MINERALOGY
OF THE
ALLCO SILVER MINES PROPERTY.

600370

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INDEX.

FOREWORD.

The writer wishes to acknowledge the help of Dr. H. V. Warren, who supervised this study, and who made it especially interesting through his unfailing enthusiasm and ready advice and suggestions. The examination of polarization effects on the minerals was done by Dr. Warren.

The writer is also pleased to acknowledge the assistance of Mr. R. M. Thompson, who gave generously of his time to sawing particular specimens, assaying and to demonstrating effective techniques in examining puzzling minerals.

INTRODUCTION.

The microscopic examination of the ore from Allco Silver Mines, Ltd. was undertaken as part of the Geology 9 course at the University of British Columbia.

The following method was used. Small slabs were cut with a diamond saw from suitable specimens of ore. These slabs were mounted in a gum preparation and then ground, first on steel laps, then on a glass plate, and finally were burnished on a lap covered with billiard-cloth, using a suitable abrasive in each process.

The polished sections were examined under a microscope and tested with minute drops of chemical reagents ($FeCl_3$, $HgCl_2$, KCN, KOH, HCl, HNO_3, Aqua Regia.) As a further test, in some cases, small pieces were drilled from the section and tested with a microchemical analysis, whereby the elements present could be determined by the crystals that grew in the field of the microscope. One mineral was examined under polarized light. These data, coupled with observed colour and hardness, enabled identification of the minerals, using the tables in "Microscopic Determination of the Ore Minerals". (Short).

THE PROPERTY.

1. Location and Accessibility.

The property of "Allco Silver Mines, Ltd" is about twenty miles north-easterly from Revelstoke, B. C. It lies at the Head of the middle fork of Silver Creek, and is reached from Silver Creek Siding, which is on the main line of the C. P. R. two miles west of Albert Canyon, B. C.

From Silver Creek Siding the route to the property follows the first four miles of the road to the "Regal Silver" mine, and then branches westerly for another four miles. The last four miles is traversed by a rough trail over which a caterpillar tractor may be taken.

The claims lie across the divide between Silver Creek (which flows into the Illecillewaet River) and Carnes Creek (which drains into the Columbia River). They are in alpine meadow country at elevations of 5900 feet to 7800 feet.

2. Development.

The property consists of twenty-six claims. Eight of the claims, comprising the "Iron Cap" and "Limestone Dyke" groups were staked in 1930.

The other eighteen claims were staked in 1934. The "Allco" syndicate was formed in 1930, when M. C. Arnold was placed in charge of development work. Work continued for seven seasons, with 1935 being the most active, when 23 men were employed. All mining was done by hand.

In 1936 R. D.Watson replaced M. C. Arnold, and employed eight men, who did 270 feet of drifting and 57 feet of crosscutting. A total of 99 tons of ore were shipped that year. The returns were as follows:

Gold	6 oz.= .06 oz/ton.
Silver	6,742 oz.= 68 oz/ton.
Lead	86,519 lb.= 43.8 %.

In 1937 six men were employed (3 underground) and they did 65 feet of shaft sinking, 50 feet of winze and 115 feet of crosscutting, and shipped 114 tons of ore, which showed:

Silver	4,469 oz.= 39.2 oz/ton.
Lead	86,640 lb= 38.1 %.

Up to 1937 a total of eleven veins had been partially developed by means of open cuts, adits, shaft, and winze. The property has been inactive since that date.

3. Geology.

A. Structure.

The rocks in the area are late pre-Cambrian sediments. They consist of crystalline limestones and argillaceous or carbonaceous sediments in various stages of metamorphism from argillite to mica schists, with lesser quantities of quartzite and chlorite schists. Two broad zones of crystalline limestone, containing graphitic schists, are separated by fairly massive quartzites. It is around these limestones that most of the work has been done. The rocks strike west of north, and dip at 30° to 60° eastward. No igneous bodies outcrop on the property, but the series as a whole has been intrusted by late Mesozoic granitic magmas.

B. Mineralization.

The mineralization is (a) associated with the limestone and (b) in quartz veins.

(a) Associated with the Limestones.

(i) Fissure Fillings.

Two small parallel fractures contain galena-sphalerite ore. Most of the ore so far opened up is highly oxidized.

A sample of selected galena assayed[1]

Gold........0.04 oz/ton.
Silver.....94.4 oz/ton.
Lead.......63. %.

Selected pyrite from this type of deposit assayed[2].

Gold........trace.
Silver......1.8 oz/ton.
Lead........nil.

(ii) Replacements.

