Bit sloppy in places

1st Class.

Geology 409 Report on

THE MINERALOGY OF THE OREGON PROSPECT, HEDLEY, B. C.

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LIST OF ILLUSTRATIONS

THE MINERALOGY OF THE OREGON PROSPECT, HEDLEY, B.C.

I INTRODUCTION

The Oregon is a gold prospect located on the north-east side of the Similkameen Valley a few miles southeast of Hedley. More specifically, it is about five miles south of Nickel Plate Mine and two miles southwest of the Good Hope Mine. The Oregon is at present under exploratory development by the Kelowna Exploration Company Ltd., and most of the specimens (Specimens 1 - 11) examined for this report are drill core samples taken from diamond drill holes placed in the course of this exploration. One specimen (Specimen 12) was taken from a diamond drill core obtained during earlier exploration, and two (Specimens 13 and 14) were taken from surface workings. The specimens examined and their locations are listed below.

Location	Specimen	Polished Section
DDH K-1 @ 28 - 30'	1	1
DDH K-2 @ 36 - 41'	2	2
DDH K-8 @ 60 - 65'	3	3
DDH K-9 @ 65 - 68'	4	4
DDH K-11 @ 41 - 47'	5	-
DDH K-23 @ 19 - 25'	6	-
DDH K-23 @ 35 - 39'	7	7
DDH K-24 @ 53 - 56'	-	8
High-grade specimen	-	9
" " "	-	10
" " "	-	11
Old DDH #4 @ 20'	-	12
Surface cut below #1 Adit	-	13
Portal of #1 Adit	14	14

II MINERALOGY

A. Macroscopic

A macroscopic examination of the specimens revealed little information of importance. Specimen 13 showed heavy bornite-chalcopyrite-safflorite mineralization, but drill core specimens showed only sparse disseminated mineralization, mainly as grains too small to be definitely identified. The gangue is a heavy garnet skarn containing some calcite.

B. Microscopic

1. Nonmetallic minerals

One thin section was prepared and examined. The nonmetallic minerals determined in it are garnet (silicate of Ca, Al, Fe, Mn) 30%; axinite (silicate of Ca, Al, (Fe, Mn), B, H.) 20%; hedenbergite (silicate of Ca, Fe, Mg), 40%; calcite ($Ca\ CO_3$), 10%; and minor quartz (SiO_2). The texture is poikiloblastic, with megacrysts of garnet, axinite, and calcite, and inclusions and groundmass of microcrystalline hedenbergite and occasional quartz. The metallic minerals appear to replace the groundmass rather than the megacrysts.

2. Metallic minerals

The metallic minerals and the sections in which they occur are listed on the following table.

Mineral	Polished Section in which found											
	1	2	3	4	7	8	9	10	11	12	13	14
Chalcopyrite $CuFeS2$	x	x	x	x	x	x	x	x	x	x	x	x
Safflorite $CoAs_2$(+Fe)	x		x	x	x	x	x	x	x	x	x	x
Bismuth Bi	x		x	x	x	x	x	x	x		x	
Bismuth tellurides -- Hedleyite $Bi_5Bi_2Te_3$ Joseite B Bi_4Te_3S			x	x	x		x	x	x		x	
Gold Au	x		x	x	x		x	x	x			
Bornite Cu_5FeS_4		x				x				x		x
Chalcocite Cu_2S						x				x		x
Covellite Cu S						x						x
Grey unknown mineral		x				x						
Molybdenite MoS_2		x						x				
Cobaltite CoAsS											x	

(a) Chalcopyrite.

Chalcopyrite is the most widespread of the minerals, but except where it is associated with bornite it occurs only in small amounts. Where associated with bornite it is the product of the exsolution of a bornite-chalcopyrite solid solution; elsewhere it occurs as replacement of gangue, safflorite, bornite, and the unknown grey mineral.

(b) Safflorite.

Safflorite is also very widespread, though it occurs in very minor amounts in most sections. It occurs in grains up to 3 mm by 6 mm where abundant, and in places shows crystal boundaries. It replaces gangue and cobaltite, but is replaced by most of the other minerals.

(c) Bismuth.

