Careful & conscientious job
75-80%

Geology 409 Report on

THE MINERALOGY OF THE A.M. PROPERTY

A Report Submitted in Partial Fulfilment of the Requirements for the Degree of Bachelor of Applied Science in Geological Engineering.

Jack Bysterbosch
Department of Geology
The University of British Columbia

April 15, 1951.

TABLE OF CONTENTS

ILLUSTRATIONS

THE MINERALOGY OF THE A.M. PROPERTY

1 INTRODUCTION

The A.M. property is a gold and copper prospect presently under development by the Canam Mining Coproation Ltd. of Vancouver, B.C. This property, consisting of eight Crown-granted claims, is located near the source of a northerly-flowing tributary of the Skagit River about thirty miles south-east of Hope, B.C. Access to the property is by a wagon road for a distance of seven miles in from Mile 30 on the Hope-Princeton Highway. The average elevation of the property is about 5600 feet.

Mineralization was discovered on the A.M. claims in 1930 and from then until 1938 the property was held by The Consolidated Mining and Smelting Company of Canada Ltd. During this time, development work included several open-cuts and six adits totalling 2700 feet in length. In 1947 two surface dia-mond-drill holes totalling 970 feet were completed by the present owners who have, since then, continued development with underground diamond drilling.

11 GENERAL GEOLOGY

The Skagit River basin lies within the Cascade Mountains of British Columbia. The area consists principally of two series of rocks and some later granitic intrusives. These series are the Hozameen Group of Upper Paleozoic age and the Dewdney Creek group of Jurassic or lower Cretaceous age.[1]

Figure 1 is a map of part of the west side of the basin covered by claims of the A.M. group. The principal rocks are the thin-bedded, somewhat tuffaceous sediments of the Dewdney series, and tabular sill-like bodies of metamorphosed ultra-basic rock. The structure in the area shown in Figure 1 is complicated by close folding and faulting.[11]

The ore deposits of the A.M. property are found in two large masses of mineralized breccia, consisting of angular fragments of Dewdney series rocks which are apparently cemented by later intruded minerals.

