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MINERALOGRAPHIC REPORT

Some Properties Situated on Bornite Mt.,

Terrace Area, B.C.

Geology 409 Charles J. Brown
U.B.C. 1951.

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Abstract

A study of the minerals and ores from some of the properties situated on Bornite Mountain, near Terrace, B.C. has been made and the following report resulted. This report is an attempt to recognize various metallic minerals present, the sequence of deposition and the extent of the secondary alteration that they have undergone.

Introduction

The following properties are covered in this report:

1. I. X. L. claim
2. Emma claim
3. Copper Mine claim
4. Arden claim
5. Ptarmigan claim

In addition to these properties a megascopic examination was made of a specimen marked "Bornite Mountain, Skeena River, B.C.".

Mineral claims were first staked in the Terrace area in about 1893, the Emma and I. X. L. properties being among the first. The Ptarmigan claim was located in 1899 and by 1910 over 200 individual properties had been recorded. (1)

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(1) E.D. Kindle, Mineral Resources, Usk to Cedarvale, Terrace, Area, Coast District, B.C.; B.C. Geological Survey, Memoir 212 Page 9.

Purpose and Method of Study

The purpose of this report is two-fold. It is primarily written in order to acquaint the writer with the methods and techniques used in the Mineralographic study of opaque minerals. The second purpose is to enlarge the writer's knowledge of mineral deposits adjacent to and in the Coast Range Batholith of B.C.

The Method of study used is standard to elementary mineralographic work. The study of specimens commenced with the examioation of ~~Hand~~ Specimens with the aid of a hand lens.[1] Polysections were made in order to identify the various mineral assemblages, to asses their reaction, to etch tests and to determine where possible their paragenitic relationships.[2] Extensive use was made of a reflecting microscope. Microchemistry was used when necessary in order to confirm the presence of some of the elements present in the various minerals recognized under the reflecting microscope.

It is hoped that the following report will be of some assistance in further work on these and similar deposits.

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(1) W.E. Ford, Dana's Textbook of Mineralogy, Fourth Edition, April, 1947.

(2) M. N. Short, Microscopic Determination of the Ore Minerals, U.S. Geological Service Bulletin 914 Second Edition 1948.

Geology

The area lies along a part of the Eastern Contact Zone of the Coast Range Batholith and the Mesozoic rocks of the Terrace Area. Outcrops of Triassic Rocks cover only a few square miles and occur as small roof pendants. The Jurassic rocks comprise what is known as the Hazelton Group. This group consists chiefly of andesitic flows, tuffs and breccias with some local sediments consisting of Sandstone, Conglomerates, slates and argillite. Both the sediment and volcanic divisions of the Hazelton group are cut by the Coast Range intrusives and contain a great number and variety of mineral deposits. These mineral despoits occur along faults, in shear zones, or in the intrusives nearby. The deposits are believed to have been derived from a common source, the Coast Range Batholith. There appears to be a gradual change in the type of deposit found as the distance away from the intrusive increases. The higher temperature minerals occur near the contact. It is probable the mineralizing fluids rose from a source directly beneath the deposits and that the horizontal gradation is, in reality, a vertical zoning as a result of the increasing depth of sediments and volcanics in a direction Northeastward from the Contact zone.

The rocks in the immediate vicinity of Bornite Mountain are andesitic lavas and tuffs, traversed in places by quartz veins striking generally in a Northeasterly direction and with a moderately steep dip. Stocks of granite, granodiorite and quartz diorite cut these volcanics and those contacts are seen on the various properties.

A specimen from the Arden claim has to be considered separately because the presence of specularite and the nature of the gangue would seem to indicate a pyrometasomatic origin.

Recognition and Paragneiss of the Minerals Contained in the Individual Ores from the Various Properties.

Specimen marked:

No. 2912 - Rich ore, Ptarmigan Mine, Singlehurst, Bornite Mt., Kitsilas.

Megascopic Examination

Only one metallic mineral could be seen with the aid of a hand lens. It had the following properties: Massive, flint black colour, H.3-4, S.G. 4.5-5, metallic lustre, opaque and had a brownish black streak. This mineral was tentatively identified as tetrahedrite.(1) The mineral appeared evenly distributed throughout the rock. It was apparently deposited as a vein material and is associated with milky coloured quartz which is the chief gangue material. There is a minor amount of malachite and azurite deposited as a coating on the surface of the tetrahidrite. There is a small amount of limonite present and it is chiefly confined to the quartz staining it brown.

