600311

MINERALOGRAPHY OF SPECIMENS

from the

FRENCH MINE,

HEDLEY, B.C.

PROBLEM #3

by

John C. Lund

February 19, 1962.

INTRODUCTION

Several hand specimens and polished sections together with one thin section were studied in preparation for this mineralographic report on ore specimens from the French Mine of Hedley, B.C. The mine is on the Oregon mineral claim situated on the east side of Cahill Creek at an elevation of 3900 ft. It is reached by an 8 mile road from Hedley, B.C.

The mine is in Triassic and later sediments described as a band of limy strata up to 60 ft. wide between fine-grained dark-colored tuffs. The mineralization is in a garnet-pyroxene skarn zone with a general dip to the north. The ore body is essentially a flat lying body of gold bearing garnet-diopside skarn of 12 ft. thick or less with an average grade, prior to 1955, of 0.8 oz. of gold/ton. The production (1960) averaged 45 to 50 tons per day with a 6 man underground crew to give a total production for 1960 of 11,553 tons milled and 6,470 oz. og gold recovered.

<u>Ref.</u> - Report of the Minister of Mines and Petroleum Resources (B.C.) 1957, 1960.

MEGASCOPIC

The three handspecimens described below are fairly representative of the suite examined.

(a) One specimen measuring 4½" by 2" is a dark dirty green colored rock with areas of brown staining and speckled by a silver-grey colored metallic platy mineral. The plates, which reach diameters of 7 mm, have a hardness of B, are brittle to the needle, and peel off in thin sheets. It is identified as Bi-telluride. Minute specks of gold, identified by the gold-yellow color, hardness of A and extreme sectility occur in close proximity to the Bi-telluride. The rock is a mass of garnet and pyroxine.

(b) This is a small specimen measuring 1¼" by 2" by 3/4" and is a green-brown rock composed essentially of diopside and garnet with silver-grey flecks of Bi-telluride and flecks of a silver-grey mineral with a pinkish cast. This latter mineral has a hardness of A, and is sectile to the needle. It is identified as native bismuth.

(c) The third specimen measures 2½" by 2" by 3½". It is a dark green-brown rock composed of diopside and garnet with nearly ½ the specimen composed of white wollastinite in massive and radiating form. It is identified by its reaction with HCl and its crystal form. The rock is speckled or flecked with soft blue-grey platy molybdenite, small bits of yellow, brittle chalcopyrite, gold, iridescent blue and indigo bornite, Bi-telluride, native bismuth, as well as two hard silver white minerals. One silver white mineral, identified as arsenopyrite, occurs as elongate prismatic crystals with a hardness of F most commonly observed in the wollastinite. The other silver white mineral occurs as formless masses, has a hardnessof F- and is probably safflorite as identified in polished section. Bits of sulphide form thin slivers between wollastinite needles.

MICROSCOPIC

<u>Thin Section</u>: The thin section is composed of granular diopside and isotropic garnets. Fractures in the garnet are filled with a mineral of high birefringent colors identified as calcite.

<u>Mineral #1</u>: Is a tin white to galena white colored mineral with a hardness of F, high relief relative to chalcopyrite and a smooth polish. It is moderately anisotropic, colors light brown to dark grey green. Etch reagents HNO_3 slowly stains grey-brown; HCl, KCN, $FeCl_3$, $HgCl_2$, and KOH negative. The mineral is identified as <u>arsenopyrite</u>. FeAsS.

<u>Mineral #2</u>: Is a galena white color with pinkish cast, has a hardness of F, relief similar to arsenopyrite and gives a smooth polish. It is isotropic. One cleavage is visible in some grains. All etch reagents give negative reactions. Identified as <u>cobaltite</u>.CoAsS.

<u>Mineral #3</u>: Occurs closely associated with cobaltite. It has a creamy white color, a hardnessof D or E, relief moderately high relative to chalcopyrite, and developes a smooth polish. It is isotropic. Etch tests HNO_3 stain brown iridescent, slight effervescence; $FeCl_3$ stains slightly; other reagents negative. X-ray confirms it as <u>skutterudite</u>.$(Co,Ni)As_2$.

