600035

I. F. Morton

Mineralographic Report on Mineralization from a Contact of the Atlin Peridotite Belt.

Report on :-
Samples from a talus slide on the West side of the Nakkin River (about 3 miles above the point where Dudidontii Creek flows into the Nakkin River).

- The material to be studied consisted of twelve polished sections and a number of fragments, most of which are large enough to form suitable hand specimens.
- According to information from other sources, this material was originally a peridotite which has since undergone some form of alteration. It has apparently come from the contact of the Cottrell Peridotite belt with limestone.
- Many of the hand specimens have a serpentinized appearance and seem to have undergone a fair amount of shearing, whilst others are much lighter in colour and have the appearance of some form of skarn material - they effervesce with HCl and hence seem to be partially calcium carbonate. Magnesite rich.
- The serpentinized rocks are fairly spectacular and are dark green in colour. They seem to vary in places from chrysotile to antigorite, whilst some of the material on the shear surfaces may possibly be picrolite or another form of chrysotile. They appear to contain about -

5% Talc (especially on the fracture planes)
40% Chromite - massive and granular.
16% Malachite - In places confined to fracture planes.
5% { Native Copper } fine grained
in Cuprite }
- a trace of limonite + Native Cu in Chalcocite, Up to 3% Chalcocite
- Up to 5% Cuprite.
- 24% of Serpentine minerals eg Antigorite + Chrysotile

Garnet

The lighter coloured rocks appear to be part of the limestone - peridotite contact and appear to have a capping, which may be part of the contact, which has a green appearance and looks like prehnite. It contains tabular - platy crystals. The rocks themselves appear to have a green substance speckled throughout them and it may prove to be "diopside" or some similar mineral of Calcium-magnesium composition. The rock has Hewettite - a trace, Cuprite - a trace Native Cu - a trace and malachite - a trace. Chrysotile and talc - a trace. These lighter rocks may prove to be a weakly altered limestone bordered by the unknown non-metallic mineral.

– An investigation of the polished section revealed the following in.

1 Section

– Native Cu – 10%, Hexagelwoodite – 20%, Chalcocite – 6% Covellite trace Digenite – a trace, Bertlandite – a trace, malachite – 20%, Quartz – a trace. An unknown mineral, blue white in colour – a trace, an unknown blue-grey mineral – a trace and "Opalized" Serpentine – 46%. There is also a reddish variety of "Opal" which appears to contain native Cu and seems to be confined to cracks across the section – a trace, Chromite – a trace and Magnetite? – a trace.

The unknown blue-white mineral had the same relief as chalcocite, but occurred between the chalcocite and the hexagelwoodite as a very minute trace. It responded to $HgCl_2$ and could not be found again, even after polishing, when it was etched with $FeCl_3$. This mineral was only seen with the aid of a high power lense.

The unknown blue-grey "mineral" was found as small specks in the native copper, more as a relict material than any other way, since "ice cake" texture was predominant. This mineral reacted to KCN only and seemed to be negative to everything else including aqua regia. A "mapping" was made from the section for the benefit of an X-Ray, but so far the resulting film has yielded no information apart for the fact that it has helped to eliminate native copper or cuprite as possible constituents. A second X-Ray is at present being taken from material dissolved from a later section, in the hope that a better film will be obtained.

The term "opaline", in the case of the polished sections, is used to cover all forms of silicification encountered. There is a tendency for the hardness of the silicified areas to vary from 5½ to a little over 6½ i.e. E to C. They all have a somewhat pitted appearance and vary in colour fairly extensively i.e. white, green, red. Hence, the term will effectively cover opal proper, chalcedony and microcrystalline varieties of silica.

#2. Section.
Pleazelwoodite - 10%, Chromite - 3%, malachite - trace. The remaining 87% of the section is "opalized" serpentine.

#3 Section
Native Cu - 15% malachite - 5%, Chromite - 5% and Pleazelwoodite - a trace, An unknown blue-grey mineral - trace and "Opalized" Serpentine 75%

#4. Section.
Chromite - 10%, Native Cu - 7%, Pleazelwoodite - 5%, malachite - 20%, covellite - trace and Chalcocite - 7%. The remaining 49% of the section is "opalized" serpentine.

#5 Section:
Pleazelwoodite - 15%, Native Cu - a trace, Chromite a trace and some malachite - a trace; "opalized" Serpentine - 85% - Native Cu containing a trace of the unknown ~~grey blue mineral~~ blue-grey mineral.

#6 Section
- Native Cu - 8%, Pleazelwoodite - 10% Chromite - trace, malachite - 5% Penthandite - trace, Covellite - 1% and Digenite - a trace. Some of the unknown blue-grey mineral in the Copper.

#7 Section.
Native Cu - 15%, Pleazelwoodite - 20%, Covellite - a trace, Quartz fragments - 5%, Chromite - a trace, Penthandite - trace, Chalcocite - 2%, Malachite - 5% and traces of the unknown blue-grey mineral. The remaining 53% is "opalized" serpentine. Magnetite? - a trace.

#8 Section
Pleazelwoodite - 10%, Native Cu - 6%, Chromite - 3%, Penthandite - a trace, Chalcocite - a trace, Malachite - 10% and "Opalized" Serpentine - 71%.

#10 Section:

- Native Cu - a trace, Malachite - ~~a trace~~ 5%, Heazlewoodite - 5%
Chromite - a trace and Pentlandite - a trace. "Opalized" Serpentine - 90%

#11 Section:

Native Cu - 1%, Covellite - trace, Chalcocite - trace, digenite - trace,
Heazlewoodite - 8%, Chromite - 5%, Malachite - 5%, "Opalized" Serpentine - 81%

#12 Section:

Native Cu - 5%, Heazlewoodite - 0.5%, Chromite - 1%,
Chalcocite - a trace, Pentlandite - a trace, Malachite - 2%.
"Opalized" Serpentine - 91.5%.

INDICATIONS.

1. Chromite :- Isotropic H = 5½, Brown streak, No discolouration of H_2O_2.
- Magnetic - needle must touch to pick up.

2. Magnetite ? - Isotropic H ≅ F. Colour grey, Black streak, turns HCl yellow?
- Strongly magnetic - fluctuating needle, very small quantity (magnetism is main evidence).

3. Penthandite :- Brassy Colour - paler than Heazlewoodite. H ≅ D.
HNO_3 tarnishes, everything else negative. Isotropic.

4. Heazlewoodite :- H ≅ C+ yellowy colour - Anisotropic - violet to greeny-yellow and Browny yellow to blue-green. Distinctive →
(Short does not mention this mineral and Dana attempts to discredit it, whilst Uytenbogaardt gives tests for it - I have since been informed of its true existence)
HNO_3 tarnishes.

