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A REPORT ON

PLASTICALLY-BANDED ORE

FROM THE SLOCAN

by

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This report is submitted in accordance with the requirements of the undergraduate course in mineralography (Geology 409) at the University of British Columbia

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ABSTRACT

This is a report on a suite of plastically-banded silver-lead-zinc ore which I collected from the Victoria Mine in the Slocan Mining District.

Microscopic examination revealed that the specimens are composed of the following minerals which are listed in respective order of deposition:

quartz
pyrite
arsenopyrite
sphalerite
chalcopyrite
tetrahedrite
galena
pyrargyrite
argentite(?)
native silver(?)
limonite

Some of the possible implications of plastic deformation in galena ore have been investigated and are included in this report.

INTRODUCTION

The Victoria Mine is located just one-half mile north of the town of Sandon, B.C. in the heart of the Slocan Mining Camp.

Though mineralized with high-grade ore (average 103 ounces of silver per ton and 47% lead) the Victoria Mine is lacking in favorable structure and has produced only seven tons of ore. [1]

Interest in a study of this ore is stimulated, however, by the proximity and en echelon relationship of the Victoria fissure to those of mines with large production records such as the Payne and Reco Mines.

The banded texture of the ore required special investigation (including the possible delineation of ore bodies by ore banding) [2] and special considerations when dealing with the paragenesis.

The gneissic texture is indicated in the polished sections by the stringing out of the other minerals in lines parallel to the galena banding. The movement and consequent fracturing of the harder minerals together with the plastic

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1 Cairnes, C.E., Descriptions of properties, Slocan Mining Camp, G.S.C. Memoir 184, p. 155, 1935.

2 Uglow, W.L., Gneissic galena from the Slocan, Ec. Geol. xii, p. 643.

deformation and possible recrystallization [3] of other minerals has made the study of the paragenesis in these specimens an interesting undertaking requiring very careful judgment before application of the normal rules of paragenetic relationships.

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3 Newhouse, W.H., and Flaherty, G.F., The texture and origin of some banded or schistose sulfide ores, Ec. Geol. 25, 1930, p. 600.

ACKNOWLEDGEMENTS

I extend my gratitude to Dr. R.M. Thompson, Dr. H.V. Warren, Mr. J.I. Fyles and Mr. J.P. Donnan all of the Department of Geology at the University of British Columbia for their instruction and guidance in the methods employed in studying the specimens.

My thanks are also extended to Mr. E.R. Nickel of McMasters' University for his able partnership in mapping the Victoria Mine and in the collecting of the ore samples for this assignment.

GENERAL GEOLOGY

The Triassic Slocan Series in which the Victoria Mine is located occupies a basin-like structure enclosed and underlain by competent pre-Cambrian and Mesozoic formations on the east, north and west and the complex granite-granodiorite Nelson batholith on the south. Mineralization of fractures in the Slocan Series is related to the Nelson batholith. [4]

At the Victoria Mine a mineralized tear fault striking northeast and dipping seventy degrees to the southeast cuts a complex section of the Slocan sediments and intrusives. The wall-rocks consist of folded, massive, black argillites and granite porphyry sills.

Though the Victoria Mine has 600 feet of workings distributed in three levels on the fissure, by far the greatest portion of the ore observed was deposited in a narrow ore shoot where the lode cuts a granite-porphyry sill. The specimens collected for this report were obtained from this porphyry-walled section where the vein reaches its maximum width of three inches in the lode which is one foot in width.

The wall-rock, gouge and ore contain a very high proportion of pyrite which was probably derived from the iron-bearing minerals in the porphyry as indicated by the bleached

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4 Cairnes, C.E., Slocan Mining Camp, British Columbia, G.S.C. Memoir, 173, 1935.

appearance of the wall-rock near the fissure.

The banding in the ore has given rise to suggestions concerning the determination of the present disposition of Slocan ore bodies. Uglow considered that "the present disposition of the ore lenses might very readily have been produced by the shearing of a tabular vein deposit in a direction parallel to the walls of the mineralized zone....Within each of the sulfide lens, the banding follows rather faithfully the outline of the lens." [5] (Illustration No. 1, p.12)

Although the present disposition of some Slocan ore deposits is considered by recent investigators to be controlled by many factors including attitude of bedding, rock competency and fault movements, Uglow's findings suggest a controlling factor which might be worth considering in attempts to locate ore bodies in regions where plastically-banded ore is common.

MINERALOGY

Macroscopic Examination

The specimens examined consisted chiefly of medium-grained galena arranged in bands showing regularly elongated and distorted cubes. The galena banding varied in width from one millimetre to four millimetres.

Irregular-shaped pieces of pyrite varying in diameter up to four millimetres were observed in lines parallel to the

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5 Uglow, W.L., Gneissic galena from the Slocan, Ec. Geol. xii, p. 650.

galena banding.

Larger portions of pyrite and minute specks of quartz bordered the specimens on the sides corresponding to the vein walls. Limonite films and streaks were common on the bordering pyrite and quartz.

Microscopic Examination

Descriptions of the Minerals

Quartz. Quartz occupies less than 2% of the sections. It occurs as anhedral and subhedral grains (average diameter 500 microns) and appears by 'mutual boundaries' to be contemporaneous in deposition with pyrite. Later-deposited quartz was observed veining sphalerite. Quartz particles (average diameter 50 microns) with sharp protrusions are aligned with fragments of other minerals in the sections. These quartz particles might have derived their shapes as fragments from quartz grains fractured during the ore movement which caused the galena banding.