<u>Mineral #4:</u> Has a galena white color, relief similar to arsenopyrite, a hardness of F and developes a smooth polish. It is strongly anisotropic, colors are shades of brown, grey, and grey-blue green. Etch reagents $FeCl_3$ slowly stains a sooty brown; HNO_3 brings out scratches and stains slightly; aqua regia stains dark. $HgCl_2$, KOH, HCl, KCN give negative

reactions. It is identified as <u>safflorite</u>. (Co,Fe)AS_2.

<u>Mineral #5</u>: Occurs as a galena white colored mineral with a hardness of E, relief near arsenopyrite and has a good smooth polish. Anisotropism, in shades of brown, is slight and difficult to distinguish. HNO_3 effervesces slightly and brings out fractures and cleavage. KOH stains slightly; all others give negative reaction. Microchemical tests give positive iron and <u>nickel</u> test, no cobalt. X-rays showed the mineral to be of the safflorite series and failure to get microchemical cobalt test suggests the mineral to be a <u>nickeliferous safflorite.</u> (Fe,Ni,Co)AS_2 (?)

<u>Mineral #6</u>: A distinct copper-pink color, strong anisotropism, hardnessof E, and smooth polish, serve to identify <u>niccolite</u>. NiAs.

<u>Mineral #7</u>: Has a grey color with a bluish tinge, a hardness of B, relief near chalcopyrite, and developes a poor, somewhat scaley polish. Anisotropism is strong, colors Etch test all negative. KCN stained slightly but rubbed off easily. It has been identified as <u>molybdenite</u>. MoS_2.

<u>Mineral #8</u>: Hardness of B, distinctive pink color and associated with chalcopyrite. The mineral is <u>bornite</u>.Cu_5FeS_4.

<u>Mineral #9</u>: A distinct yellow color, hardness of C, moderate relief and good polish are indicative of <u>chalcopyrite</u>.$CuFeS_2$.

<u>Mineral #10</u>: Occurs as small grey bodies in or at the contacts of chalcopyrite. It has hardness of D, relief just above chalcopyrite, and gives a good polish. Negative tb all etch tests. Internal reflection test not conclusive. The mineral is identified as <u>sphalerite</u>. (ZnFe)S.

Mineral #11: Occurs as minute blue grey to blue white veins and small bodies in chalcopyrite and bornite and along boundaries. It has a hardness of possibly C. Tests not conclusive but it may be chalcocite. Cu_2S.

Mineral #12: Is soft, has a hardness of A , white color, low relief, and developes a smooth polish with some pits. It is very slightly anisotropic with shades of grey. Etch reagent HNO_3 stains black, streaky; $FeCl_3$ speckled grey; HCl gives a grey color, KOH a dark stain that comes off easily, and $HgCl_2$ stains slight brown iridescent. Microchemical tests for Bi and Te proved positive. The mineral has been identified as Bismuth telluride, designated bismuth telluride. "(A)". (hedleyite Bi_5. Bi_2Te(?))or (joseite Bi_4 xTe_2-xS(?)).

Mineral #13: Is a smooth grey white colored mineral with a hardness of A, and a relief lower than mineral #11. It shows very slight pleochroism, moderate anisotropism, colors light and dark grey. HNO_3 quickly stains a patchy sooty-grey, slight effervescence; $FeCl_3$ stains slight blue iridescent; $HgCl_2$, blue iridescent, KOH stains dark, off easy. KCN and HCl give negative reactions. Microchemical tests positive for Bi and Te. Mineral desegnated bismuth telluride"(B)" (hedleyite or joseite).

Mineral #14: Is a smooth pinkish tan to pinkish white colored mineral with a hardness of A, sectile, and low relief. It is slightly anisotropic. Etch tests HCl turns black immediately; HNO_3 effervesces and stains blue iridescent; KCN test slight stain; $FeCl_3$ proved negative contrary to Short in "Microscopic Determination of Ore Minerals." Identified as native bismuth.

Mineral #15: Has a bright yellow color beside chalcopyrite, a hardness of A, and gives a smooth polish. Etch tests all negative except KCN which stains quickly dark. Mineral is identified as gold.