5. Quartz :- H ≅ 6½. Intense reflection and higher relief than the other minerals + Luster - vitreous and clear.

6. An Unknown Mineral : Found embedded in the native copper and bluish-grey in colour, semi-metallic. Reacts only to HCN
OK - One X-Ray has proved unsuccessful, whilst another is at present being attempted.

7. Native Copper: Colour, Ductile H ≅ B+. HNO_3 effervesces. Isotropic.

A nickel bearing variety is supposed to have originally been observed near heazlewoodite, but I find that the copper in the vicinity of this mineral is redder and softer than elsewhere. On examination, it seems somewhat difficult to obtain copper free of heazlewoodite - if near heazlewoodite, since the copper seems to have originally occurred in fractures and veins through the heazlewoodite. This copper has not been tested for this reason, but the somewhat paler variety, further away, does not seem to give a reasonable test for Nickel either. Hence, only a normal variety of native copper is reported here.

8. Digenite. Isotropic, blue-grey. H ± B. HNO_3 turns blue, $FeCl_3$ (-ve)
9. Chalcocite Anisotropic, HNO_3 ± blue, $FeCl_3$ - blue, blue-grey H ± D.
10. Covellite - High polarization colours H = B+.
11. Opal ? H ± E, diffused internal reflection, Waxy appearance
12. Chalcedony? - H ± G. similar to opal in appearance and grades into it.
- Internal reflection, Colour varies.
13. Malachite Colour, H ± C+ Microchemical test for Cu.
14. Cuprite. Seen only in the hand specimen. Internal reflection
- associated with native copper and other copper minerals.
- Rust red colour.
15. Antigorite ? Seen in the hand specimen. Greasy luster - platy.
H ± D, No visible cleavage.
16. Chrysotile - Seen in the hand specimens. Fibrous H ± C.
- Various shades of green.
17. Unknown ? (Garnet-by X-Rays) Appears similar at first to pyrite, it is green, vitreous. H ± G.
- Refractive index of individual grains - ground up ? and placed on slide in immersion liquid ± 1.59 to 1.60.
- Crystals appear tabular and platy under binoculars
- " " Monochromatic under petrographic microscope
- Uniaxial negative and inclined extinction of ± 35°.
- When mounted on a slide in an air medium - obtain numerous colour rings in the isogyre similar to those of calcite but this is believed due to the unusual thickness of the fragments rather than the high birefringence.
18. Talc H = A, Greasy luster, white, and association.
19. Pyrrhotite? Appears to form a columnar structure in some of the shear planes. It is normally associated with shear planes. However, this may turn out to be a modified form of chrysotile.

20. Diopside (or Calcium - Magnesium mineral of similar composition)?
- Presence of a green mineral in a contact-limestone with ultrabasic rock.

21. Calcite? The fact that the rock effervesces with HCl indicates a carbonate and since this is in a limestone contact, the assumption is pretty fair. The rock has H & C.

22. An Unknown Mineral — blue-white, same relief as chalcocite, reacts to $HgCl_2$ and HCl, and disappears with $FeCl_3$
- Nothing else works eg KCN, KOH.
- HNO_3 unable to be tried.

Its association with the boundary between heazlewoodite and chalcocite may indicate a form of reaction rim. Thus it may perhaps be some copper-nickel mineral. It certainly appears to have formed, if not by reaction between the heazlewoodite and chalcocite, by exsolution from the chalcocite. However, the texture previous to etching was difficult to see and there is no real clue as to its composition or origin. I have been informed that a mineral of similar nature had previously been found and it apparently reacted to HNO_3. My own mineral was isotropic.

?

Hypogenesis

From information received and by the appearance of many of the samples, the rock we are examining was originally a peridotite. This is supposedly the source of the chromite, magnetite and nickel sulphides.

Chromite is usually reported in ultra-basic rocks of this nature with small quantities of magnetite. Since, however neither mineral is in contact with the other, as can be seen in the sections, they may have been contemporaneous or the chromite may have appeared before magnetite - as it is often supposed to do. However, since magnetite is somewhat doubtful in these specimens, due to the infinitely small amount of material and the possible confusion with chromite - which is so abundant, the two minerals will be regarded as almost contemporaneous

The nickel sulphides may be expected to accumulate after the chromite by some type of magmatic segregation. The pentlandite is found to have been intruded fairly frequently by the heazlewoodite and may hence be regarded has the first sulphide to be deposited. This would have then been followed by heazlewoodite.

Copper appears to intrude the heazlewoodite and seems to have been replaced by all the other minerals in the sections, which have not been mentioned in the paragenesis, except for quartz. The quartz appears as relict fragments in both the native copper and the "opalized" serpentine, but in no other minerals. Consequently, it appears that quartz was deposited before native copper and after heazlewoodite. The native copper, upon etching with ammonium persulphate, showed a well crystallized texture - thus indicating a hypogene origin. Relict veinlets of copper are found with relict fragment of highly fractured heazlewoodite in "opalized" serpentine. The fractures appear to have been ~~replaced~~ filled by a somewhat harder form of silica, which is sometimes red due to the presence of native copper and stands out in relief above normal "opalized" serpentine. Hence, it appears that after the heazlewoodite had been deposited, it was fractured and hypogenetic copper was deposited.

Since, the ~~the~~ harder variety of siliceous material intrudes the

the native copper, and minerals above this in the paragenesis, and is veined by chalcocite, we can surely assume that native copper was followed by some form of "opalescent" siliceous material.

Now, the chalcocite in certain areas is found to be separated from the native copper by this "opalescent" siliceous material in the form of a vein. Hence, the silica appears to intrude the copper and is in turn intruded by the chalcocite. In other places, the digenite has apparently intruded the native copper. However, the relationship between digenite and chalcocite was somewhat disconcerting, because they had a mutual boundary between them, the apex of which appeared initially to be in the digenite - thus indicating the digenite was replaced by chalcocite. On further examination with stereoscopic photographs, it was decided that the boundary consisted of three curves whose apices were in the chalcocite. Thus the silica appears to have been followed by chalcocite and digenite respectively. Covellite is found intruding the chalcocite in various places and may be assumed to have been deposited after digenite, because it is usually the last sulphide formed.

A further deposition of silica appears to have formed the "opalized" serpentine, which is fairly soft (= E, Allis) appears to have intruded all the minerals previously mentioned and seemingly replaced some of the later malachite. The malachite, if so, could not have formed before silicification, because it would be silicified rather than intruded and signs of silicified cuprite would be evident in the hand specimen. Hence, the cuprite was probably formed after silicification ~~in the~~ just above the water table. Later, when the water table had dropped a little, some of the copper minerals evolved into malachite and left a relict intruded matter of "opalized" material.