Microscopic Examination

A polysection was made and the following minerals were identified:

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(1) W.E. Ford, Dana's Textbook of Mineralogy, Fourth Edition April, 1947, Page 453.

Contemperaneous Deposition

Chalcopyrite
Tetrahidrite
Sphalérite
Galena(?)

Secondary

Malachite
Azurite
Chalcocite
Limonite

Gangue

Quartz
Calcite

Tetrahedrite

This was the most abundant mineral in the section. It was identified optically by the following properties: Colour gray, Isotropic, medium hardness and in polarized light had a reddish brown streak.. The mineral conformed to the usual etch tests as set out in "Short". The presence of antimony was confirmed by a microchemical test. Dispersed throughout the tetrahedrite were blebs of chalcopyrite and sphalerite. Some galena was noted inside the tetrahedrite. These minerals were more or less evenly distributed through the tetrahedrite and presented a "mutual boundaries" texture.(1) The tetrahedrite is highly fractured and the fractures are filled with chalcocite and calcite. The calcite was of a later deposition and is possibly secondary along with the chalcocite.

Chalcopyrite

This mineral was identified by the following optical properties; very weak anisotropism, brass yellow colour, medium hardness and powdered streak. It was negative to the usual etch reagents except for HNO_3 which tarnished the mineral slightly, The Chalcopyrite blebs were intimately associated with sphalerite. The two minerals formed smooth

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(1) Edwards, The Texture of the Ore Minerals; Australasian Institute of Mining & Metallurgy, 1947. Page 111.

curved, mutual boundaries of which the sphalerite usually surrounded the Chalcopyrite, although the reverse of this was not uncommon. The chalcopyrite is also associated in the same fashion with galena although the galena was scarce.

Sphalerite

Sphalerite was identified by its isotropism, medium hardness gray colour and whitish powdered streak. The etch tests as set out in "Short", were not satisfactory for its identification, so a microchemical test for zinc was made. The sphalerite showed little internal reflection if any and the streak was grayish in polarized light. When present it appears associated with chalcopyrite or galena and seldom wae seen alone. Tetrahedrite appears in part to be replacing the sphalerite but, on the whole, they are probably contemperaneous in deposition. The sphalerite had smooth mutual contacts with the other primary minerals.

Galena

Galena plays a very minor role in the section. It was identified by its isotropism, softness, galena white colour and cleavage. When present, it was either associated with sphalerite or chalcopyrite or both. It has smooth mutual grain boundaries with both these minerals. In one instance it was noted that both sphalerite and chalcopyrite were completely surrounded by galena but no evidence of replacement was noticed. Some galena was also noted inside the tetrahedrite. It is possible that these four minerals represent X-solution deposition, however, it is evident that they are more or less of contemperaneous with possibly the galena being deposited later. In some of the galena, minute inclusions of a silver coloured mineral which was isotropic was seen but these inclusions were too small for regular examination.

Chalcocite

The chalcocite present is very fine grained and is of the sooty type. It is completely isotropic. It showed positive reaction to etch tests except for HNO_3, which stained the mineral blue but did not bring out any etch cleavage. The mineral proved to be of later deposition than the other minerals and is probably of secondary origin. It was seen surrounding galena grains and presents a banding effect which would indicate that a time element was involved and that chalcocite has been deposited at successive intervals. Some chalcocite was deposited in the fractures of the tetrahedrite along with calcite. Some limonite also accompanys the chalcocite.

Azurite & Malachite

These two minerals representing the carbonates of copper are distributed more or less as a stain throughout the gangue minerals along with limonite.

Limonite

The limonite was slightly anisotropic. It was distributed as a stain in the gangue and in some cases associated with the Chalcocite.

Gangue

Quartz was of the massive milky type. It evidently was the first of the minerals to have been deposited as the rest of the minerals fill all cracks, crevices and fractures in the quartz. The calcite is of later deposition and was seen surrounding some of the quartz grains and filling the fractures of the tetrahedrite.

Specimen Marked

No. 2915 - Emma, Kitislas.

Megascopic Examination

The most plentiful mineral in the rock was Chalcopyrite. A grey metallic mineral which might be tetrahedrite along with Bornite were also present. The minerals are deposits in a gangue of massive milky white quartz which in places has been stained with malachite and limonite.

