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A MICROSCOPIC STUDY OF ORE FROM LYNN CREEK ZINC MINES Near Vancouver, British Columbia

A report submitted
In partial fulfilment
of the course Geology 409
at the University of
British Columbia.

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The writer is also indebted to A. B. Edwards for his excellent book "Textures of the Ore Minerals and Their Significance", 1947, which was used as a text.

The microscopic properties for the determinations of the mineral were taken from U. S. Geology Survey Bull. 914, 1948, written by M. N. Short.

A MICROSCOPIC STUDY OF

ORE FROM LYNN CREEK ZINC MINES

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ABSTRACT

A suite of ores from Lynn Creek Zinc Mines, near Vancouver, British Columbia, was examined microscopically in 8 polished sections. The hypogene metallic minerals identified, in probable order of major periods of deposition are as follows: pyrrhotite, sphalerite-chalcopyrite-cubanite (ex-solution), pyrite (?); sphalerite, galena. There was some continuation of silication after deposition of the pyrrhotite.

A strong suggestion of ex-solution of sphalerite from chalcopyrite indicates a temperature of deposition of over 550°C.

Sphalerite is the ore mineral and by far the most abundant of the metallics. It is very clean, and a recovery of 90 percent, or better, is forecasted.

C O N T E N T S

I L L U S T R A T I O N S

INTRODUCTION

Purpose of the Study:

A suite of ores from the property of Lynn Creek Zinc Mines was examined microscopically in polished sections to determine the metallic minerals present and their paragenesis.

The results are expected to be of aid in studying the conditions of ore deposition and the metallurgical treatment of the ore, as well as to illustrate some measure of the practical technique and knowledge gained by the writer from the course Geology 409.

Location of the Property:

The property of Lynn Creek Zinc Mines lies in the Vancouver Mining Division near Vancouver, British Columbia. The eight claims which constitute the holding lie seven miles directly north of North Vancouver on the south slope of a spur extending eastward from Crown Mountain.

The claims stretch over a vertical range of 2500 feet from the West Fork of Lynn Creek, at an elevation of 1500 feet, to the top of the ridge. The claims included are the following:

	No.
Kemptville Extension	1609
Evening Star	1633

	No.
Russell	3748
Jersey	3749
Lynn Fraction	3750
Cascades	3752
Fleming	4025
Pretty Bess	4026

The ore examined came from Kemptville Extension and Evening Star, which lie approximately in the centre of the group and cover the principal outcrops.

The ground lies within the North Vancouver Water Shed, and a permit from the Water Board is required to visit them. A passable vehicle road exists from the Water Shed boundary, at the lower intake on Lynn Creek, to the upper intake, a mile away. From there approximately five miles of rather difficult trail lead to the location. An old timbered logging trail, if it may still be called such, follows the east bank of the creek to where the West Fork comes in. From there, a former pack trail pursues the north bank of the West Fork, angling up the hillside, to end on Kemptville Extension Claim on the lower end of Zinc Canyon. Here, at an elevation of 2100 feet, are the Lower Workings, from which the majority of the ore came.

GEOLOGY

General:

The lower course of the Fraser river, with Vancouver at its mouth, marks the physiographic southern margin of the great Coast Range Batholith. Lynn Creek occupies a typical Coast Range valley with precicipitous walls exhibiting a relief of 3000 feet.

Forming the drainage basin of the headwaters of the creek, and undifferentiated topographically, is one of the xenoliths so common to this part of the batholithic intrusive. The body measures about 3 miles by 1½ miles, and trends northwesterly.

The rocks are a complex series of andesites, quartzites and limestones of probable late Palaeozoic or early Mesozoic age. They strike a little north of west, are sharply folded, and in part recrystallized.

Economic

The mineralization is related to the batholith but is localized entirely by the thin, lensing limestone members of the pendant. Only four such beds have been noted. The most easterly, on the west slope of Lynn Ridge, is connected with some copper mineralization of a spotty nature. The two most important beds outcrop at the western contact of the xenolith on the properties under consideration.

The ore is controlled by favorable beds in the limestone, which is now largely altered to skarn, and by a number of sets of shears. The mineralizing solutions have followed shears in the limestone where available, replacing the beds for one to five feet on either side of the break. The grade of ore gradually diminishes outward, so the ore limits are in part assay boundaries. The sediments strike about N. 10° E. where exposed in the canyon at the Lower Workings, and dip very steeply to the west, abutting against the intrusive contact on the west wall of the gulley. The ore uncovered so far is all within a few tens of feet of the intrusive. The average sample assays about 17 percent zinc, and less than 0.5 ounces of silver. Samples from the Pearson Shoot, however, which were rich in galena, carried about 35 percent lead, 30 percent zinc and 5 ounces of silver. Outside of the Pearson Shoot, the chief ore mineral is sphalerite.

The second ore zone is exposed 2000 feet to the northwest and 200 vertical feet below the ridge crest, on the nose between Zinc and Fleming Canyons. The beds here strike N. 45° E. and dip about 60° to the northwest. The veins here are several hundred feet from the contact.