The alteration of the ~~per~~ gangue minerals in the peridotite to their present form probably took place around the period of copper deposition, because this mineral and the other copper minerals are ~~they~~ found in the altered limestone as well as the serpentine. The other minerals - pentlandite, heazlewoodite and chromite - are existent in minute traces in the limestone, and may be regarded possibly as having been

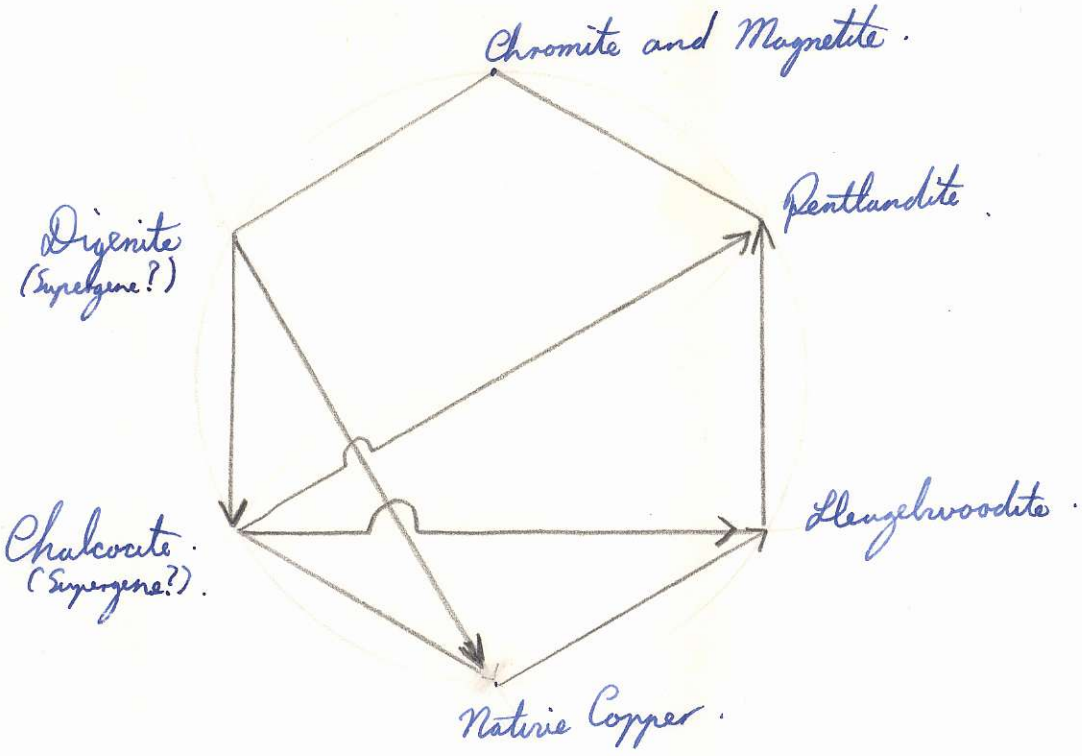
carried in with the other minerals from the peridotite. Not only does the evidence of a predominance of native Cu and associated copper minerals in the limestone seem to indicate this, but this is also the first period of silicification - in which "opal" - like silica was deposited. This might possibly indicate alteration in the peridotite commencing when the silica of the rock minerals was re-deposited with a corresponding break down in those minerals. The talc and malachite appear to have formed after the time of shearing, because both minerals occur frequently in shear planes.

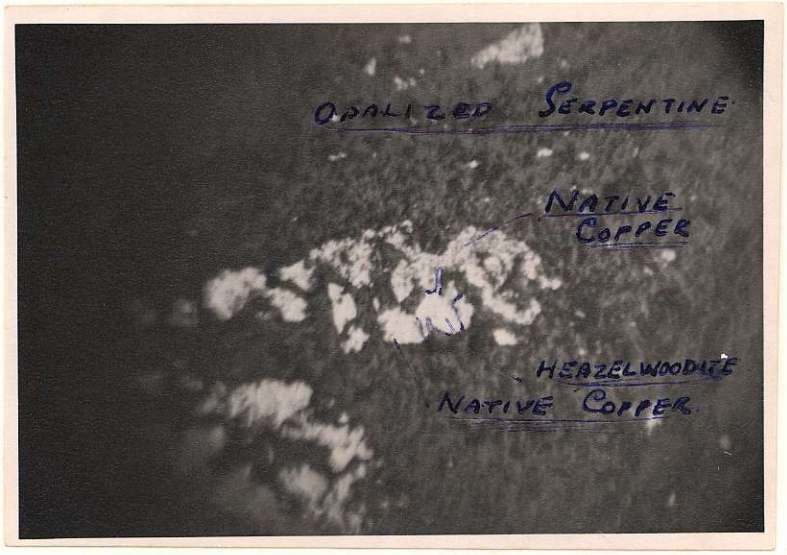
Hence, there were probably five stages in the mineralization. The first possibly consisted of the accumulation of chromite and magnetite by a form of magmatic segregation, followed by the second stage in which nickel minerals - Heazlewoodite and pentlandite - accumulated by magmatic segregation processes again. Both these stages are probably hypothermal of magmatic origin. The third stage appears to have consisted of the introduction of quartz and native copper with "opalescent" silica, which is probably a variety of quartz. The coarsely crystalline condition of the native copper suggests a hypothermal deposit of hydrothermal origin, because [redacted] re-crystallization below 450°C is known to produce a fairly imperfect type of crystallization. However, the presence of clear quartz in the copper and "opalescent" silica, probably quartz, tends to give the impression of a mesothermal environment. Hence it is somewhat unclear as to whether the conditions are hypothermal, mesothermal or a hybrid of the two. The fourth stage is characterized by the introduction of Chalcocite, digenite, covellite and opal type material. This assemblage appears to exist under two types of condition. The first is epithermal of hydrothermal origin, whilst the second is supergene by secondary enrichment below the water table. Part of the chalcocite may have been of epithermal hydrothermal origin previously, but with the presence of opal type material ~~most~~ a supergene origin seems to be more likely for most of the Chalcocite and more definitely for the digenite and covellite. The fifth stage appears to have been the formation of cuprite and malachite by secondary enrichment in the oxidation zone, due to a possible drop in the water table.

Therefore the probable sequence is.

STAGE 1. { Chromite and possibly magnetite.
STAGE 2. { Pentlandite.
Heazlewoodite.
STAGE 3. { Quartz.
Native Copper.
"Opalescent" silica - probably quartz and the possible conversion of peridotite to serpentine.
STAGE 4. { Chalcocite.
Digenite.
Covellite.
Opal.
STAGE 5. { Cuprite
Malachite and Talc.