Microscopic Examination

The following minerals were identified in polysection:

Primary Minerals	Secondary Minerals	Gangue
Bornite	Chalcocite	Quartz
Chalcopyrite	Covellite	~~Calcite~~
Tetrahedrite	Limonite	
Pyrrhotite	Malachite	
Argentite (?)		

Chalcopyrite

This mineral occupied the greater part of the section: Laths of chalcopyrite were seen inside the bornite demonstrating a crystalographic intergrowth with chalcopyrite developed in the (111) planes of the bornite. This is positive indication of deposition from a fast cooling solid solution.(1) The relationship between the tetrahedrite and Pyrrhotite indicate contemperaneous deposition with the Chalcopyrite. The association of these three minerals is very similar to the previous section.

Bornite

Bornite was identified by its isotrepism, pink colour and inferior hardness. It reacted to the etch reactions ~~identically~~ as ~~these~~ set out in "Short."(2) The mineral acts as a host for the chalcopyrite of which it forms the above mentioned solid solution. Bornite was distributed fairly

(1) (2) See Page 9.

evenly through the section and had mutual smooth grain boundaries with the tetrahedrite indication a contemperaneous deposition.

Tetrahedrite

The occurence of this mineral is similar to that of the previous section. In this section, it plays a very minor role and seems to have been deposited simultaneously with the Chalcopyrite but, in places, it seemed to be replacing the Chalcopyrite.

Pyrrhotite Why?

It was surprising to find two very small blebs of pyrrhotite inside the Chalcopyrite and forming smooth curved mutual grain boundaries with the Chalcopyrite. It was identified by its strong polarization colours which were gray, blue and brown. Under ordinary light it appeared off colour as compared to the chalcopyrite It was fairly hard and had a powdered streak. The powder was slightly magnetic. The etch reactions were as follows[1]; HNO_3 tarnishes, HCl drop turned a light brown but, otherwise, negative, KOH stained a light brown; the rest of the reagents were negative. The mineral probably represents, if not a solid solution, a contemperaneous deposition with the chalcopyrite.

Argentite (?)

A very small, dark, gray grain was noted at the edge of the Chalcopyrite. It had a high relief, was sectite and isotropic. In order to carry out etch tests the section was repolished and, unfortunately, the grain could not be found again.

Secondary Alteration and Enrichment

Covellite

This mineral was bright blue under ordinary light and polarized a fiery red. It appeared chiefly confined to the Bornite

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(1) Edwards, Texture of the Ore Minerals, Australasian Institute of Mining & Metallurgy, 1947. Page 83.

(2) M.N. Short, Microscopic Determination of the Ore Minerals Second Edition, 1948, Bulletin 914. Page 119.

but a little was noted in the Chalcopyrite. The covellite is replacing the Bornite along fractures, cleavage planes and grain boundaries.

Chalcocite

This mineral was seen in both the chalcopyrite and tetrahedrite and was in part replacing them. It was nearly always associated with limonite.

This section presents an interesting and typical example of selective replacement and secondary enrichment in copper deposits. The bornite in all cases, was extensively replaced by covellite. The chalcopyrite on the other hand was rather fresh and unaltered, but in part was replaced by chalcocite and limonite precipitated by the action of water on the resulting $FeSO_4$. (1) These reactions may be shown by the following equations:

Bornite - Covellite

(a) $5Cu_5FeS_4 + 11CuSO_4 + 8H_2O \rightarrow 18Cu_2S\downarrow + 5FeSO_4 + 8H_2SO_4$

$FeSO_4$ transported and

(b) $2FeSO_4 + 2H_2O \rightarrow Fe_2O_3 \cdot nH_2O\downarrow + 2H_2SO_4$

Chalcopyrite - Chalcocite

$2CuFeS_2 + CuSO_4 \rightarrow CuS\downarrow + FeSO_4$

$2FeSO_4 + 2H_2O \rightarrow Fe_2O_3 \cdot nH_2O + 2H_2SO_4$

When the bornite had a mutual grain boundary with the chalcopyrite and a fracture traversed both the minerals it was noted that the covellite was replacing the bornite and abruptly at the grain boundary the enrichment changed to chalcocite in the chalcopyrite. The section has undergone an incipient enrichment. Malachite and Azurite represent the carbonates of copper and are present as a stain in the gangue.