Pyrite. Enhedral to anhedral pyrite grains ranging in average diameters from two microns to three millimetres occupy about 15% of the polished sections.

Arsenopyrite. Arsenopyrite was very rare in the specimens. It was identified by its galena white colour, hardness, polarization colours (greenish, yellow, brown, violet) and by its etch reaction with HNO_3. Arsenopyrite was observed veining and replacing pyrite.

Sphalerite. Sphalerite is fairly common in the specimens and occurs in anhedral grains ranging in size from grains with average diameters of one millimetre to small specks due to fracturing of the larger grains. Sphalerite was identified by its hardness, gray colour, and resin-coloured internal reflection.

Chalcopyrite. This mineral is extremely rare in the specimens and was observed in only one instance. It occurs as a small irregular form (75 microns long) and was identified by its brass yellow colour, hardness and weak anisotropism. It appears to be replacing sphalerite.

Tetrahedrite. Tetrahedrite was observed in many sections as small rounded blebs with average diameters of twenty to forty microns. Its gray colour, hardness greater than galena, and relief make it discernible in galena where it commonly occurred. Tetrahedrite was also observed bordering and enclosing fragments of sphalerite, quartz and pyrite. Reaction with $FeCl_3$ suggested that the tetrahedrite is argentiferous and might better be named freibergite.

Galena. About 85% of the polished sections is occupied by galena. It was identified by its white colour, hardness and triangular pits.

Pyrargyrite. Pyrargyrite occurs fairly commonly as blebs in the galena. Most of the ruby silver grains are elongated with lengths ranging from twenty to 250 microns. In a few cases pyrargyrite occurred in contact with grains of galena and moved fragments of sphalerite, quartz and pyrite.

Pyrargyrite was identified by its softness, red internal reflection, bluish gray colour and moderate anisotropism.

Argentite(?) An unknown mineral (thought to be argentite) was observed in galena and in contact with pyrargyrite. The unknown bleb has a diameter of about 150 microns. It resembles somewhat the tetrahedrite observed in the sections but is softer, has a lighter colour and has less relief than that mineral. The absence of internal reflection, extremely faint anisotropism, and association with ruby silver lead one to believe that this mineral is argentite.

Minute Blebs of Silver Minerals. Etching galena with HNO_3 revealed the presence of minute, white, soft grains considered to be silver minerals. These mineral grains are of varying shapes and sizes with maximum diameters of only sixteen microns and were therefore far too small to be removed from the sections for microchemical analysis. These small grains appeared in quantity only when etching was performed near tetrahedrite or pyrargyrite grains suggesting some genetic relationship to those more easily recognized silver minerals.

Application to Ore-dressing and Metallurgy

An average of the shipment assay values given by Cairnes shows the average values in this ore to be 103 ounces of silver per ton and 47% lead. [6]

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6 Cairnes, C.E., Description of Properties, Slocan Mining Camp, G.S.C. Memoir 184, p. 155, 1935.

The silver value in the ore is probably due to the presence of argentiferous tetrahedrite, pyrargyrite, argentite (?), minute microscopic silver grains in galena, submicroscopic particles, and silver in solid solution in galena.

Tetrahedrite is probably the most prolific source of silver in the ore. Robinson stated that "tetrahedrite probably accounts for 80% of the silver in 'wet ore'."[7] Guild has had tetrahedrite analyses show as high as 36.90% silver.[8]

The minute microscopic blebs of silver minerals in the galena probably account for a large portion of the high silver values. Probably less than 0.015% of silver exists as sub-microscopic particles or in solid solution in galena.[9]

The silver-bearing minerals are associated mainly with galena. A small percentage of the grains of tetrahedrite and pyrargyrite, however, are closely associated with fragments of sphalerite, quartz, and pyrite.

The average grain diameters of the valuable minerals present are as follows:

tetrahedrite	30 microns
pyrargyrite	100 microns
argentite (?)	150 microns
minute silver grains	10 microns
galena	2 mm
sphalerite	500 microns

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7 Robinson, M.C., An Analysis of the depth problem in the Slocan Mining Camp, B.C., U.B.C., April, 1948, p. 73.

8 Guild, F.N., A microscopic study of the silver ores and their associated minerals, Ec. Geol., Vol. xii, June, 1917, p.305.

9 Warren, H.V., Distribution of silver in base-metal ores, Trans. A.I.M.M.E., 115, p. 81

PARAGENESIS

By linking the relationships of the minerals present I have concluded that the following paragenesis is the most probable for this ore.

The earliest-deposited minerals appear to be quartz and pyrite as is suggested by their even or mutual boundaries (Sketches Nos. 1 and 2). The next mineral deposited was probably arsenopyrite which is intimately related with and replacing pyrite (Sketch No. 3).

Sphalerite closely followed by chalcopyrite and tetrahedrite appear to be the next minerals to have crystallized. The replacement of sphalerite by chalcopyrite is strongly suggested (Sketch No. 5).

The next mineral to crystallize was probably galena. It was observed veining sphalerite (Sketch No. 1)

A late deposition or continued deposition of quartz is shown by that mineral veining sphalerite (Sketch No. 5).