Van de Veen Diagram.





See Section #3. PSA20

HP

Hengelwoodite intruded by native copper

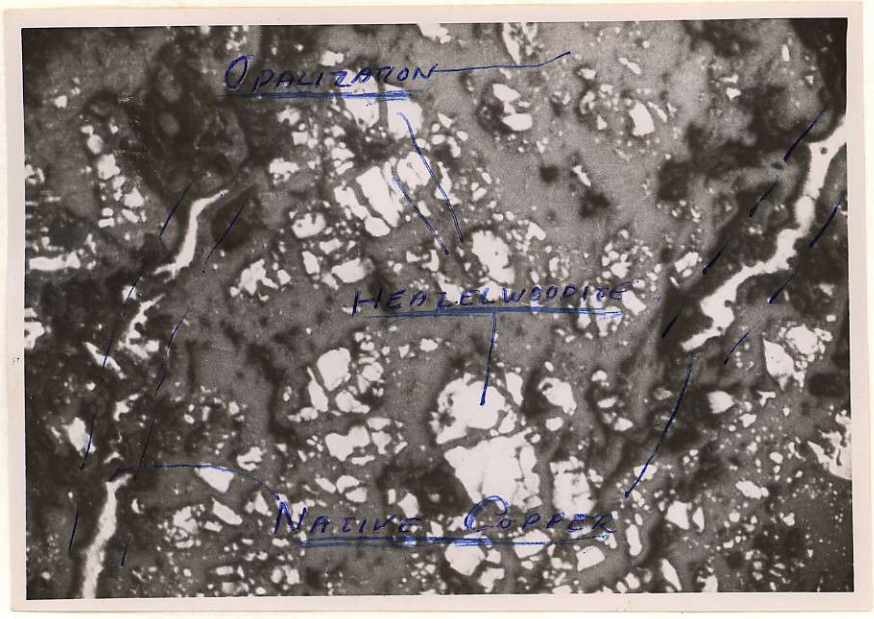
The following films were taken with a fine grained Ilford film of ASA 200. This was developed as for ASA 100.

1 sec

LPX

Section 1

Cu veining "opalized" serpentine with relict hexagelwoodite.



1 sec.

LPX

Section 1.

as above.

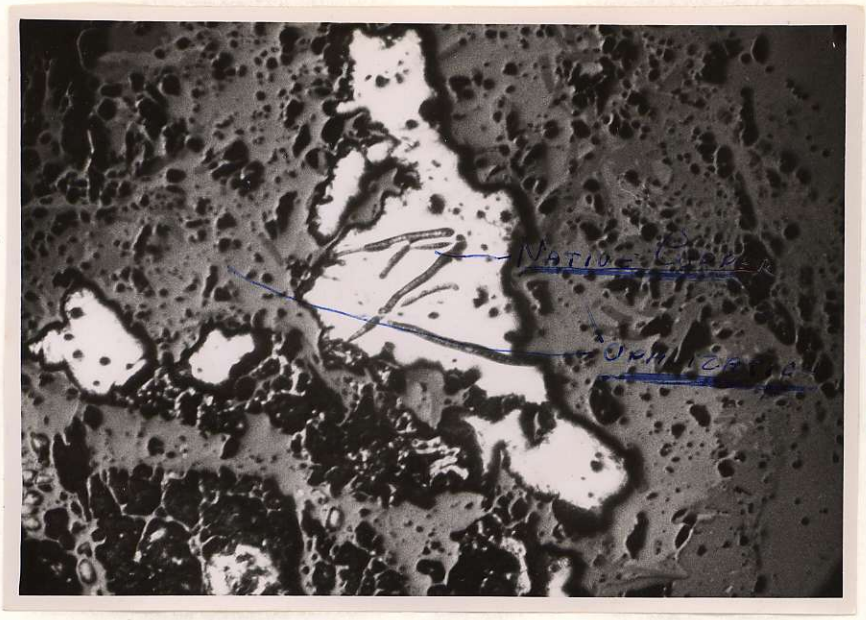
I see.

MPX
Section 8
Cu in Hazelwoodite

(very good stereoscopic pair).

as above

One can also see the more "opalescent", siliceous material of higher relief amongst the Cu here - probably just a variety of quartz.

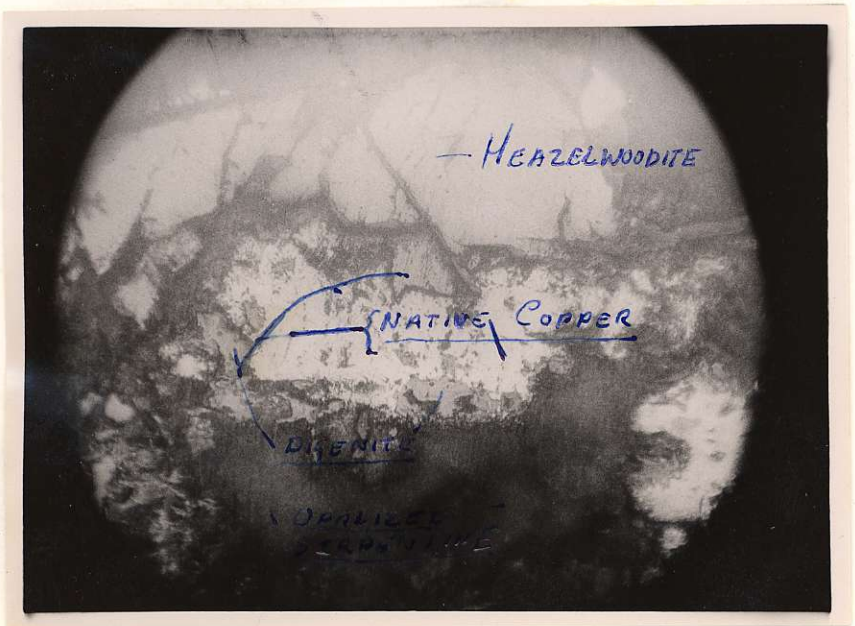


1 sec.
LP X
Section 1

Copper in opalized Serpentine - somewhat harder variety of silica than the variety of opal found elsewhere - probably variety of quartz

