Rough in spots
2nd Class.

23/35

600259

ACKNOWLEDGMENT

The author wishes to express his appreciation to Professor H. M. Howard, of the Mining and Metallurgy Department of U.B.C., who obtained the Emerald Glacier Ore. Also he wishes to thank Dr. R. M. Thompson, and other members of the Geology Department of U.B.C. for assistance in the mineralogical study of the ore with the microscope.

Dalton L Russell.
April, 1952.

CONTENTS

ILLUSTRATIONS

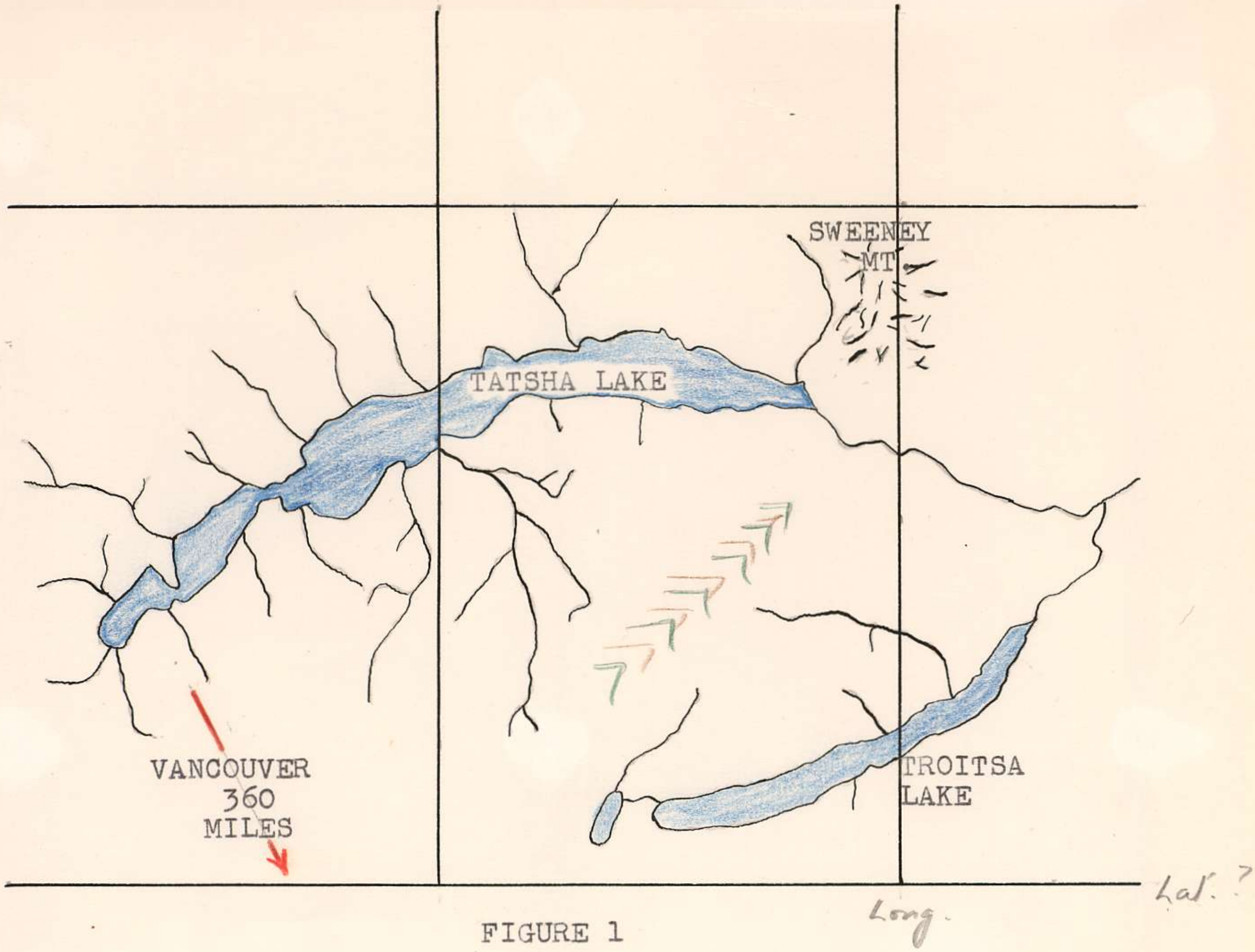


FIGURE 1

MINERALOGRAPHIC STUDY OF THE

EMERALD GLACIER ORE

BY D. L. RUSSELL

INTRODUCTION

The Emerald Glacier Ore was given to the author as a research problem in mineral dressing. Permission was granted by Dr. R. M. Thompson to work on the ore as a mineralographic problem in Geology 409.