Minerals Present and Percentages:

Primary:	Arsenopyrite	FeAsS	-	1%
	Cobaltite	CoAsS	-	0.5%
	Skutterudite	$(Co,Ni)As_2$	-	11 %
	Safflorite	$(Co,Fe)As_2$	-	34 %
	Safflorite (nickeliferous)	$(Ni,Fe,Co)As_2$ (?)	-	.1%
	Niccolite	NiAs	-	2 %
	Molybdenite	MoS_2	-	8 %
	Bornite	Cu_5FeS_4	-	29.5%
	Chalcopyrite	$CuFeS_2$	-	5 %
	Sphalerite	(ZnFe)S	-	.2%
	Chalcocite (?)	Cu_2S	-	.2%
	Bismuth-telluride Hedleyite Joseite	$Bi_5.Bi_2Te$) $Bi_{4+x}Te_{2-x}S$)	-	5 %
	Native Bismuth	Bi	-	2 %
	Gold	Au	-	1.5%
Gangue Minerals:	Diopside	$Ca(Mg,Fe)Si_2O_6$		
	Garnet	$X_3Y_2(SiO_4)_3$		
	Calcite	$CaCO_3$		
	Wallastinite	Ca SiO_3		

Textures:

Safflorite, the most abundant mineral present, occurs as massive irrègular bodies and as subhedral grains showing an outline of two and sometimes three crystal faces. It forms replacement bodies within skutterudite leaving remnants of unreplaced mineral in the safflorite (Fig.1). In fig.3 safflorite forms corroded boundaries in part with Bi-telluride "B" suggesting replacement by the telluride. Pseudomorphs of safflorite after diopside show a definite replacement of the gangue minerals by safflorite. (Fig.2). It is replaced by niccolite along grain boundaries (Fig.2) and penetration of niccolite along gangue-safflorite contact. Crystal outline of diopside in niccolite is probably the replacement of the safflorite pseudomorphs by niccolite.

Relationships between arsenopyrite and the other minerals was not definitely established. One occurrence of a safflorite grain partially enclosed by arsenopyrite with chalcopyrite forming a narrow rim around the safflorite obliterating the safflorite-arsenopyrite contact, definitely shows the arsenopyrite to be earlier than chalcopyrite as would be expected. The only other definite relationship between arsenopyrite and safflorite suggested an intergranular texture and therefore contemporaneous deposition.

Skutterudite is present as massive irregular bodies which in some places show one or two cleavages. Replacement of cobaltite by skutterudite is suggested by the relationship shown in Fig. 4. Both cobaltite and skutterudite are replaced by chalcopyrite which forms corroded contacts with, and penetration into each, along cobaltite-skutterudite contact. Preference to skutterudite is shown by the greater penetration into this mineral.

Chalcopyrite forms exsolution bodies along crystalographic planes of bornite (Fig.7), penetration and replacement along laths of molybdenite (Fig.8), or caries texture in safflorite (Fig.1). Graphic intergrowths of chalcopyrite in Bi-telluride is probably replacement by Bi-telluride. Small inclusions of chalcopyrite occur within the skutterudite.

Molybdenite exhibits a flow texture around the nickeliferous safflorite showing a definite preference to the gangue minerals and an age relationship indicating a later deposition of molybdenite (Fig.6).

Bornite occurs as massive bodies with partial replacement of gangue minerals and skutterudite along the skutterudite-gangue contact (Fig.11).

Bi-telluride "A" and Bi-telluride "B" form mutual boundaries and caries texture in part which show no definite age relation. The occurrence of "B" on the periphery of "A" may be interpretted as replacement of "A" by "B".

Gold occurring as small blebs commonly in close relation to chalcopyrite (Fig.4, Fig.5), replaces chalcopyrite and possibly Bi-telluride. The relation to Bi-telluride is not conclusive however if Fig. 3 was to include the whole grain of gold it would be seen that the gold extends into the Bi-tellurides with smooth boundaries and may be a later placement of gold.