Bismuth occurs in most of the sections and is notably associated with chalcopyrite, bismuth tellurides, and gold. It is later than the bornite-chalcopyrite and later chalcopyrite mineralization, apparently contemporaneous with the bismuth tellurides mineralization, and earlier than the gold mineralization.

(d) Bismuth tellurides.

Two bismuth tellurides were found in the sections, hedleyite ($Bi_5Bi_2Te_3$) and joseite B (Bi_4Te_2S). They are treated together because there is no evidence to suggest that they were not deposited contemporaneously, and because they cannot be distinguished from one another except by X-ray determination unless they occur in contact. When the two are in contact, hedleyite is distinguished by its slightly darker [lighter] ? color. The tellurides are apparently contemporaneous with the native bismuth. X

(e) Gold

Gold occurs in many of the sections but is not abundant and is usually in grains less than 0.02 mm in diameter. It is in marked association with bismuth and the bismuth tellurides and appears to be later than these minerals. It is conspicuously absent from sections showing heavy bornite-chalcopyrite mineralization.

(f) Bornite.

Bornite does not occur in many of the sections, but where it does occur it is very abundant, and often in fairly large grains. It almost invariably contains exsolved chalcopyrite as lamellae or rounded grains. Bornite is later than safflorite and earlier than covellite, chalcocite, late chalcopyrite, and bismuth.

(g) Chalcocite.

Chalcocite occurs in minor amounts in several of the sections but is abundant in none. It occurs in or is associated with bornite, and replaces it, but indications of age relationships with any of the other minerals except covellite are lacking. It is possible that the chalcocite is supergene, but no evidence is present to either prove or disprove this possibility.

(h) Covellite.

Covellite, like chalcocite, occurs in very minor amounts associated with bornite, which it replaces. It is replaced by chalcocite, and may be either supergene or hypogene.

(i) Molybdenite.

Molybdenite occurs in only two sections, and is abundant in only one, Section 10. It replaces gangue, and is replaced by bornite and the bismuth tellurides.

(j) Cobaltite.

Cobaltite occurs in only one section, but is abundant in that section and occurs in large grains, some showing crystal boundaries. It was deposited before safflorite, and is apparently the oldest mineral occurring in the sections examined.

(k) Unknown Grey Mineral.

This mineral occurs in only two sections, and is associated with bornite in both. In Section 2 it occurs as replacements of gangue and bornite, and in Section 8 it occurs as rims around bismuth and chalcocite, apparently replacing bornite. It is replaced by the late chalcopyrite mineralization and therefore cannot be supergene. It is a very soft mineral, blue-grey in color (in polished section), weakly anisotropic, and negative to all standard etch reagents. An X-ray photograph did not give positive identification, but the pattern showed its strogest lines in the vicinity of the lines of petzite $[(Ag,Au)_2Te]$.

3. Descriptions of Polished Sections.

(a) Section 1.

Safflorite, chalcopyrite, bismuth, gold.

Safflorite is most abundant and is first deposited, occurring as irregular replacements in the gangue, ~~and~~ some up to 1 mm long. Chalcopyrite is next most abundant, and occurs as blebs and mesh-like replacements in gangue and as rim replacements of safflorite. Bismuth is minor and occurs as replacement of gangue, frequently in association with safflorite and chalcopyrite but with no definite age relationship. (Fig. 1). Gold occurs in a few places as small blebs (up to 0.01 mm) in chalcopyrite.

(b) Section 2.

Bornite, chalcopyrite, unknown grey mineral, molybdenite.

Bornite is most abundant, occurring as replacements of gangue in irregular grains up to 0.35 mm in diameter. It shows definite vein and core replacement of a grain of molybdenite. Chalcopyrite is next most abundant and appears to be of two ages of deposition. It occurs early as exsolution blebs in bornite, replaced in places by the unknown grey mineral, and later as irregular replacements of gangue and vein replacements of bornite and the unknown grey mineral. The unknown grey mineral is fairly abundant also, occurring as replacements of gangue, bornite, and early chalcopyrite. Molybdenite occurs only in one equidimensional grain, about 0.35 mm in diameter, as a replacement of gangue, and is replaced by bornite.

(c) Section 3.

Safflorite, chalcopyrite, bismuth tellurides, bismuth, gold.