The majority of the ore so far exposed must be classified as contact-metamorphic by virtue of its position and the accompanying wall rock alteration.

MINERALOGY

The microscopic study of the mineralogy of this ore was begun with the hope, common to student and master, of finding some rare mineral occurrence or association. When the writer became convinced that no such discovery was forth-coming, he turned his efforts to unravelling the paragenesis of the minerals. The fine-grained nature of the minerals in the sections facilitated such a study, for border relations were innumerable, and veining characteristics quite frequent.

MEGASCOPIC EXAMINATION

The gangues will be considered first, then the metallics in order of abundance.

Gangue Minerals

Siliceous "contact-rock"

This is the normal gangue of the specimens from the West Vein. It is a hard dark-green siliceous rock deriving its color from secondary, contact-metamorphic silicates. The nature of the original rock which it represents is rather obscure.

Epidote:

The clean sphalerite developed abundantly at the intersection of shears is set in a gangue of nearly pure epidote.

Quartz:

Coarse-grained white quartz, somewhat vugghy, occurs only in the Pearson Shoot, where it is the principal gangue of the high-grade galena-sphalerite ore.

Metallic Minerals

Spalerite:

Sphalerite is the most important ore mineral in this suite and by far the most abundant. The grains range in size from 1 cm down to dust-like particles, the majority ~~are~~ less than 3 mm. Most of the sphalerite is massive, but in epidotized shear-fillings it occurs evenly disseminated in medium-sized grains covering about half of the surface, giving the rock a characteristic speckled appearance. It is often associated with minor chalcopyrite.

In the specimens from the Pearson Shoot, sphalerite appears in close connection with galena, both massive and disseminated through the quartz. It is more equi-granular here, averaging 2-4 mm where disseminated, and slightly more where massive.

Galena:

The presence of galena is restricted entirely to the Pearson Shoot specimens. Its occurrence is very similar to that of the sphalerite in this body. Where massive, the grain size reaches 1 cm, but the average is between 3 and 5 mm. The smaller disseminated grains show the cubic crystal habit quite strongly.

Pyrrhotite:

This mineral occurs very fine-grained and massive. Pyrite or marcasite in one specimen is closely associated in a vein about 3 mm wide. The pyrrhotite is also somewhat allied to the chalcopyrite but seems to shun sphalerite.

Chalcopyrite:

This single copper representative is not abundant, but it is found quite commonly with the pyrrhotite and the sphalerite as irregular patches less than 1 cm in extent. It would probably best be described as a light spattering.

Pyrite:

For a mineral commonly so sociable and ubiquitous, the pyrite is here noticeable for its isolation and scarcity. It is habitually disseminated but with a linear arrangement of grains. The grains grew as large as 2 mm where the mineral was concentrated, but decreased in size with dissemination, to mere pin points. A rather poor cubic crystal habit is suggested in some of the larger grains.

MICROSCOPIC EXAMINATION

Primary Minerals

To give the reader as clear a picture as possible of the formation of the deposit, the minerals will be treated in what was their probable order of deposition.

Gangue I :

Most of the gangue falls into this category, which probably represents the original hard, silicified country rock.

Gangue II:

Much less abundant than the original gangue, it occurs as slightly lighter colored veins up to 2 mm wide. Greater ease in polishing shows it to be a little softer than the other gangue, but too hard to scratch with a needle. It is entirely older than the ore.

Pyrrhotite:

Pyrrhotite was recognized in polished section by its characteristic color, extreme anisotropism, and negative reaction to HNO_3. The lack of copper in chemical tests disproved the possibility of cubanite.

Though usually by itself, it is more often contiguous to chalcopyrite than sphalerite. The solutions have been fairly fluid, for the mineral forms veins in the gangue only a few microns wide. The pyrrhotite has also been active in replacing the gangue in minute irregular bodies (Fig. 1). In section A, the pyrrhotite has been largely altered to marcasite by surface weathering.

Gangue III:

This gangue is seen to be a slightly different grey from either of the first two when all three are together under the microscope. When only two of the gangues were seen together, the writer could not be sure which they were unless they could be traced to a mass of pyrrhotite. Here, one is very distinctive in that it continues as very fine branching veinlets and wisps throughout the metallic mineral (Fig. 2). This late siliceous phase is hard, like the earlier ones.

Sphalerite:

The sphalerite was easily identified under the microscope by its blue-grey color and softness. Its isotropic property and inertness to nitric acid were considered sufficient verification.

