A MINERALOGRAPHIC REPORT OF A SAMPLE OF ORE FROM THE SUMMIT CAMP AT THE HEADWATERS OF THE TULAMEEN RIVER. SIMILKAMEEN MINING DISTRICT.

A report submitted in partial fulfillment of the requirements of Geology 409, part of the course in Geological Engineering leading to the degree of Bachelor of Applied Science, at the University of British Columbia.

R. A. Barker

The University of British Columbia

April, 1949.

TABLE OF CONTENTS

Acknowledgements	1
General Purpose	2
Introduction	2
Megascopic Examination	3
General Geology	4
Economic Geology	5
Assaying	6
Microscopic Examination	7
-Galena	7
-Argentiferous Galena	7
-Sphalerite	8
-Tetrahedrite	9
-Chalcopyrite	9
Paragenesis	11
Classification of Deposit	12
Conclusions	12
List of Sections	14
Bibliography	15
Illustrations	16

ACKNOWLEDGMENTS

The writer wishes to acknowledge the advice and instruction, in the laboratory, of Dr. R.M. Thompson, Professor of Mineralogy.

Thanks are also extended to Mr. J. Donnan, Technician, for his assistance and instruction in the mounting and polishing of specimens.

GENERAL PURPOSE OF THE INVESTIGATION

The general purpose of this report is to apply those techniques - recognition of the opaque minerals by means of the reflecting microscope, cutting, grinding, and polishing of ore specimens, microchemical methods - learned in the first term, to a particular suite of ores for a critical examination.

This more particular examination was carried out for the purpose of:

1. Determining the minerals present paying particular attention to rare or unusual occurrences.

2. Studying the relationships of the minerals present and if possible determining the paragenesis of the deposit.

INTRODUCTION

The samples of ore herein described were presented to the writer by Dr. R. M. Thompson. They are reportedly from the property of Fred Jenson at the Summit Camp near the headwaters of the Tulameen River.

The exact location of the property is unknown to the writer, but since Cairnes reports that there is a rather remarkable uniformity of physical and mineralogical characteristics throughout the "ore-bodies" of the camp, it is assumed that these samples are more or less representative of the camp.

MEGASCOPIC EXAMINATION

The samples available consisted of several pounds of material containing medium to fine grained sulphides of lead, zinc, iron and copper in a gangue of quartz and minor calcite and ankerite. The walls are composed of a slightly calcareous argillaceous rock.

The main sulphide mass consists of about equal amounts of galena and sphalerite, approximately 40% each, and a lesser amount of pyrite, about 20% of the total sulphides.

The major mineralization occurs in a fissure vein 2 to 3 inches wide. In the hand specimen no conclusive evidence as to order of deposition appears. In one specimen pyrite was more confined to one wall with galena in the central position and sphalerite in abundance on the other wall. But this was by no mean typical since in other specimens there appeared no orderly arrangement of the sulphides. In general though it might be said that the galena appeared most frequently in the centre portions of the vein or veins.

The galena occurs in well crystallized medium to fine grained masses mostly confined to the centre portions of the veins but also found scattered throughout and even filling small fractures in the walls. The sphalerite, also found throughout, but tending to be concentrated along one wall, is finely crystalline and of the dark lustrous variety indicating a fairly high iron content. The pyrite, tending to be concentrated on the wall opposite the sphalerite, is noticeably anhedral in outline. Though some subhedral grains were observed in the fine grained aggregate no well crystallized cubes were seen. The pyrite presents a fractured appearance with the fractures being penetrated by all the other minerals including the quartz. The very minor amounts of chalcopyrite, appearing in small blebs, are mainly intimately associated with the sphalerite but some are associated with the galena.

The quartz occurs as stringers and small masses ramifying from wall to wall throughout the vein. Small stringers of calcite appear here and there while the ankerite appears along the walls.

GENERAL GEOLOGY (2)

Summit Camp lies at the headwaters of Amberty and Sutter Creeks, tributaries of the Tulameen River, about 25 miles from the Tulameen and nearly the same distance from Hope. Its approximate position is 121°07' West Longitude and 49°25' North Latitude.