Safflorite is most abundant, occurring as fairly regular grains in the gangue, some as much as 1.0 mm in diameter. Chalcopyrite is fairly abundant and occurs as very irregular replacements of gangue. Bismuth and bismuth tellurides are minor, and occur free in the gangue and associated with chalcopyrite, but the age relation is not indicated. Gold occurs as grains up to 0.02 mm associated with bismuth and chalcopyrite. In one place it shows fairly conclusive evidence of replacement of chalcopyrite along a grain boundary.

(d) Section 4.

Safflorite, chalcopyrite, bismuth, bismuth tellurides, gold.

Safflorite is the dominant mineral in this section, and occurs as roughly equidimensional grains up to 2 mm in diameter replacing gangue minerals. Chalcopyrite occurs as irregular grains in gangue and also as a replacement of safflorite, in veins and along grain boundaries, Bismuth occurs as irregular grains, usually associated with chalcopyrite. It is common as rounded blebs in chalcopyrite, of doubtful age relation. In one place it occurs with chalcopyrite as the filling of a fracture in safflorite. Bismuth telluride is very sparse and is unassociated with other minerals. Gold occurs only once, as a small grain enclosed in chalcopyrite.

(e) Section 7.

Bismuth telluride, bismuth, chalcopyrite, safflorite, gold.

Bismuth telluride and bismuth are the dominant minerals, and in most grains are together. They occur as intergrowths and blebs of one in the other and appear to be of contemporaneous deposition. Chalcopyrite and safflorite are sparse and occur as separate small grains replacing gangue. Gold occurs in several places in association with bismuth telluride and bismuth and appears to be of later deposition, though no definite evidence of this is apparent.

(f) Section 8.

Safflorite, bornite, bismuth, chalcocite, grey unknown mineral, chalcopyrite, covellite.

Safflorite is most abundant and occurs as grains up to 2 mm in diameter, some showing straight crystal boundaries. It is apparently the first mineral deposited, and seems to be less easily replaced by later minerals than the gangue, for the later minerals frequently occur as gangue replacement bounded on one side by crystal boundaries of safflorite. Inclusions of gangue in the grains are common, some replaced by chalcocite. Bornite is next most abundant, occurring mainly as replacements of gangue, but occasionally as rim replacements of safflorite. Bismuth and chalcocite have similar modes of occurrence, but nowhere show evidences of their relative ages. They occur as small grains replacing gangue, and as grains replacing bornite, frequently at the tips of elongated bornite grains. In one place chalcocite occurs in a replacement veinlet cutting bornite, exsolved chalcopyrite, and a veinlet of covellite. (Fig. 2). Chalcopyrite occurs as exsolution lamellae in bornite. The grey unknown mineral occurs in this section as rims around grains of bismuth and chalcocite in bornite, and appears to be advancing outward, replacing the bornite. (Fig. 3).

(g) Sections 9, 10, 11.

Bismuth telluride, bismuth, chalcopyrite, safflorite, gold, molybdenite.

These sections were cut from the same specimen, and with one exception contain the same minerals. The exception is Section 10, which contains molybdenite in addition to the minerals found in Sections 9 and 11. Molybdenite occurs in lath-shaped grains up to 3 mm long replacing gangue. Bismuth and bismuth tellurides occur as disseminated grains in gangue, frequently intergrown and suggesting contemporaneous deposition. Bismuth tellurides also occur associated with molybdenite in a manner that suggests replacement of the molybdenite along crystal planes. (Fig. 4) In Section 9, bismuth occurs in one place as an almost complete core replacement of a grain of chalcopyrite. Gold is fairly abundant in the section and occurs in grains up to 0.25 mm in length that may be either free in the gangue or associated with other minerals. (Fig. 5). The age relation of the gold to the other minerals is not indicated.

(h) Section 12.

Bornite, chalcopyrite, chalcocite, safflorite.

The mineralization of this section is fairly heavy, though disseminated, and is made up largely of bornite and exsolved chalcopyrite, indicating deposition of the two minerals as a solid solution. The bornite has occasional thin veinlets of covellite crossing the grains. Small grains of safflorite occur in a few places as replacements of gangue.

(i) Section 13.

Safflorite, bornite, chalcopyrite, chalcocite, covellite.