1 Summary Report of the Geological Survey of Canada (1911), (1923).

11 B.C. Minister of Mines Annual Report (1949) Dr. W.H. White.

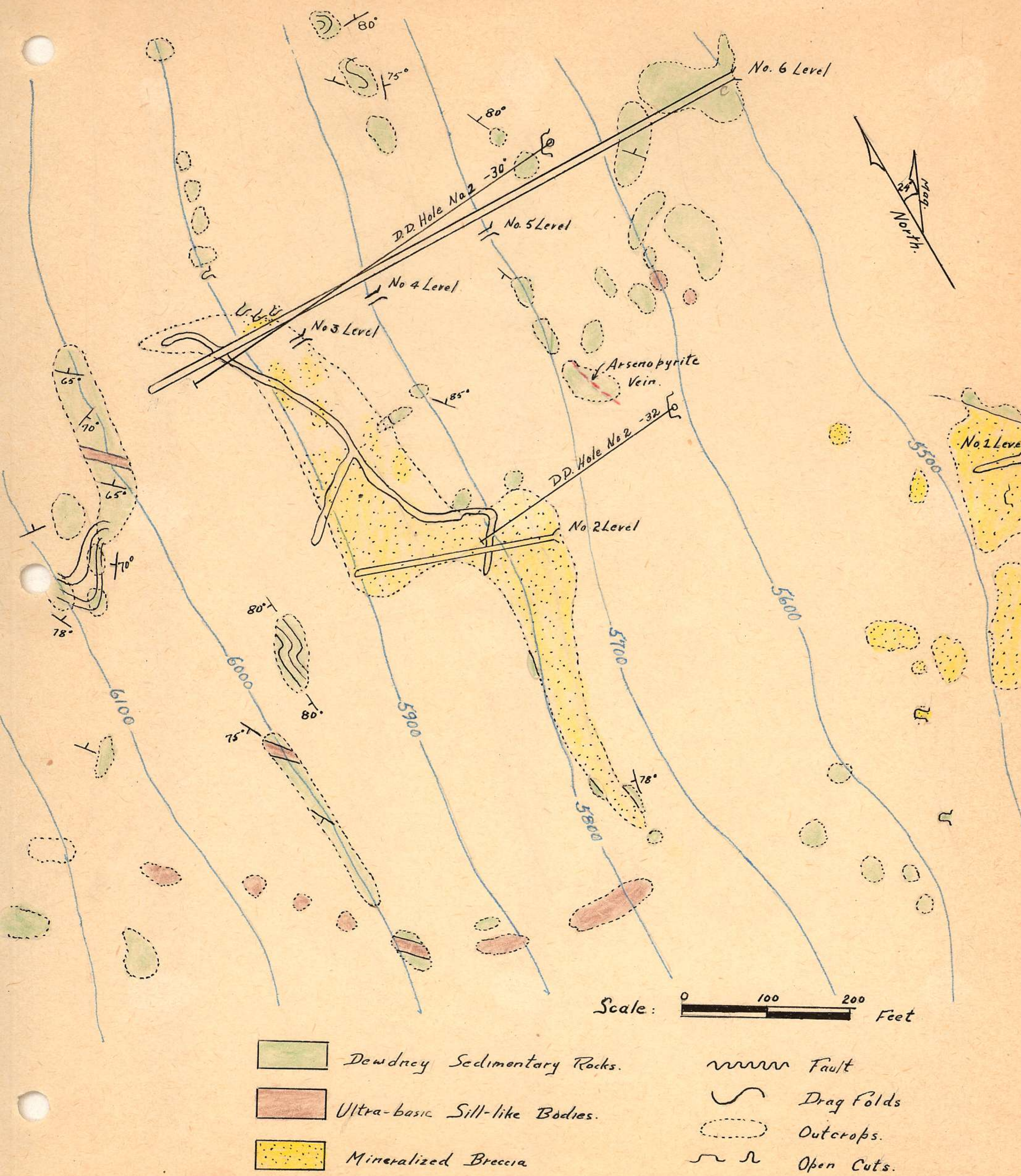

Fig. 1. PART OF A.M. GROUP, SKAGIT RIVER

after White, W. H.

111 MINERALOGY

A General

The ore specimens examined in this report were all taken from No. 6 adit (Fig.1). Three grab samples were provided: Sample A was taken from near the face; sample B was taken 35 feet back from the face; sample C was taken from near the portal. However, the bulk of the specimens examined were all taken from a single diamond-drill hole placed about 35 feet back from the face of the adit. This hole, striking S 65° W and dipping -6°, was drilled to a depth of 50 feet. Samples were selected at intervals of five feet along the length of the hole, thus totalling ten samples in all. From these core samples, ten polished sections were made. These sections are numbered from one to ten, from collar to end of hole.

B Macroscopic Examination

The three grab samples (6 to 8 cubic inches) were examined macroscopically only. Except for lesser mineralization in sample C, these grab samples were very similar in appearence.

The rock appears to be somewhat oxidized with limonitic stains running through it. The rock is a typical breccia with angular fragments ranging up to two or three inches in length. The original bedding planes are still evident in some of the specimens. The breccia fragments may be either lighter or darker than the usually green colour of the rocks.

Mineralization generally occurs in fissures around the breccia fragments and along the bedding planes. The chief minerals present are chalcopyrite, pyrite and pyrrhotite. The chief gangue minerals seen in the fissures are calcite and tourmaline.

The drill core specimens are, macroscopically, of similar appearance to the grab samples described above. They have, in general, a fresher appearance than the face samples, except for those from the last ten feet of the hole which are more oxidized, suggesting the presence of a fault zone.

The mineralization is more or less consistent all the way down the diamond drill hole. Chalcopyrite, pyrite, and pyrrhotite are abundant in nearly all the core specimens. One large crystal of sphalerite was noted in one of the specimens. Chalcopyrite is the most abundant mineral, followed by pyrite and pyrrhotite. The chalcopyrite is fairly consistent throughout this 50 foot zone. The pyrite and pyrrhotite occurrences are more irregular, the pyrite being more abundant in the first part of the hole and the pyrrhotite more common in the last half of the hole.