The area is in a physiographic transition zone between the Cascade Mountains and the Interior Plateau region of British Columbia. The camp is situated on the divide between the Coquihalla and the Tulameen Rivers, chiefly on the eastern slope between the headwaters of Amberty and Sutter Creeks, tributaries of the Tulameen River, and Dewdney Creek, which flows west into the Coquihalla River.

The properties occur in two formations :

1. The older Dewdney Series which consists of thinly bedded, in part more massive, tuffaceous rocks which strike about north 30° west and dip at generally high angles to the southwest. With these tuffs are associated normal sedimentary types chiefly fine grained argillaceous rocks sometimes slightly calcareous. This assemblage is intersected by many dark, coarse grained, hornblende lamprophyre sills and by dykes of more siliceous

and feldspathic composition.

2. The overlying younger formation is a series of sediments ranging from a fairly coarse basal conglomerate to upper calcareous shales. This series appears to have a faulted or unconformable relation with the underlying Dewdney Series. It contains no fossils and is intersected by a number of porphyry dykes, but by none of the lamprophyre sills so common in the Dewdney.

Fossils gathered in the Coquihalla region indicate that the Dewdney Series is either Cretaceous or Jurassic.

With the exception of the higher peaks (above 6500 feet), the entire upland surface of the area has been scored by a regional ice cap which moved over the area in a south westerly direction.

ECONOMIC GEOLOGY(2)

The ore bodies at Summit Camp are fissure-vein deposits of the silver-lead type. In the early days, in the upper portions, they were fairly rich in silver, but in common with other deposits of this type they have shown a rather rapid decrease in silver content over a relatively short vertical range.

The lines of fissuring are in some cases persistent over hundreds of feet. The fissure veins themselves rarely exceed a few inches in width, but replacement of the wall rock by mineralizing solutions has, under favourable conditions, extended for several feet on either side.

The principal ore minerals include galena, sphalerite, chalcopyrite, pyrrhotite, and pyrite. Magnetite, arsenopyrote, and tetrahedrite are less frequently observed. The principal gangue mineral is quartz, but calcite, ankerite, and zeolites have been encountered.

Galena and sphalerite are the prominent minerals in the ore-bearing fissure veins themselves. Pyrite is more common in the zone of replacement on either side of the fissure.

As far as can be determined by the writer little, if any, ore has been shipped from any of the properties in the camp even though values as high as 500 oz. of silver per ton of pure galena have been reported. On some of the properties fairly extensive tunnelling has been done in past years but as far as is known there is no activity at the camp at present.

ASSAYING

An assay of the ore was undertaken by the writer (no data on the precious metal content of the ore being available) to determine:

1. The amounts of precious metals in the ore.

2. If silver was present in any amount since no silver minerals had been observed in the polished sections.

Several pieces of sulphide-rich material were chosen on which to perform the assaying. These were taken together, crushed and pulverized to obtain a product suitable for fire assaying.

Two assays were performed giving the following results:

Sample	A	B	
Silver	24.6	24.5	oz/ton
Gold	trace	---	

Since no silver minerals had been observed in the polished sections it was thought that this silver might occur as argentite or native silver in the galena and etch tests were carried out to examine this possibility.

In 1922 Cairnes reported assays of up to 150 OZ. of silver per ton of pure galena. It is probable that the present samples were obtained within the last few years from a lower horizon in the veins accounting for the marked difference in values.

MICROSCOPIC EXAMINATION

Five representative sections of the ore were prepared and polished. The following minerals were determined and are here presented in order of their importance.

GALENA PbS

All thegalena observed, both in the hand specimen and under the microscope, appeared fresh indicating a position late in the sequence of mineralization. The galena showed the typical development of triangular pits in nearly all cases.