The zinc mineral is intimately mixed with chalcopyrite where the two minerals are abundant, as in section D. Each is found in the other in grains of all sizes down to less than 10 microns, but the chalcopyrite is far more abundant in the sphalerite. Some large patches of chalcopyrite show numerous blebs of sphalerite near the centres, but in most cases the sphalerite is peripheral. The inclusions show all the variations of shape, from well-rounded to most irregular. Amongst the latter, typical "caries" texture is abundant, and any one example can be matched by

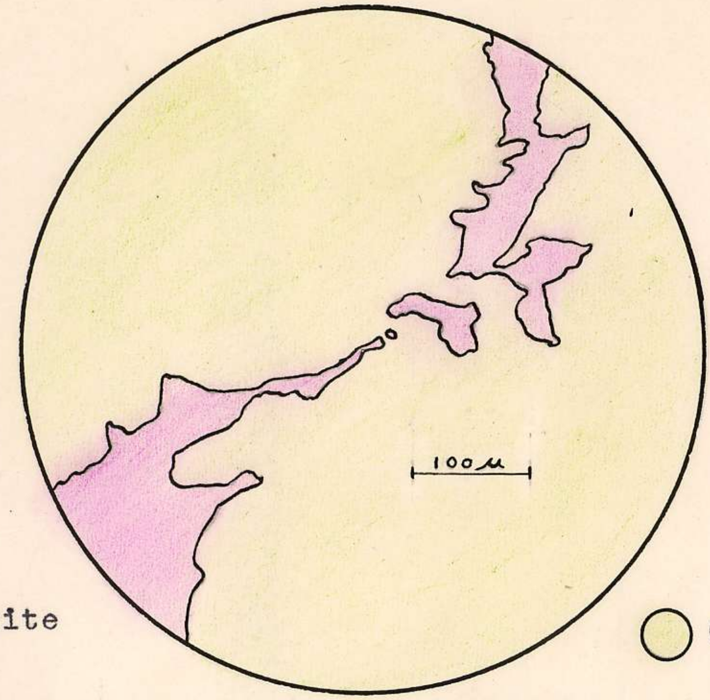

Fig. 1. Pyrrhotite veining and replacing gangue.

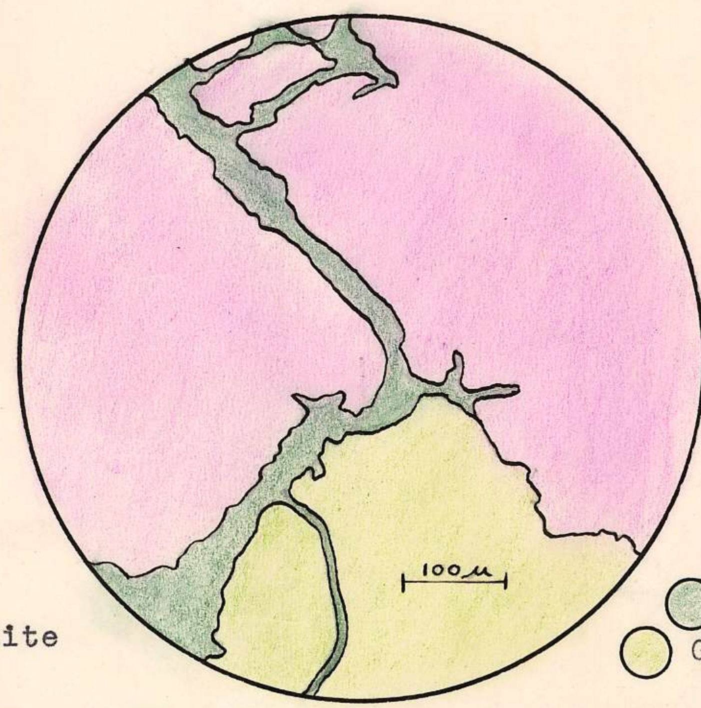

Fig. 2. GangueIII veining Gangue I and pyrrhotite.

another fully as contradictory. This, together with the lack of any hind of orientation of inclusions, suggested contemporaneous deposition. However, Edwards (p. 58) states that this orientation is not evident in what he terms "emulsion" textures of ex-solution minerals. Section D exhibits an almost identical texture to that shown by Edwards (fig. 76) as typical of this process, except that the chalcopyrite is somewhat more abundant in Edwards' example. Since sphalerite-chalcopyrite ex-solution has been proven in the laboratory, the writer is convinced that in the ore represented by section D, at least, the two minerals were deposited together in solution.

The occurrence of the sphalerite in the chalcopyrite in this form is rather uncommon, for it requires a high temperature of deposition. According to Borchert[1], the unmixing occurs at about 550°C.

A few inclusions of pyrrhotite are found in the sphalerite, the reverse situation is rarely present. Nowhere is the sphalerite found veining the pyrrhotite, However, a blanket study of the inclusions shows stronger evidence of replacement by sphalerite if "caries" texture is to be given weight at all (fig. 9). Sphalerite veins the gangue abundantly and preferentially.

Cubanite:

Cubanite was located in two places, both in section D, where it occurs as ex-solution bodies in the chalcopyrite. Both occurrences were toosmall to identify

[1]Borchert, H., Chemie der Erde, 9, pp. 156-157 (1934).