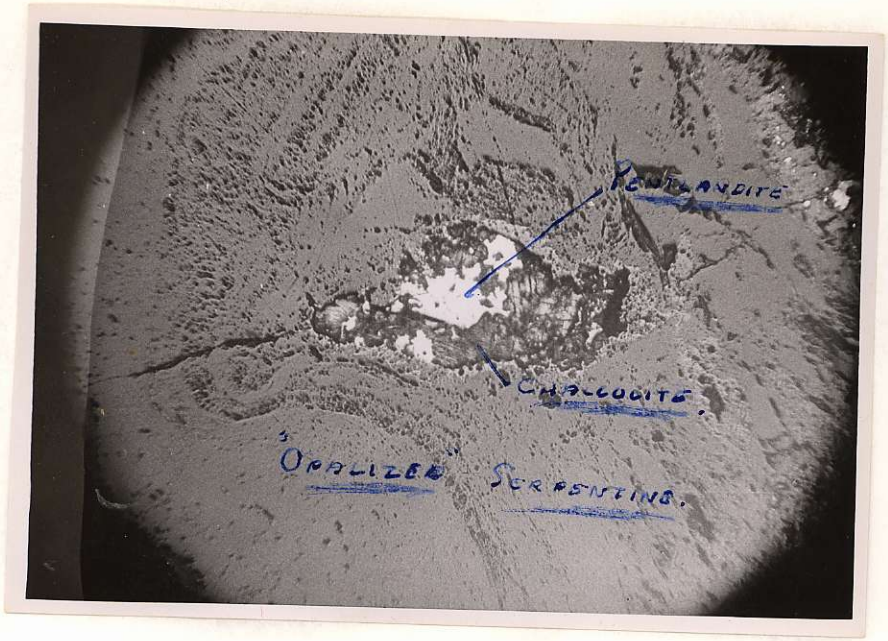
1 sec.
LP X
Section 1

Pentlandite in Heazlewoodite.



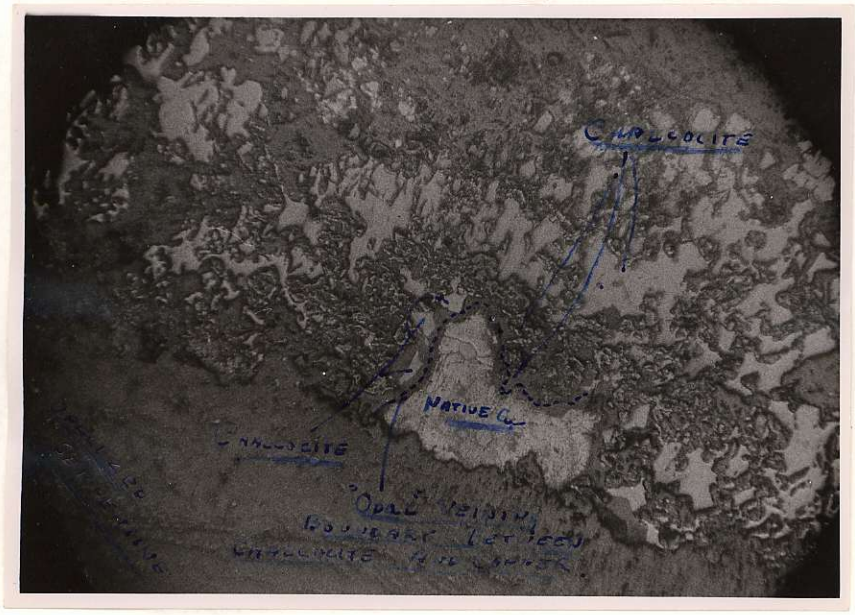
1 sec
MP X
Section 1

Digenite in Native Cu.



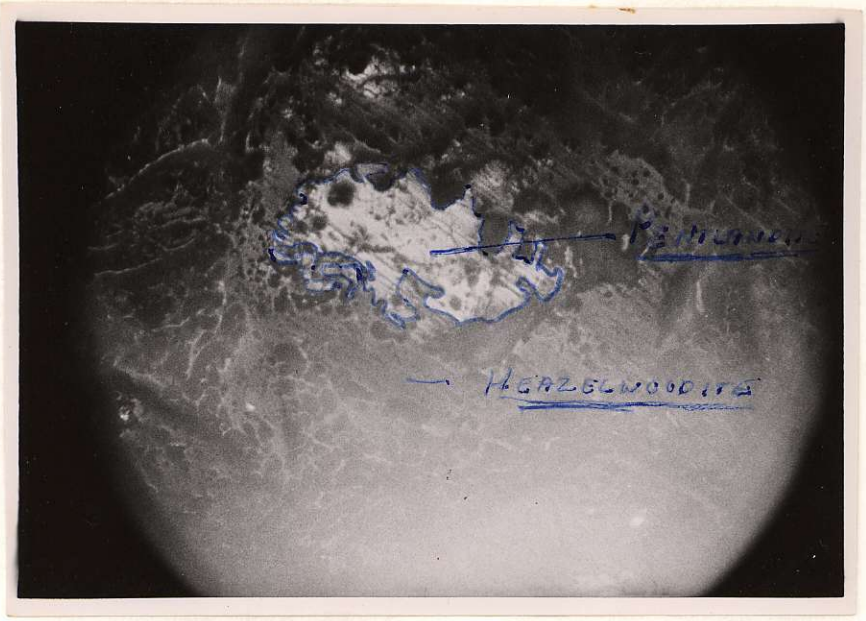
1 sec
MPX
Section #6

Pentlandite intruded by chalcocite, surrounded by opalized serpentine



1 Sec
MPX
Section #4
½ crossed nicols.

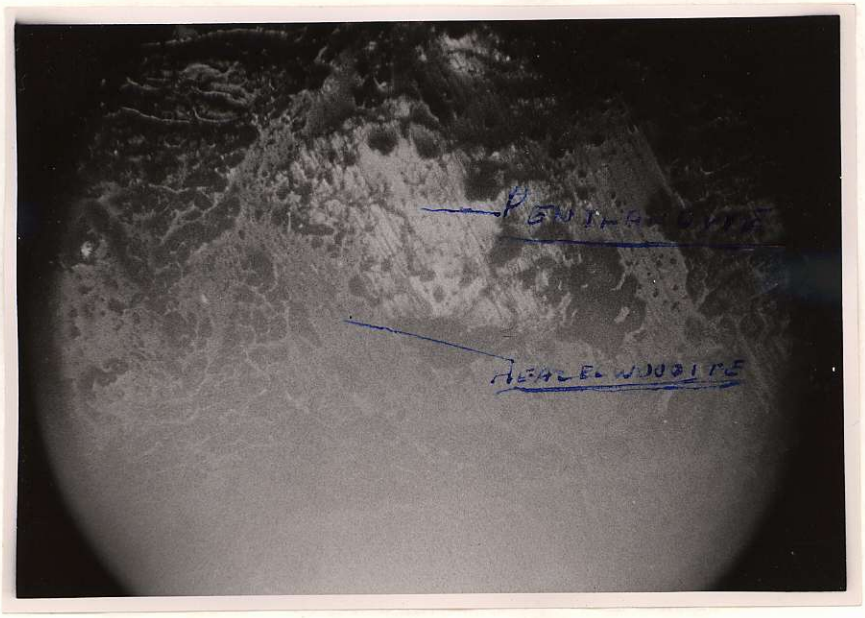
Native copper intruded by siliceous material, which in turn is intruded by chalcocite.