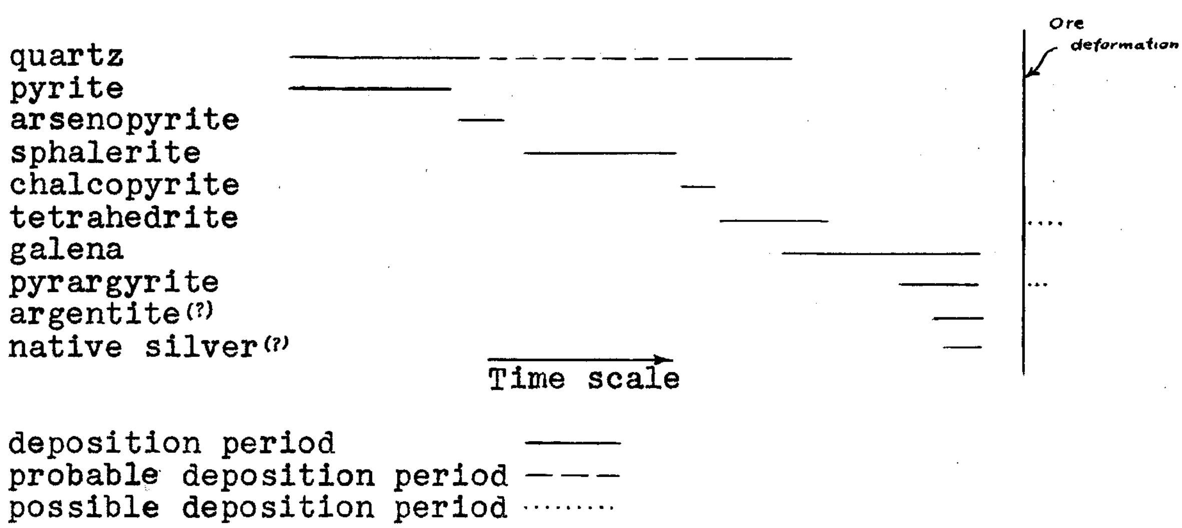
Pyrargyrite, argentite (?), and the minute silver mineral grains all occur as blebs in galena with their smooth boundaries giving the indication of contemporaneous deposition (Sketches Nos. 4, 7, 8).

Movement of the ore which caused the galena banding probably occurred after the primary deposition of all the minerals in the deposit.

There appears to have been a redeposition of the previously deposited tetrahedrite and pyrargyrite, however, during the plastic deformation of the galena. The relationships of tetrahedrite bordering and enclosing moved fragments of quartz and sphalerite (Sketches Nos. 6, 9, 11), and pyrargyrite filling interstitial spaces between moved sphalerite fragments (Sketch No. 10) are of particular interest and appear to be due to flowage of the tetrahedrite and pyrargyrite during the ore movement which caused the galena banding.

A discussion of the possible redeposition of the silver minerals will follow this section.

The paragenesis suggested is illustrated in the following diagram.



Possible Redeposition of Silver Minerals

After observing many occurrences of tetrahedrite and pyrargyrite in the specimens I have come to consider it possible that these minerals have been caused to flow plastically or to have flowed and recrystallized in contact with fragments of sphalerite, quartz, and to a lesser extent pyrite.

Tetrahedrite is shown enveloping quartz grains in Sketches Nos. 6 and 11 and enclosing sphalerite in Sketch No. 9. Pyrargyrite is shown filling spaces between sphalerite fragments in Sketch No. 10.

I suggest that the tetrahedrite and pyrargyrite have flowed and recrystallized to obtain these relationships for the following reasons:

(1) Sharp-bordered fragments of quartz are enclosed in the tetrahedrite grains (Sketches Nos. 6, 11) although tetrahedrite has not been observed replacing quartz in any of the sections. Tetrahedrite therefore appears to have enveloped these quartz grains by flow and recrystallization.

(2) Lack of silver minerals in the lodes between galena deposits in the Slocan and the consistency of silver minerals in galena with depth reduce the possibility of post-movement hypogene or supergene deposition of the tetrahedrite and pyrargyrite.

(3) The intensive plastic deformation of the galena suggests that the dynamic metamorphism experienced by the ore might even have been intense enough to have caused plastic flow er recrystallization of the brittle tetrahedrite and pyrargyrite.

(4) Relative movement of the sphalerite, pyrite and quartz grains caused by their lagging effect

during the plastic deformation of the galena would have caused them to move against the tetrahedrite and pyrargyrite. This forceful contact would have aided these minerals in redepositing on the borders of the more competent minerals.

(5) The lag effect of the mineral fragments in the plastically-deformed galena is evidenced by the lining-up of mineral fragments (Sketch No. 6). The flow of the plastically-deformed galena past the lagging mineral fragments might possibly be indicated also by the alignment of minute silver mineral inclusions in curved lines around the larger mineral fragments (Sketch No. 7).

(6) Newhouse and Flaherty observed galena cyrstals which they interpreted as having recrystallized in plastically banded ore.[10] These investigators also concluded with regard to plastically-deformed ore that "unless complete recrystallization of the entire ore mass takes place two generations of each mineral should be found."[11]

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10 Newhouse, W.H., and Flaherty, G.F., The texture and origin of some banded or schistose sulphide ores, Ec. Geol. 25, 1930, p. 615.

11 Ibid., p. 619.

CONCLUSION

Banding of the galena and the distribution of the other minerals in the ore indicate that movement of the lode walls took place and that this movement probably occurred after all of the minerals present had been deposited.

The high silver value of the ore is due mainly to the presence of argentiferous tetrahedrite and pyrargyrite. These minerals are intimately associated with galena. A small percentage of their grains, however, are closely associated with fragments of sphalerite, quartz, and pyrite. This relationship might have been caused by flow and recrystallization of the silver-bearing minerals, during the ore movement which caused the galena banding.

