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A MINERALOGICAL REPORT ON OCCURANCES OF  
HEAZLEWOODITE AND MILLERITE IN THE NAHLIN  
RIVER AREA OF BRITISH COLUMBIA

by

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April 15, 1957

Could be polished up to a  
1st class report.  
English & spelling!!

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April 15, 1957

Dr. R.M. Thompson  
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Dear Sir:

I herewith submit a report, entitled "A Mineralogical Report on Occurances of Heazlewoodite and Millerite in the Nahlin River Area of British Columbia", in partial fulfilment of the requirements of Geology 409.

Yours truly,

*Alan R. Archer.*

Alan R. Archer.

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## INTRODUCTION

### Location

The Nahlin River lies about 80 miles <sup>north-west G.E.L.</sup> ~~south-east~~ of Telegraph Creek, British Columbia. Staking of nickel mineralization has been active between Nahlin River and Tedideech Lake to the east (see map in pocket). This area is within the Atlin Mining District.

### Geology

The geology of the area has not, as yet, been studied in detail.

In general the claim staking has followed the contact of a limestone body with the Atlin peridotite belt. This contact is thought to mark a zone of extensive movement and resultant shearing and brecciation.

The limestone which lies to the north-east forms a high ridge paralleling the contact. The peridotite which lies to the south-west has been highly serpentized and in places intruded by diorite dykes and plugs.

The most extensive body of millerite mineralization is

found along this sheared zone in the vicinity of Opal Lake. The occurrence of heazlewoodite according to Mr. S. Muldal, is located in the peridotite body south of the intersection of the sheared zone and the Nahlin River.

General Statement

This report describes a mineralogical study of specimens from the heazlewoodite and millerite occurrence.

As these occurrences are thought to be distinctly separate and bearing no relation to one another, the report is divided into two parts.

Part A refers to the mineralogical report on the heazlewoodite specimens and Part B refers to the millerite specimens.

*How were specimens obtained?*

*Acknowledgements?*



PART A

HEAZLEWOODITE BEARING SPECIMENS

Megasopic

A large specimen weighing about three pounds and several smaller specimens are in this collection. The rock is a green to black serpentine which has been highly silicified. The serpentine has been sheared and shows rock flowage. When broken, the rocks shatter into thin, extremely sharp fragments.

*just like that*

Native copper and yellow grains of heazlewoodite can be seen in finely disseminated blebs and in grains up to several millimeters. These metallic minerals comprise about 2% of the specimens.

On a weathered surface cuprite due to oxidation of the native copper and an emerald green alteration product, presumably due to oxidation of heazlewoodite can be noted.

?

Microscopic

Ten polished sections of the rock were studied. In all, six minerals (magnetite, heazlewoodite, pentlandite, chalcocite, unknown white mineral and native copper) were seen. These minerals and their descriptions are listed as follows in order of their paragenetic sequence.

Magnetite ( $Fe_3O_4$ ).....The magnetite is usually seen scattered throughout the specimens in random distribu-

tion. It occurs as large grains (about 500 $\mu$ ) that are usually rounded but are, occasionally, well crystalized. The magnetite takes a poor polish, is grey in colour and yields a magnetic powder when scratched.

Magnetite was also seen in blebs and worm-like intergrowths (Fig.10) in the heazlewoodite. This texture was only seen in one polished section and is similar to magnetite as described by M.A. Peacock (1947).

Heazlewoodite ( $Ni_3S_2$ ).....This mineral took an excellent polish, was pale yellow, had a hardness of D and showed lilac pink to green polarization colours.

The heazlewoodite gave the following etch reactions:  $HgCl_2$  tarnished greenish-brown;  $KOH$ ,  $FeCl_3$  and  $KCN$  had no reactions;  $HCl$  tarnished grey;  $HNO_3$  and aquaregia stained dark grey. When exposed to air for several days the heazlewoodite oxidized to a pale green-yellow colour.

These properties and reactions correspond quite closely to those given for heazlewoodite by M.A. Peacock and V. Papizik (1955). An X-Ray powder photograph was interpreted by Dr. R.M. Thompson as identical to that of heazlewoodite.

The heazlewoodite was seen in grains from ten to several thousand microns in size. These grains were

usually fractured with breaking occurring most commonly along grain boundaries in the heazlewoodite or along contacts of heazlewoodite and chalcocite (Fig.2).

Heazlewoodite is replaced by all minerals in the section except magnetite (Fig.2,3,6,7,&8).

Pentlandite  $(Fe,Ni)S_{\frac{8}{7}}$  .....This mineral takes a poor pitted <sup>sl</sup> polish, is pale brassy yellow, isotropic and has a hardness of D.

The pentlandite gave the following etch reactions:  $HgCl_2$  tarnishes a golden brown;  $KOH$ ,  $FeCl_3$ ,  $KCN$  and  $HCl$  were negative;  $HNO_3$  slowly stains brown to iridescent.

The etch reaction with  $HgCl_2$  seems to be rather anomalous as M.N. Short (1940) lists no such reaction for pentlandite. However, pentlandite was positively identified with an X-Ray powder photograph.