Lenses and disseminations of sulphides, chiefly pyrite and sphalerite, occur as replacements in silicified limestone. Selected sphalerite assayed[3].

Gold........trace.
Silver......1 oz/ton.
Lead........nil.
Zinc........42 %.

(b) Quartz veins.

Most of the quartz veins occur in argillite. They are mineralized with grey copper, with minor amounts of sphalerite and galena.

[1] Report of B. C. Minister of Mines, 1935, p. E 19.
[2] Ibid.
[3] Ibid.

THE SAMPLES.

Sample 1.

From "Vein No. 1." of the fissure-filling type. The ore is partially oxidized, and coated with limonite and a mixture of cerussite ($PbCO_3$) and anglesite ($PbSO_4$). A fresh surface shows, in order of abundance, galena, sphalerite, and pyrite. The galena is medium grained. The ore is vuggy, and some of the cavities show well developed cerussite and anglesite crystals. Specific gravity determinations by R. M. Thompson gave:

Cerussite--spec. 1-- S.G.= 6.43.
spec. 2-- S.G.= 6.45.
Anglesite-- S.G.= 6.28.

Sample 3.

The same material as sample 1, but apparently higher in the vein and more oxidized. The so called "carbonate ore" contains cerussite and anglesite approximately in the proportion 10:1. This material is white and granular, with some limonitic streaks.

Sample 4.

From "No. 2" fissure vein, at a depth of about 170 feet. Most of the sample is too altered to yield fresh surfaces on breaking.

The galena is more coarsely crystalline than in sample 1. A little fine grained quartz is present, and gives the material a honeycombed appearance on weathering. Sphalerite is not abundant on a megascopic examination.

Sample 5.

This sample is massive brown sphalerite with pyrite. The ore has been fractured and oxidized in these fractures. The sphalerite is a light red-brown, indicating that it is not high in iron.

Sample 6.

This is the quartz vein type. The quartz is milky white, and crystalline. The grey-copper occurs in stringers and in chunks up to 3/8 of an inch in size. No pyrite is visible to the naked eye, and galena is only sparingly visible. The green stain is due to malachite, which is an alteration from grey-copper.

An assay showed that the grey-copper might be classed as freibergite, as it contains four percent of silver.

A spectrographic analysis by D. Carlisle gave Cu, Sb, Pb, Ag, As, Zn, Bi (weak), Cd (trace) and Sn and Hg nil.

THE POLISHED SECTIONS.

1. Sections 1 and 4A, 4B.

A. Minerals.

Pyrite FeS_2.

Pyrite is the earliest metallic mineral and remains in small, corroded grains. (see diag. 1)

Sphalerite ZnS.

Sphalerite is the most abundant mineral in section 1, but in sections 4A and B has been mostly replaced by galena.

Tetrahedrite $3Cu_2S. Sb_2S_3$.

Tetrahedrite occurs in minor amounts in section 1. It was not definitely proven in sections 4A and B. It is contemporaneous with, or slightly later than the sphalerite. The boundaries between galena and tetrahedrite are smoother than those between galena and sphalerite, indicating that the tetrahedrite was less susceptible to replacement.

Galena PbS.

Galena is the latest metallic mineral. It is altered to anglesite in patches and stringers. The galena contains small pin-points of another white mineral, which show up when the galena is etched. This may be argentite or tetrahedrite, probably the latter. The unevenness of the etch patterns indicates impurities.

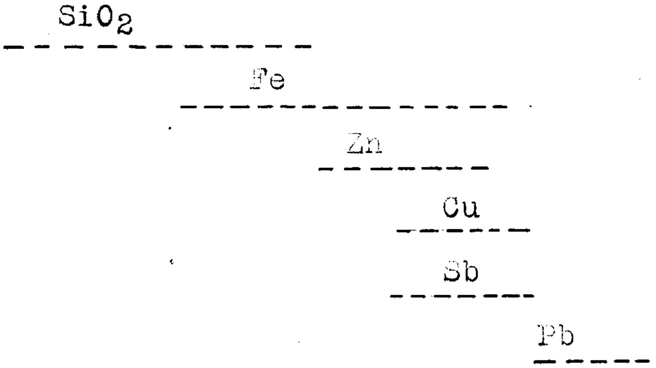
No bournonite was found associated with the tetrahedrite in section 1. It is not necessarily to be expected here merely because it appeared with tetrahedrite in sections 6, because the specimens are from different types of deposits, number 1 is fissure-filling, while number 6 is a mineralized quartz vein.