C Microscopic Examination

(1) Non-metallics.

A thin section was made of sample No.2, which is from ten feet down the hole. The principal gangue minerals determined were: Tourmaline, Quartz, Apatite, Calcite, and Chlorite.

The thin section examined consists chiefly of an altered ground mass of very fine grained quartz and feldspathic materials with a wide fracture of euhedral grained quartz, tourmaline, sulphides, apatite and calcite running through it. (Fig.2)

Tourmaline was identified to be of the schorlite variety which in hand specimens is black but in thin sections is olive to brown. It occurs as short and long prismatic crystals as well as columnar to fibrous radiating aggregates. The widths of the larger tourmaline crystals range up to 2 m.m. The finer fibres of tourmaline appear to be closly associated with the quartz, both in the ground mass and the coarser grained materials. Although it is one of the earliest minerals deposited, it has been subjected to little replacement by later forming sulphides.

Quartz occurs in two distinct varieties; fine even-grained crystals, and large euhedral crystals. The larger quartz grains appear to be a recrystallization product of the finer grains, probably due to the introduction of later high temperature minerals. The original quartz was probably deposited earlier than, or contemporaneously with the tourmaline. Recrystallization of the quartz undoubtedly took place during the chalcopyrite-pyrrhotite mineralization since there is evidence of these minerals being trapped within euhedral crystals of quartz (Fig.6).

Apatite was determined, along with the quartz, to be one of the earliest minerals deposited. It occurs as large,

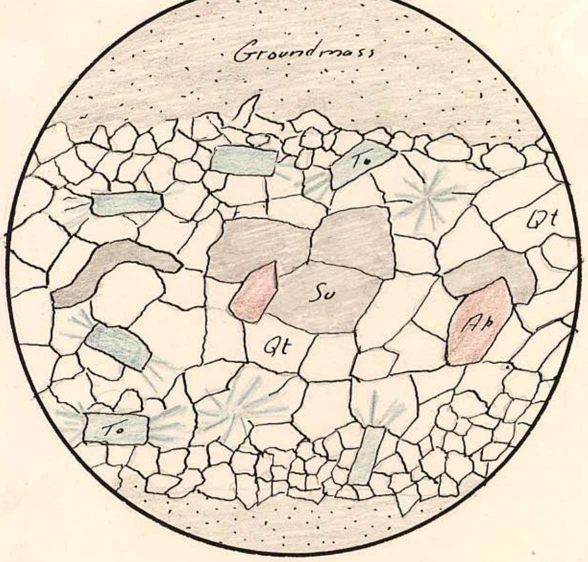

Fig. 2
Thin section showing fissure filling of recrystallized quartz (Qt) sulfides (Su), Apatite (Ap) and Tourmaline (To).

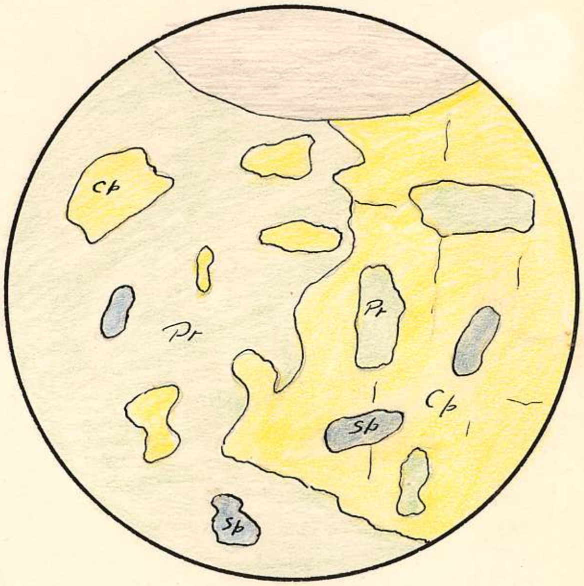

Fig. 3
Ex-Solution of Chalcopyrite (Cp) Pyrrhotite (Pr) and Sphalerite (Sp).