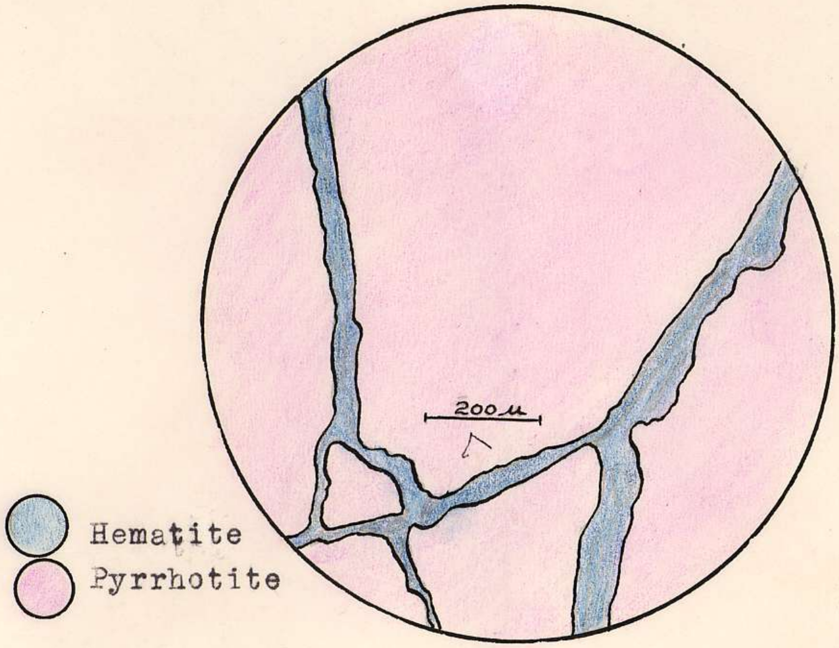

Fig. 3. Hematite veins through pyrrhotite

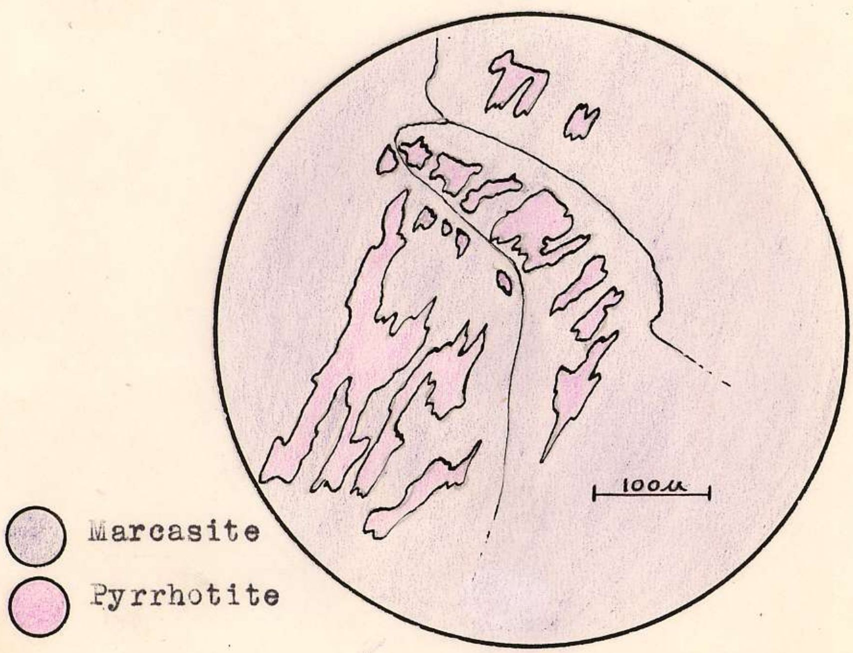

Fig. 4. Marcasite replacing pyrrhotite from fractures.

by micro-chemistry, but the following evidence satisfied the writer that the identification was correct. -

Color - Slightly paler than pyrrhotite

Hardness- To the eye, it polishes unpreferentially to chalcopyrite, but the Becke line shows it to be slightly softer.

Etch - Negative to HNO_3

Anisotropism - Strong

The largest body was a straight composite lath about 30 microns by 150 microns, which is perfectly exemplified by Edwards (fig. 84). The other occurrence was a small group of parallel hair-like bodies only a few tens of microns long, at the edge of a chalcopyrite grain.

Chalcopyrite

This mineral is easily differentiated from any mineral except gold by its color, isotropism, and chemical inertness.

The relationship shown in section D between chalcopyrite and sphalerite was discussed under the latter mineral, Section B, however, from a different vein, suggests the chalcopyrite to be later than all of the primary minerals present. Here the chalcopyrite is prolific in megascopic veins. An overall examination leaves a strong impression that the copper mineral is replacing both country rock and former sphalerite veins without decided preference. The "car#ies" texture in the section also bears this out (fig.5 and 7), though nowhere is the chalcopyrite very