A sample of the Emerald Glacier Ore was shipped to the University of British Columbia by Kenville Mines Ltd., Nelson, B. C. Specimens for mineralographic study were picked out, cut and polished. The following is a report on the procedure and results obtained by the author.

LOCATION AND GENERAL GEOLOGY

The Emerald Glacier deposit is located at Sweeney Mountain at the east end of Tahtsa lake, approximately 360 miles north-northwest of Vancouver, B. C. in the Tweedsmuir Park area.

See figure 1. page I.

The earliest geological information concerning the district is contained in a report by G. M. Dawson, (Geol. Surv. Can., Ann. Rept., 1876) who explored the country immediately to the east. In 1916 and again in 1919 J. D. Galloway examined mineral claims on Whitesail lake, south of Tahtsa lake, and Sweeney mountain.

The area is mainly occupied by a very thick assemblage of volcanic rocks with lesser amounts of waterlain tuffs, limestones, and argillites. These rocks are referred to the Hazelton group. They are intruded by a number of diorite dykes. The flow rocks, in the Hazelton group, range from rhyolites to basic porphyrites, but massive andesites, either porphyritic, or non-porphyritic, form by far the greater part of the assemblage. Vesicular lavas are present, but are not abundant. The basic varieties are characteristically purple or green, whereas the tuffs and rhyolites, where not stained red, are commonly ash-grey, or white, and in places even black.

The valuble metals present are silver, lead and zinc. Other minerals present but not of commercial value are chalcopyrite, pyrite and arsenopyrite.

MEGASCOPIC EXAMINATION

There are a number of hand specimens which were examined. Some of these were the remainder of the pieces which were polished others were used for hand specimens only.

The first hand specimen examined is approximately 2 x 3 x 2 inches. The first property noticed is the high specific gravity of the specimen. This high specific gravity (5 - 6) is due to high galena content.

The galena is easily recognized by the lead gray colour, metallic lustre, cubic cleavage and hardness. It appears as definite areas in the specimen. All areas show distinctive cubic cleavage. The surface appears fresh that is not oxidized to any extent.

The second mineral observed is chalcopyrite. It is identified by the brass-yellow colour, metallic lustre, and hardness (3.5 - 4). The surface is tarnished due to oxidation. The mineral is massive and is associated with the galena and another paler brass yellow mineral, pyrite. The chalcopyrite appears throughout the specimen.

A third mineral present is pyrite. This mineral is identified by the metallic lustre, pale brass yellow colour, and hardness. At one place it appears massive but in another it is crystalline. It is associated with galena, chalcopyrite and appears in the quartz.

Quartz stringers appear throughout the minerallized area. This quartz is highly crystalline.

Also present is one of the common rock forming minerals a porphritic andesite.

Estimated percentages by volume of important minerals are:

(1) Galena - 25 per cent
(2) Chalcopyrite - 10 per cent
(3) Pyrite - 15 per cent
(4) Remainder gangue minerals.

The remaining specimens will be treated more generally.

Specimen 2 - This specimen, 2 x 1 x 1 inches, is composed mainly of sphalerite. The mineral was identified by the cleavage, yellow-brown streak.

Also present is a small amount of pyrite. The remaining mineral is mainly quartz.

Estimated amounts of minerals present by volume are:

(1) Sphalerite - 75 per cent
(2) Quartz - 25 per cent
(3) Others approximately 1 per cent.

Specimen 3 - In this specimen, approximately 3 x 3 x 2 inches, the ground mass is definitely quartz the valuable minerals being dispersed throughout it.