The galena is seen to be apparently replacing all other minerals except perhaps chalcopyrite. As seen in Fig. 1 the galena fills the fractures in the pyrite and also replaces it. Thegalena-sphalerite relationship is not so readily determined. This relation in general tends to conform with Edwards' (4,p.146) description of most lead-zinc ores "----, in which the soft brittle galena occurs largely as angular areas filling the interstices between more or less equiangular grains of harder sphalerite". Also the galena has the general appearance of replacing the sphalerite. Fig. 2 shows the galena apparently dissolving the tetrahedrite. Since this is the only area of tetraherite observed . the evidence is scarcely conclusive but it is surely indicative. An intimate relation between galena and chalcopyrite was observed which will be discussed later.

ARGENTITEROUS GALENA (?)

Since it was known from assay results that the sulphides contained up to 24.6 oz. of silver per ton and since no obvious source for this silver was apparent (in the form of silver minerals) it was necessary to look for some microscopic occurence of this mineral.

It was found upon etching the galena with nitric acid that many minute white areas could be seen under high magnification. These minute blebs, about 1 or 2 microns in diameter, appeared to have a rhombic shape. The size of these blebs precluded any direct testing but it was assumed that these were included silver minerals of some sort. Edwards' (4, pp. 90-91) states that: "Argentiferous galena containing less than 0.1% silver (a maximum of about 30 oz. silver per ton of galena) tends to be homogeneous, but galena with silver in excess of this amount invariably contains included silver minerals. Commonly the silver minerals occur as minute blebs, only 1 to 2 microns in diameter, -------, and presumable precipitated from solid solution in the galena".

SPHALERITE ZnS

All the sphalerite in the sections is of the dark fine grained variety indicating a high iron content. As seen in Figs. 3 and 4 sphalerite actively replaces and fills the fractures in the pyrite. Though the evidence is by no means conclusive in all cases, the sphalerite generally appears to be dissolved by all the other minerals.

Most of the sphalerite shows the typical occurrence of included chalcopyrite blebs. This unmixing phenomenon gives rise to a myriad of minute blebs of chalcopyrite dispersed through the sphalerite, some blebs oriented along crystallographic planes and some in uniform distribution giving the so-called "emulsion" or "mottled" texture (4, Fig. 76 and p.80).

PYRITE - $Fe\ S_2$

The pyrite in virtually all cases is rounded and "old" looking. In only once case was a shape approaching the cube observed. This anhedral pyrite exhibits a general seriate arrangement of the grains. This texture may be due to fracturing and brecciation and /or dissolving by the later minerals.

Pyrite is obviously the first mineral deposited. It would seem that sometime after this deposition took place fracturing and brecciation occurred. Following this the deposition of the other minerals, including quartz, took place. All the other minerals either dissolve the pyrite or fill the fractures in it.

TETRAHEDRITE $3Cu_2S \cdot Sb_2 S_3$

Only one small area of tetrahedrite was observed. This, as shown in Figs. 2 and 5, is an irregular aggregate. It can be seen dissolving and filling fractures in pyrite and apparently replacing sphalerite. Fig. 2 shows tetrahedrite being actively replaced by galena.

The tetrahedrite, similar to the galena and sphalerite, contains irregular patches of chalcopyrite from 10 to 50 microns in size. This will be more fully discussed below.

It was presumed, from the facts that the galena was silver bearing and the tetrahedrite was in such small amount, that the tetrahedrite was not an important source of silver.

CHALCOPYRITE $CuFeS_2$

As has already been stated chalcopyrite shows an intimate association with galena, tetrahedrite, and sphalerite. Though of only minor importance the chalcopyrite presents a problem in the determination of the paragenesis of this ore.

The chalcopyrite - sphalerite relation has been discussed to some extent above. It is found also as irregular patches, approximately 20 to 50 microns in size, included in the terahedrite. In this occurrence the chalcopyrite would appear to be replacing the tetrahedrite. The chalcopyrite exhibits a similar relation with the galena. The relatively large area of chalcopyrite in section 4 is almost surely dissolving the galena.