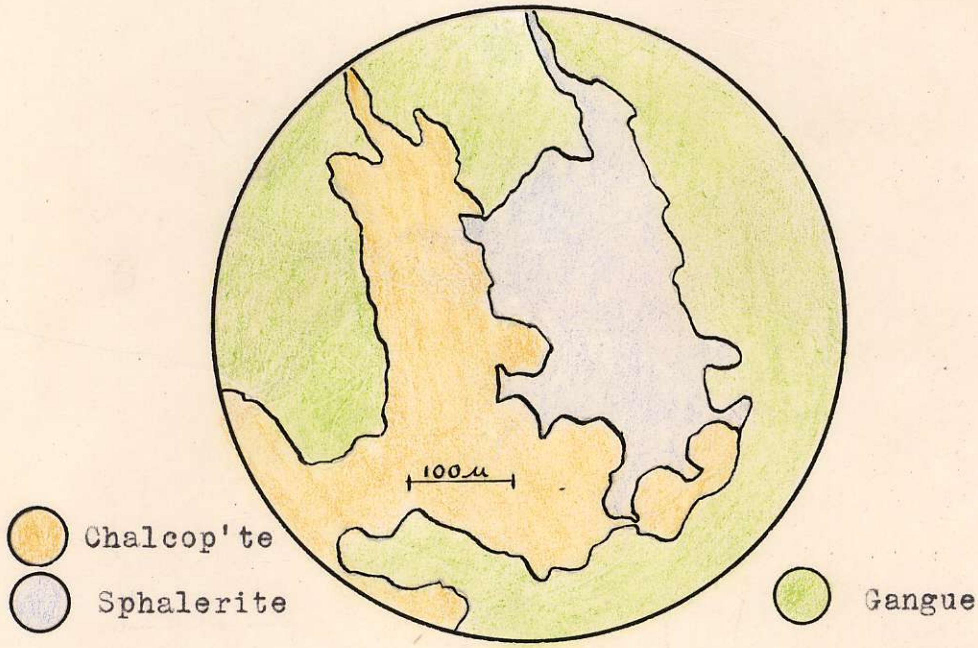

Fig. 5. Chalcopyrite exhibiting 'caries' texture toward sphalerite.

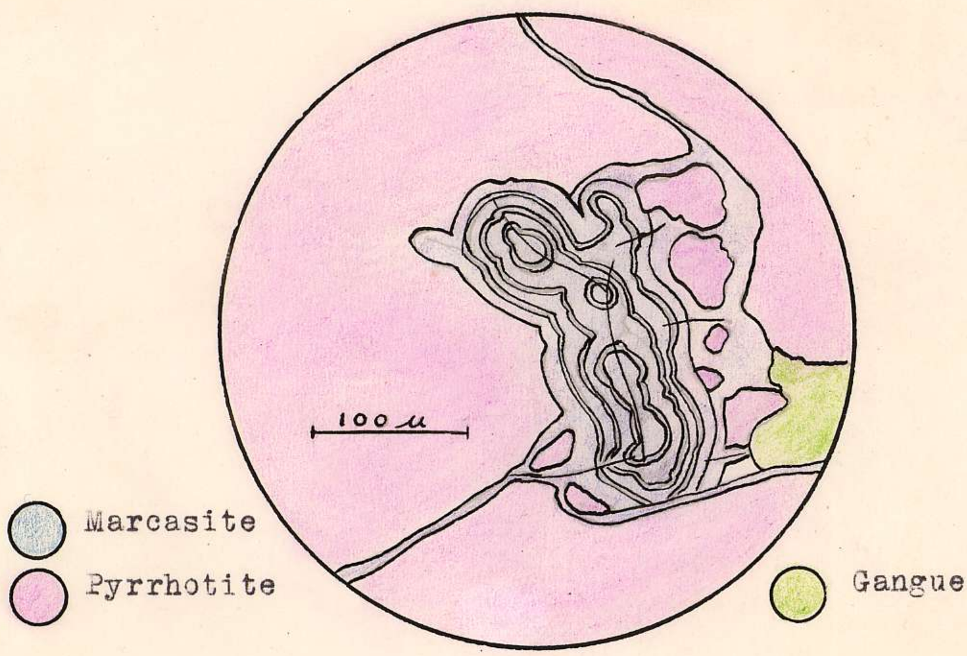

Fig. 6. Colloform habit of marcasite replacing pyrrhotite outward from fractures.

definitely veining sphalerite.

This situation leaves the observer the choice between two conclusions. Either there was overlapping deposition of the chalcopyrite, or a second generation. The small proportion of chalcopyrite, compared to sphalerite, in the ore as a whole makes overlapping deposition seem unlikely to the writer. On the other hand the assumption of more than one generation of a mineral is frowned upon by some investigators unless there is very good evidence to support it. The writer admits such evidence is lacking.

Pyrite- (Marcasite ?):

The pyrite was distinguished in poly-section by its hardness and color, except where confused with marcasite. In such cases the writer relied upon isotropic properites but must admit that in this distinction there was doubt in some instances. The origin, age, and distinction between pyrite and marcasite was one of the most confusing problems. Everywhere the pyrite shows lack of good crystal outline. In the only section where the pyrite is uniform and nearly isotropic, it occurs alone (section F) in elongated, vein-like replacement bodies. In section A the marcasite and pyrite can quite definitely be separated on polishing characteristics. However, no definite borders between them can be seen, even though the two are always closely related. In some cases the colloform rings of marcasite are convex outward from the pyrite toward the pyrrhotite grains, as if the pyrite represented an older core of marcasite, altered since to pyrite. The writer does not know whether this is possible or not under ordinary conditions of weathering. Too, it might be argued that the pyrite as well as the pyrrhotite was altering to marcasite. Where the irregular "pyrite" masses have no secondary marcasite bordering them they show heterogenity under crossed nicols, unlike the homogeneous pyrite in section F.