ILLUSTRATIONS

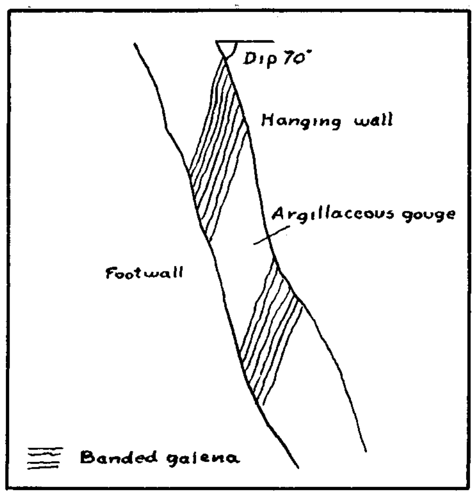
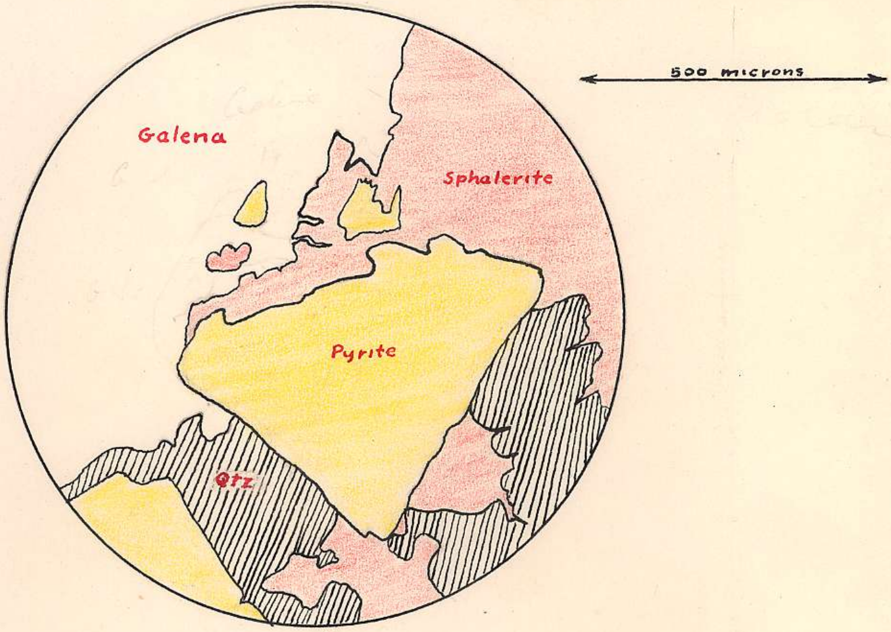


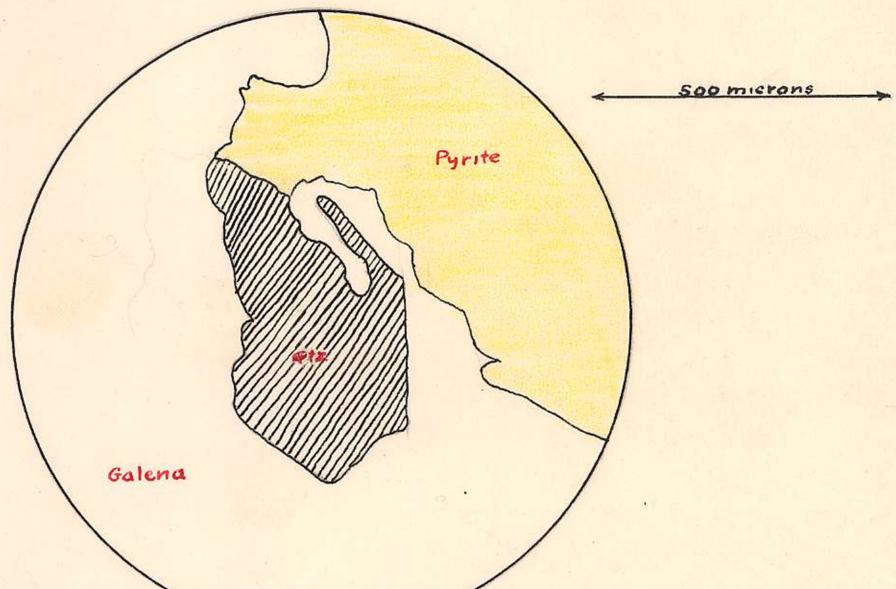
Illustration No. 1: Showing a suggested relationship between ore banding and the disposition of deposits. (from Uglow) 12