Pentlandite is usually seen in the heazlewoodite which it is replacing (Fig.3) and is very difficult to distinguish from heazlewoodite without etching. It occurs in grains from 10 to 500 microns in size and is often highly fractured.

Pentlandite is replaced by chalcocite and native copper.

Chalcocite  $(Cu_2S)$ .....The chalcocite takes an excellent polish, is blue-grey, weakly anisotropic and has

a hardness of B.

The chalcocite gave the following reactions:  
 $\text{HgCl}_2$  and  $\text{KOH}$  negative;  $\text{FeCl}_3$  stains blue and brings out etch cleavage;  $\text{KCN}$  stains black and corrods surface;  $\text{HCl}$  tarnishes slightly;  $\text{HNO}_3$  effervesces, stains blue and brings out etch cleavage (Fig.H).

The chalcocite is seen in grain sizes similar to heazlewoodite and is highly fractured (Fig.2).

Chalcocite replaces heazlewoodite (Fig.2,7,&8) and pentlandite and is replaced by native copper and the unknown white mineral.

Unknown White Mineral....This mineral took an excellent polish, was galena-white, isotropic and had a hardness of D.

It gave the following etch reactions:  $\text{HgCl}_2$  instantly blackend and pitted;  $\text{FeCl}_3$  stained brownish and brought out a fine grain mosaic texture;  $\text{HCl}$  blackened and pitted the mineral;  $\text{HNO}_3$  effervesced slowly and tarnished grey;  $\text{KOH}$  and  $\text{KCN}$  negative. *leading to ?*

This mineral was noted in only two places on the polished sections and occurred as a replacement of chalcocite and heazlewoodite along their contacts (Fig.7 &8). In one place this mineral was replaced by native copper (Fig.8).

Native Copper.....This mineral took an excellent polish, was copper pink to light pink in colour, isotropic and sectile.

The native copper gave the following etch reactions:  $\text{HgCl}_2$  quickly stains iridescent;  $\text{KOH}$  slowly tarnishes brown;  $\text{KCN}$  tarnishes slightly;  $\text{FeCl}_3$  etches grey and brings out grain texture;  $\text{HCl}$  slowly stains light brown;  $\text{HNO}_3$  effervesces, stains brown and brings out grain texture (Fig.4).

The variance in colour of the native copper was investigated. The colour was noted to vary between a copper pink and light creamy pink. All variations between these colours was seen and several large grains of pinkish copper contained small (200 microns) rounded blebs of coppery pink copper. An X-Ray powder photograph of the pinkish copper was determined by Dr. R.M. Thompson to be native copper with nickel in the lattice. Micro-chemical tests gave a strong positive test for nickel in similar material.

The native copper was the last mineral formed and is seen replacing all minerals (Fig.5,6,&8) other than magnetite. It occurs in masses or veinlets several thousand microns in size to small rounded blebs less than one micron. The light pink variety of native copper seemed to be most abundant where heazlewoodite

was being replaced by the native copper.

When etched with HNO<sub>3</sub> the native copper exhibited a recrystallized or annealed texture (Fig.4) similar to that described by A.B. Edwards (Page 5).

Upon very high magnification a peculiar dendritic structure was noted around some of the small blebs of native copper (Fig.I2).

#### Relative Mineral Abundance

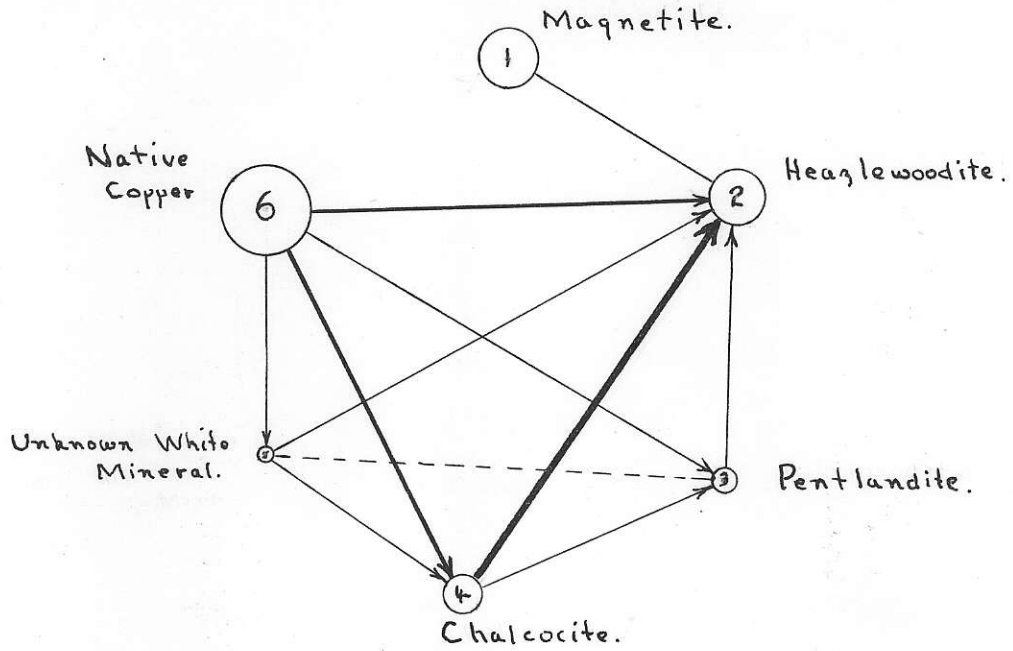
The approximate relative percentages of the six minerals described are as follows: 45% native copper, 23% magnetite, 20% heazlewoodite, 10% chalcocite, 2% pentlandite and a trace of the unknown mineral.