Thus, excluding for the moment the chalcopyrite, the order of deposition of the minerals, as determined from mutual relations, is: pyrite (first), sphalerite, tetrahedrite, galena (last). The problem now arises as to where to place the chalcopyrite in this sequence. Since it is known that some of the chalcopyrite was precipitated more or less contemporaneously with the sphalerite several alternatives for the placing of the chalcopyrite in the sequence may be suggested:

1. Continuous deposition of chalcopyrite beginning with sphalerite and continuing through and following the deposition of tetrahedrite and galena.

2. Two separate periods of deposition for the chalcopyrite - the first period more or less contemporaneous with the sphalerite and the second period following the galena.

3. Flowage of the chalcopyrite due to post-mineralization deformation.

Because conclusive evidence for anyone of these alternatives is lacking the possibilities must be examined.

The third alternative would at once appear unlikely. If deformation had occurred producing flowage of the chalcopyrite it would seem most probable that deformational effects would be apparent in the brittle sphalerite. Since this evidence is lacking this suggestion can be discarded.

An examination of the evidence does not directly reject either of the other two alternatives. Many writers have proposed a second generation of chalcopyrite mineralization in deposits of this type but Edward's (4,p.118) states: "The possibilities of resurgence and repeated mineralization cannot be dismissed, but this example is sufficient to indicate the difficulties that attend such an interpretation, which should not be invoked unless the weight of evidence renders a simpler explanation impossible". If Edwards' views are accepted the likelihood of the second suggestions (i.e. two periods of chalcopyrite mineralization) is limited.

Therefore, by elimination the most likely alternative appears to be that of continuous deposition of the chalcopyrite. Since it is presumed that the minerals were precipitated from "one" solution (varying in composition), then it can be suggested that this "continuous" deposition need not imply a very long period of time. If this is the case then there is some plausibility to this suggested manner of deposition. But this view seems at variance with the paucity of chalcopyrite in the ore.

The writer favours the suggestion of two periods of mineralization for the chalcopyrite but it can only be concluded here that lack of sufficient evidence prevents the determination of the position of chalcopyrite in the paragenesis.

PARAGENESIS

This writer has concluded, from reading the literature on the subject and from direct observation, that most paragenetic criteria are, at best, only suggestive. It must also be pointed out that a very limited number of illustrations can be used to substantiate any conclusions which may be reached. Thus, the reader, unfamiliar at first hand with the ore, may easily invalidate certain specific criteria which the writer has presented. However it must be remembered that conclusions regarding paragenesis are not reached merely by the study of a limited number of examples of criteria, but by a general impression created by an intensive and long study of polished sections of the ore.

The paragenesis suggested below is presented after a careful examination of all available evidence.

Order of deposition:

1. Pyrite - followed after cooling by a period of deformation in which the pyrite was fractured and brecciated.
2. Quartz.
3. Sphalerite and (?) chalcopyrite.
4. Tetrahedrite.
5. Galena - with silver in solid solution.
6. (?) Chalcopyrite.
7. Carbonate gangue.

CLASSIFICATION OF DEPOSIT

This deposit can be classed as a typical silver - lead - zinc mesothermal deposit.

It may be noted that this deposit has a mineralogic zoning very similar to the silver - lead - zinc deposits of the Slocan district of British Columbia. This zoning is characterized by very high silver values over a very limited vertical range. Further, in the Slocan, a change from a predominance of lead to a predominance of zinc occurs with depth. Although this has not yet been proved in the Summit Camp (owing to the relatively limited amount of work done in the area) the mineralization surely suggests the same zonal arrangement.

CONCLUSIONS

CONCLUSIONS

The following minerals, in their suggested order of deposition, were determmned: pyrite, sphalerite, tetrahedrite, galena (silver bearing), chalcopyrite.

The deposit can be classified as a typical silver - lead - zinc mesathermal deposit.

The writer feels that although no rare or unusual occurrences of minerals were encountered, the prime purpose of the investigation has been achieved. An understanding has been gained of the approach to the techniques involved in a critical examination of a suite of ores.

LIST OF SECTIONS

Minerals are listed in the order of their abundance in each section.