Stokes[1] and Tarr[2] have found that both marcasite and pyrite can occur as primary minerals in the same deposit under slightly differing conditions of temperature and acidity. Marcasite cannot exist above 450°C according to Tarr, and if the two are precipitated alternately, it must be at a temperature of about 100°C.

The writer sees only two possible explanations for the marcasite and pyrite mineralization in this ore. There may be two types of marcasite, one primary looking like the pyrite but showing a wavy anisotropism, the other definitely secondary. The alternative is to have two types of pyrite, one primary (section F), and the other resulting from the alteration of secondary marcasite, and retaining a semblance of anisotropism.

The writer doubts the presence of a primary marcasite, and therefore is forced to offer the second explanation.

Galena:

The grain boundaries of the galena are quite smooth and regular, even more so than the sphalerite with

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[1] Stokes, H. N., On pyrite and marcasite, U.S. Geol. Survey Bull. 186, 1901.

[2] Tarr, W. A., Alternate deposition of pyrite, marcasite, and possibly melnikovite, Amer. Mineral, 12, 1927.

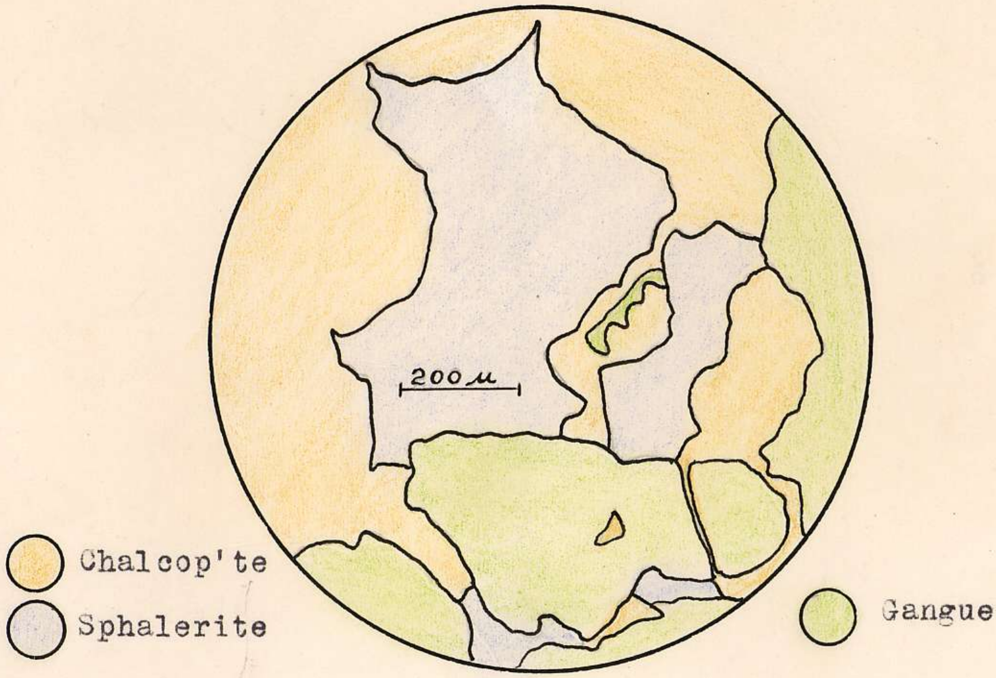


Fig. 7. Chalcopyrite showing 'caries' texture and semblance of veining sphalerite.

