also occurs intergrown with jamesonite laths.

Mineral No.12

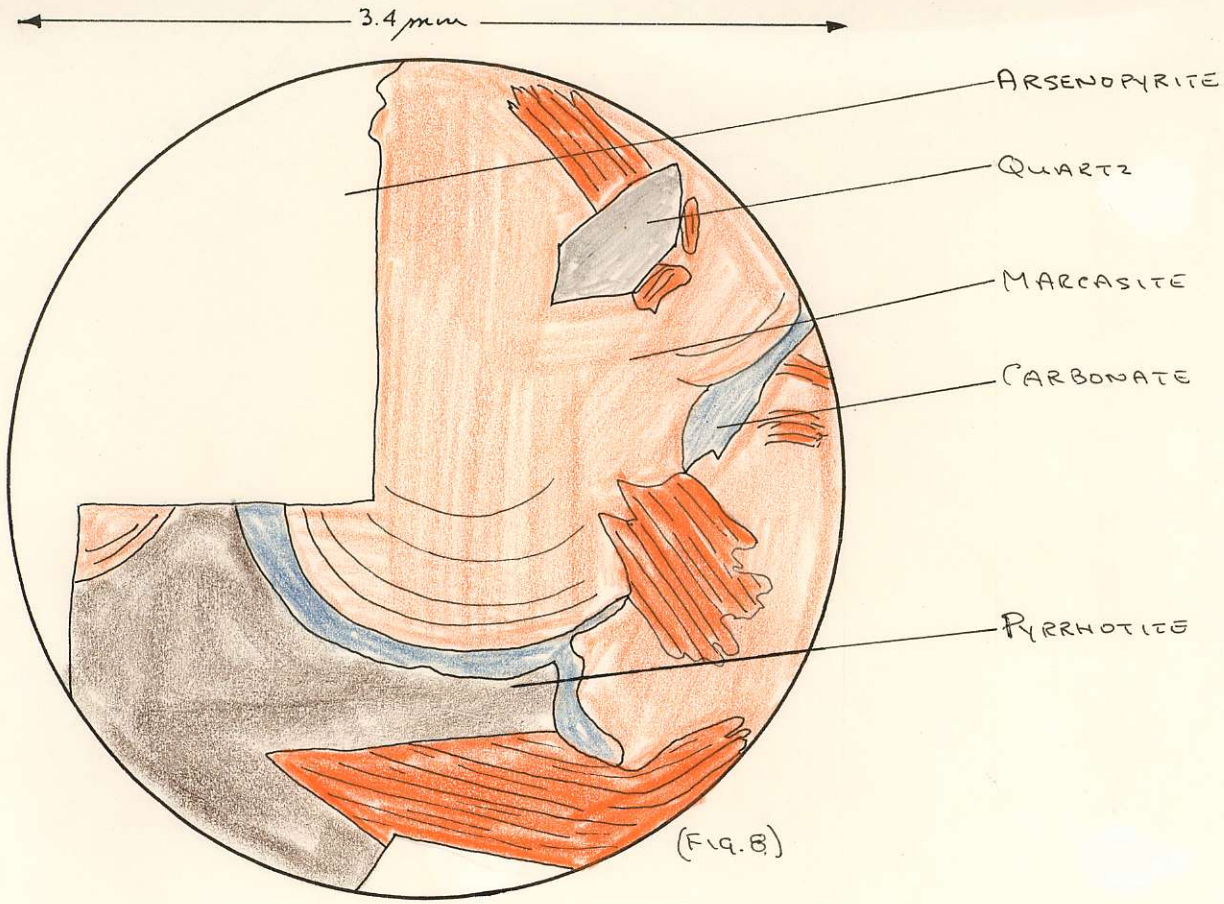
-Good polish, H:B, white color, strongly anisotropic in light blue, gray, dark gray. Acicular twinning under crossed nicols. $HgCl_2$, $FeCl_3$, KCN negative; KOH slowly stains, HCl stains light brown, HNO_3 effervesces, instantly stains black leaving a coating. Microchemical tests were not conclusive. Identified by X-ray analysis as Jamesonite.

-Occurs as massive grains and acicular crystals in chalcopyrite. Intergrown with galena and tetrahedrite. Replaces chalcopyrite, sphalerite, and tetrahedrite by intrusions. Also replaces galena, extending along cleavages (Fig.6).

Mineral No.13

-Poor polish, brass color, H?needle, strongly anisotropic in blue, green-yellow , and purplish. Identified as Marcasite.