The material around the less altered portions of ore in sections 4 has a somewhat micaceous habit. In a search (unsuccessful) for argento-jarosite crystals, seven long hexagonal prisms, too small to remove for a microchemical examination, were seen under the high-power lens.

Sections 4 contain a number of micaceous-looking enclusions with parallel orientation. They lie just inside the edges of the fresher portions of ore, and are either alteration products or unreplaced wall-rock. (see diag. 2)

B. Paragenesis.

The metallic elements were introduced in the following order.



2. Sections 5A, 5B.

A Minerals.

Quartz SiO_2

There are either two generations of quartz, or else a long continued period of deposition. The latter is more likely. Diagram 3 shows quartz veining pyrite, but there are other instances of pyrite lying along fractures in quartz, so that continuous deposition is apparent.

Pyrite FeS_2.

In sections 5A the pyrite is in bands about 1/10 of an inch wide. The individual grains average 1/20 of an inch in diameter. In section 5B the banding is not regular, and the grains are about 1/15 of an inch across.

The pyrite is early and has been veined by quartz and sphalerite. Most of the crystal outlines have been destroyed by the fracturing.

Arsenopyrite $FeAsS$.

The arsenopyrite is well crystallized, and diamond and triangular cross-sections are common in the polished sections. The crystals average about 1/60 of an inch in size. In rare cases they are entirely surrounded by pyrite, with which they are contemporaneous in age. Where in contact with pyrite, the arsenopyrite usually shows its superior crystallizing power at the expense of the pyrite.

Sphalerite ZnS.

The sphalerite veins the pyrite (see diag.3) and is itself veined by a soft, non-carbonate gangue.

Tetrahedrite $3 Cu_2S. Sb_2S_3$.

Occurs in minor amounts, associated and contemporaneous with chalcopyrite.

Galena PbS.

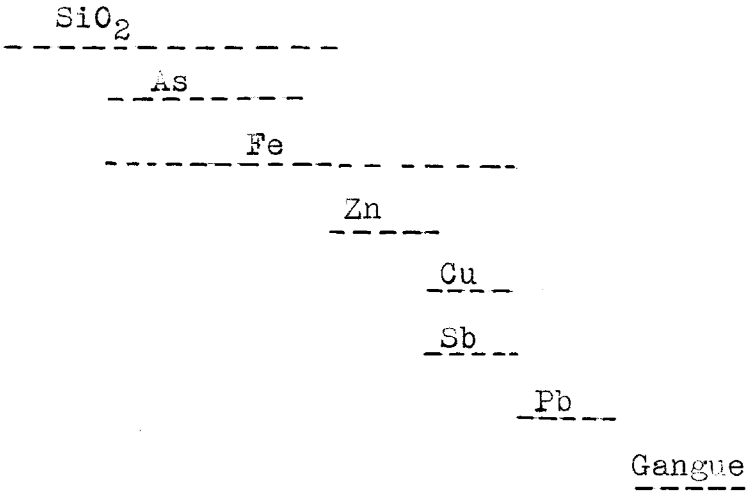
Small spots in the sphalerite were taken to be galena, but they were too small for distinctive microchemical tests and may have been tetrahedrite.

Chalcopyrite $CuFeS_2$.

Chalcopyrite occurs in blebs and streaks through the sphalerite. It is commonly aligned along cleavage cracks. This indicates replacement rather than exsolution (see diag. 4). Three of the streaks in section 5A are composed of intergrown chalcopyrite and tetrahedrite, indicating simultaneous deposition.

B. Paragenesis.

The paragenesis for sections 5A and 5B is as follows.



3. Sections 6A, 6B, 6C, 6D.

A. Minerals.

Quartz SiO_2

Quartz is definitely the earliest mineral. It is cut by tetrahedrite (see diag. 7), which also fills cavities between quartz crystals (see diag.8).

Pyrite FeS_2.

The pyrite grains are all small. They occur both in the quartz and the tetrahedrite. They are noticeably concentrated along the quartz-tetrahedrite boundary (see diag.9). From this it would appear that the pyrite was later than these minerals, and came in along a pre-existent contact. On the other hand, pyrite is replaced by tetrahedrite (see diag. 10) and on this evidence I place pyrite as the earlies metallic.

Sphalerite ZnS.

Sphalerite is not abundant, and was not seen either to vein or to be veined by the tetrahedrite. The mutual contacts are smooth. Lacking definite evidence to the contrary, I place them as contemporaneous.

Tetrahedrite $3Cu_2S. Sb_2S_3$.

This mineral composes about 90% of the metallics in the sections. It carries 4% silver. The tetrahedrite stains light brown with KCN, perhaps because of its silver content. It is extremely pitted. Its contact with quartz is irregular.