#### History of Mineralization

A history of mineralization is<sup>proposed</sup> as follows:

- 1....Crystallization of magnetite.
- 2....Introduction of heazlewoodite with some incorporation of pre-existing magnetite into the grains.
- 3....Introduction of pentlandite followed by chalcocite.
- 4....A period of movement and brecciation with some rock flowage occurring.
- 5....Introduction of unknown white mineral followed by native copper.
- 6....A later period of stress to produce annealed texture in native copper.

### Vanderveer Diagram



### Temperature Type

The native copper exhibits an annealed texture. According to Edwards (Page 5) such recrystallization does not begin in copper until a temperature exceeding 500°C has been reached.

According to the Metals Handbook copper may take nickel into solid solution at temperatures exceeding 1100°C. Although no suggestion of such an extreme temperature is made, it does indicate the possibility of a necessity for high temperature to allow diffusion of nickel into the copper lattice.

Other evidence for high temperature are the etch cleavage in the chalcocite and the intergrowth of heazlewoodite and magnetite.

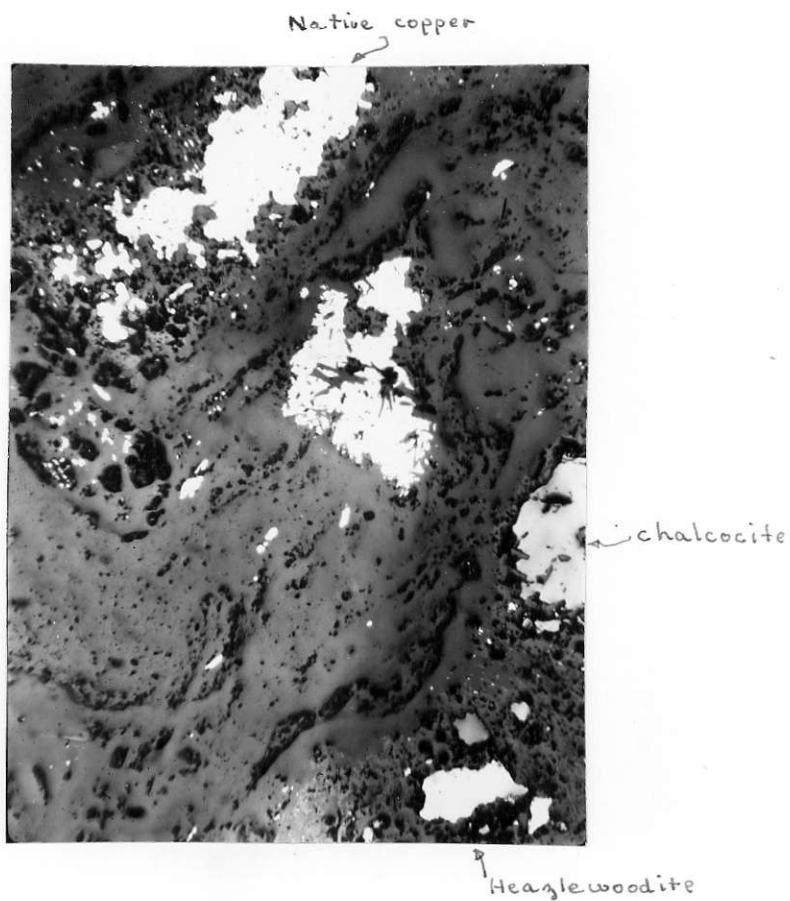
However, during brecciation, the heazlewoodite must have been cooler than its melting temperature of 787°C. Also, the

introduced native copper did not melt sharp edges on the already brecciated heazlewoodite.

The above information would indicate that the mineralization is probably hypothermal. Most certainly, the minerals were deposited at a temperature exceeding 500° C and likely closer to 600° C.



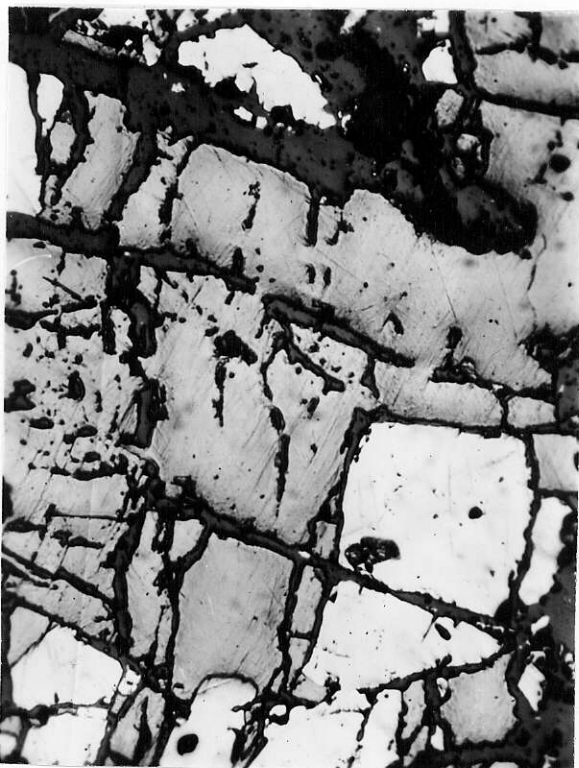
Figure I



X 100

Native copper, chalcocite, heazlewoodite and a grain of copper-nickel at centre of photo. Note flow-like structure in gangue.