Gangue

Quartz was the gangue mineral recognized and appeared to have been the first mineral deposited.

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(1) Bateman, Economic Mineral Deposits, John Wiley & Sons, New York, 1942. Page 277.

Specimen Marked

No. 2908 The King, Bornite Mt.

Megascopic

Chalcopyrite and tetrahedrite were identified with the aid of a hand lens. These minerals are deposited in an erratic fashion through a quartz gangue. No particular structure was noted but the specimen appears to represent a quartz vein type of deposit. The surface of the rock is in parts covered with a maroon limonite which, in places, tends to be rather cellular.

Microscopic

The minerals identified in polished section were -

Primary	Secondary
Tetrahedrite	Chalcocite
Sphalerite	
Chalcopyrite	

Tetrahedrite

Tetrahedrite occupies the greater partof the section and is similar in occurence as the other specimens. It has a close association with sphalerite and chalcopyrite. These three minerals have smooth grain boundaries and no positive evidence of replacement was noted. The tetrahedrite is badly fractured.

Chalcopyrite & Sphalerite

The sphalerite appears to have been in solid solution with the chalcopyrite because wherever chalcopyrite is present, the sphalerite has formed around it with smooth mutual grain boundaries. The chalcopyrite in parts appears to be replacing the sphalerite and tetrahedrite but, on the whole, the three minerals are contemperaneous in deposition and possibly were in solid solution or solutions.

Chalcocite

Chalcocite as in the previous sections, is the chief secondary mineral. It was seen in the cracks and fractures of the copper minerals present. It is chiefly confined to the tetrahedrite and may, in part, be replacing it. On the whole, the specimen is rather fresh as compared to the previous sections.

Specimen Marked.

2913 - Gold Copper Ore
Bornite Mt., Skeena River, B.C.

Megascopic Examination

Two metallic minerals were recognized as chalcopyrite and Bornite. They have been deposited as vein minerals in a quartz gangue. The quartz is a milky colour and rather coarse.

Microscopic

Two polished sections were made and the following minerals were recognized -

Primary	Secondary
Bornite	Covellite
Chalcopyrite	
Tetrahedrite	

Chalcopyrite & Bornite

As before, these two minerals are intimately associated. The bornite was heavily altered and replaced by covellite along the cleavage planes, in the fractures and around the grain boundaries. On the other hand, the chalcopyrite was rather fresh and unaltered except in a few minor fractures.

Tetrahedrite

A small amount of tetrahedrite was seen in the section. There appears to be a small amount of tetrahedrite veining in the chalcopyrite however the over-all relationship between the two minerals indicates a possible contemperaneous deposition with chalcopyrite. The tetrahedrite in this section was rather fresh and unaltered.

Covellite

Where present, this mineral replaces bornite and chalcopyrite but shows a preference for the former. Secondary alteration plays a minor role in these polished sections. The reason for this is probably chalcopyrite composes most of the section.

Specimen Marked.

2906 - Sphalerite and Quartz.
I.X.L. Claim, Kitsilas Canyon, Skeena River.

Megascopic

The specimen consists almost entirely of black sphalerite. There is a very minor amount of galena present. The sphalerite presents rather good cleavage faces but otherwise is massive. The Galena was easily identified by its high lustre and perfect cubic faces. There is very little gangue in this section.

Microscopic

The following minerals were identified in polished section:

Sphalerite
Chalcopyrite
Pyrite and possibly (Marcasite)
Galena

Sphalerite & Chalcopyrite

Sphalerite occupies over 95% of the section. The sphalerite has undergone a fair amount of fracturing. Associated with the sphalerite are very small blebs of chalcopyrite. The chalcopyrite appears as elongated blebs completely surrounded by sphalerite. These small blebs have a rough parallel orientation and appear to be Ex-solution bodies.

Galena

A very few small grains of galena were noticed in one part of the polished section. The galena appears to have partly replaced the sphalerite. It was nowhere seen in contact with the chalcopyrite.

Pyrite & Marcasite

Pyrite was seen veining in the sphalerite. It was identified by its pale yellow colour, superior hardness and isotropism. It was extremely fine graned and apparently slightly altered. An anistropic, fine grained material was seen dispersed amongst the pyrite grains. This material is though to be marcasite but positive identification was not possible because of the extremely small grain size and lack of good polish. The pyrite is later in deposition than the sphalerite.