Mineralization is heavy, with safflorite, bornite, and chalcopyrite as the chief minerals. Safflorite occurs in irregular grains up to 3 mm by 6 mm as a replacement of gangue. It is badly fractured in places. Bornite occurs as fairly large grains replacing safflorite and gangue. Fractures in safflorite are interrupted by patches of bornite in the grains of safflorite. Chalcopyrite occurs wholly as exsolution from bornite. Stages of exsolution from minute lamellae of chalcopyrite through small blebs of chalcopyrite in bornite to large rounded grains of almost pure chalcopyrite are illustrated. (Figs. 6,7). Chalcocite occurs as small rounded blebs in bornite and gives no good indication of age relationships.

(j) Section 14.

Cobaltite, safflorite, bismuth tellurides, bismuth, chalcopyrite.

This section also shows heavy mineralization, but cobaltite is the most prominent mineral. It occurs generally as irregular grains up to 6 mm in diameter replacing gangue, but in some places shows straight crystal boundaries. Safflorite occurs as replacements of gangue and cobaltite, (Fig. 8), in some places it has almost completely replaced cobaltite grains but still contains small irregular inclusions of cobaltite. The cobaltite and safflorite are badly fractured; continuous fractures pass through gangue, cobaltite, and safflorite, but are interrupted by blebs and veinlets of bismuth and bismuth tellurides. Bismuth and bismuth tellurides occur as irregular blebs and smooth grains in gangue, cobaltite, and safflorite. They are intergrown in places and occur as inclusions in one another, suggesting contemporaneous deposition. In one place bismuth shows good evidence of replacement of cobaltite along a crystal boundary within a grain. Chalcopyrite is of minor importance and gives no indication of its age relation with the other minerals.

III PARAGENESIS

An examination of the occurrences of the various minerals as shown on page 4 and the age relations as described under the section dealing with the individual minerals reveals several features that appear to be too uniform to be coincidental, even though the number of sections examined was small. These features are:

(i) the Co-As minerals are early and widespread.

(ii) the Cu minerals are all intermediate in age and are fairly restricted.

(iii) the Bi-Te minerals and gold are late and are widespread, though not so much so as the Co-As minerals.

These features suggest that the mineralization took place in three stages, and that the sequence of deposition is as follows:

Stage 1. Cobaltite
Molybdenite
Safflorite

Stage 2. Bornite - chalcopyrite
Unknown grey mineral
(Covellite)
(Chalcocite)
Chalcopyrite

Stage 3 Bismuth - bismuth telluride
Gold

Supergene ? ? Covellite
Chalcocite

The position of molybdenite and gold in their respective stages is conjecture, but their position in these stages appears fairly definite. The widespread occurrence of chalcopyrite suggests that it may be a part of the mineralization of Stage 3, but its composition suggests Stage 2. It may be that the chalcopyrite represents a transition from Stage 2 to Stage 3.

IV TEMPERATURE OF DEPOSITION *

The presence of cobaltite, molybdenite and safflorite in Stage 1 suggests a temperature of over 500° C.; the deposition of the bornite-chalcopyrite solid solution in Stage 2 suggests a temperature of 475° C or higher; and the presence of bismuth in Stage 3 suggests a temperature of 270° C or lower. It is possible that the change in mineralogy from Stage 1 to Stage 3 is the expression of a continuous reduction of temperature, and that the complete mineralization was achieved in one period. The presence of exsolution lamellae of chalcopyrite in the crystal planes of bornite indicates a comparatively rapid cooling**, and thus supports the idea of a single period of mineralization.

* Edwards, A.B., Textures of the Ore Minerals pp 118-129 Australasian Institute of Mining and Metallurgy, 1947.

** loc. cit., p 82.

V TYPE OF DEPOSIT

The mineralogy and textures of the specimens studied are typical of contact metamorphic deposition.

Acknowledgments.