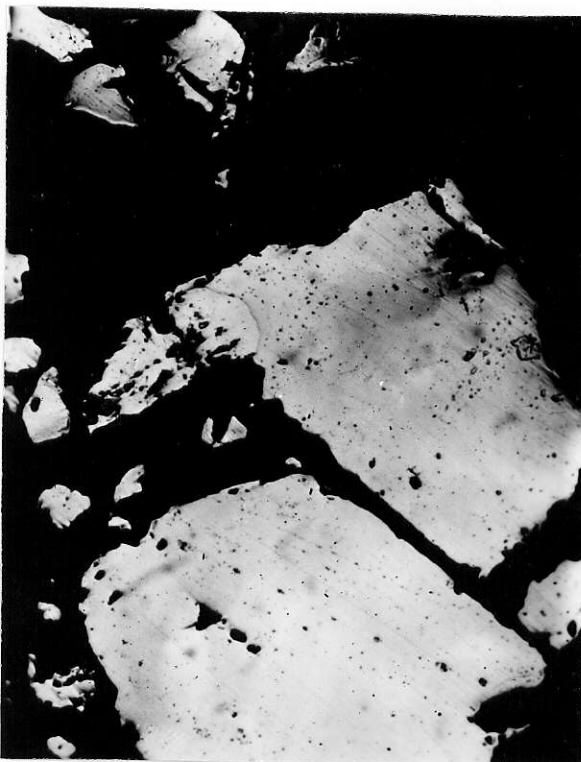
Figure 2



X 210

Chalcocite (grey) and heazlewoodite (white) with gangue (black and very dark grey). Note brecciation favouring grain boundaries.

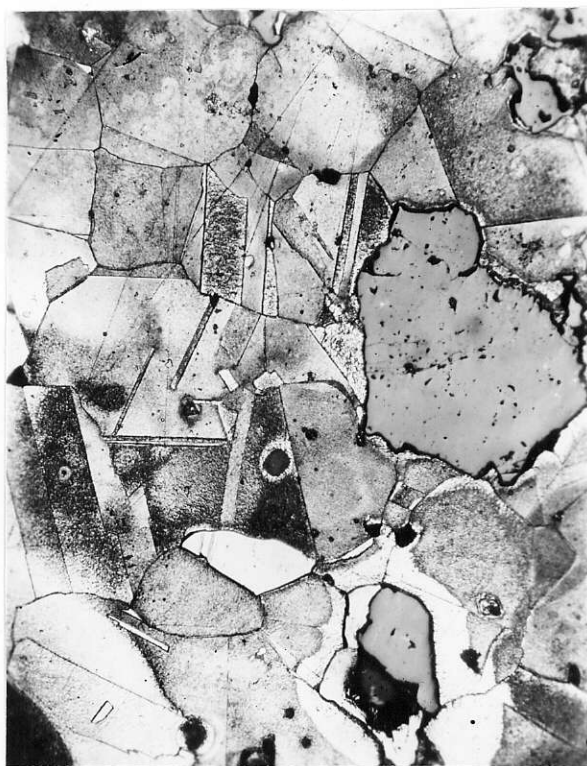
Figure 3



X 210

Pentlandite (light grey, small grain) replacing heazlewoodite (darker grey, large grains). Note fracturing of both minerals.

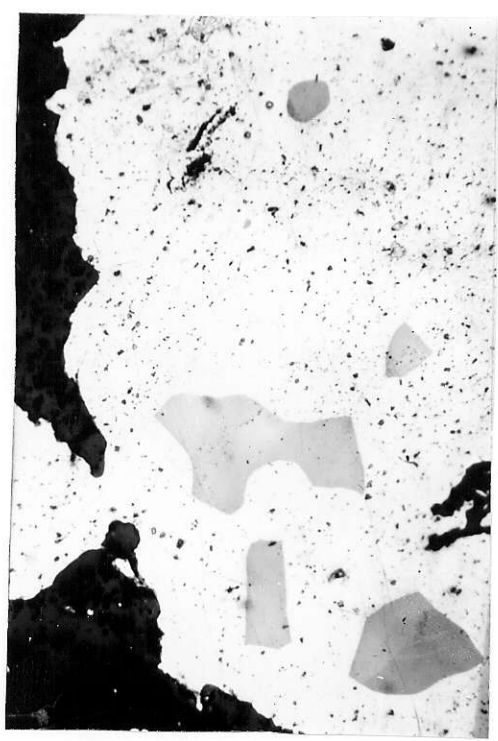
Figure 4



X 120

Native copper etched with nitric acid. Note grain of chalcocite (white) with small grain of heazlewoodite (also white and outlined in pencil) in it. Large grey grains and small black grains are gangue.