Minerals easily identified and estimated amounts present by volume are:

(1) Galena - 10 per cent

(2) Chalcopyrite - 10 per cent

(3) Sphalerite - 10 per cent

(4) Pyrite - 5 per cent

(5) Remainder mostly quartz plus a few other gangue minerals.

Some of the other hand specimens show a gangue mineral which I believe is rhodochrosite. A few of the gangue minerals are definitely carbonates because they effervesce with hydrochloric acid.

Why -

It should be noted that the percentages of minerals estimated for the specimens are for the specimens only and are not a true indication of the assay of the ore.

CONCLUSIONS FROM MEGASCOPIC EXAMINATION.

The ore is a lead-zinc-copper ore with associated minerals present. More will be learned about these minerals from the microscopic examination.

MICROSCOPIC EXAMINATION

Eleven specimens were cut, mounted and polished by the author. After examination of these specimens the author was given the nineteen specimens mounted and polished by Mr. Minifie who had worked on this ore previously. The author wishes to thank Mr. Minifie for his work.

The following will be a report on each specimen.

Specimen No. 1 - The first mineral readily identified even without the microscope is chalcopyrite. It is a bright brass yellow and was easily identified from previous experience.

See figure 2 for example.From specimen No. 3

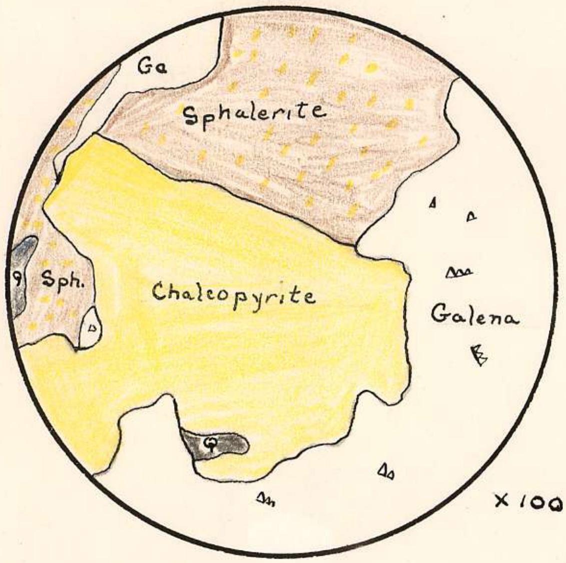


FIGURE 2

The second mineral of great abundance is a dark gray mineral. The author was not sure it was sphalerite so the standard procedure for determination was carried out.

The colour as stated is dark gray. The hardness determined was C or C plus. The mineral is definitely isotropic. The etch test results were:-

positive - Aqua regia effervesced and stained dark brown
- HNO_3 fumes tarnished slightly

negative - KCN, $FeCl_3$, KOH and $HgCl_2$

These tests put the mineral in a group with sphalerite. By a microchemical test zinc was proven to be present thus the mineral is sphalerite.

Appearing throughout the sphalerite are minute blebs of chalcopyrite. They also appear to be definitely lined up. See photo figure 3. From specimen No. 2

X 100

CHALCOPYRITE (LIGHT) IN SPHALERITE (DARK): REAL BLACK IS GANGUE.
FIGURE 3

The following explanation from Edwards, "Textures of the Ore Minerals", applies in this case.

Sphalerite and chalcopyrite are capable of some degree of solid solution at temperatures above 350°C to 400°C and solutions of chalcopyrite in sphalerite unmix at about these temperatures. Solution of sphalerite in chalcopyrite develops at rather higher temperatures, and unmixing occurs at about 550°C. Solution does not take place with the speed and ease that distinguishes some systems and the extent of the solution is not known. From the microtextures it would appear that chalcopyrite is soluble to the extent of about 10 per cent in sphalerite and sphalerite to a somewhat less extent in chalcopyrite.