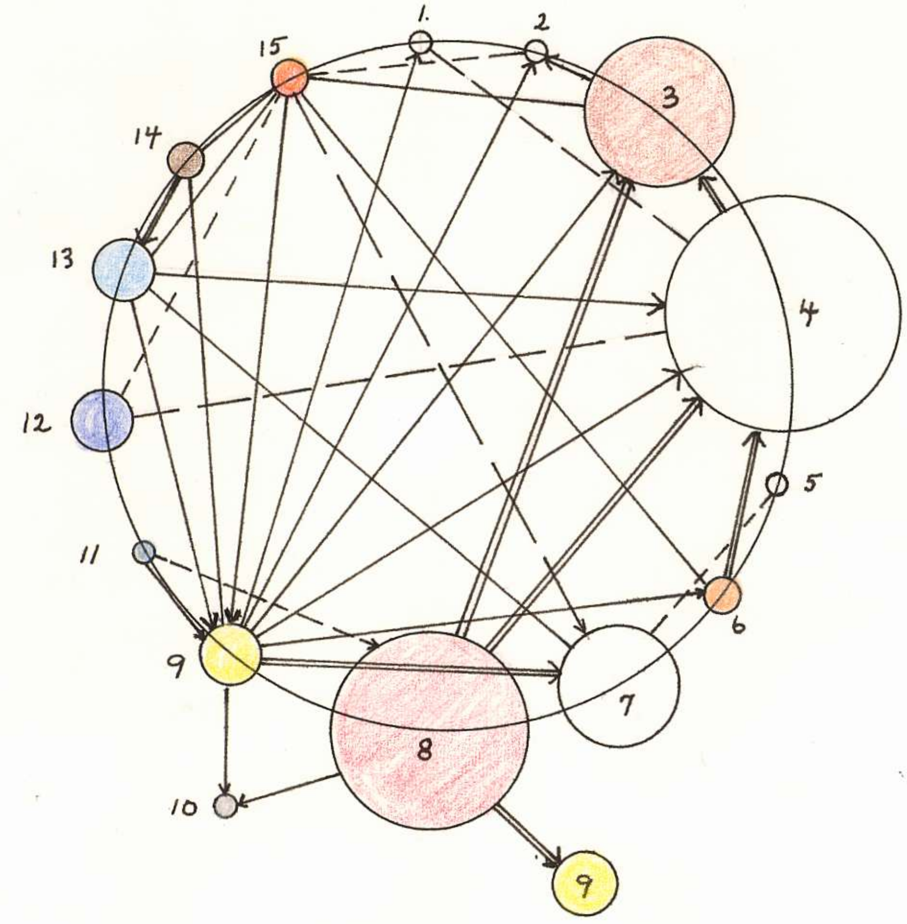
Native bismuth forms long lath-like replacements of Bi-telluride generally along the margins of the telluride (Fig.10). The bismuth comes in contact with but does not replace chalcopyrite.

Classification of Deposit and Conclusions:

The presence of high temperature metalic minerals safflorite, arsenopyrite, and cobaltite as well as others, and nonmetalic high temperature gangue minerals places the deposit in the high temperature class. Wollastinite forms at 450°C., chalcopyrite forms solid solution with bornite at 475°C and with rapid cooling developesslivers and star-like exsolution bodies of chalcopyrite along (111) crystallographic planes of bornite. The euhedral grains of diopside and arsenopyrite, the radiating character of the wollastinite as well as the evidence for rapid cooling suggests a high temperature -- low pressure formation.

The deposit is probably a high temperature -- low pressure replacement deposit, that is, a pyrometasomatic deposit.

Paragenetic sequence



1. Arsenopyrite
2. Cobaltite
3. Skutterudite
4. Safflorite
5. Safflorite (Nickeliferous)
6. Niccolite
7. Molybdenite
8. Bornite
9. chalcopyrite
10. sphalerite (?)
11. chalcocite (?)
12. Bi-telluride "A"
13. Bi-telluride "B"
14. Native Bismuth
15. Gold.

No such animal.

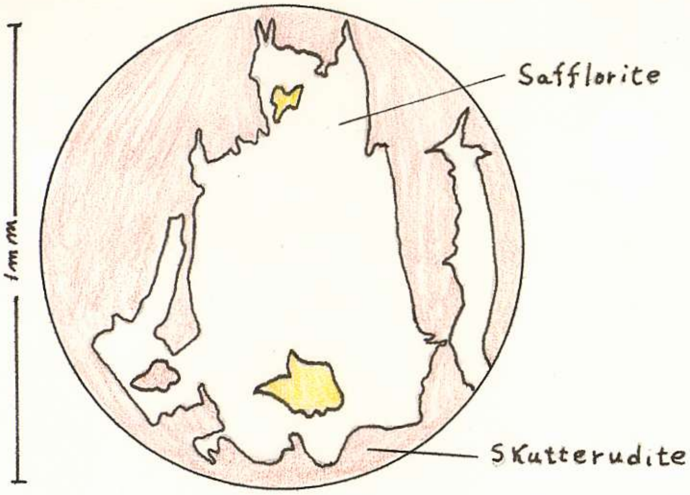


Fig 1

Replacement of skutterdite by safflorite. Remnant of the replaced mineral in the safflorite.