Figure 5



X 120

Native copper (white) replacing chalcocite (grey).

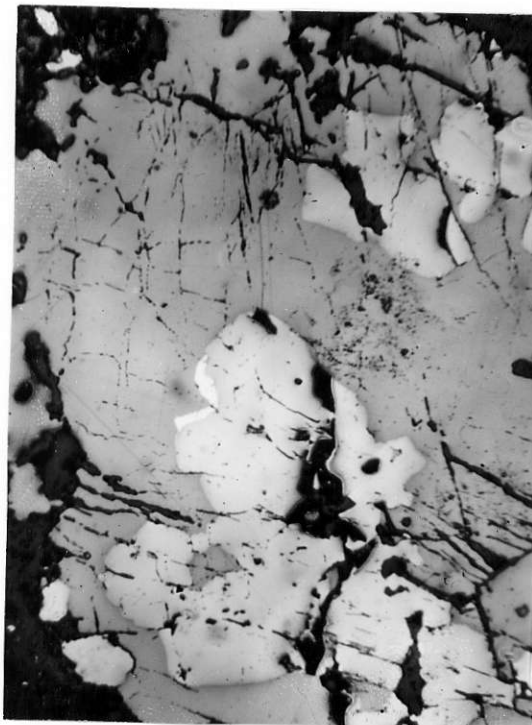
Figure 6



X 2500

Native copper (white) replacing heazlewoodite (grey).

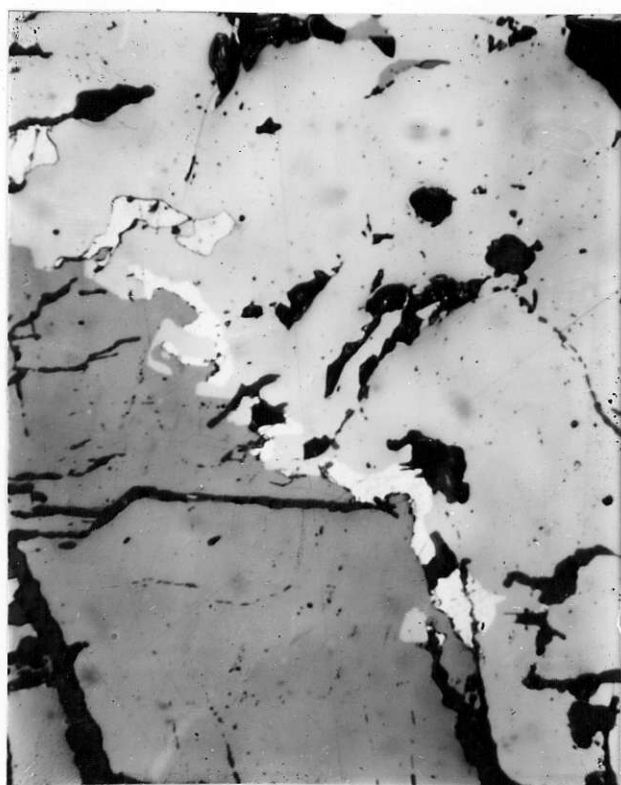
Figure 7



X 250

Chalcocite (dark grey) replacing heazlewoodite (light grey).  
Note unknown white mineral in centre of photo replacing  
both chalcocite and heazlewoodite, white grains on side  
of photo are native copper.

Figure 8



X 275

Chalcocite (dark grey) replacing heazlewoodite (medium grey). Note unknown white mineral replacing chalcocite and heazlewoodite. Note also native copper (light grey) replacing all three minerals.



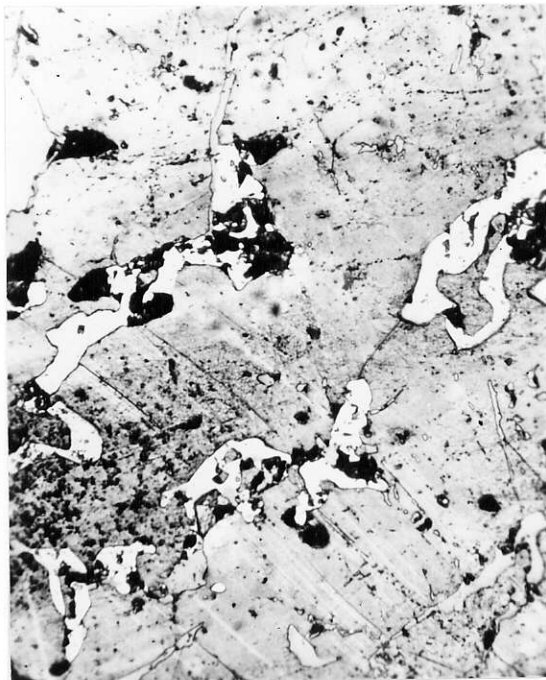
Figure 9



X 120

Chalcocite (grey-white) with crystal of heazlewoodite  
(white).