- Occurs in two distinct forms. The first is with a well


3.4 mm
ARSENOPYRITE
QUARTZ
MARCASITE
CARBONATE
PYRRHOTITE

(Fig. 8)

developed colloform texture with inclusions of carbonate. The colloform masses abut against arsenopyrite grains. The second form is a coarse lamellar type with included angular pyrite grains. This form results from the alteration of pyrrhotite under conditions of slight stress. Complete transitions from pyrrhotite through the coarsly lamellar marcasite to the colloform marcasite were observed (Fig.8).

Abundance of the Ore Minerals

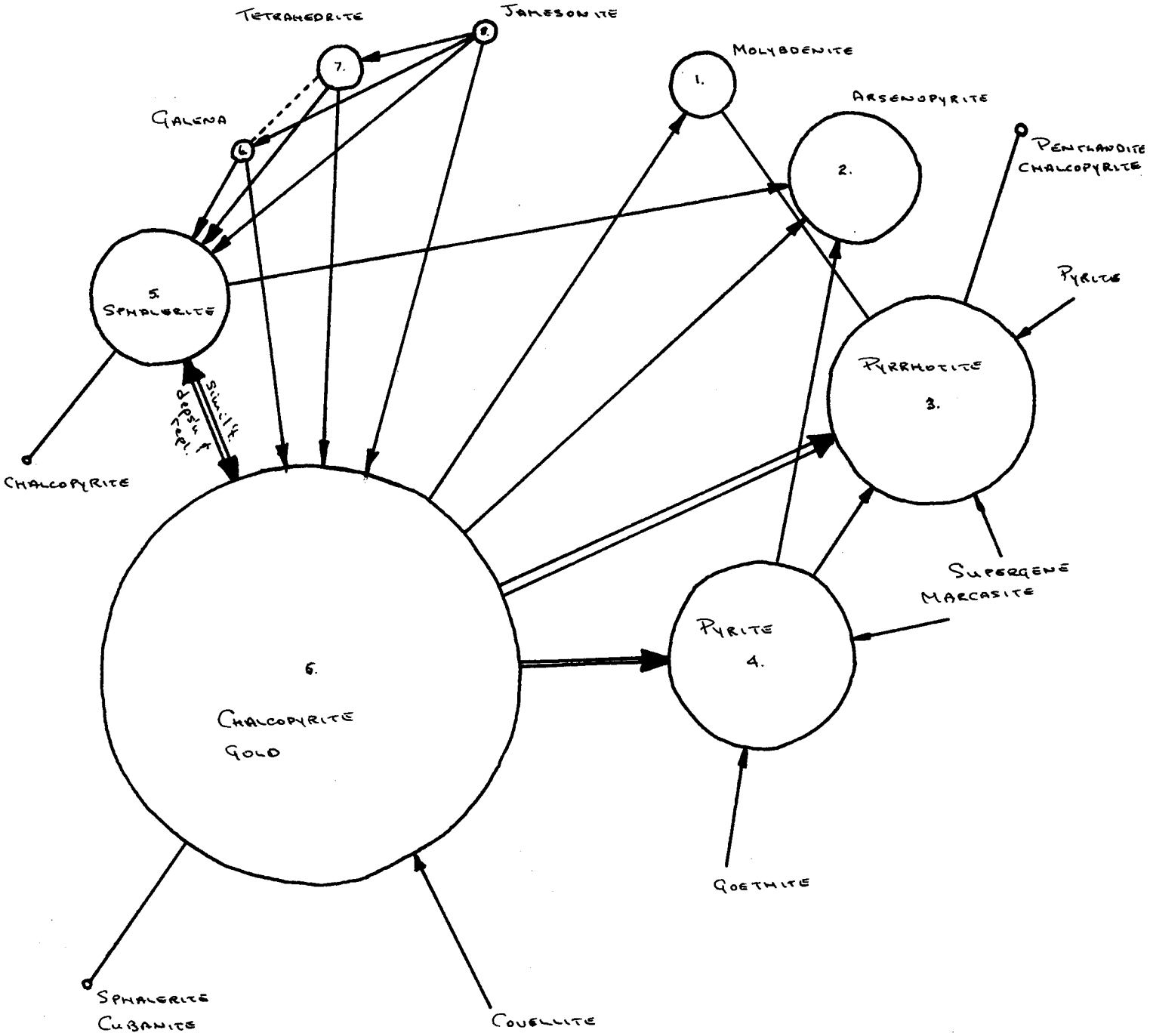
: as estimated from 16 polished sections.

Chalcopyrite	-55%
Pyrite	-15%
Pyrrhotite	-12%
Arsenopyrite	- 8%
Marcasite	- 5%
Sphalerite	-3%
Molybdenite	- 2%

plus minor amounts of :-

Tetrahedrite
Jamesonite
Pentlandite
Galena
Gold
Cubanite

decreasing %



PARAGENETIC SEQUENCE DIAGRAM.