The two minerals crystallize in different systems, but chalcopyrite, though tetragonal, has its angles very close to those of the cubic system. The common bisphenoids are very nearly regular tetrahedra, and the crystals were at one time thought to be cubic, with the symmetry of sphalerite. The crystal structure is closely related to that of sphalerite. The unit cell of chalcopyrite resembles two cubic unit cells of sphalerite stacked one on top of the other, so that the c-axis is nearly twice as great as the a-axis. In sphalerite the zinc atoms are arranged in a face-centred cubic lattice, and the sulphur atoms, which are arranged in a similar lattice, lie so that each is between four zinc atoms. In the chalcopyrite structure, the zinc atoms are replaced alternately by copper and iron atoms, so that each sulphur atom lies between two copper and two iron atoms at the corners of a tetrahedron, instead of between four zinc atoms.

On cooling, unmixing occurs. A solution of chalcopyrite in sphalerite gives rise to a myriad of minute blebs or blades of chalcopyrite dispersed through the sphalerite. (See figure 3). In some instances the inclusions are distributed in the (111) or (100) directions of the host, but often the crystallographic distribution is not apparent, and the chalcopyrite blebs are more or less uniformly distributed through the sphalerite, giving the so-called "emulsion" or "mottled" texture. Frequently the chalcopyrite bodies show a wide range in size, and an unequal distribution throughout a single sphalerite crystal. In such instances the distribution is generally seriate, and sphalerite adjacent to a coarse exsolution body of chalcopyrite, or to a grain boundary of a chalcopyrite crystal, appears to be "drained" of ex-solution chalcopyrite. Not common in these specimens. Such intergrowths are the result of progressive unmixing, and both solid solutions may unmix simultaneously in the same ore, giving use to an intergrowth of granular crystals of chalcopyrite and sphalerite, in which the chalcopyrite contains ex-solution bodies of sphalerite, and the sphalerite encloses ex-solution bodies of chalcopyrite. The rate of diffusion slows as the concentration of the solute is reduced, and the temperature falls, and this results in the formation of more numerous, smaller blebs of chalcopyrite, which often fail to diffuse to the grain boundaries.

Ex-solution intergrowths of sphalerite in chalcopyrite are relatively uncommon, because the unmixing occurs at rather higher temperatures than that of solutions of chalcopyrite in sphalerite. The sphalerite may develop as blades, oriented in the crystallographic planes of the chalcopyrite, or, more rarely, form a micrographic intergrowth with it, but frequently it is precipitated as star-shaped, skeletal crystals, elongated in the (111) planes of the chalcopyrite (the directions that present least opposition to the growths of the sphalerite crystals).

See photo figure 4. From specimen No. 2

x100

SPHALERITE STARS (DARK) IN CHALCOPYRITE (LIGHT)

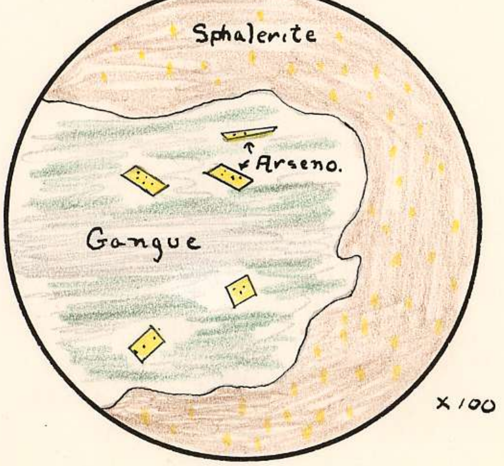
FIGURE 4

The majority of the blebs are about 1 - 2 microns in diameter. The massive chalcopyrite ranges up to 1 - 2 centimeters. The sphalerite stars which appear best in section 2 are approximately 1 - 2 microns in size.

The next mineral identified was pyrite. It was identified from previous experience with the mineral. The masses range from 10 microns to .25 centimeters across. Crystals, true crystals, of pyrite were fairly rare in all specimens examined.

The fourth mineral identified was galena. The galena is present in small amounts in this specimen. Previous experience with galena, the triangular pits, and galena gray colour, made it readily identifiable.

The fifth mineral present is arsenopyrite. This was identified from the hardness F plus, anisotropic polarization colours of greenish yellow, brown and violet. Diamond-shaped cross sections were also observed. See figure 5. From specimen No. 3.



ARSENOPYRITE IN GANGUE
FIGURE 5

The arsenopyrite diamond-shaped cross sections range from 1 to 5 microns across.