4 secs MPX
Section 1.
± crossed nicols

Pentlandite intergrown by Heazlewoodite.

(almost a stereoscopic pair).



4 secs. MPX
Section 1
X - nicols.

as above.

HPX

4 Ires

Section 1

X-d nicols

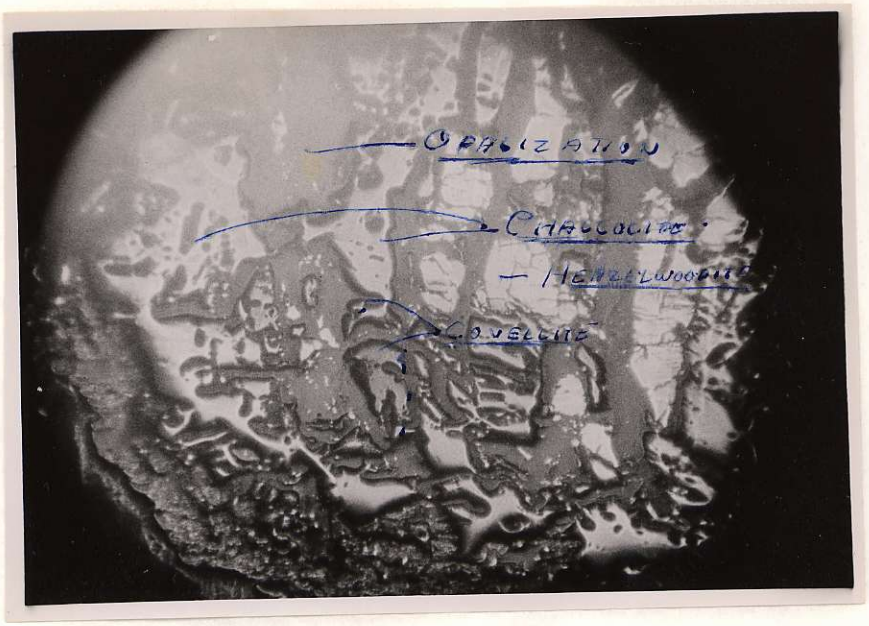
Chalcocite and covellite.

HPX

1 Ires

Section 1

Chalcocite > covellite.



1 sec HPX
Section 1

Chalcocite → Covellite with Heazlewoodite.

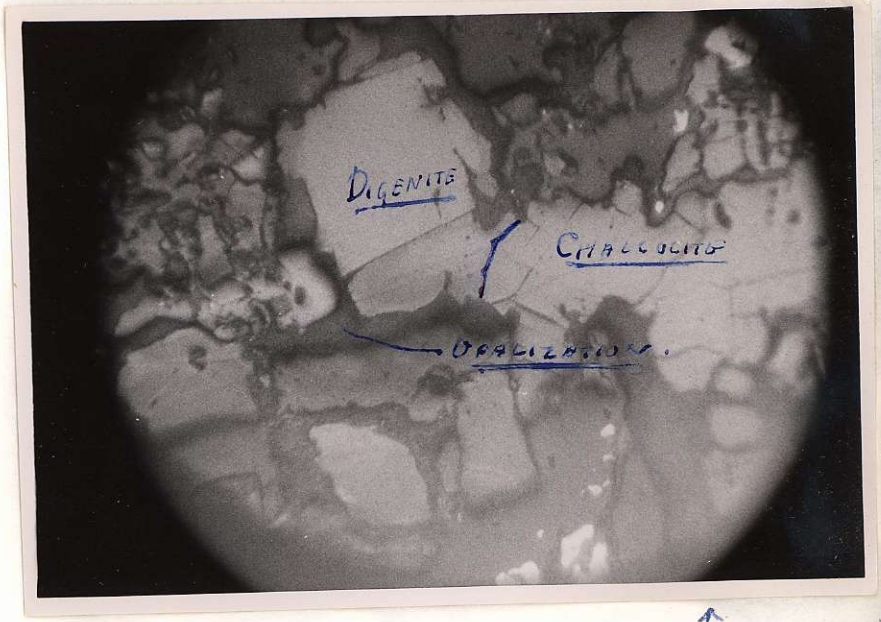
(Slightly Stereoscopic pair).

4 secs. HPX
Section 1
Xd nicols

As above — Chalcocite → covellite show up darker than heazlewoodite. covellite shows darker than Chalcocite.