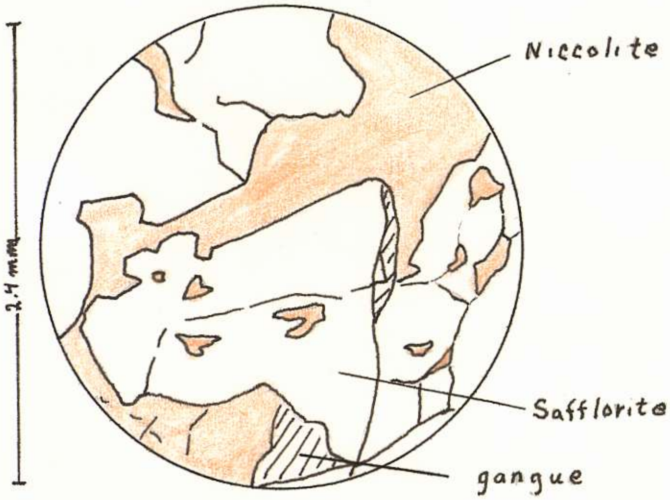


Fig 2

Replacement bodies of nicc-olite along grain boundaries of safflorite.
Note the Xtal outline in saff-lorite; probably pseudomorph after diopside. The pseudom-orphs in turn are replaced by niccolite.

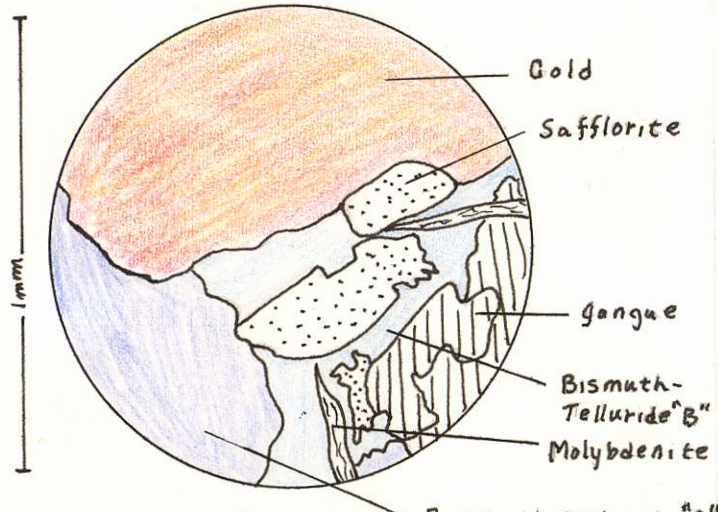


Fig 3

Mutual boundaries between gold and Bi-tellurides. Corrode texture in part of safflorite in contact with Bi-telluride "B". suggests replacement of safflorite.

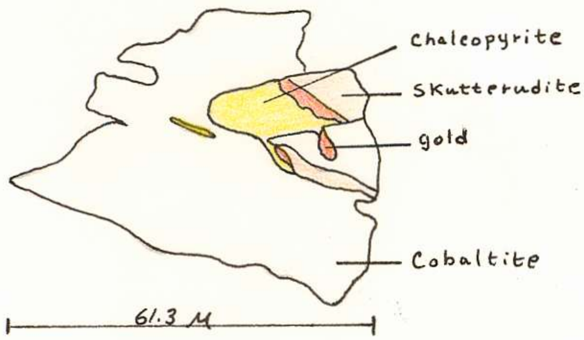


Fig 4

Replacement of Cobaltite by Skutterudite.
Partial replacement of Skutterudite by chalcopyrite.
Gold replaces chalcopyrite along skutterudite-chalcopyrite contact

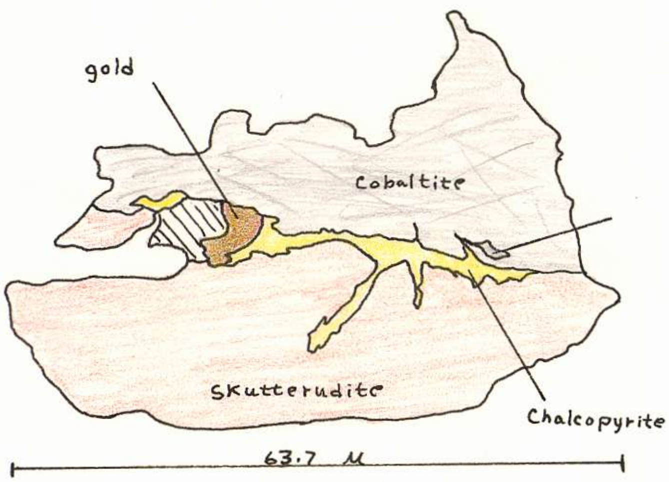


Fig 5

HNO_3 Etch: Replacement by chalcopyrite of cobaltite and skutterudite along the contact.
Note the apparent preference to skutterudite.
Gold is dark from KCN etch Test.