Chalcopyrite $CuFeS_2$.

Chalcopyrite occurs in a few irregular blebs in tetrahedrite. It is not oriented in any definite fashion, and I have no evidence as to whether it is a replacement or exsolution.

Galena PbS.

Galena comprises about 4% of the sections. The galena-tetrahedrite boundaries are smooth, and neither was found to vein the other. However, bournonite veins the tetrahedrite but not the galena (see diag. 11) so on that basis which is further discussed under "bournonite", I place galena later than these.

Covellite CuS.

This is a secondary mineral from tetrahedrite, and is the latest metallic mineral in this group of sections. It occurs in small amounts, and can be confused with light effects under the high-power lens of the microscope.

Late Gangue.

A soft gangue, which does not react with HCl, veins the quartz and tetrahedrite. The other minerals occur.

Bournonite $Cu_2S.2PbS.Sb_2S_3$.

A white, soft, mineral was found to be bournonite. It occurs in two characteristic relations.

1. Associated with galena.

The bournonite rims galena (see diag. 11) The galena-bournonite contact is smooth, and the bournonite was nowhere seen to vein the galena. The tetrahedrite-bournonite contact is uneven, and the bournonite runs off in veinlets into the tetrahedrite. It is not a reaction rim between galena and tetrahedrite because it does not corrode the galena.

2. In tetrahedrite.

Bournonite occurs veining and irregularly cutting the tetrahedrite, entirely away from any galena (see diags.12, 13). It is more readily altered then the tetrahedrite (see diag. 14).

B. Method of Determining Bournonite.

Bournonite is slightly lighter in colour than tetrahedrite, and darker than galena. The best way to show it up ~~is~~ in the sections is to stain the tetrahedrite with KCN, and if galena is present, to stain this with $FeCl_3$. The bournonite remains unchanged. It is negative to KCN, $FeCl_3$, $HgCl_2$, KOH, and HCl. It sometimes darkens with HNO_3 but the test is not conclusive. It stains irridescent and effervesces with aqua regia.

Microchemical analyses were not particularly satisfactory because of the small size of the mineral veinlets. A veinlet of bournonite entirely surrounded by tetrahedrite gave a lead test. A copper test was obtained from some bournonite that projected into quartz. In the antimony test ("double iodide") the yellow colour appeared when KI was added, but the $CsCl_2$ did not give satisfactory hexagonal crystals.

Polarization colours gave a good check for bournonite. They are greenish grey, dark brown, and purple.

The following are the minerals listed by Short in the same etch test group as bournonite, and the reasons for ruling them out.

Chalcophanite--colour grey. HCl drop colours brown.

Chalcopyrite--entirely dissimilar.

Cubanite--invariably found with chalcopyrite. Colour brownish or pinkish cream.

Cinnabar--entirely dissimilar.

Freieslebenite--polarization colours light grey, dark grey.

Metacinnabar--entirely dissimilar.

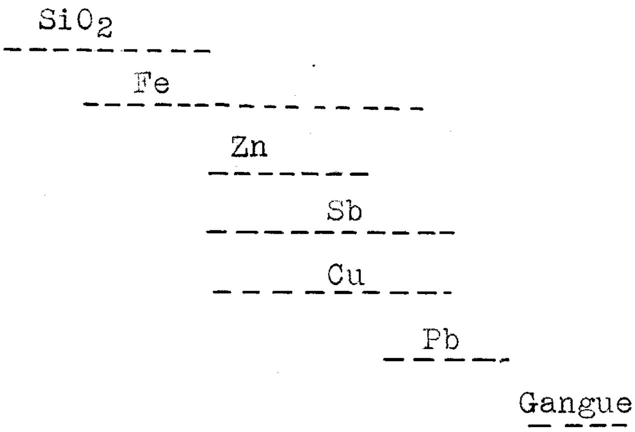
Nagyagite--habit platy, flexible polarization colours light grey, brown, dark grey.

Sulvanite--very rare. No reason to expect vanadium in ore. KCN usually stains.

C. Paragenesis.

Bournonite is evidently not a reaction rim between galena and tetrahedrite, because the galena-bournonite boundary is smooth. It does not appear to be a fracture filling in the tetrahedrite because the walls of the veinlets do not match. (see diag.12). It does not vein the galena. Two conclusions may be drawn. One--the bournonite is later than the galena and tetrahedrite, and came in along the pre-existing contact, where it replaced tetrahedrite in preference to galena. If this were the case, however, I would expect to find bournonite along other pre-existing contacts, such as those with quartz and pyrite. This is not found. Two--the galena is later than the bournonite. I believe this to be the case, and that bournonite replaces tetrahedrite. This could all happen in a continuous deposition. A solution rich in Sb and Cu was depositing tetrahedrite, and then, as Pb appeared, bournonite was formed. Finally, the Sb and Cu played out, and galena was precipitated. Such an explanation is, of cours, impossible of proof, but I believe that the deposition is in that order.