Magnification ?

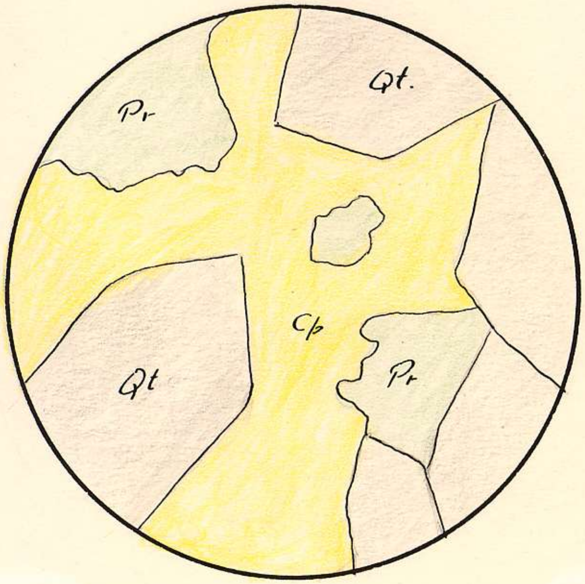

Fig. 4
Euhedral quartz (Qt) crystals surrounded by chalcopyrite (Cp) and pyrrhotite (Pr).

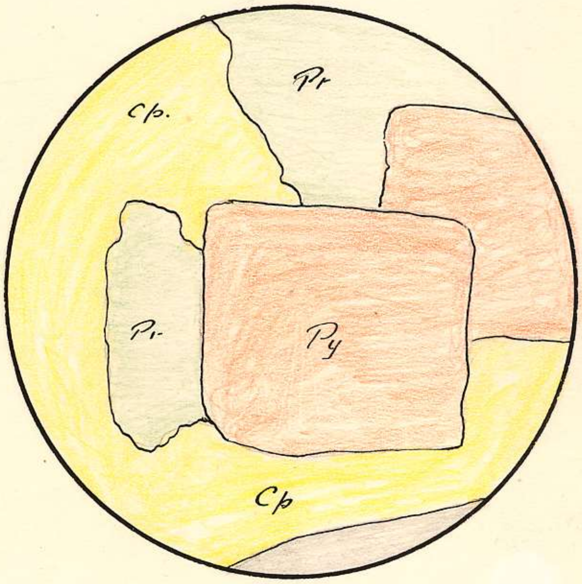

Fig. 5
Euhedral crystals of pyrite (Py) surrounded by chalcopyrite (Cp) and pyrrhotite. (Pr).

euhedral crystals replaced to some extent by calcite and sulphides.

Feldspar, apparently orthoclase, occurs in large anhedral crystals but it is generally badly altered and replaced by calcite and chlorite.

Calcite and chlorite are the most common alteration products and are among the last gangue minerals to be deposited.

From a study of the thin section, it is apparent that the fine-grained material makes up the breccia fragments of the Dewdney type rock, while the coarser-grained materials of quartz, tourmaline, apatite and sulphides, is the actual matrix or cementing material of the breccia.

(2) Metallics.

The eleven metallic minerals determined and the sections in which they were found are listed below in their approximate order of abundance:

Mineral	Sections									
	1	2	3	4	5	6	7	8	9	10
1 Chalcopyrite	x	x	x	x	x	x	x	x	x	x
2 Pyrrhotite	x	x	x	x	x	x	x	x	x	x
3 Pyrite	x	x	x	x	x	x		x	x	x
4 Arsenopyrite			x		x	x		x	x	
5 Marcasite				x		x		x		
6 Molybdenite	x	x	x	x	x	x	x	x	x	x
7 Sphalerite		x	x	x	x	x	x	x	x	x
8 Hematite	x					x	x	x	x	
9 Galena								x		x
10 Bornite			x					x		
11 Gold (Silver)		x	x	x				x	x	