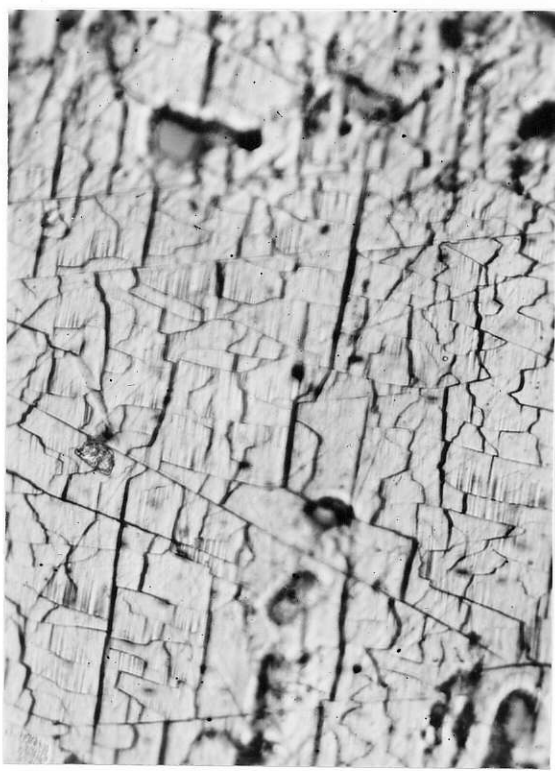
Figure 10



X 220

Etched heazlewoodite (grey) with worms of magnetite (white).

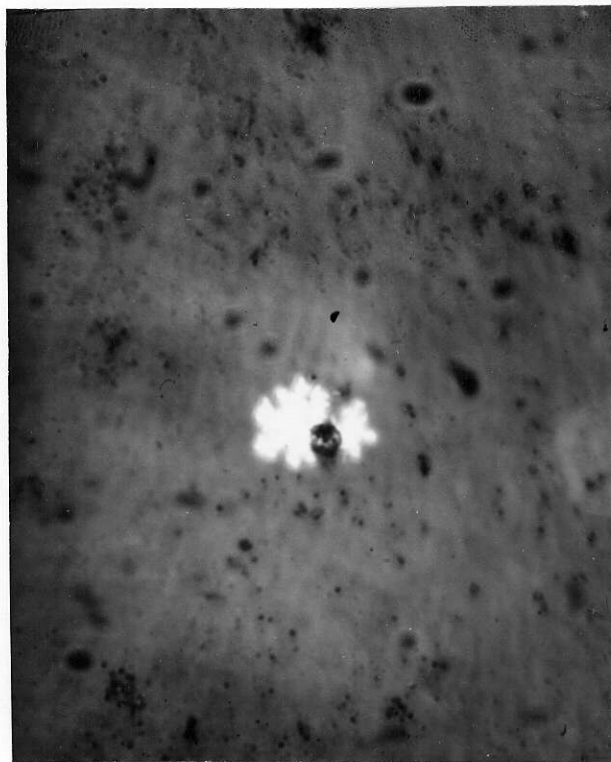
Figure II



X 575

Chalcocite etched with  $HNO_3$ . Note development of etch cleavage and fine lines which may be twinning.

Figure 12



X 3900

Peculiar dendritic structure surrounding grain of native copper.

in crystals around 50 microns. These masses and crystals are often broken and shattered.

The pyrite is seen being cut and replaced by millerite (Fig.3).

Marcasite ( $\text{FeS}_2$ ).....The marcasite is pale brass yellow, cannot be scratched with a needle and is strongly anisotropic with polarization colours from grey to blue and purple.

Marcasite gave the following reactions:  $\text{HgCl}_2$ , KOH  $\text{FeCl}_3$ , KCN, HCl negative;  $\text{HNO}_3$  effervesced slowly and stained brown.

The marcasite is seen in spongy masses up to several millimeters in size. These masses are usually in the chalcedony and often border millerite grains.

The marcasite has a fine grained texture with no evidence of zoning. It is replaced by millerite (Fig.4).

Bravoite  $(\text{Fe,Ni})\text{S}_2$  ...The bravoite is white with a very faint violet tint and can just be scratched with a needle. It was isotropic and had the following etch reactions:  $\text{HgCl}_2$ , KOH,  $\text{FeCl}_3$ , KCN, HCl negative;  $\text{HNO}_3$  stained light brown.

The bravoite was seen in small quantities in two of the polished sections and occurred in grains of 500

microns and less (Fig.6). The large grains showed no crystal form and when etched with  $\text{HNO}_3$  showed no zoning. Several smaller (50U) well crystallized grains showed faint zoning when etched with  $\text{HNO}_3$  and had crystals of violarite in their centres. No boundary relations with other minerals was seen.

The bravoite was identified by an X-Ray powder photograph which was interpreted by Dr. R. M. Thompson using information on bravoite given by M.A. Peacock and F.G. Smith (1941). Micro-chemical tests indicated a nickel content in the bravoite.

Millerite (Nis).....The millerite takes a good polish, is brass yellow and anisotropic with polarization colours from light yellow to purple. It had a hardness of E and the following etch reactions:  $\text{HgCl}_2$  stained differentially light brown;  $\text{KOH}$ ,  $\text{FeCl}_3$ ,  $\text{KCN}$  and  $\text{HCl}$  were negative;  $\text{HNO}_3$  effervesced and stained brown.