The paragenesis for the quartz-tetrahedrite deposit is:



SECTION 4 A

Galena Replacing Pyrite

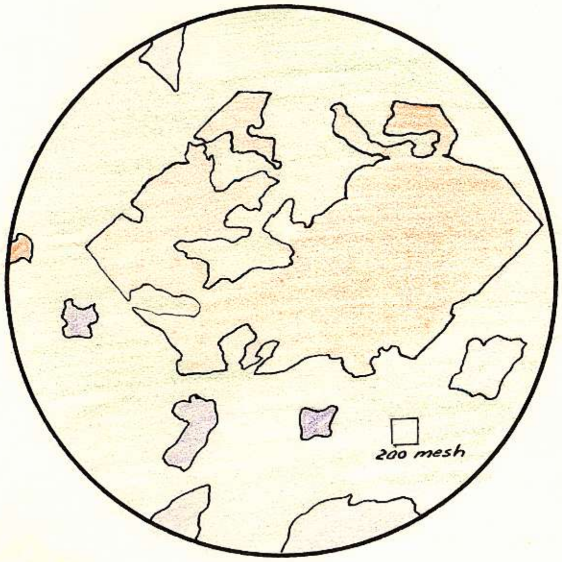


Diagram 1

Green - Galena

Orange - Pyrite

Purple - Sphalerite

Gray - Quartz

Black - Inclusions

Section 4 B

Oriented Inclusions in Galena

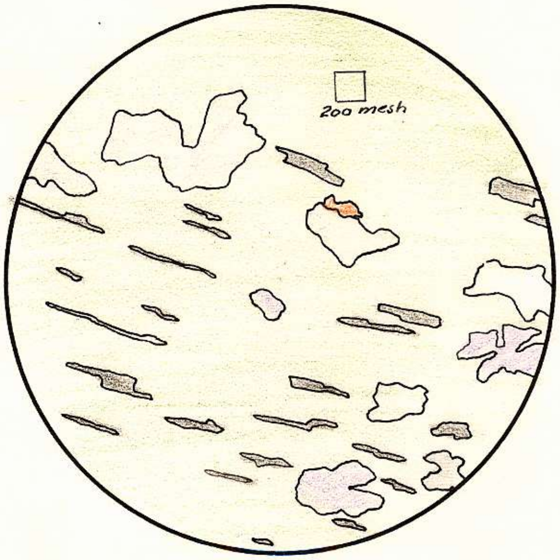
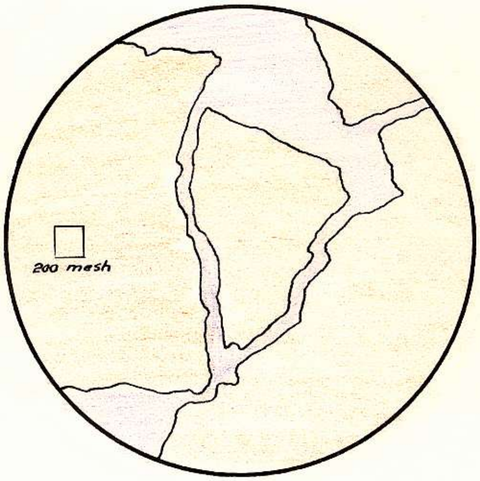