The minerals and the means by which they were determined are listed as follows:

Minerals		Determinations
1. Chalcopyrite	-	brass yellow colour; weakly anistropic; negative to most reagents; gives powder when scratched; copper microchemical test.
2. Pyrrhotite	-	pinkish cream colour; hardness D; strongly anisotropic; light and blue-grey polarization colours; HNO_3, HCl and KOH give positive reactions; magnetic.
3. Pyrite	-	pale brass yellow colour; hardness F; most reagents are negative although HNO_3 and aqua regia fumes tarnish.
4. Arsenopyrite	-	galena white colour; hardness F; polarization colours greenish yellow, brown; HNO_3 positive diamond-shaped cross sections.
5. Marcasite	-	pale brass yellow colour; hardness E; anisotropic; HNO_3 stains brown; very poor polish.
6. Molybdenite	-	colour galena white; soft; strongly anisotropic, four extinctions per revolution; curved lathes,
7. Sphalerite	-	gray colour; HNO_3 and HCl tarnishes; resin-coloured internal reflection.
8. Hematite	-	gray colour; hardness G; somewhat anisotropic; powders when scratched with needle.
9. Galena	-	white colour; soft; HCl and $FeCl_3$ stains iridescent.

10. Bornite - pinkish-brown colour; soft; HNO_3 effervesces; KCN stains brown; $FeCl_3$ stains orange.

11. Gold - yellow colour; soft and sectile; KCN stains black.

Modes of occurrence and mutual relations of these minerals are described as follows:

1 Chalcopyrite

Chalcopyrite is the most abundant of the metallic minerals and was found in all the specimens examined. It is closely associated with pyrrhotite, being deposited contemporaneously with it, probably as a result of a solid solution relationship (Fig.3). The chalcopyrite occurs as large, massive blebs which, along with pyrrhotite, comprises a principal part of the cementing material between the breccia fragments. Euhedral crystals of pyrite and quartz surrounded by massive chalcopyrite and pyrrhotite indicates a later stage of deposition by the latter minerals (Fig.4 & Fig.5). Replacement of arsenopyrite by chalcopyrite is very evident in section 10 (Fig.11). Chalcopyrite was observed as filling fissures in apatite crystals. (Fig.7) Grain size?

2 Pyrrhotite

Pyrrhotite occurs in all the sections in fair abundance. As described above, it is closely associated with the chalcopyrite as a fissure filling material. A large amount of pyrrhotite occurring in section 8 has very fine stringers of marcasite running through it. This suggests that there is some replacement of pyrrhotite by later marcasite which does not seem to occur in the chalcopyrite (Fig.8).

3 Pyrite

Pyrite is also fairly well distributed throughout the specimens. It occurs in large euhedral grains up to 5 mm

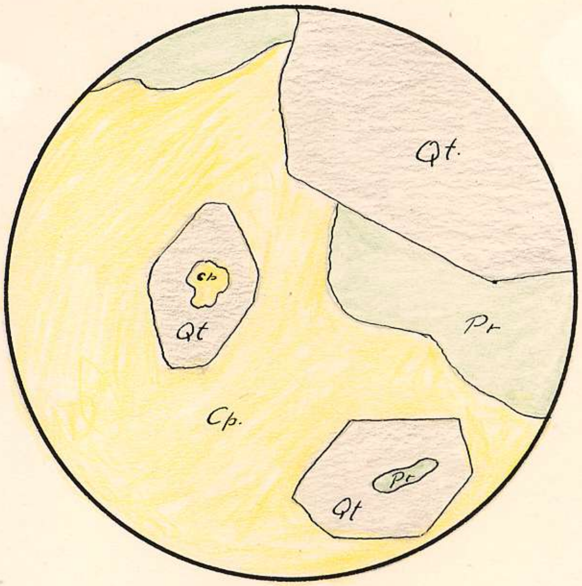

Fig. 6
Sulfide minerals trapped within recrystallized quartz (Qt)