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Fig. 1: Association of safflorite, bismuth, and chalcopyrite (Section 1)

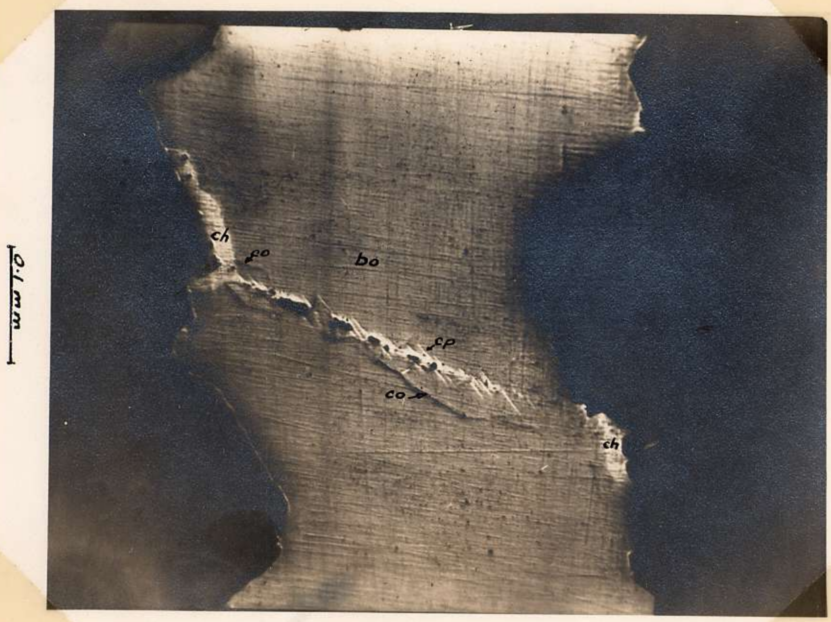

Fig. 2: Bornite (with exsolution lamellae of chalcopyrite) showing replacement by chalcocite (Section 8)

bi bismuth; bo bornite; co covellite, cp chalcopyrite; sa safflorite.

Fig. 3: Bismuth and unknown grey mineral in bornite (Section 8)

Fig. 4: Molybdenite lath with replacement of bismuth tellurides along crystal planes (Section 10)

bi bismuth; bo bornite; mo molybdenite; te bismuth telluride; u unknown grey mineral.

Fig. 5: Association of gold, bismuth tellurides, and chalcopyrite (Section 11)

cp chalcopyrite; g gold; te bismuth telluride.

Fig. 6: Early stage of exsolution of chalcopyrite from bornite-chalcopyrite solid solution (Section 13)

Fig. 7: Late stage of exsolution of chalcopyrite from bornite-chalcopyrite solid solution (Section 13)

bo bornite; cp chalcopyrite.

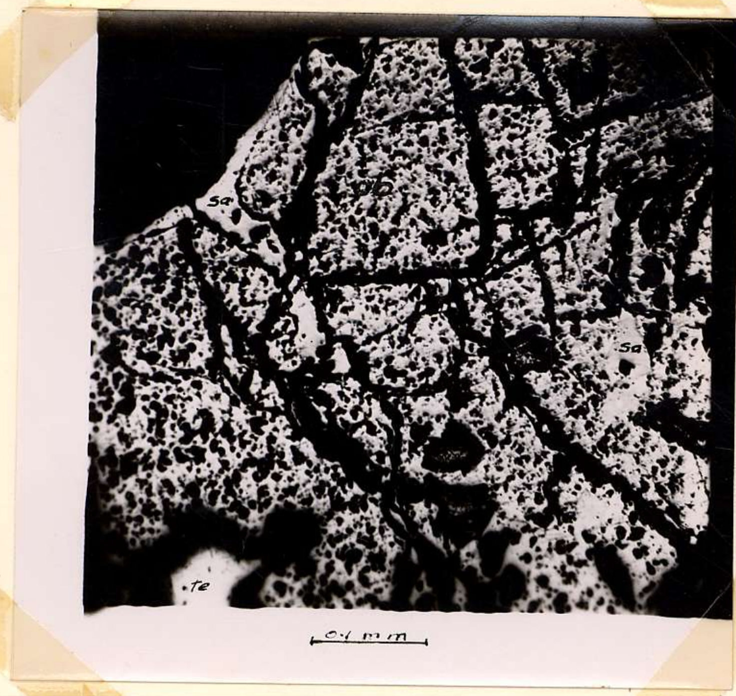

Fig. 8: Replacement of cobaltite by safflorite along a fracture (Section 14)

cb cobaltite; sa safflorite; te bismuth telluride.