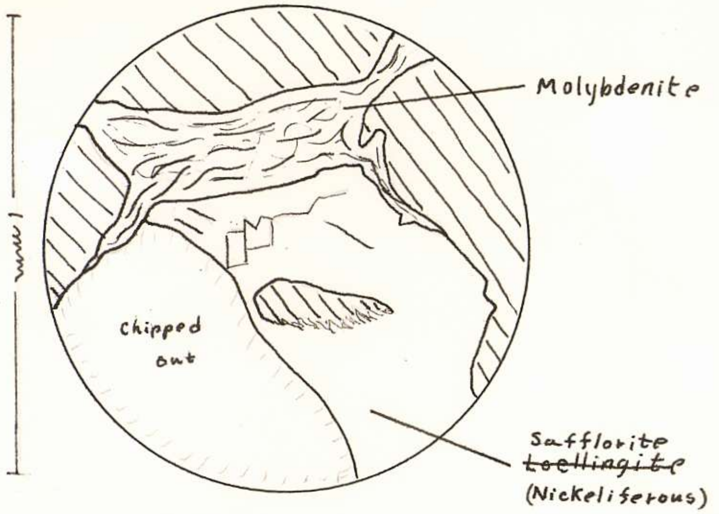


Fig 6

Molybdenite replaces the gangue minerals in preference to the ~~loellingite~~. Safflorite
Note the flow texture of the molybdenite around ~~loellingite~~ safflorite

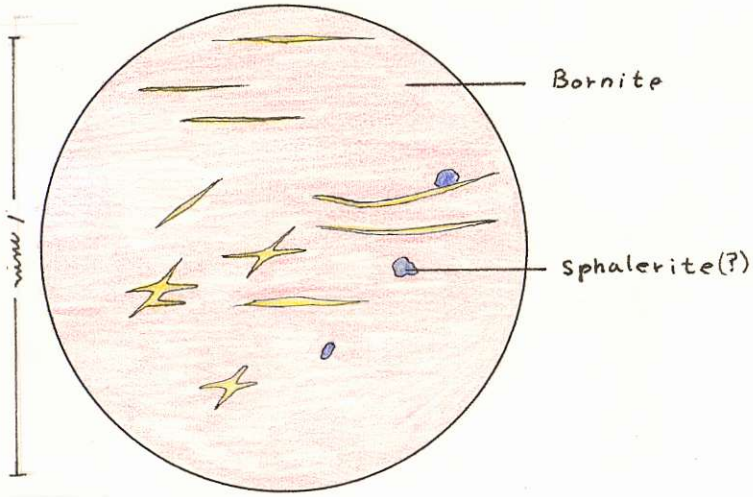


Fig 7

Exsolution texture of Chalcopyrite from bornite along Crystallographic planes

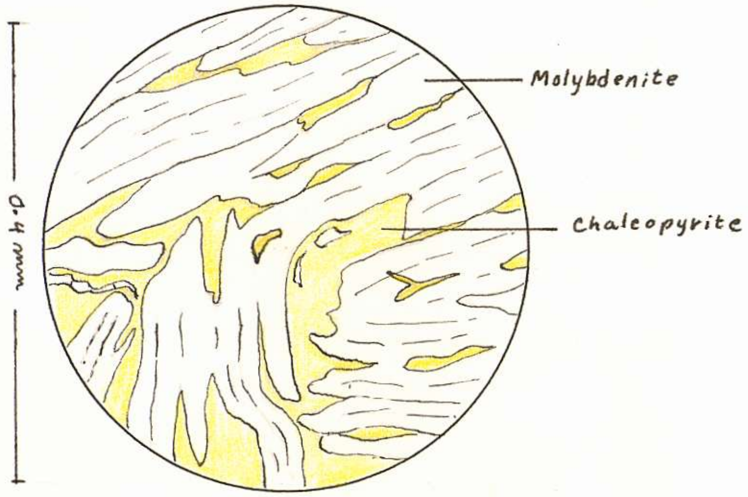


Fig 8

Penetration of chalco-pyrite along Molybdenite "laths" with partial repl-acement of Molybdenite.