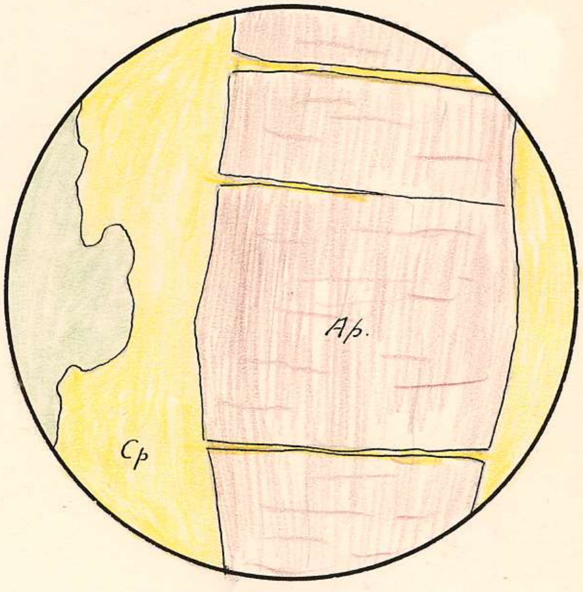

Fig. 7.
Large apatite crystal with fissures of chalcopyrite (Cp)

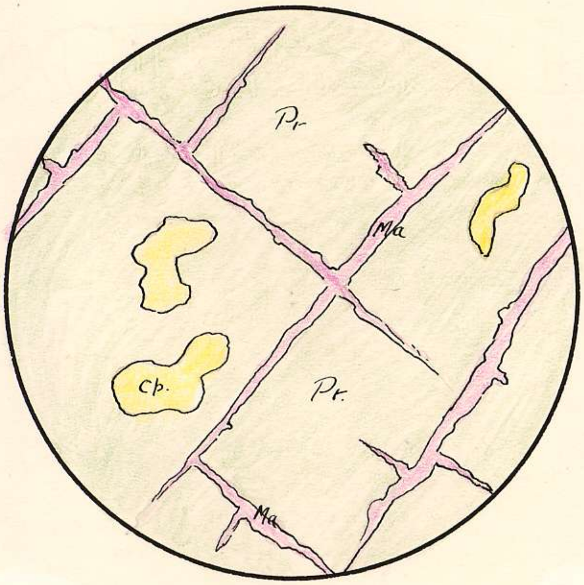

Fig. 8
Massive pyrrhotite (pr.) cut by stringers of Marcasite (Ma)

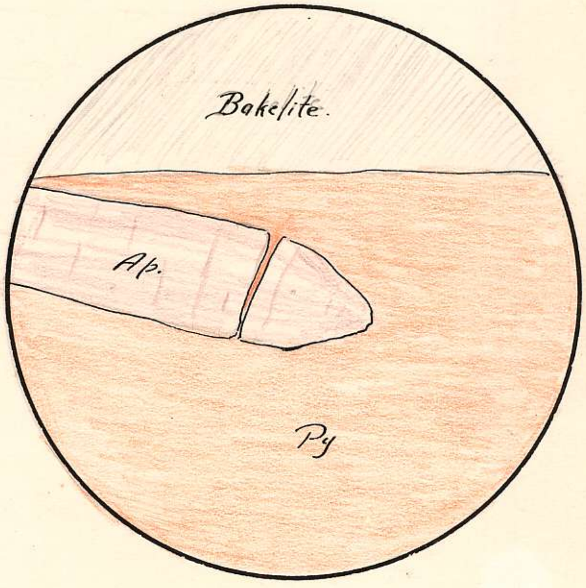

Fig. 9.
Apatite (Ap) crystal surrounded and fissure-filled by pyrite (Py).

in diameter. In most cases, it appears to replace the gangue. However, some evidence for its being of later deposition than apatite is seen in Section 2 (Fig.9). Pyrite was probably one of the earliest metallics to crystallize since all other minerals seem to fill in around the pyrite grains (Fig.5). In places, the pyrite is weekly anisotropic, which may indicate some replacement by marcasite. ?