Diagram 2

SECTION 5 A

Diagram 3 Sphalerite Veining Pyrite



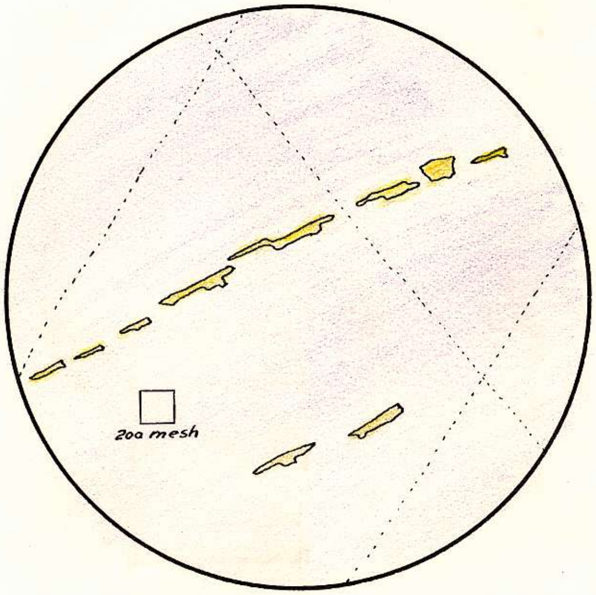
Orange - Pyrite

Purple - Sphalerite

Yellow - Chalcopyrite

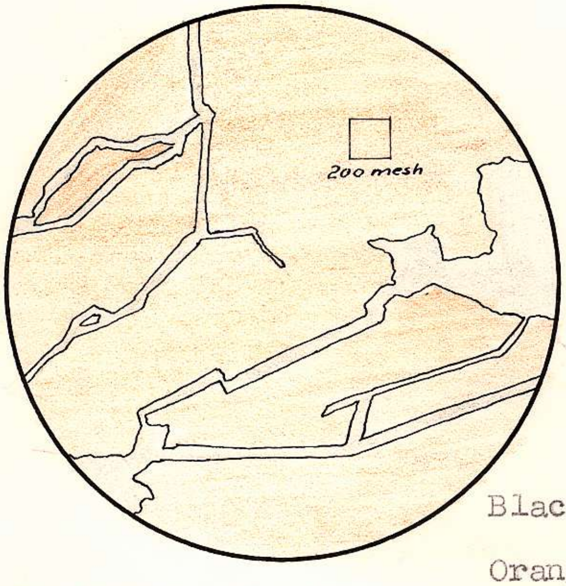
Diagram 4

Chalcopyrite in Sphalerite



SECTION 5 B

Diagram 5



Quartz Veining Pyrite

Black - Arsenopyrite

Orange - Pyrite

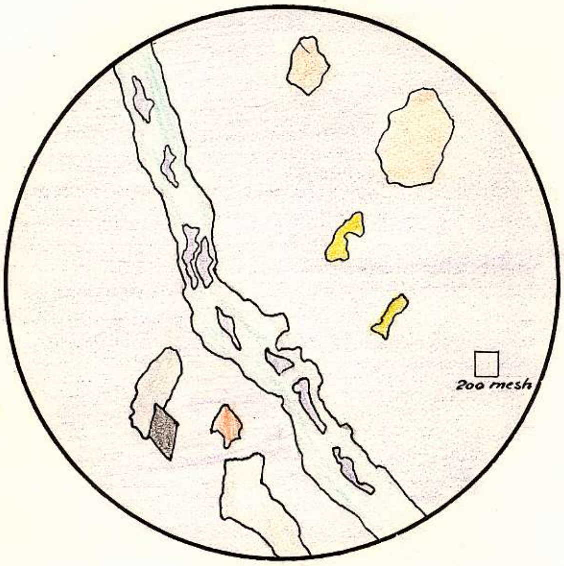
Purple - Sphalerite

Yellow - Chalcopyrite

Grey - Quartz

Green - Alteration

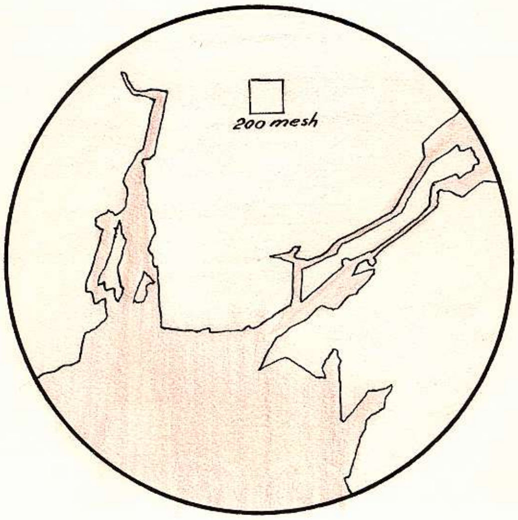
Diagram 6



Alteration Veinlet in Sphalerite

SECTION 6 A

Diagram 7