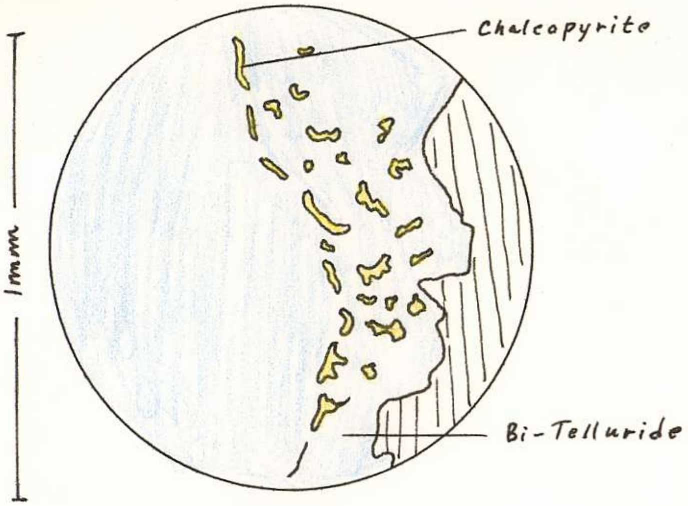


Fig 9

Graphic intergrowth of chalcopyrite in Bi-telluride.
Replacement of chalcopyrite by Bi-telluride.
Note the marginal occurence of chalcopyrite.

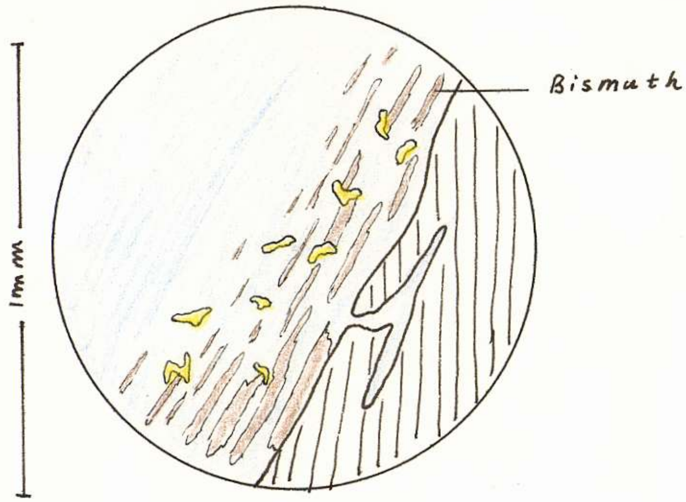


Fig 10

Replacement of bismuth -telluride by native bismuth.
Note particularly the bismuth chalcopyrite relation. The bismuth is in contact with but does not replace chalcopyrite.

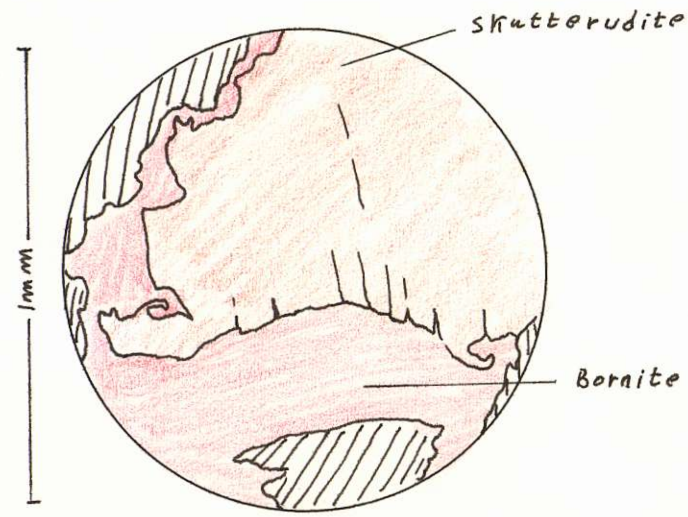


Fig 11

Penetration of bornite along skutterudite-gangue contact with partial replacement of both gangue and skutterudite.