Section 1 - major - Sphalerite
Pyrite
minor - Galena
Chalcopyrite

Section 2 - major - Pyrite
minor - Sphalerite
Chalcopyrite

Section 3 - major - Pyrite
Galena
Sphalerite
minor - Chalcopyrite
Tetrahedrite

Section 4 - major - Pyrite
Galena
minor - Sphalerite
Chalcopyrite

Section 5 - major - Sphalerite
minor - Pyrite
Galena
Chalcopyrite

BIBLIOGRAPHY

1. Bostin, E.S., Etal, "Criteria of Age Relations of Minerals with Especial Reference to Polished Sections of Ores", Econ. Geol. vol. 26, pp. 562-610, 1931.

2. Cairnes, C.E., "Geological Explorations in Yale and Similkameen Mining Divisions, Couth-Western British Columbia," Geol. Surv. of Canada, Sum. Rep., 1922, Part A, pp. 88-122.

3. Danad, E.S., "A Textbook of Mineralogy", 4th Ed., revised by W. E. Ford, John Wiley and Sons, Inc., New York, 1945.

4. Edwards, A.B., "Textures of the Ore Minerals", Australasian Institute of Mining and Metallurgy (Inc.), 1947.

5. Guild, F. N., " A Microscopic Study of the Silver Ores and their Associated Minerals", Econ. Geol. vol. 12 pp. 298-340, 1917.

6. Harvey, R.D., "The Geometrical Pattern of Contacts in Determinative Paragenesis", Econ. Geol. vol. 26, pp 764-711, 1931.

7. Lindgren, Ealdemar, "Processes of Mineralization and Enrichment in the Tintic Mining District", Econ. Geol. vol. 11, pp. 225- 240, 1916.

   - "Pseudo-Eutectic Textures", Econ. Geol. Vol. 25, pp 1 - 13, 1930.

8. Nissen, A. E. and Hoyt, S. L., "On the Occurrence of Silver in Argentiterous Galena Ores", Ecpn. Geol. vol. 10, pp. 172 - 179, 1915.

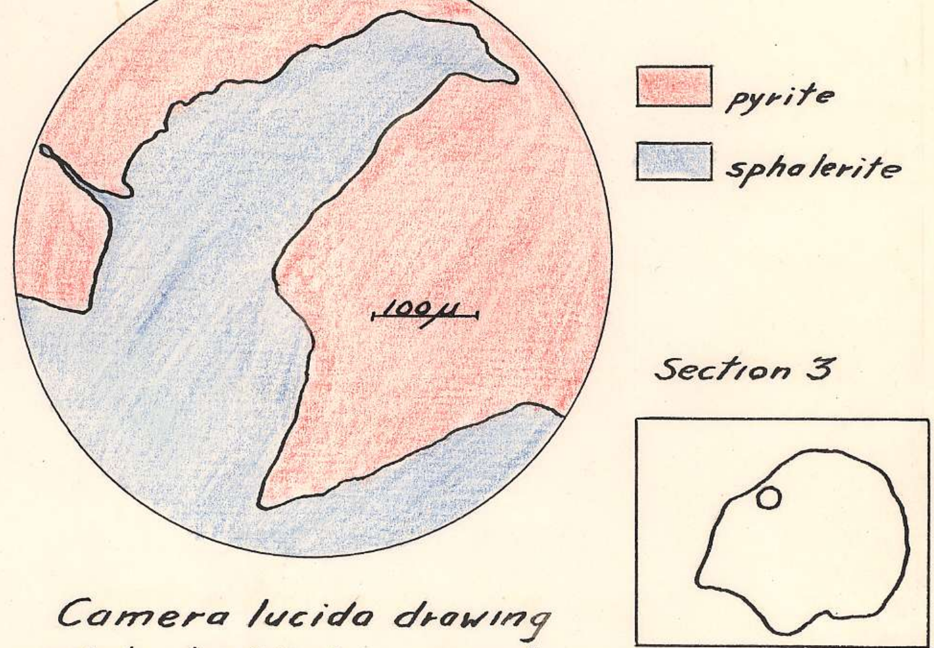
9. Schwartz, G. M.,"Textures Due to Unmixing of Solid Solutions"m Econ. Geol. col. 26, pp. 739 - 763, 1931.