4 Arsenopyrite

Arsenopyrite was found to occur in lesser amounts than pyrite. It occurs in euhedral, diamond-shaped crystals ranging from 400 to 1000 microns in size, and appears to have been deposited contemporaneously with the pyrite. (Fig.10) Although the pyrite has been altered very little, the arsenopyrite has been replaced, to a large extent, by chalcopyrite (Fig.11) and also in some places by gangue.

There was no indication of gold occurring in visible sizes in either pyrite or arsenopyrite.

5 Marcasite

Marcasite occurs both as fairly large blebs associated with chalcopyrite (Fig.12) and as late fissure filling in pyrrhotite. The latter occurrence is particularly evident in section 8 which shows massive pyrrhotite with marcasite fissures running through it (Fig.8). Replacement of pyrrhotite is seen where the marcasite has extended laterally from the fissures.

6 Molybdenite

Molybdenite is very widespread although it occurs

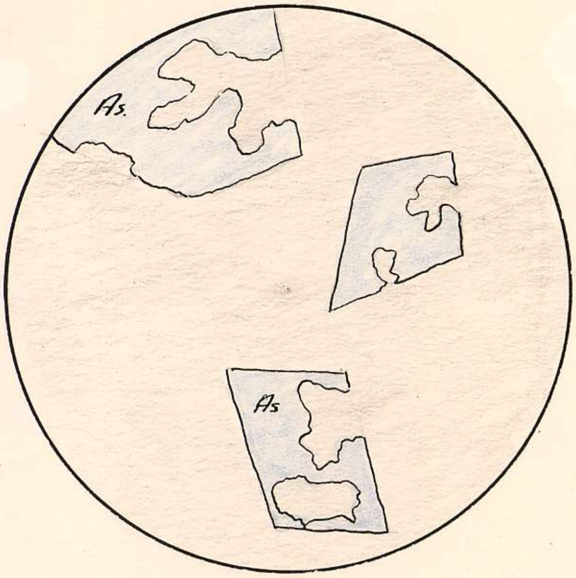

Fig 10
Diamond-shaped arsenopyrite (As) Crystals, replaced in part.

Fig. 11
Arsenopyrite (As) crystal replaced by chalcopyrite (Cp).

Fig. 12
Massive Marcasite (Ma) in chalcopyrite

only in minor amounts in most of the sections. It occurs as small euhedral lathes ranging up to 50 microns in width. These molybdenite lathes are usually disseminated with the gangue minerals and never in close association with the main sulphide mineralization.

7 Sphalerite

Sphalerite is widely spread throughout all the sections and it occurs most commonly as ex-solution blebs in the chalcopyrite and also in the pyrrhotite (Fig.3). The average size of these blebs in the chalcopyrite-pyrrhotite mixture rarely exceeds 100 microns. Minor sphalerite also occurs freely within the gangue, although in one hand specimen a fairly large crystal of sphalerite was seen with the unaided eye. It seems apparent that there are two stages of sphalerite, the free state preceding the chalcopyrite-pyrrhotite mineralization.

8 Hematite

Hematite was observed in small amounts but is widely distributed throughout the sections. Like the molybdenite it also occurs in small belbe, up to 100 microns in diameter, disseminated throughout the gangue and not closely associated with the sulphide mineralization. Both hematite and molybdenite, along with the tourmaline, are amongst the first minerals to appear in the sequence of deposition.

9 Galena

Galena occurs in small amounts and was observed in only sections 8 and 10. It is closely associated with the pyrrhotite and chalcopyrite but is probably somewhat later in deposition. The largest particle of galena did not exceed 100 microns in size. In one section the galena appeared to be replaced by a carbonate.

10 Bornite

Bornite occurs in extremely small blebs as ex-solution products in the chalcopyrite, and apparently belonging to the same stage of mineralization. It was noticed in only two sections as very small particles not over 10 microns in size.