The millerite was seen in masses of interlocking or intergrown prisms. These were seen in groups up to several millimeters in size (Fig.1) and occurred in the chalcedony. Individual prisms were 500 microns or smaller with hexagonal basal sections 25 microns or less (Fig.2).

The millerite was seen replacing pyrite and marcasite (Fig.3&4) and was replaced by violarite (Fig.5).

Violarite  $(\text{Ni,Fe})\text{S}_4$ ....This mineral was pale violet, isometric, and had a hardness of 6. Violarite has the following etch reactions: KOH,  $\text{HgCl}_2$ ,  $\text{FeCl}_3$ , KCN, and HCl negative;  $\text{HNO}_3$  slowly effervesced and stained brown.

The violarite was seen as small grains (200U) in the chalcedony and as a replacement of millerite (Fig.5). The replacement of millerite by violarite was very active and about 10% of the millerite had been so replaced.

The violarite was identified by an X-Ray powder photograph.

#### Relative Mineral Abundance

The six minerals described constitute about 15% of the specimens. Their relative abundance is as follows: 50% millerite, 20% marcasite, 15% violarite, 10% magnetite, 5% pyrite and traces of bravoite.

#### History of Mineralization

On the basis of grain boundary relations a history of mineralization is proposed as follows:

- 1....Magnetite formed with original rock.
- 2....Fracturing of serpentine with introduction of chalcedony, pyrite and marcasite (bravoite also probably crystallizing at this time).

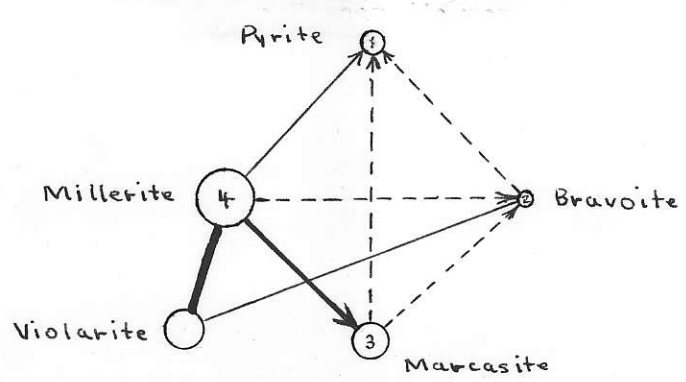
- 3....Introduction of millerite with additional chalcedony.
- 4....Violarite produced by later surpergene replacement of millerite and bravoite.

*Whose?*

The source of the mineralizing fluid has been considered. According to several theories silica is released during the conversion of ultra-basic rocks to serpentine. Thus, silica along with nickel and iron may have been carried by hydrothermal solutions to the fracture zone <sup>during</sup> the serpentinization of the peridotite body. The sulfur may have been derived from the sedimentary rocks.

The violarite has been considered to have been produced by supergene replacement because such is its usual mode of occurrence. However, violarite was seen in the cores of bravoite crystals and replacing millerite which was imbedded in solid chalcedony. These facts would suggest the possibility that violarite may have been hypogene in origin. If such were the case it would have been the last mineral introduced.

VANDEVEER DIAGRAM





### Temperature Type

The mineral suite, particularly the chalcedony, suggests a low temperature hydrothermal deposit.

A similar deposit in California has been described by C.D. Woodhouse and R.M. Norris as being hydrothermal with a mineral suite strongly suggesting low temperature.

This information would suggest that the deposit is epithermal.

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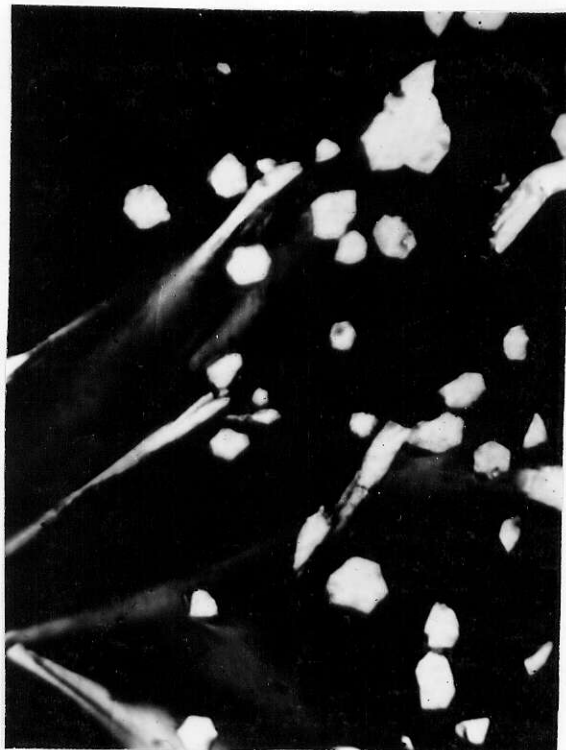
Figure I



X 120

Typical radiating groups of millerite crystals.