Specimen Marked

No. 2911 Arden Claim
Bornite Mountain, Kitsilas

Megascopic

This specimen consists of crystalline specularite and small amount of chalcopyrite deposited in a highly altered tuffaceous material. The metallic minerals are deposited in a very erratic fashion. There are vein like bodies running through the gangue but the walls are very irregular and do not match. These minerals seem to have been deposited at very high temperatures and are indicative of a pyrometasomatic deposition.

Microscopic

The following minerals were recognized in polished section:

Chalcopyrite   Specularite

Specularite

needle-like

This mineral occurs in acicular crystals which have no definite pattern. It was identified by its extreme hardness, steel gray colour, negative reaction to etch tests and metallic streak. The mineral was slightly anisotropic. The needle like crystals are piled on top of each other in a haphazard fashion with many open spaces between.

Chalcopyrite

This mineral occurs in small amounts between the crystals of specularite. It assumes no definite structure or form.

Gangue

The gangue consists of a tuffaceous material which appears to have been partly metamorphosed to a brownish green siliceous material. There is a very small amount of malachite present.

Pyrogensis of the Minerals

1. Quartz
2. Specularite, Pyrrhotite, Chalcopyrite
   Bornite, Sphalerite, Tetrahedrite, Galena
3. Pyrite

The general nature of the intergrowth between the Chalcopyrite and Bornite with the Chalcopyrite forming blades in the (111) planes of the Bornite indicates a deposition from a solid solution at a temperature of 450° - $500^{\circ}C$. If the Chalcopyrite and Tetrahedrite were in solid solution their temperature of deposition would be $500^{\circ}C$.

The full nature of the relationship between the Chalcopyrite and Pyrrhotite could not not be fully understood because of lack of material although it is probable that the Pyrrhotite represents an ex-solution body and, if so, unmixing occurs between 350° and 500° C. Sphalerite and Chalcopyrite seemed to also indicate a solid solution and the temperature deposition would be in the neighbourhood of 500°C. In the polished section, tetrahedrite seemed, in places, to be replacing the Chalcopyrite so that the tetrahedrite may have been deposited later.

It may be that the"mineralizing fluids" contained these minerals in solid solution (where present) and when a certain temperature was reached which would be in the neighbourhood of 550°C, the minerals started to precipitate in the following order; Chalcopyrite and Tetrahedrite, Chalcopyrite and Pyrrhotite, Chalcopyrite and Sphalerite, and Chalcopyrite and Bornite. The Galena may have been contemperaneous with the latter. The fluids were supersaturated with copper thus causing a continuous deposition of Chalcopyrite and, as the temperature dropped, the other minerals were precipitated as solid solutions in order. It is thought that the primary minerals are the result of a more or less contemperaneous deposition above 300°C and below 600°C thus causing the minerals to be placed in the hypothermal group of deposits. The Arden Claim probably represents a contact metamorphic deposit in a tuffaceous horizon of one of the Triassic roof pendants or inclusions. No references dealing with this property could be found and itis probable that the claim has been abandoned for many years.

Conclusions.

These mineral deposits can be classified as hypothernal vein deposits. They have probably been deposited under high temperatures and at a very moderate depth. Their location is in close proximity to the intrusives and it is presumed that the Batholith dips eastward beneath them thus limiting their vertical extent. There is no replacement evident outside.the secondary incipient enrichment.

Economic Significance.

These deposits all carry copper but it is very unlikely that they can be worked for their copper content as the veins are reported to be narrow and restricted.(1) It would be possible to work some of the properties on Bornite Mountain for their gold and silver content. These operations would necessarily be limited and confined chiefly to "High Grading". It is very possible that a mine of economic importance may someday be found in this area because of the favourable geological formations and their close proximity to the Coast Range intrusives.

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(1) Kindle, Mineral Resources of Terrace Area, Coast District, B.C.; British Columbia Geological Survey, Memoir 205. Page 8.

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E. D. Kindle, Mineral Resources of Terrace Area, Coast District, B. C., Ottawa, King's Printer, 1937, Canada, Department of Mines and Resources, Geological Survey, Memoir 205.

Properties

King Group

Victoria, Annual Report of the Minister of Mines, B. C., 1914, p.142; 1923,p.105; 1928, p.145.