Primary minerals in order of abundance are:

(1) Sphalerite - 60 per cent by area

(2) Chalcopyrite - 35 per cent by area

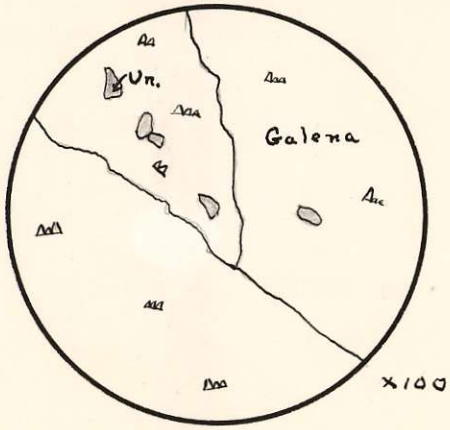
(3) Pyrite, galena, arsenopyrite - remaining 5 per cent plus some gangue

Specimen No. 2 - Minerals present that were identified in specimen No. 1 are:- (1) chalcopyrite, (2) galena, (3) pyrite, (4) sphalerite and (5) very little arsenopyrite.

These minerals have all the characteristics of minerals in section No. 1. It was from this section that the photographs were taken.

There is present in this section one more mineral which will have to remain unknown. This section (No.2) is the only one the author found to contain this mineral. The mineral is in the galena but is a slightly darker gray.

See figure 6. From specimen No. 2.



UNKNOWN IN GALENA
FIGURE 6

The hardness determined is B.

The mineral is strongly anisotropic having polarization colours of blue to gray. The etch tests were masked due to the etching of the galena. The author tried microchemical tests on the largest piece 1.5 microns by 15 microns but no positive results obtained. The remaining blebs of mineral are approximately 1 - 2 microns in diameter which is to small to work with.

Primary minerals, section No. 2, in order of abundance are:

(1) Chalcopyrite	-	50 per cent by area
(2) Sphalerite	-	15 per cent
(3) Pyrite	-	15 per cent
(4) Galena	-	10 per cent
(5) Arsenopyrite	-	Unknown and
gangue	-	10 per cent

The "Unknown" amounts to less than one per cent.

The remaining specimens of suite contain only minerals previously described. Therefore the author will list each giving per cent by area of each mineral in specimen.

Specimen No. 3

(1) Sphalerite	-	60 per cent
(2) Galena	-	20 per cent
(3) Chalcopyrite	-	10 per cent
(4) Pyrite	-	1 per cent
(5) Arsenopyrite less than 1 per cent		
(6) Gangue	-	remaining 8 - 9 per cent

Specimen No. 4

(1) Sphalerite - 5 per cent
(2) Pyrite - 3 per cent
(3) Galena - 1 per cent
(4) Chalcopyrite - 1 per cent
(5) Arsenopyrite - 1 per cent
(6) Gangue - remaining 90 per cent

Specimen No. 5

(1) Sphalerite - 10 per cent
(2) Pyrite - 5 per cent
(3) Chalcopyrite - 2 per cent
(4) Galena - less than 1 per cent
(5) Arsenopyrite - less than 1 per cent
(6) Gangue - remaining 80 per cent

Specimen No. 6

(1) Sphalerite - 65 per cent
(2) Chalcopyrite - 3 per cent
(3) Pyrite - 1 per cent
(4) Galena - less than 1 per cent
(5) Arsenopyrite - less than 1 per cent
(6) Gangue - remaining 30 per cent

Specimen No. 7

(1) Sphalerite - 85 per cent
(2) Galena - 10 per cent
(3) Pyrite - 2 per cent
(4) Chalcopyrite - 2 per cent
(5) Arsenopyrite - 1 per cent