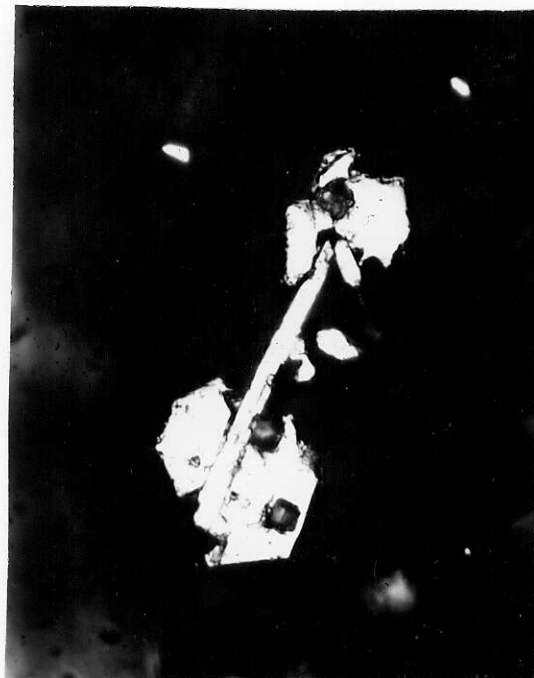
Figure 2



X 1900

End sections of millerite laths. Note hexagonal shape and curved crystal faces. Also note twinning.

Figure 3



X 820

Two pyrite crystals being cut and replaced by a single prism of millerite.

Figure 4



X 210

Large spongy mass of marcasite (white, poor polish) cut by laths of millerite (white, good polish). Note several hexagonal end sections of millerite.

Figure 5



X 1900

Lath of millerite (white) being replaced by violarite  
(grey).

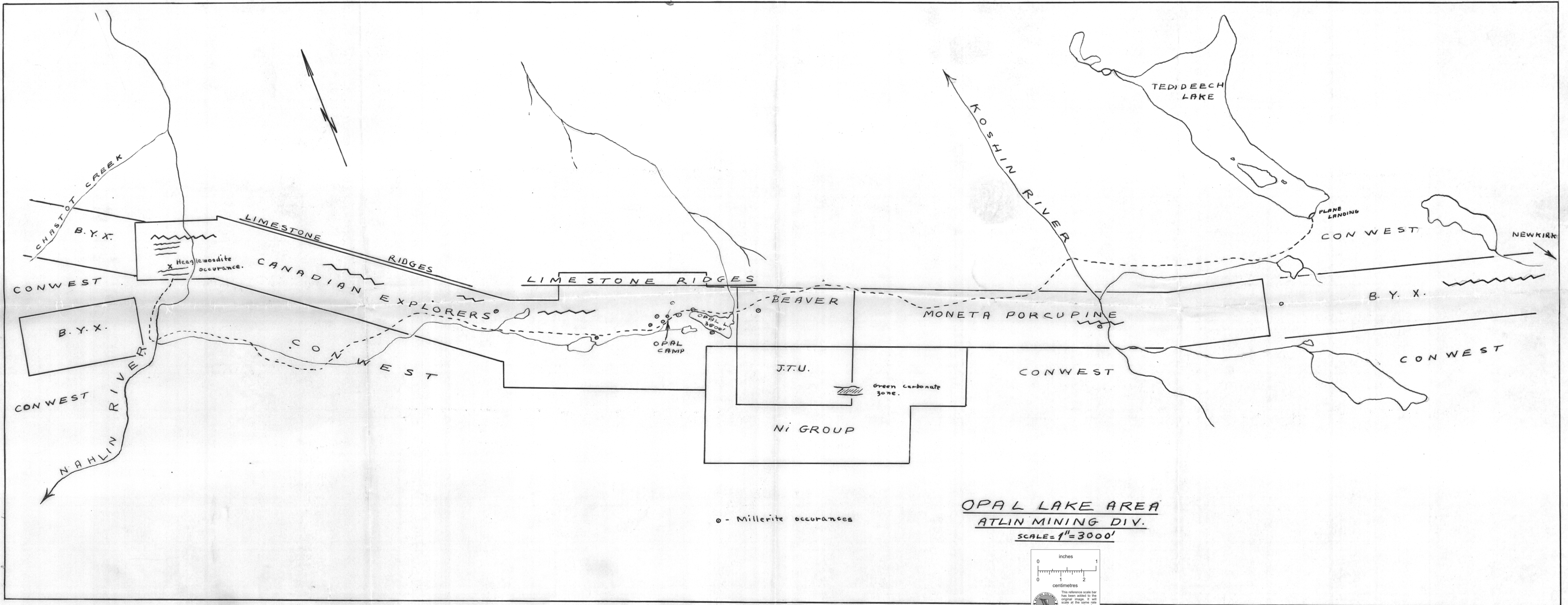
Figure 6



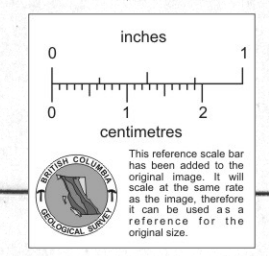
X 500

Grain of brovoite etched with  $\text{HNO}_3$ . Note lack of zoning.





**OPAL LAKE AREA**  
**ATLIN MINING DIV.**  
**SCALE = 1" = 3000'**



o - Millerite occurrences