12 Uglow, W.L., Gneissic galena from the Slocan, Ec. Geol. xii, p. 650.

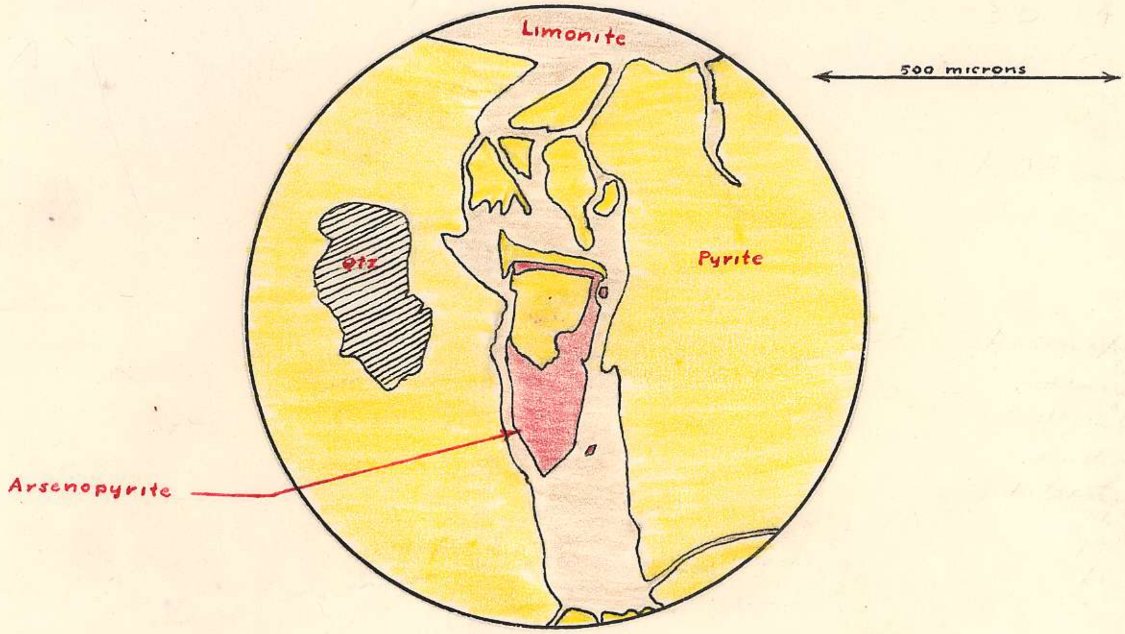
SKETCHES OF MICROSCOPIC FIELDS



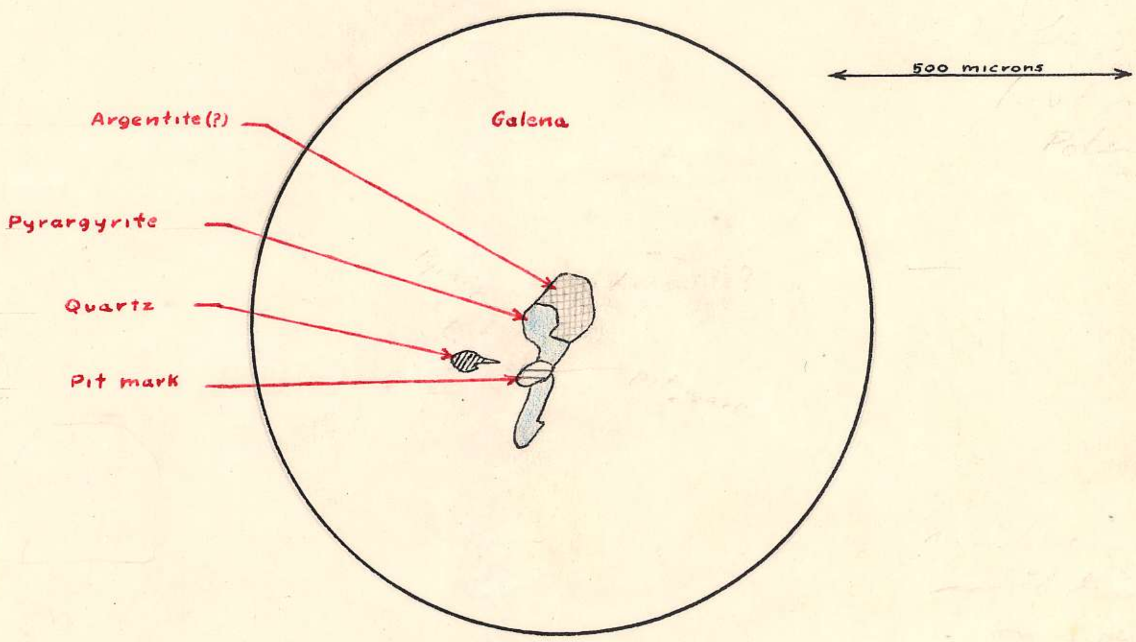
Sketch No. 1
(Section A)



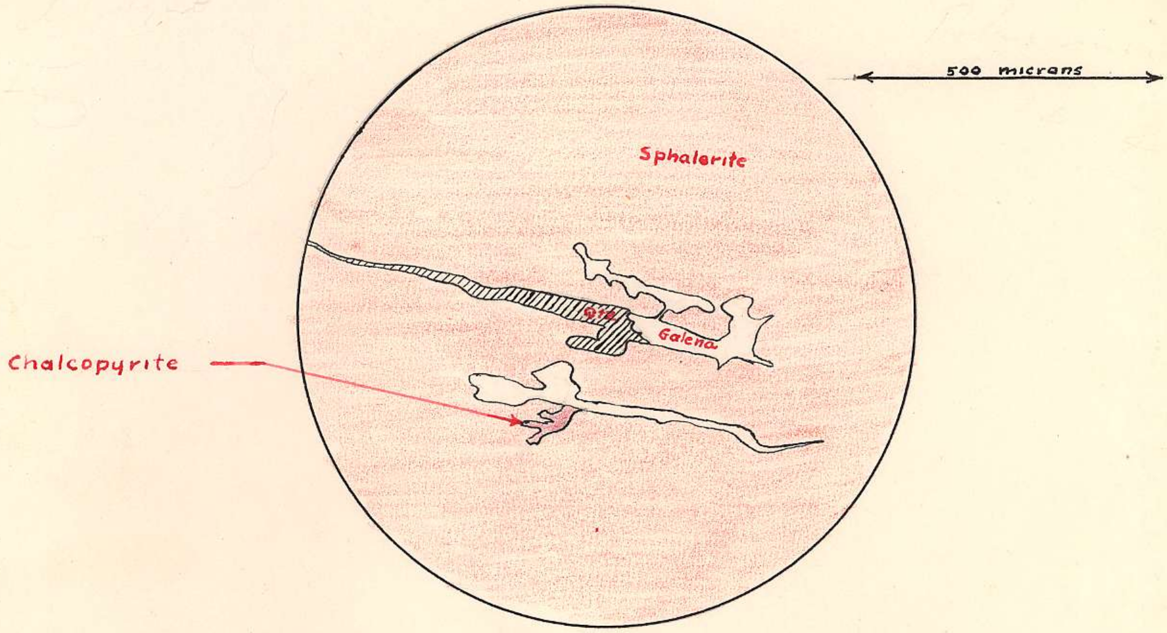
Sketch No. 2
(Section A)