10. Short, N. M., "Microscopic Determination of the Ore Minerals", U.S. Geol. Surv. Bull., 914.

11. Teas, L. P., "Relation of Sphalerite to Other Sulphides in Ores", A.I.M.E. Trans. vol. 59, pp..68-88, 1918.

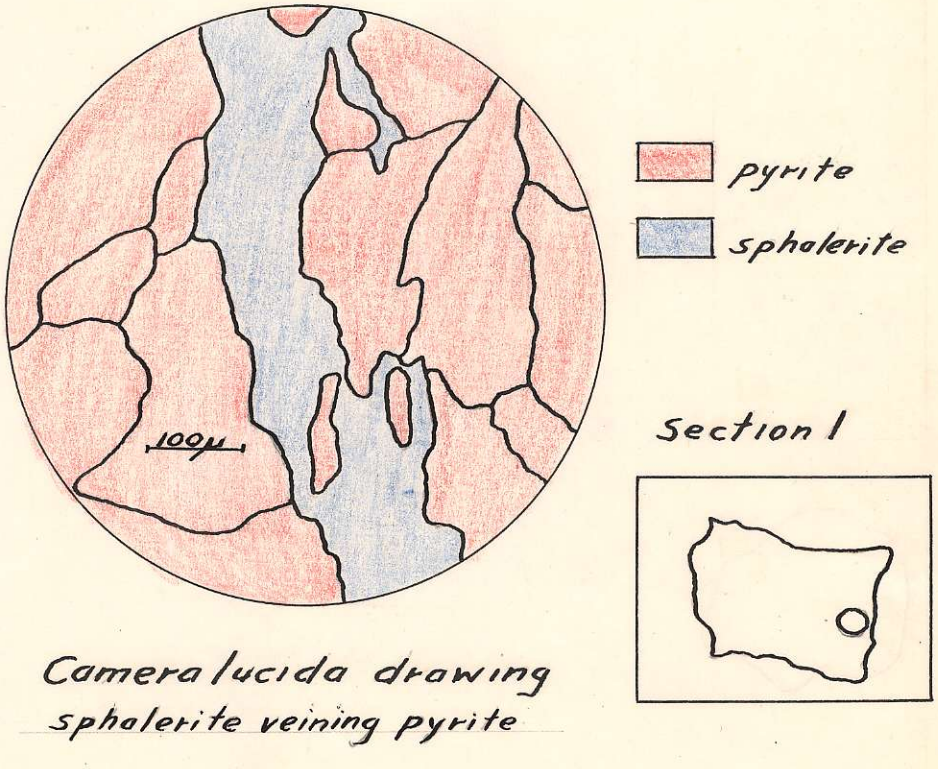
12. Whitehead, W. L., "The Paragenesis of Certain Sulphide Intergrowths", Econ. Geol. Vol.11, pp. 1 - 13, 1916.