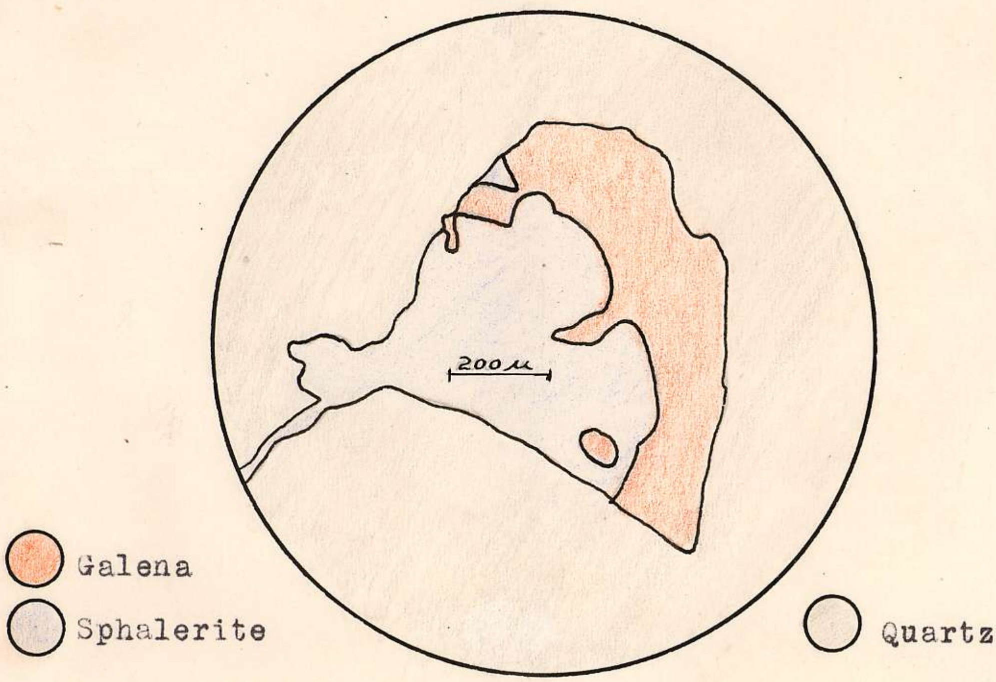


Fig. 8. 'Reversed caries' texture of sphalerite and galena.

which it is closely associated. There is no certain evidence that it is younger than the sphalerite, but that is the general impression received, without being able to point it out conclusively at any one place. If such is the case, the reverse "carries" habit of sphalerite and galena, mentioned by Edwards (p. 107), is present here (fig. 8). It is very possible that the sphalerite in this section C from the Pearson Shoot is a second generation. The characters of the metallic minerals and the quartz vein suggest this to be the case.

Secondary Minerals

Marcasite:

Marcasite is ubiquitous as a weathering alteration of pyrrhotite working inward from grain boundaries and cracks in its typical colloform manner (fig. 6). In a well polished section it is not obvious, but it is a little rougher and in slight relief to the pyrrhotite. Slight etching with HNO_3 brings it out very clearly.

Hematite (?)

Late veins of a mineral which is probably hematite cut all the other minerals. The mineral looks very much like sphalerite but is seen to be slightly darker where the two are in contact. By internal reflection it could not be definitely distinguished from sphalerite and some of the gangue minerals. Small veins occur in the pyrrhotite and pinch out rapidly in adjacent minerals.

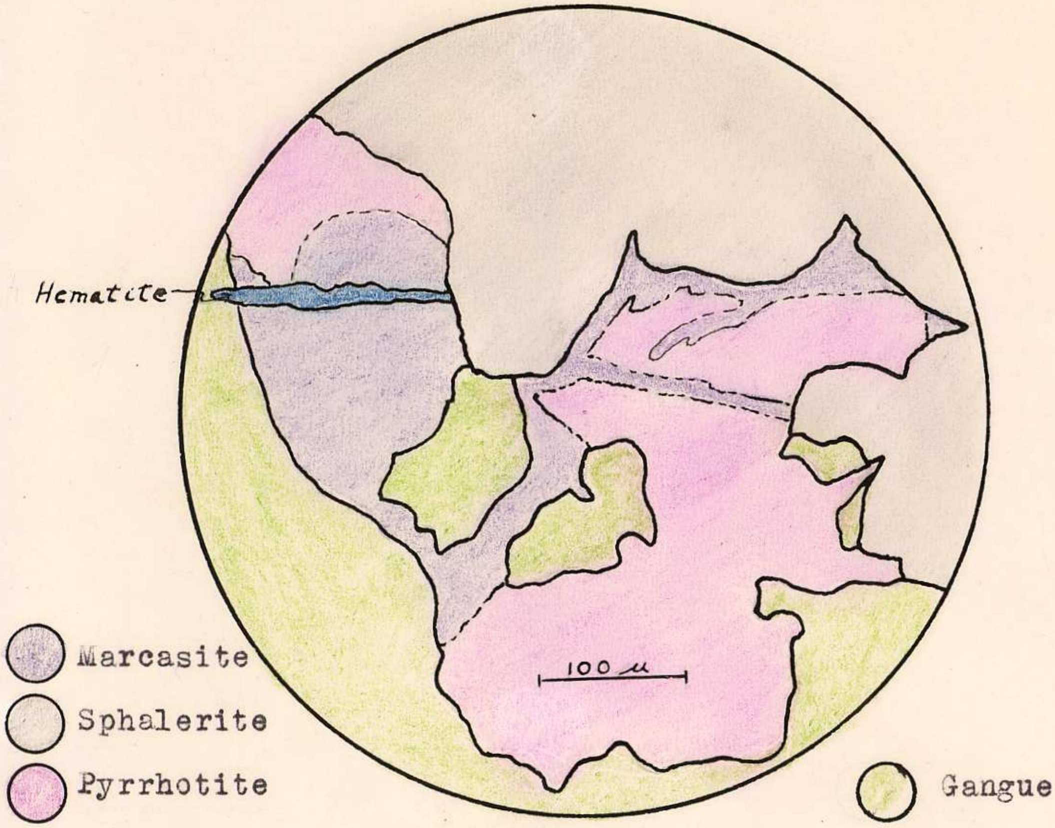
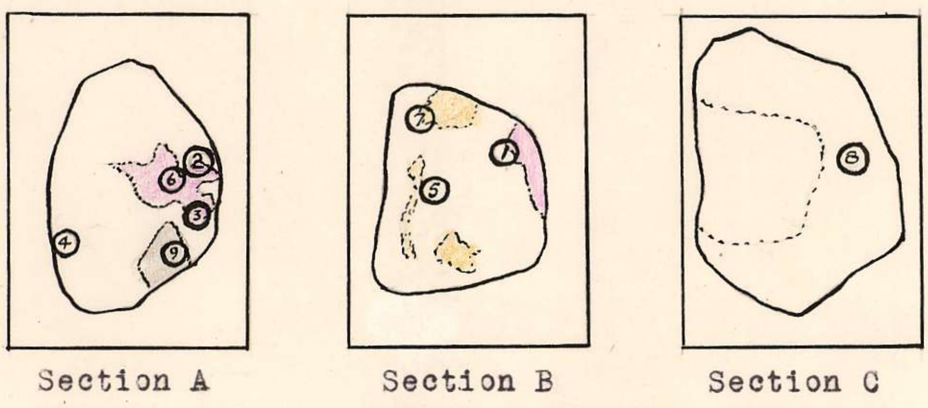