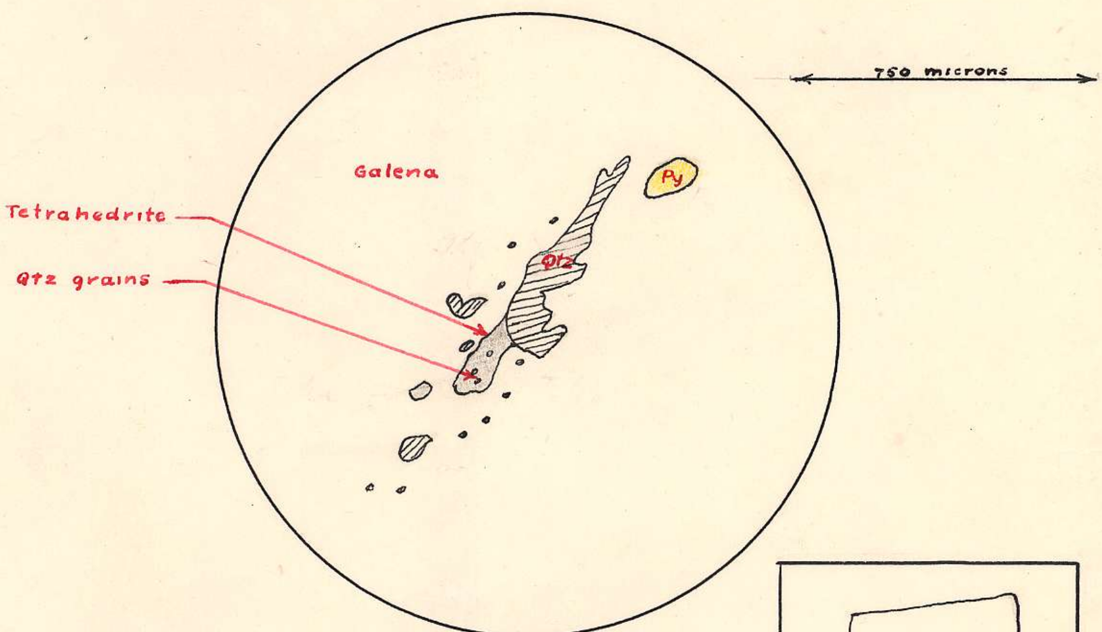
Sketch No. 3
(Section B)

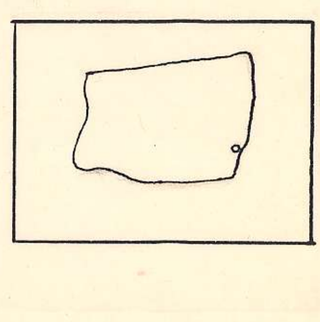


Sketch No. 4
(Section B)

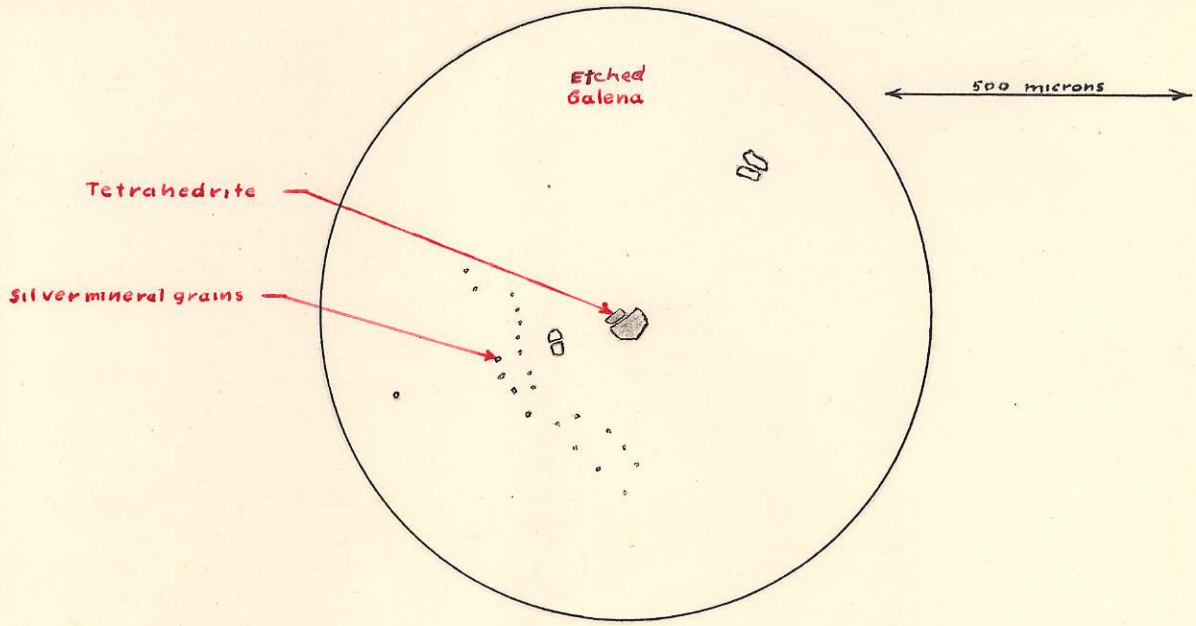


Sketch No. 5
(Section C)