FIG. 3



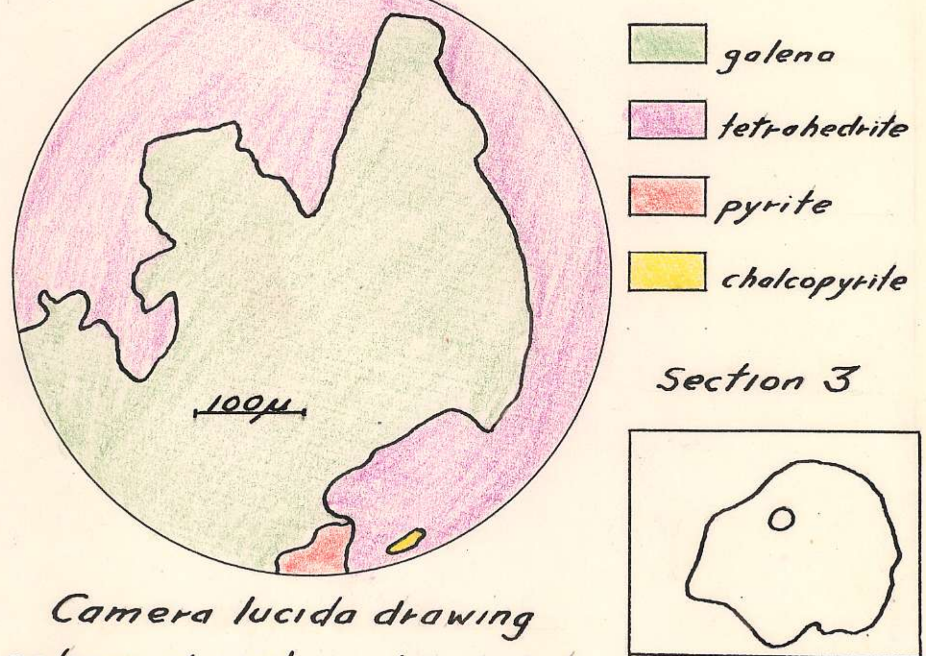
Camera lucida drawing
sphalerite dissolving pyrite

FIG. 4



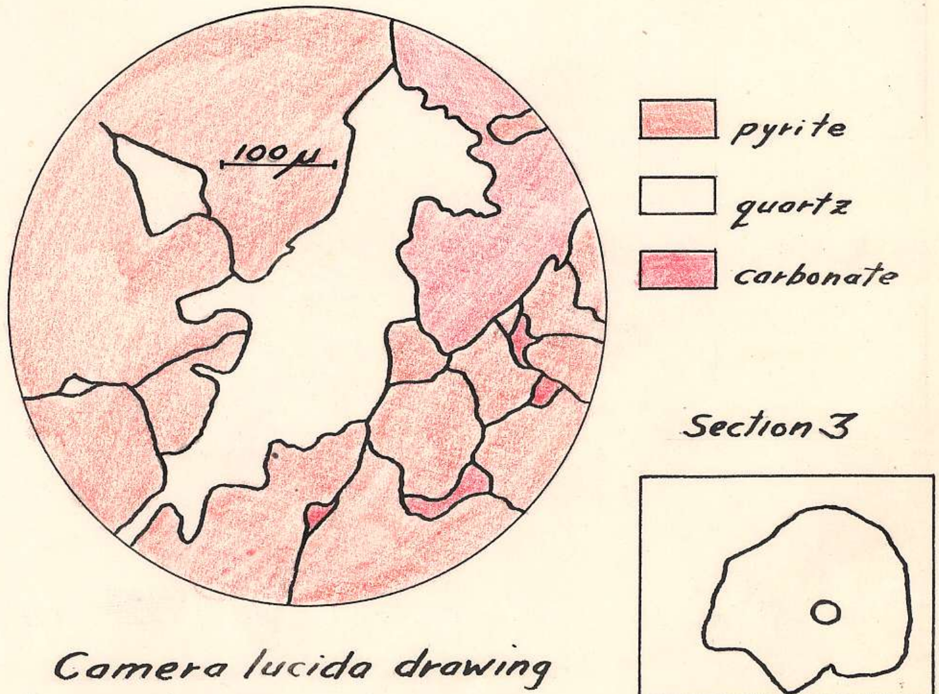
Camera lucida drawing
sphalerite veining pyrite