Fig. 9. 'Caries' texture of sphalerite toward pyrrhotite; alteration of pyrrhotite to marcasite producing excess iron in the form of hematite veinlets.

LOCATION OF FIGURES



In other places, larger veins, when going through pyrrhotite, widen out sharply upon entering the mineral and narrow as rapidly on the other side. The veins seem to prefer sphalerite to gangue, for they follow earlier sphalerite veins, and often part of the sphalerite remains along side the hematite.

The writer is led to believe that the hematite veins are a result of the excess iron produced in the extensive alteration of pyrrhotite to marcasite.

CONCLUSIONS

1. Paragenesis

The paragenesis of the minerals suggested by the writer is shown below.

```
Gangue I     ..?——
Gangue II    . .   .——
Pyrrhotite   . . .   .——
Gangue III   . . . . . .——
Sphalerite-Chalcopyrite- . .
Cubanite     . . . . . . . .——
Chalcopyrite . . . . . . . .    ——
 Pyrite (?)  .  . . . . . . . .   ——
 Quartz      . .  . . . . . . . . . .  -?——
 Sphalerite  .  . . . . . . . . . .      ——
 Galena      . .  . . . . . . . . . . .     ——

 Marcasite . .  . . . . . . . . . . . .        —
 Hematite  . .  . . . . . . . . . . . .        —
 Pyrite(?) .. .  . . . . . . . . . . . .       —
                 ——————→
                   Time
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2. Temperature

The indicated ex-solution of sphalerite from chalcopyrite shows that the probable temperature of deposition was over 550°C. The almost certain ex-solution of cubanite from chalcopyrite sets a minimum temperature of 450°C.

3. Precious Metals:

Since no silver mineral was identified, it is assumed that the few ounces of silver carried by the ore is probably present as argentiferous galena[1].

The ore carries only a trace of gold, and this may be connected with the pyrite.

4. Milling:

The ore as a whole is exceptionally clean and no difficulty should be encountered to free it from impurities. The gangue is brittle and should crush easily.

The writer sees no ~~reason why~~ difficulty in attaining a zinc recovery of 90 percent, or better, from about a 50 percent concentrate.

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[1] Warren, H. V., "Distribution of silver in base metal ores", Trans. Amer. Inst. Min. Met., Eng., 115, (1935).

LIST OF MINERALS BY SECTIONS

Section A. Pyrrhotite, sphalerite, chalcopyrite, pyrite, marcasite, hematite.

B. Chalcopyrite, pyrrhotite, sphalerite, pyrite, marcasite.

C. Sphalerite, galena.

D. Chalcopyrite, sphalerite, cubanite.

E. Pyrrhotite, marcasite, pyrite (?).

F. Pyrite.

G. Sphalerite.

BIBLIOGRAPHY

Allen, E. T., Crenshaw, J. L., and Johnston, J.: The mineral sulphides of iron, Amer. Jour. Sci., 33, 1912.

Borchert, H.: Chemie der Erde, 9, 1934.

Edwards, A. B.: Textures of the ore minerals and their significance, Aus. Inst. M. M., 1947.

Gruner, J. W.: Magnetite-martite-hematite, Ec. Geol., 21, 1926.

Short, M. N.: Microscopic determination of the ore minerals, U. S. Geol. Survey Bull. 914, 1948.

Stokes, H. N.: On pyrite and marcasite, U. S. Geol. Survey Bull. 186, 1901.

Tarr, W. A.: Alternate deposition of pyrite, marcasite, and possibly melnikovite, Amer. Mineral, 12, 1927.

Warren, H. V.: Distribution of silver in base metal ores, Trans. Amer. Inst. Min. Met. Eng., 115, 1935.