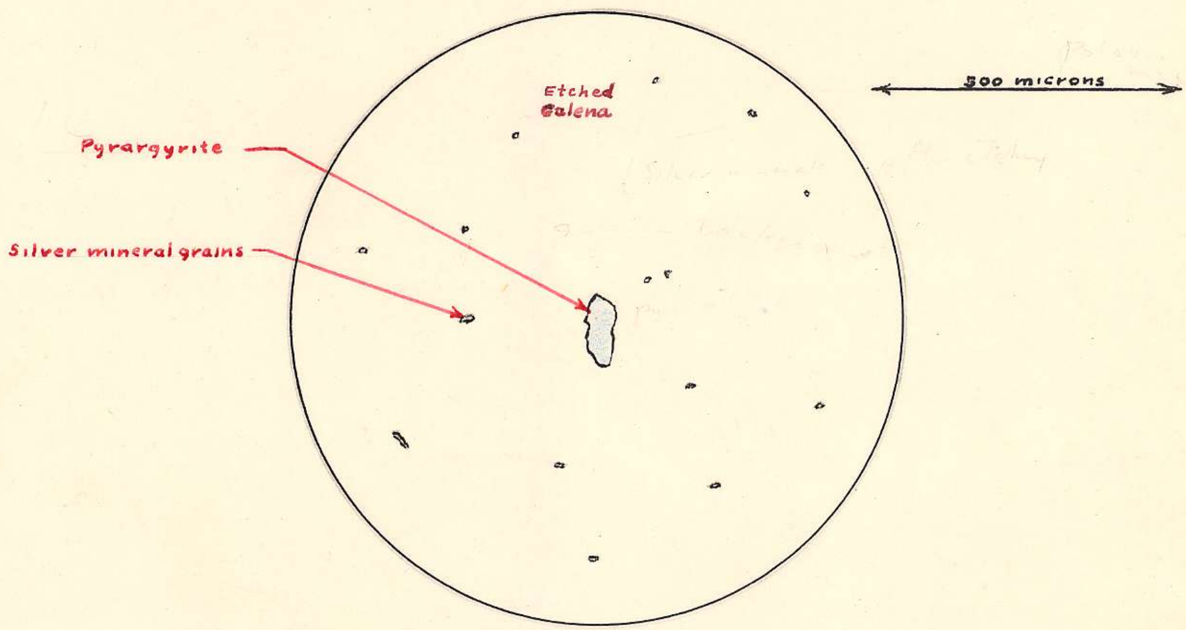




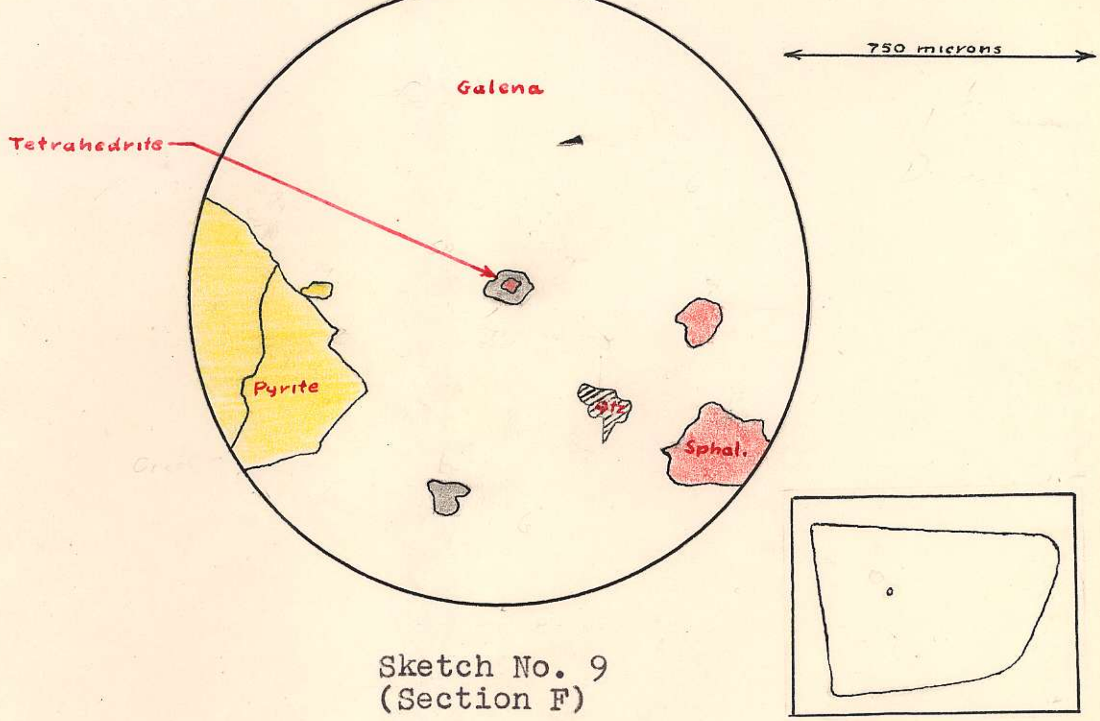
Sketch No. 6
(Section D)