Specimen No. 8

(1) Sphalerite - 10 per cent

(2) Pyrite - 7 per cent

(3) Chalcopyrite - 1 per cent

(4) Galena - 1 per cent

(5) Arsenopyrite - 1 per cent

(6) Gangue - remaining 80 per cent

Specimen No. 9

(1) Sphalerite - 20 per cent

(2) Chalcopyrite - 2 per cent

(3) Galena - 1 per cent

(4) Pyrite - less than 1 per cent

(5) Gangue - remaining

Specimen No. 10

(1) Sphalerite - 90 per cent

(2) Chalcopyrite - 8 per cent

(3) Arsenopyrite - 1 per cent

(4) Galena - 1 per cent

(5) Pyrite - less than 1 per cent

Specimen No. 11

(1) Sphalerite - 80 per cent

(2) Chalcopyrite - 10 per cent

(3) Pyrite - 2 per cent

(4) Galena - 1 per cent

(5) Arsenopyrite - 1 per cent

(6) Gangue - remaining 5 per cent

TABLE OF SPECIMEN CONTENTS

Specimen	Sphal.	Galena	Chalco.	Pyrite	Arseno.	Unknown
1	x	x	x	x	x	
2	x	x	x	x	x	x
3	x	x	x	x	x	
4	x	x	x	x	x	
5	x	x	x	x	x	
6	x	x	x	x	x	
7	x	x	x	x	x	
8	x	x	x	x	x	
9	x	x	x	x		
10	x	x	x	x	x	
11	x	x	x	x	x	

Kept this one
Discarded all the
rest.

Mr. Minifie reported pyrrhotite and tetrahedrite present in some of his sections last year. This author examined Mr. Minifie's sections and could not find any pyrrhotite present. As for tetrahedrite this author found some in Mr. Minifie's section 16.

See figure 7. From Mr. Minifie's section 16.

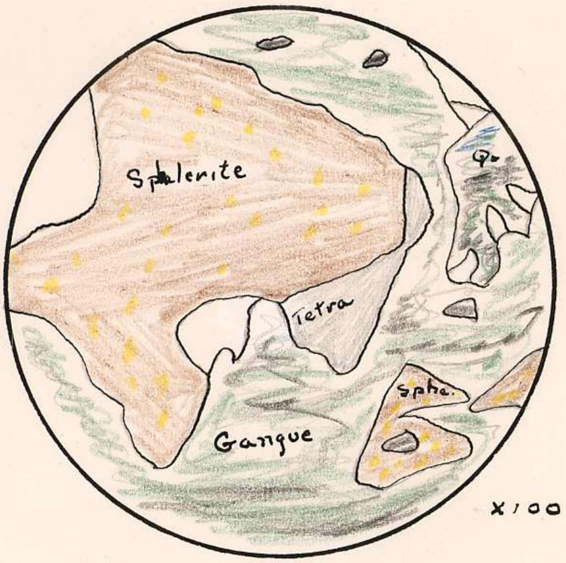


FIGURE 7

TETRAHEDRITE IN SPHALERITE

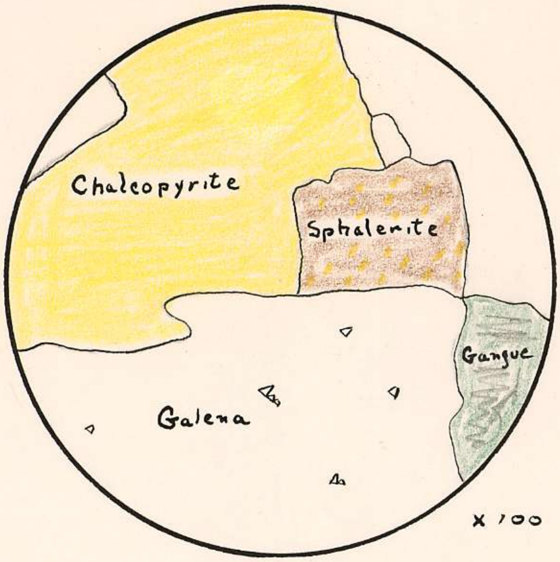
No tetrahedrite was found in the eleven sections mounted and polished by this author.

PARAGENISIS OF THE MINERALS

The quartz, pyrite and arsenopyrite were deposited or crystallized from solution first. The sphalerite, chalcopyrite and galena came next. The unmixing of the sphalerite and chalcopyrite to give "mottled" or "emulsion" texture and stars as shown in figures 3 and 4 is evidence that they solidified together.