Section 1

HPX

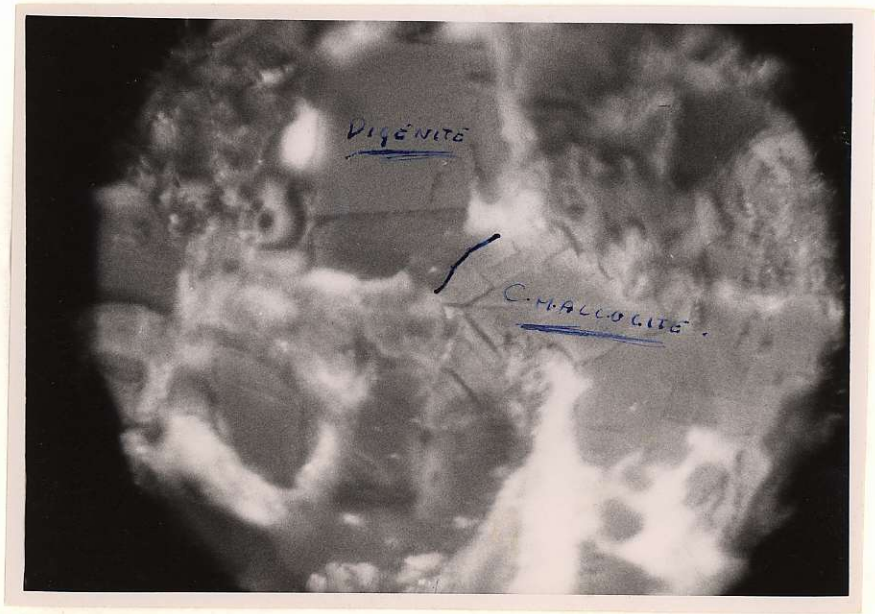


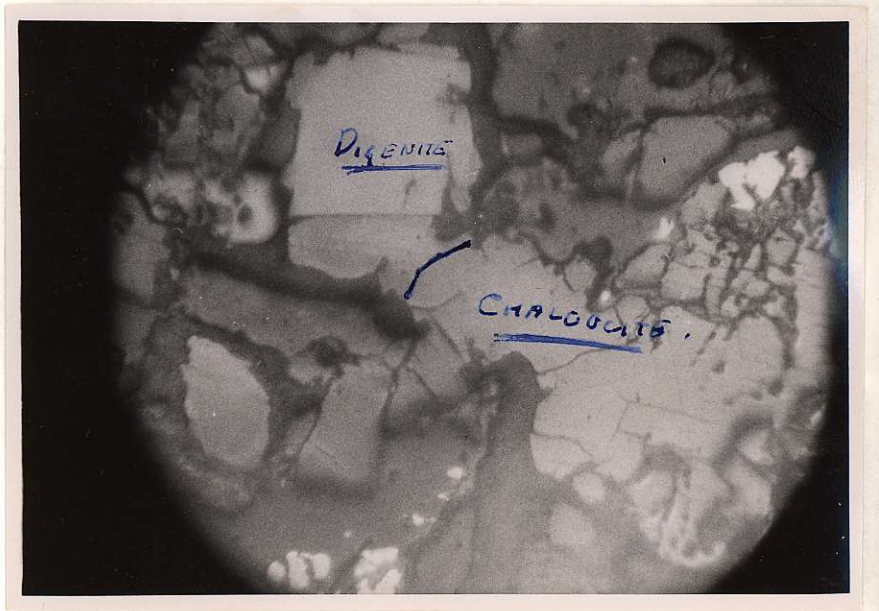
almost a good (Stereoscopic picture)

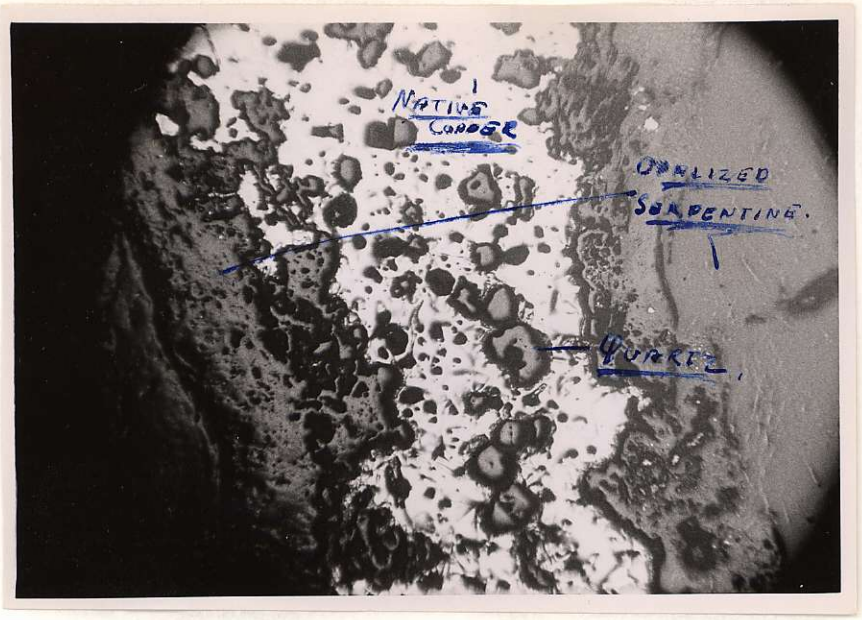
Xd - Nicols - 4 secs.

Digénite intergrowing Chalcocite.

1 Sec.

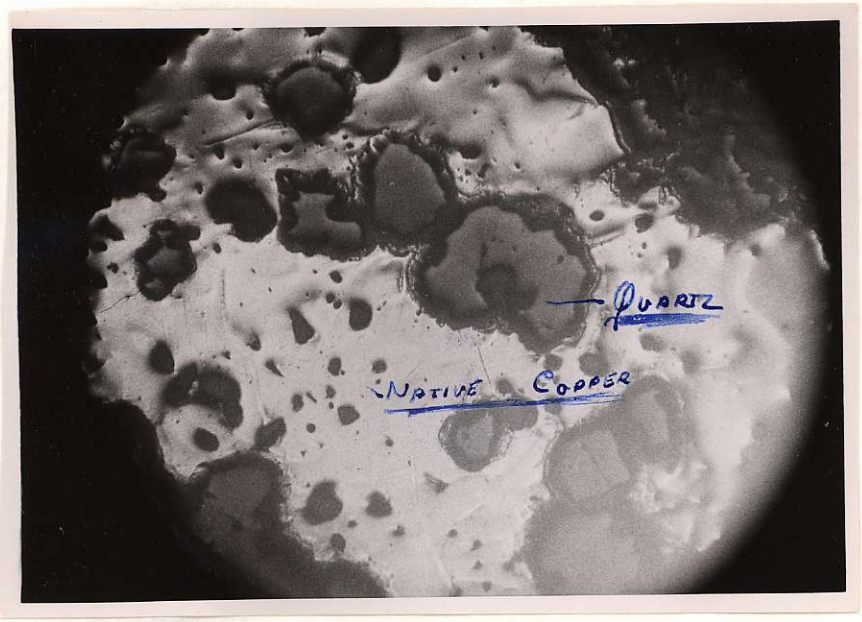






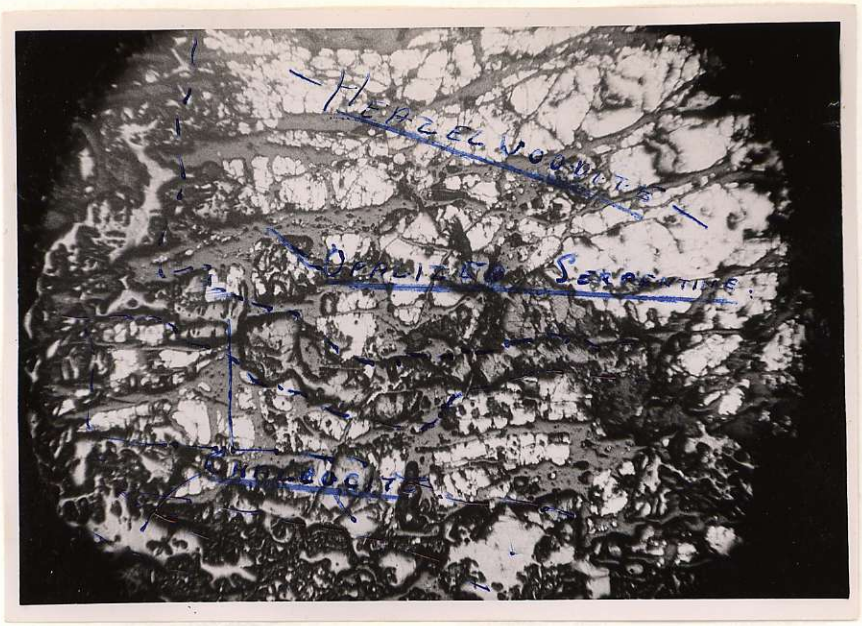
1 Sec LPX
Section 1

Native copper with clear relict quartz.