Part B. Canam Suite

Megascopic Description

The samples examined consist of numerous split drill cores and several hand specimens, the average size of which is 4" x 3" x 2". The specimens are comprised of laminated, limey argillite and cherty breccia. The angular to slightly rounded fragments range in size up to 1½" in length. All rock fragments are highly chloritized.

Ore mineralization occurs in the spaces between the rock fragments. The mineralized spaces are irregular and unequal in width, being up to 1" wide. The mineralization has cemented the breccia fragments making the ore very compact with no vugs or open spaces. Recognizable ore minerals are massive chalcopyrite (altering to covellite), coarsly crystalline arsenopyrite, pyrrhotite, pyrite (altering to Limonite), massive sphalerite, and fine grained molybdenite. Visible gangue minerals are crystalline quartz, tourmaline, calcite and chlorite.

The specimens are greenish-gray to black on a fresh surface. They have a sharp, uneven fracture. They are deeply weathered to a soft crumbly material. Their color on weathering is rusty, yellowish gray, or light gray.

Microscopic Description

Seven thin sections and four polished sections were made from the drill cores. Examination of the polished sections showed the same primary ore mineral assemblage and genetic relationship existed as was found in the Invermay Annex suite:- Chalcopyrite, sphalerite, molybdenite, pyrrhotite, pyrite, arsenopyrite and marcasite. The absence of tetrahedrite, galena, and

jamesonite was noted.

Study of the thin sections revealed that the mineralizing fluid caused recrystallization of chlorite and quartz along the edges of, and also between, the rock fragments. Other gangue minerals identified in the breccia spaces were :-

i) Tourmaline - Schorl type. Well developed prismatic and fibrous crystals. Occurs in the ore mineralization and in the recrystallized areas of breccia.

ii) Grossularite - Colorless, euhedral crystals, occuring in the recrystallized quartz.

iii) Calcite - Occurs as coarsly crystalline and as irregular microcrystalline masses in the mineralized areas.

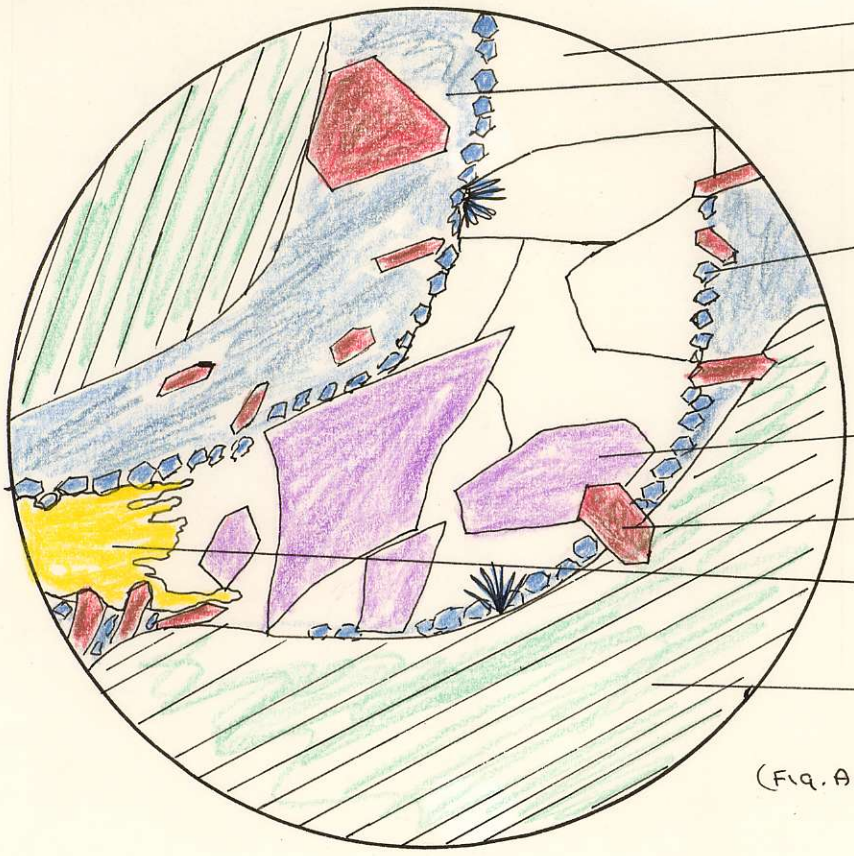
iv) Axinite - Angular crystals occuring in the ore mineralization.

v) Lamprobolite - Red-brown euhedral prismatic crystals, occuring with tourmaline and ore mineralization.