FIG. 5



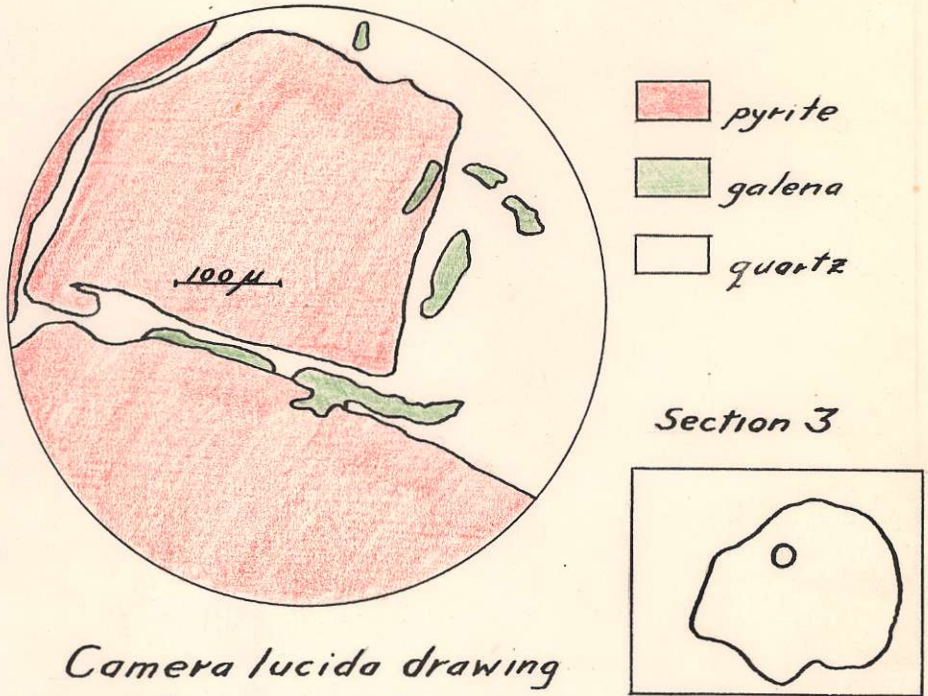
Camera lucida drawing
galena dissolving tetrahedrite

FIG. 6



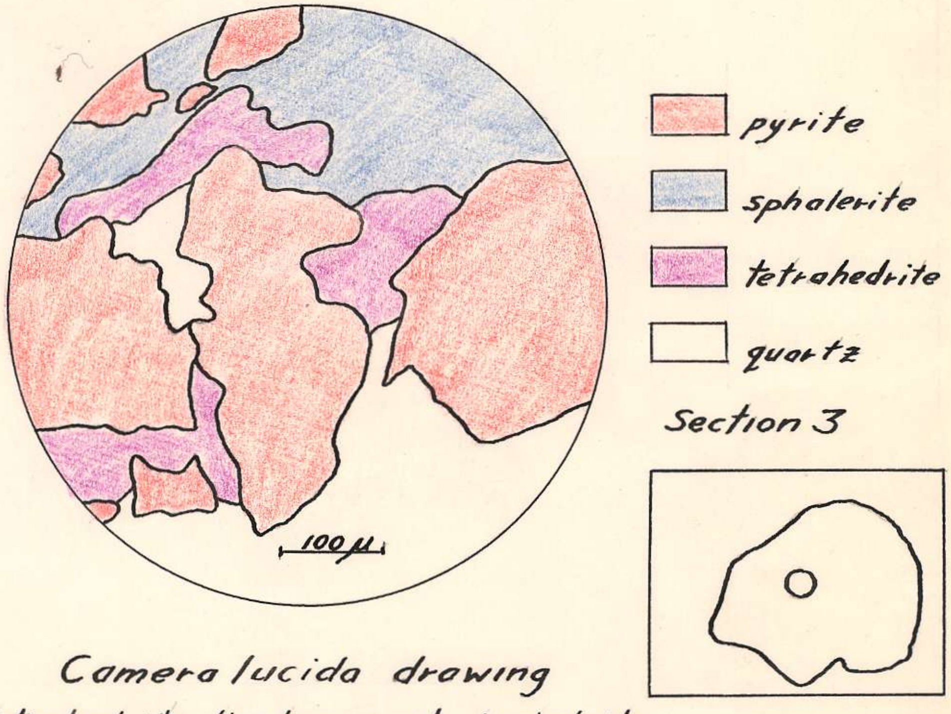
Camera lucida drawing
quartz dissolving pyrite
carbonate dissolving quartz & pyrite

Fig. 1.



Camera lucida drawing
quartz & galena filling fractures & veining pyrite

Fig. 2



Camera lucida drawing
tetrahedrite dissolving pyrite & sphalerite