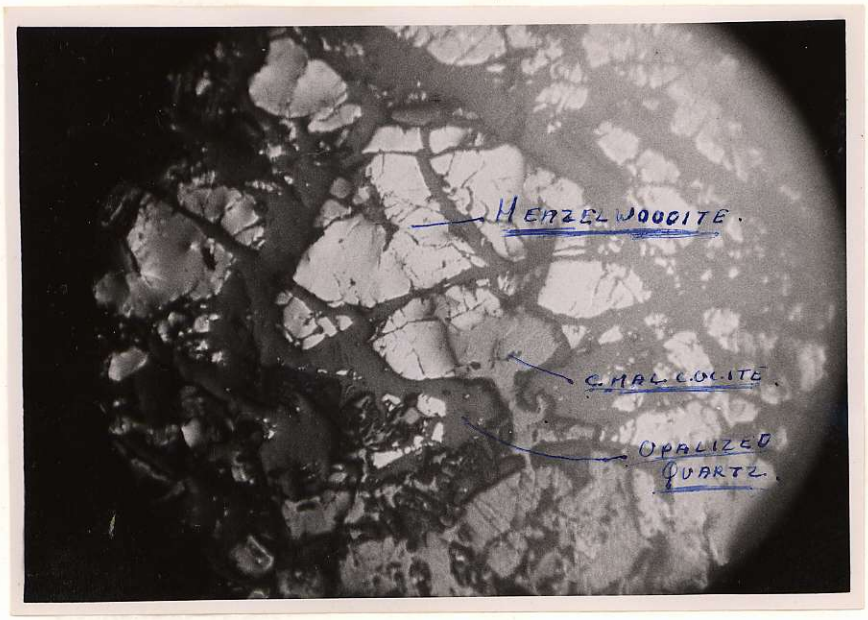
1 Sec MPX
Section 1

as above.



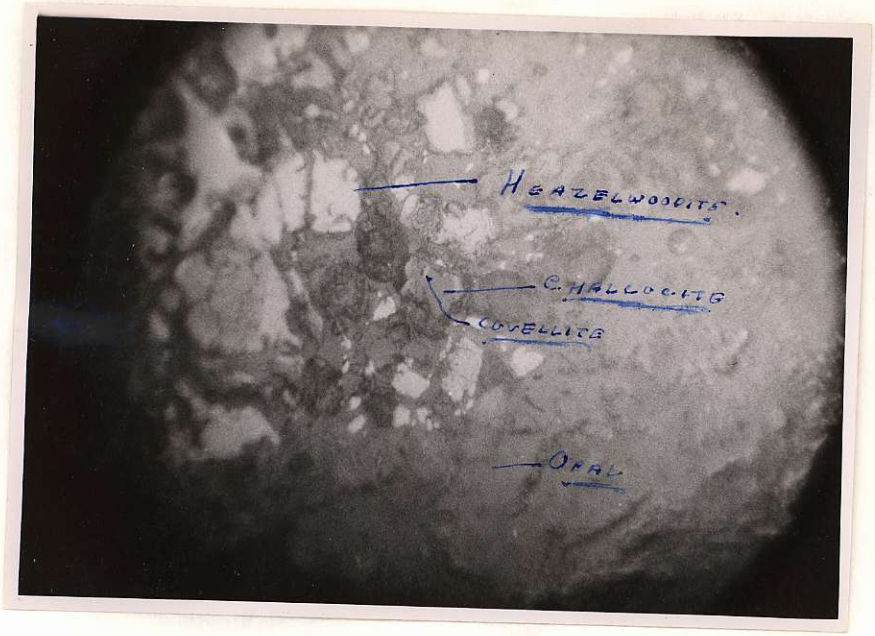
LPX
1 Sec
Section 1

Shows Chalcocite veining through "opalescent" silica and the fractures in heazlewoodite.



MPX
4 sec
Section 1
+ X-d nicols.

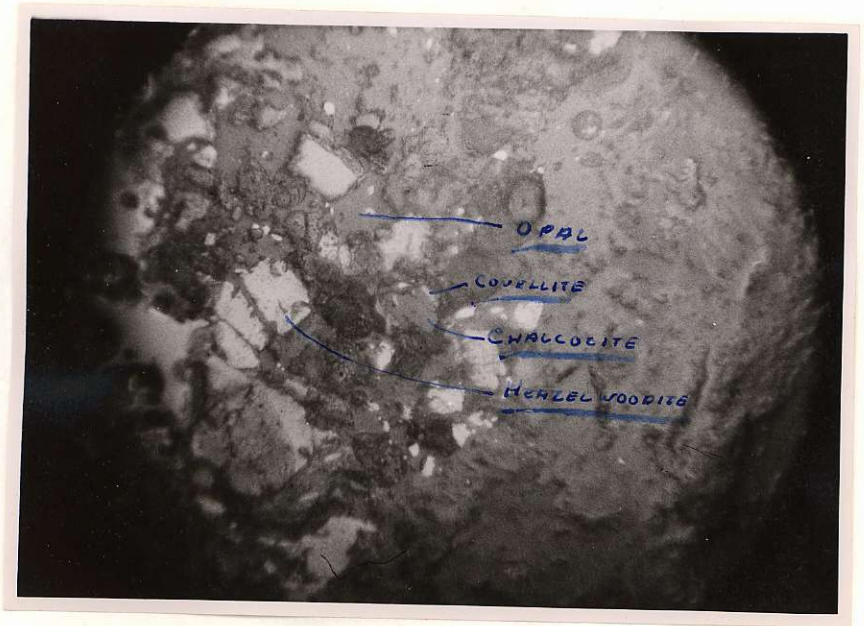
Shows Chalcocite intruding heazlewoodite.
- This is taken from the centre of the upper picture



1 sec HPX

Section 4

Covellite intruding Chalcocite.



As above

N.B.- Taken at a point where the pleochroic blue does not confuse the covellite with Chalcocite.

~~[illegible]~~

4 Secs x-d nicols

LPX

Section 1

Relationship of the malachite to Chromite and the relationship of the harder cupiferous variety of silica to malachite and heazelwoodite.

As above.