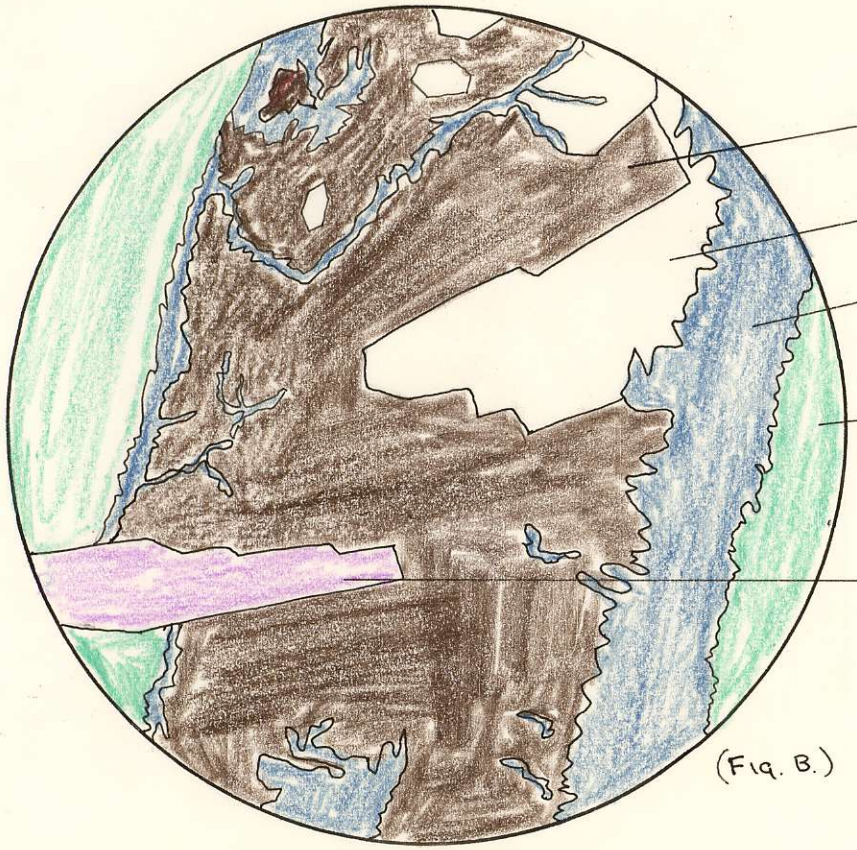
Two diagrams of the thin sections are presented to illustrate the occurence of the gangue silicates (Fig.A), and their association with the ore mineralization (Fig.B).

A thin section of the colloform marcasite showed it's occurence in a cavity lined by carbonate coated, euhedral quartz crystals. Carbonate also occured between the marcasite layers. The absence of included silicates in the marcasite and it's association with the carbonate, indicates that the marcasite formed later than the main period of ore deposition by supergene replacement of pyrrhotite and pyrite.

5.4 mm



(Fig. A.)



(Fig. B.)

5.4 mm

Abundance of the Ore Minerals

: as estimated from hand specimens and drill cores.

Chalcopyrite	-75%
Pyrite	-10%
Pyrrhotite	- 6%
Arsenopyrite	- 3%
Sphalerite	- 3%
Molybdenite	- 2%

plus minor amounts of Marcasite
Covellite

Classification as to Temperature Type

Part A. Invermay Annex

Several geological thermometers are present among the ore minerals. They are listed below with their temperature of formation.

Mineral Relationship	Temperature
Chalcopyrite & exsolution Pyrrhotite	-600 C°.
Sphalerite & exsolution Chalcopyrite	-550 C°.
Chalcopyrite & exsolution Sphalerite	-500 C°.
Pyrrhotite & exsolution Pentlandite	-450-425° C.
Chalcopyrite & exsolution Cubanite	-450 C°.

(Reference- Bateman)

The relationship of sphalerite exsolution bodies in chalcopyrite and vice-versa represent all stages in the arrested diffusion of the exsolution bodies to the grain boundaries of the

host. This textural relationship is indicative of high temperature deposits that have cooled quickly. (Reference-Edwards) On the basis of this relationship, the temperature of formation 400° to 600° C., and the mineral assemblage, the deposit is classified as a pyrometasomatic type.

Part B. Canam

The silicates found in examination of the thin sections of this suite were formed before and during the period of ore deposition. They resulted from chemical reactions between the ore-forming fluid and the breccia. Their assemblage -grossularite, tourmaline, axinite, and basaltic hornblende ; is characteristic of pyrometasomatic deposits.

Milling Considerations

Grinding of the ore to particles 0.15mm diameter is necessary if the galena is to be freed from the copper concentrate. Grinding to this size would also release the molybdenite grains. Finer grinding is required if the gold grains (40-45μ diameter) are to be separated.