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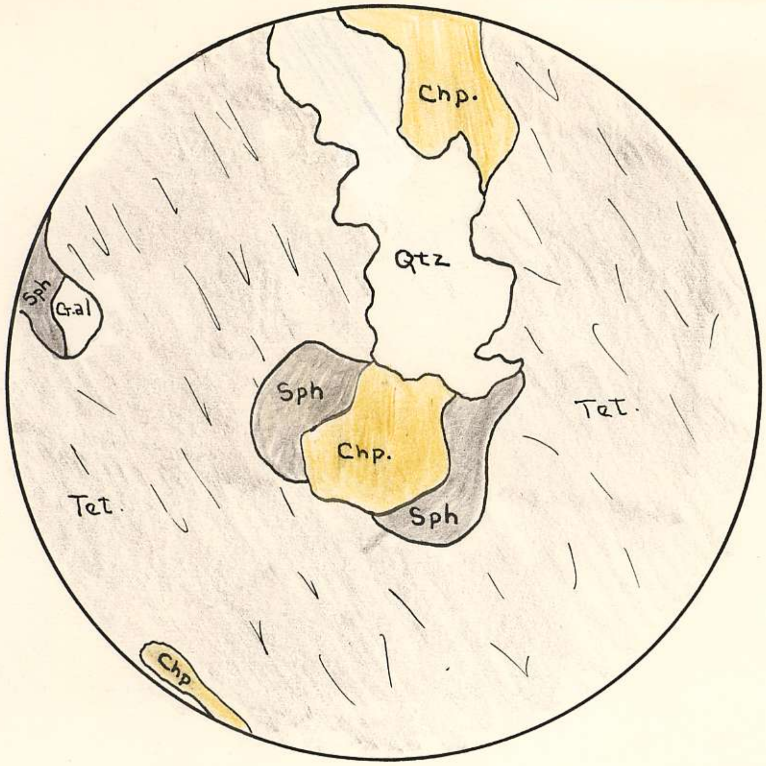
Canada, Department of Mines and Resources, Summary Report, Ottawa, King's Printer,1925, Part A, p. 116.

Ptarmigan Claim

British Columbia, Annual Report of the Minister of Mines,B.C., Victoria,1924,p.48; 1930,p.78.

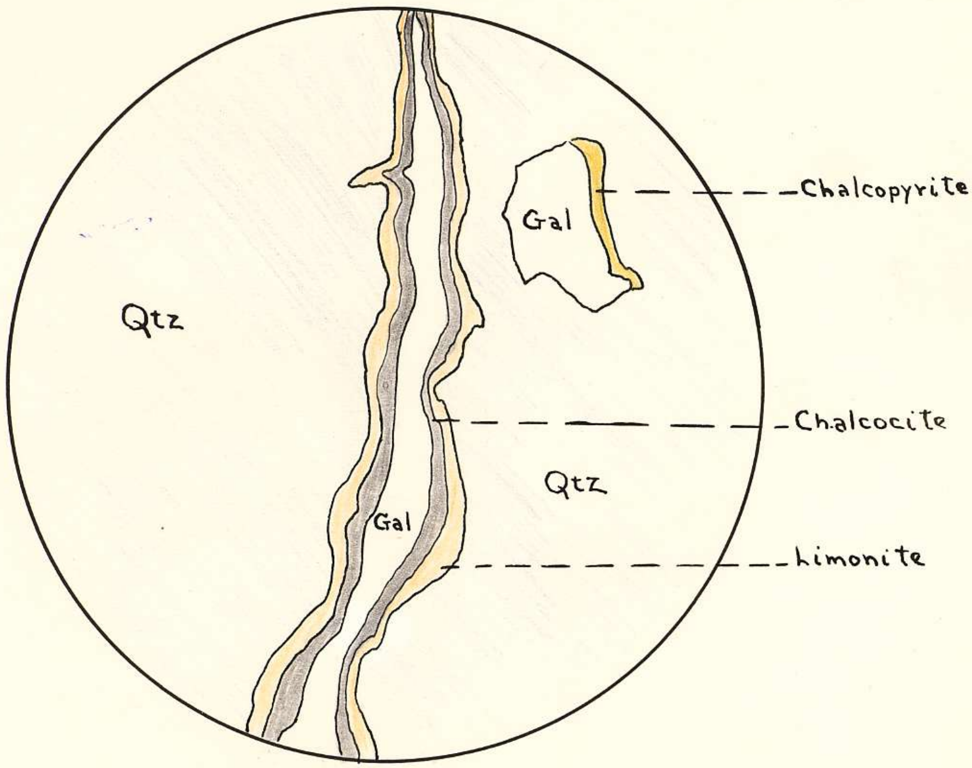
Properties (cont)

Canada, Department of Mines and Resources, Summary Report, Ottawa, King's Printer, 1925,Part A, p. 118.