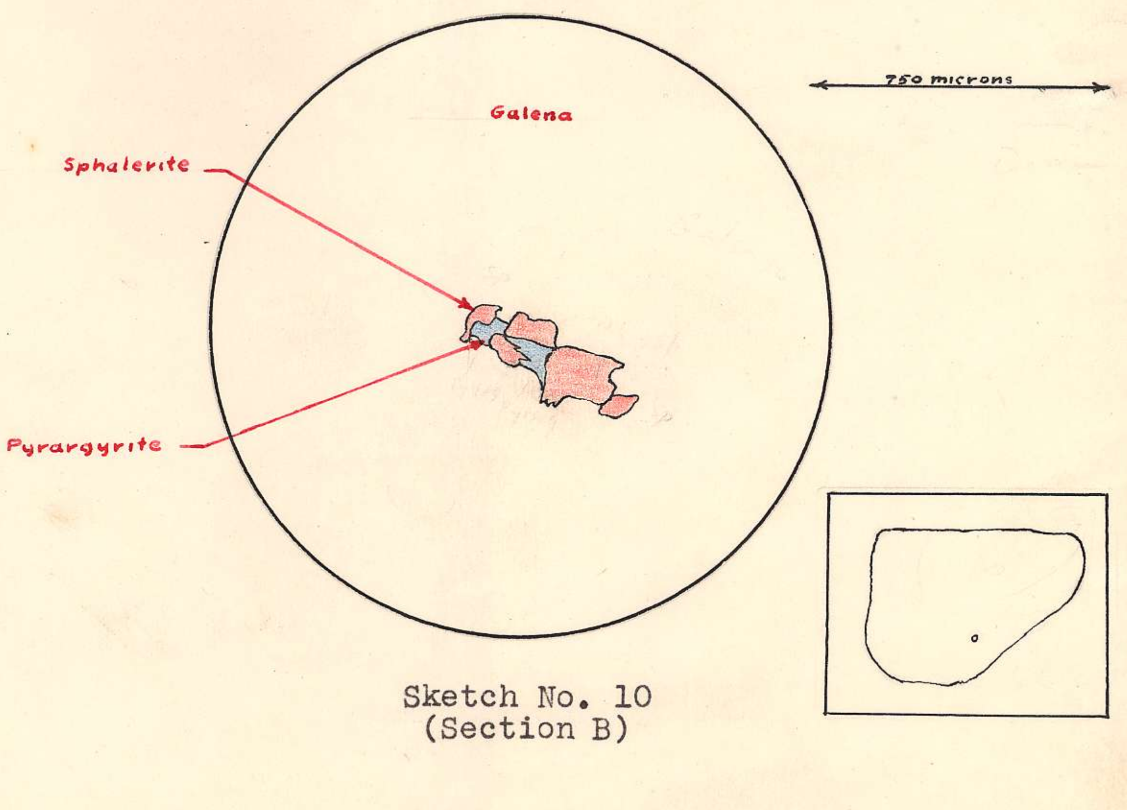
Sketch No. 7
(Section C)



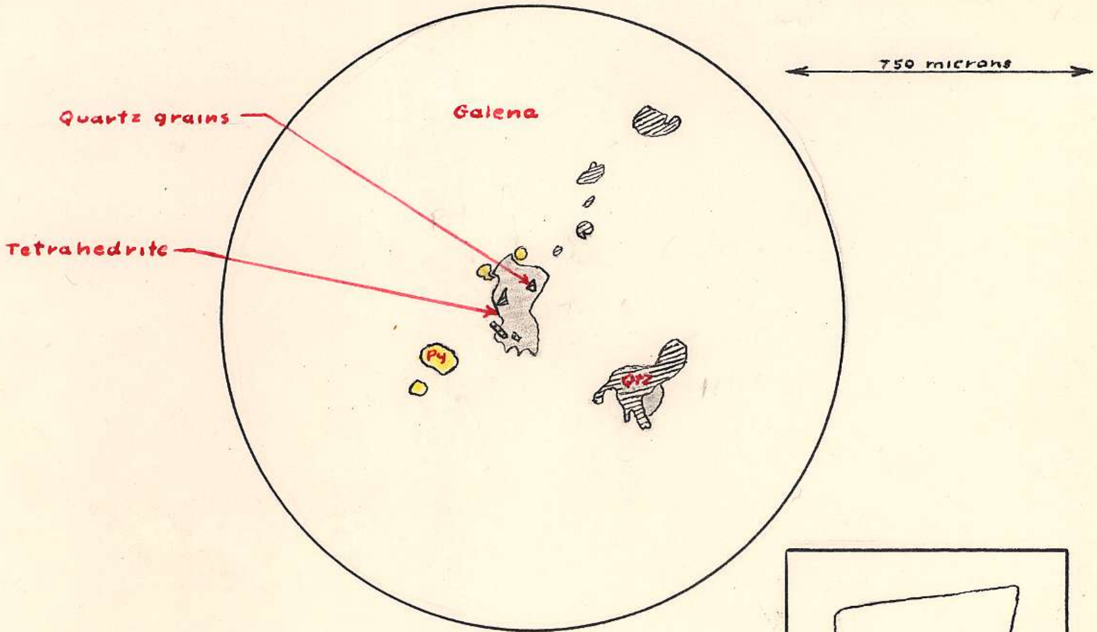
Sketch No. 8
(Section E)

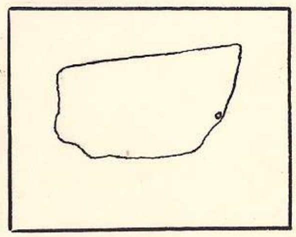


Sketch No. 9
(Section F)



Sketch No. 10
(Section B)





Sketch No. 11
(Section D)

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