11 Gold

Gold was observed in very minor amounts in five of the ten sections examined. In all cases, it occurs as ex-solution blebs in the chalcopyrite. One particle which appeared to be gold was noticed to occur within the pyrrhotite but this particle was too small for its identity to be ascertained. The gold particles vary in size from 10 to 40 microns. In one section the gold occurred in the shape of a lath, 45x10 microns in size. The colour of this lath is slightly paler than that of pure gold. The unusual shape and colour indicates that, what is considered as gold in this ore is probably electrum, an alloy of gold and silver. This is supported by the fact that the assay values include silver even though there is no evidence of any silver minerals in the ore. Since the gold, or electrum occurs only with the chalcopyrite, it is evident that it is associated with the chalcopyrite-pyrrhotite stage of mineralization and not with the pyrite or arsenopyrite.

D Paragenesis

The occurrences and age relations of the various minerals as described above reveal several features which may be used as criteria in determining the paragenesis of this ore.

Some of these features are:

(a) The molybdenite, tourmaline, and hematite are early and generally confined to the fissure boundaries.

(b) The pyrite and arsenopyrite are also early but differ from the above stage in being confined more to the middle zone of the fissures.

(c) The chalcopyrite-pyrrhotite mineralization is later than the above minerals and, along with recrystallization of the quartz, this stage completes the fissure-filling. Minor amountsof gold, bornite, galena, and sphalerite are associated with this stage.

(d) Replacement by marcasite and calcite is the latest occurrence of mineralization.

The above observations suggest mineralization in four stages and a sequence of deposition as follows:

Stage 1.	Tourmaline
	Molybdenite
	Apatite
	Hematite
	Quartz
Stage 2.	Pyrite
	Arsenopyrite
Stage 3.	Quartz (recrystallized)

Pyrrhotite

Chalcopyrite

Sphalerite

Bornite

Gold

Galena

Stage 4. Marcasite

Calcite

The order, in which the minerals are placed in any one of the above stages, is not to be depended on as a rigid time sequence of deposition for it is quite probable that many of these minerals were formed contemporaneously.

lV CONCLUSIONS

It seems apparent that the ore deposit is of the hypothermal type, the breccia zone providing ideal channel-ways for the introduction of hydrothermal solutions. The sequence of mineral deposition indicates fissure-filling followed by a certain amount of replacement. The chief high-temperature indicators are tourmaline and molybdenite, suggesting that stage 1 mineralization occurred at a temperature of over 500° C. The later sulphides of stages 2 and 3 were probably deposited at lower temperatures.

Mineralization in this area is definitely confined to the breccia zone. However, the breccia body seems to be conformable with the bedding of the enclosing strata[1]. Consequently

1. B.C. Minister of Mines Annual Report (1949) Dr. W.H. White.

it may be said that the deposit is structurally controlled by the bedding.

As determined from assay values, the minerals of chief economic importance in this ore are copper, gold and silver.

Chalcopyrite is the principal copper-bearing sulphide. Since it occurs in massive quantities, fine grinding would not be necessary for a mill recovery of the copper.

Since the gold occurs as extremely small particles in the chalcopyrite it may be necessary for much finer grinding to ensure a good gold recovery. Although there were no visible traces of gold in the pyrite or arsenopyrite it may be present in submicroscopic sizes.

Galena and sphalerite occur in only minor quantities so that lead and zinc values are not to be expected.

ACKNOWLEDGEMENTS

The writer wishes to express his appreciation for the assistance and advice given by Dr. R.M. Thompson, Dr. H.V. Warren, Mr. J. Gower, and Mr. J.P. Donnan in the preparation and examination of polished and thin sections for this report.

BIBLIOGRAPHY

1. Camsell, Summary Report of the Geological Survey of Canada, 1911.
2. Cairnes, Summary Report of the Geological Survey of Canada, 1923.
3. White, W.H., B.C. Minister of Mines Annual Report (1949).
4. Edwards, A.B., Textures of Ore Minerals Australasian Institute of Mining and Metallurgy.
5. Rogers, A.F. and Kerr, P.F., Optical Mineralogy McGraw-Hill Book Company Inc.
6. Short, M.N., Microscopic Determination of the Ore Minerals G.S.A. Bulletin 914.