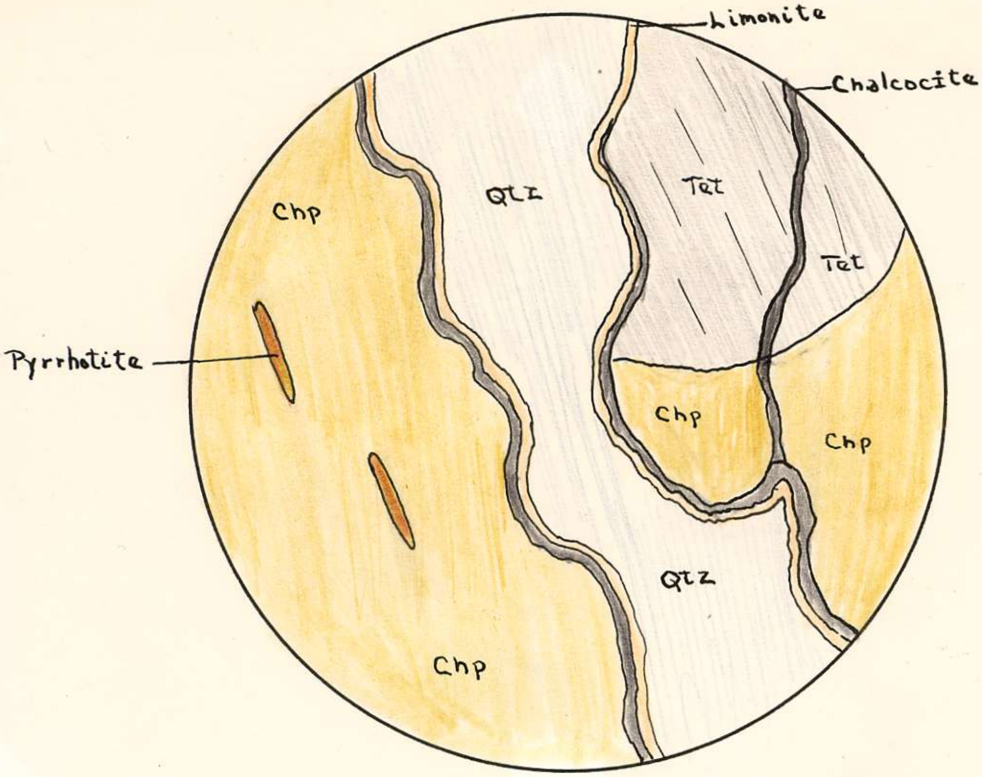
Section 2912

Possible ex-solution of Sphalerite, Chalcopyrite, Tetrahedrite and Galena.