As to whether the galena or the sphalerite-chalcopyrite came first presented a problem. There is evidence of the "mutual boundary" texture.

See figure 8. From specimen No. 3.



MUTUAL BOUNDARY TEXTURE

FIGURE 8

This implies that the minerals were deposited at the same time. But evidence, figure 9, proves galena came after the sphalerite. From specimen No. 3.

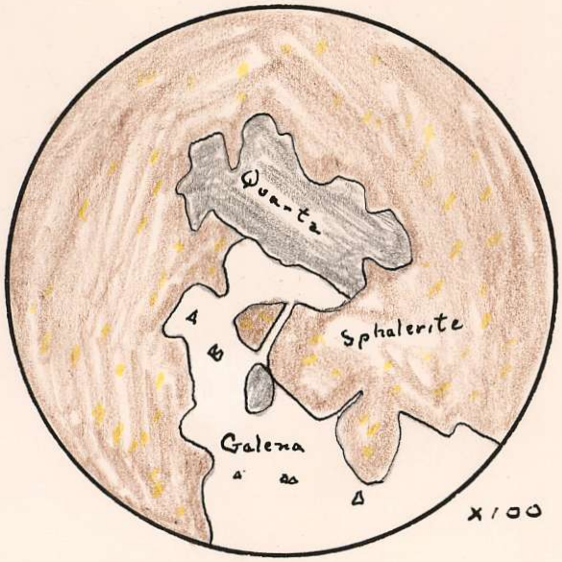


FIGURE 9

GALENA REPLACING SPHALERITE

The difference in time of deposition of these minerals was very small that is why it is possible to get mutual boundary texture.

Evidence of sphalerite and galena coming after pyrite is given in figure 10, which shows pyrite being replaced by sphalerite and galena simultaneously. From specimen No. 7.

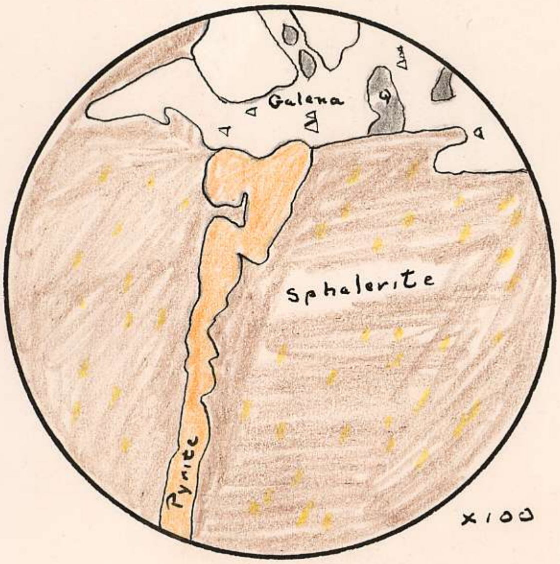


FIGURE 10

PYRITE BEING REPLACED BY SPHALERITE AND GALENA

Thus the paragonisis of the ore in order of deposition is:-

(1) Quartz

(2) Arsenopyrite and pyrite

(3) Sphalerite and chalcopyrite

(4) Galena

(5) The unknown which appears as blebs in the galena see figure 6. It could have been deposited from solid solution and thus would have been deposited at the same time as the galena.

TEMPERATURE OF DEPOSIT

Due to the presence of galena, sphalerite and chalcopyrite the author believes the deposit is mesothermal. It is definitely one of the hydrothermal deposits because according to Edwards "Textures of the Ore Minerals" unmixing of sphalerite and chalcopyrite occurs at approximately 350°C.

CONCLUSIONS

The ore is a lead, zinc, copper ore. The lead being in the form of galena; the zinc in the form of sphalerite and the copper in the form of chalcopyrite. It is seen from the microscopic work that to recover all the chalcopyrite in a flotation circuit would be impracticable because all the chalcopyrite would be freed only at the 1 micron size. This is very impractical.

The assay of the ore from flotation tests are approximately zinc 13 per cent lead 7 per cent and copper .7 per cent. The lead concentrate assayed 54 ounces of silver per ton. This leads the author to believe there maybe another silver bearing mineral present.

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