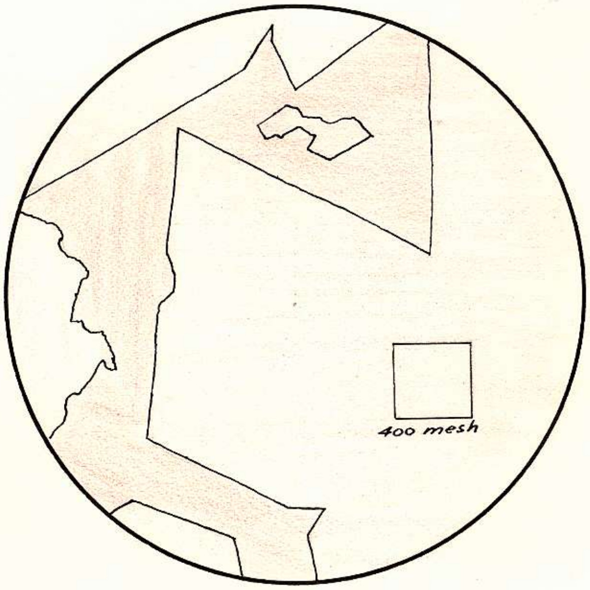


Tetrahedrite Veining Quartz

Brown - Tetrahedrite

Grey - Quartz

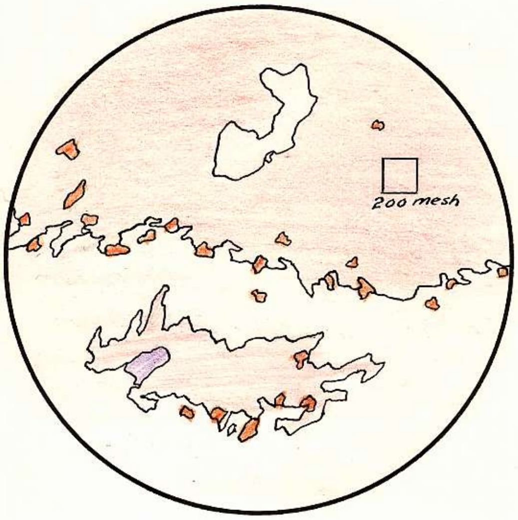
Diagram 8



Tetrahedrite Filling Spaces Between Quartz Crystals and Partly Replacing Them

SECTION 6 B

Diagram 9



Pyrite Concentrated on the Quartz-Tetrahedrite Boundary

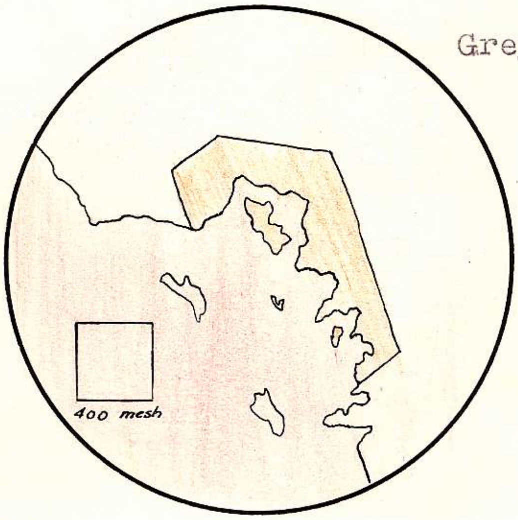
Brown - Tetrahedrite

Orange - Pyrite

Purple - Sphalerite

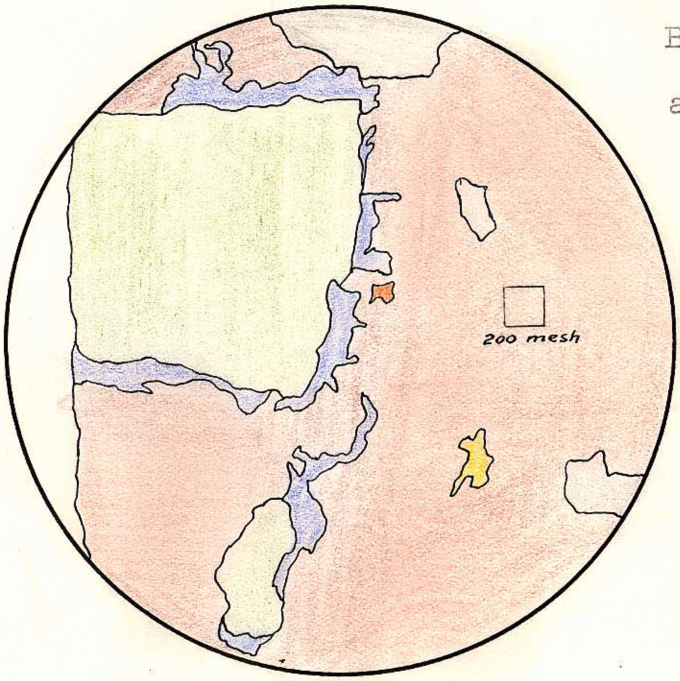
Grey - Quartz

Diagram 10



Tetrahedrite Replacing Pyrite

SECTION 6 B



Bournonite Rimming Galena and Cutting into Tetrahedrite.