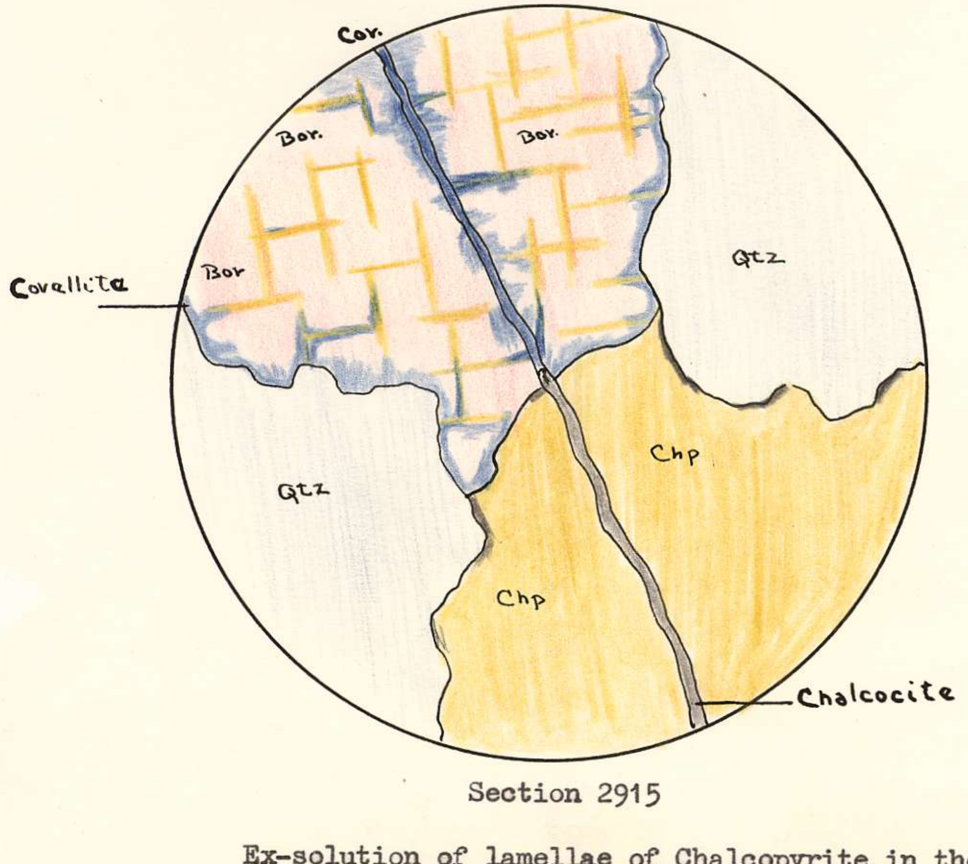
Section 2912

Secondary Limonite and Chalcocite.



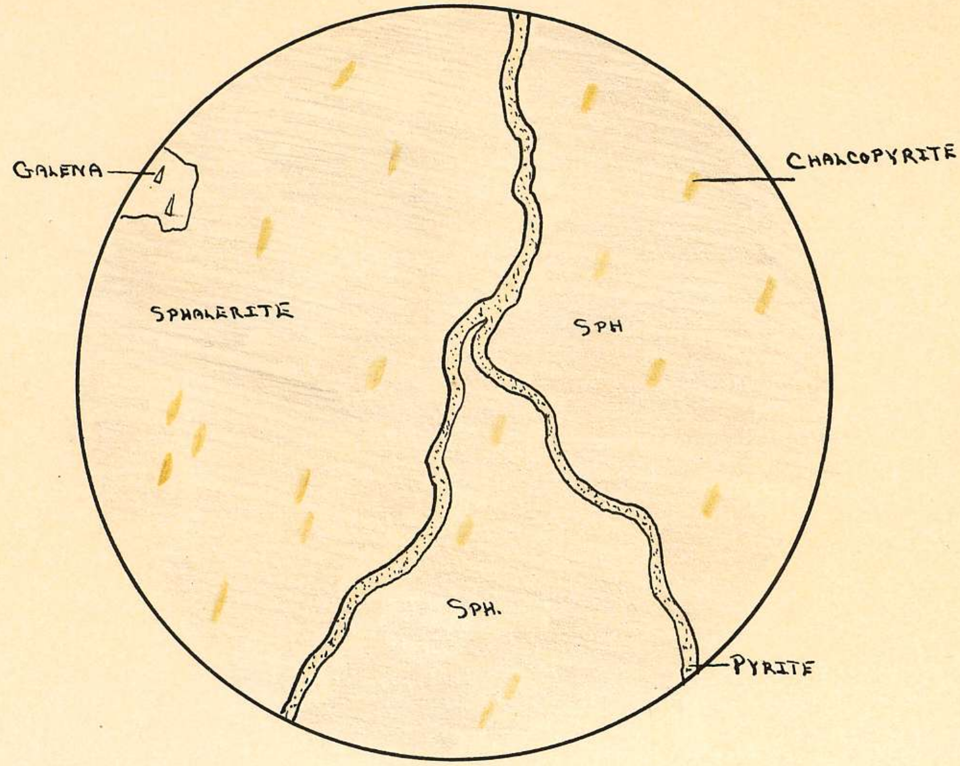
Section 2915

Ex-solution bodies of Pyrrotite and possible ex-solutions of Tetrahedrite and Chalcopyrite.



Section 2915

Ex-solution of lamellae of Chalcopyrite in the (111) planes of Bornite. Incipient secondary enrichment.



Ex-solution bodies of Chalcopyrite in Sphalerite.
Veining of Pyrite