Blue - Bournonite

Green-Galena

Brown - Tetrahedrite

Orange - Pyrite

Yellow - Chalcopyrite

Grey - Quartz

Diagram 11

SECTION 6 c

Bournonite in Tetrahedrite

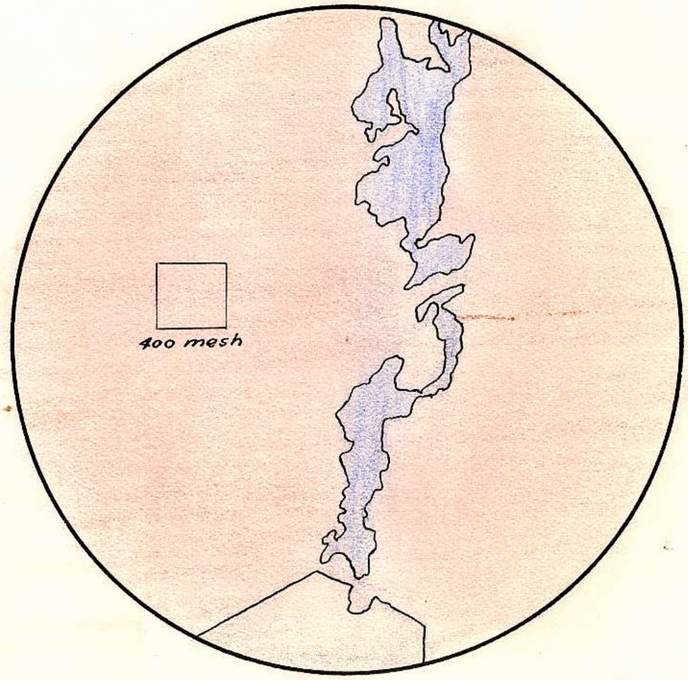
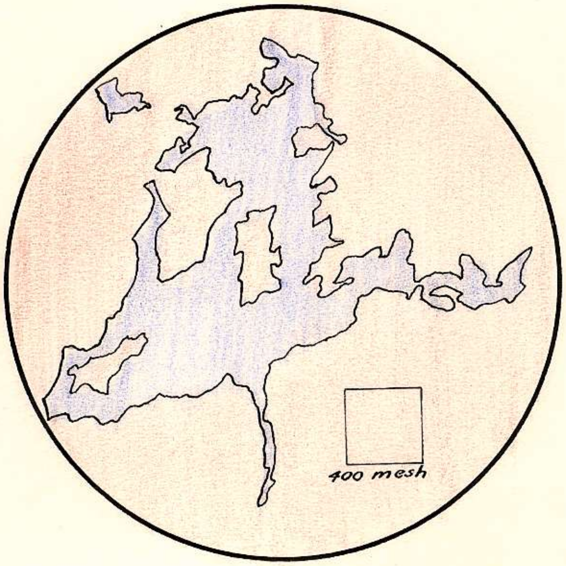


Diagram 12

SECTION 6 a

Diagram 13



Bournonite Occurring Irregularly in Tetrahedrite

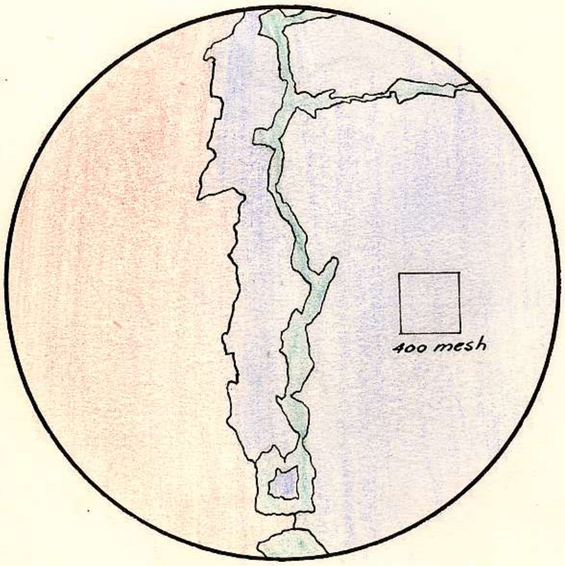
Blue - Bournonite

Brown - Tetrahedrite

Green - Alteration

SECTION 6A

Diagram 14



Bournonite More Easily Altered Than Tetrahedrite.

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