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A MINERALOGRAPHIC STUDY

OF THE

ORE OF THE PROVIDENCE MINE

by

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5th Year Geological Engineering

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C O N T E N T S

I Acknowledgments

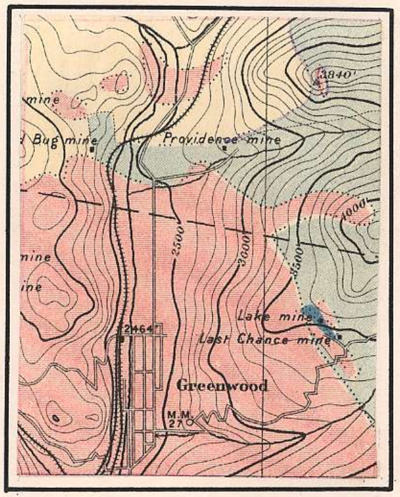
The writer wishes to express his appreciation to L. Madden of the Providence Mine for the donation of the specimens examined in this study. He is also indebted to Dr. H.V. Warren of the University of British Columbia for the help which he has given and the interest which he has taken in this work.

II Location

The Providence Mine is situated on the western slope of the valley of Boundary Creek at a point about 1 mile north of the town of Greenwood. Greenwood is on the Kettle Valley Line of the Canadian Pacific Railway which connects with the Great Northern Railway at Midway on the International Boundary, 6 miles to the south.

III Geology

The ore deposit of the Providence Mine occupies a fissure in a group of rocks which consist of augite porphyrites, agglomerates and porphyrite tuffs. These rocks have been so highly metamorphosed that it is impossible to



Granodiorite.

Limestone.

Chlorite & Hornblende Schists.

Augite porphyrite, Porphyrite tuffs, agglomerates.

GEOLOGICAL MAP

OF THE

VICINITY OF THE PROVIDENCE MINE

Scale: 1 inch = 1 mile

determine their structure. In places, the vein cuts through irregular masses of granodiorite which are thought to be apophyses of the Greenwood batholith which outcrops about 500 feet from the mine. The vein, which varies in width from 6 to 18 inches, is cut by numerous faults along which small displacements have taken place and also, by a few porphyry dykes of post-mineral age.

IV Mineralogy of the Ore

The following list gives, in order of abundance, the minerals which were identified in polished sections of the ore of the Providence Mine.

1. Quartz
2. Calcite
3. Sphalerite
4. Galena
5. Chalcopyrite
6. Tetrahedrite
7. Ruby silver
8. Pyrrhotite

All of these minerals, with the exception of tetrahedrite and pyrrhotite, are readily observable upon a megascopic examination of the ore. In addition to the minerals identified in the polished sections, a small particle of pyrite in quartz was identified in one hand specimen.

V Descriptions of the Polished Sections

Section No. 1

The only mineral which is apparent upon a megascopic examination of this section is sphalerite which is dark brown or almost black in colour. This sphalerite was obtained from a specimen of ore in which the metallic minerals were contained in a calcite gangue.

Although sphalerite is the only mineral which is apparent megascopically, it is seen, under the high power of the microscope, that there are several minute blebs of galena and tetrahedrite in the sphalerite. The contacts between the galena, tetrahedrite and sphalerite are smooth regular curves indicating that the three minerals were deposited contemporaneously. This mutual-boundary pattern is shown in Figure 4 which is a sketch of the largest grain of galena and tetrahedrite observed in the section.

Section No. 2

The sphalerite for this section was obtained from a specimen of ore in which the metallic minerals were contained in a quartz gangue. It was prepared in order that the writer might determine whether there was any difference in the purity of this sphalerite and that obtained from the ore with a calcite gangue. Under the high power it was seen that, just as in Section No. 1, there were several small grains of tetrahedrite and galena with the sphalerite.

Section No. 3

Upon a megascopic examination, it is seen that this section consists of fractured quartz containing sphalerite and a small amount of chalcopyrite and ruby silver.

Under the microscope, a few grains of chalcopyrite, galena and terahedrite become apparent in the sphalerite. When the chalcopyrite which was observable with the naked eye is examined under the high power, it is seen to contain numerous grains of sphalerite and, in one place, a small bleb of pyrrhotite. The smooth contacts which indicate that the chalcopyrite, sphalerite and pyrrhotite were deposited contemporaneously, are sketched in Figure 2. Galena is present in this section associated with a small amount of tetrahedrite as a narrow veinlet in the quartz. The ruby silver occurs along the contact of chalcopyrite and quartz and in the smaller fractures in the quartz itself as is shown in Figure 5.

Section No. 4

In this section, sphalerite and ruby silver can be readily observed with the naked eye in the calcite gangue. The ruby silver tends to follow cleavage planes in the calcite as is shown in Figure 12.

Under the microscope, it is seen that, between the large mass of sphalerite containing a vew grains of chalcopyrite and the narrow veinlets of ruby silver in the cleavage planes of the calcite, there is a transitional zone composed of sphalerite, chalcopyrite and ruby silver. The presence of smoothly curving contacts (Figure 6 & 13) between these three minerals indicates that they were deposited contemporaneously. However, the presence of ruby silver in the extremeties of the fractures would indicate that some of it remained fluid after the chalcopyrite and sphalerite had crystallized and, for this reason, it was able to work its way into the narrow openings (Figure 7). Associated with the ruby silver in one of the very narrow fractures of this section, there are two small blebs of pyrrhotite as shown in Figure 14.

Section No. 5

Upon a megascopic examination, Section No. 5 is seen to contain the minerals galena, chalcopyrite and ruby silver in fractured quartz.

Under the microscope, numerous grains of tetrahedrite and sphalerite become apparent in the galena. These minerals show mutual-boundary patterns, (Figure 3) , indicating that they were deposited at the same time. Pyrrhotite occurs in abundance in one place in this section in contact with chalcopyrite, galena, tetrahedrite, sphalerite and ruby silver. The chalcopyrite, sphalerite and ruby silver seem to have been deposited at the same time as the pyrrhotite, but the galena and tetrahedrite appear to have been deposited later since they form tongue-like projections into it, as shown in Figure 11. In this section, just as in Sections No. 3 and No. 4, the ruby silver occupies the narrow extremities of the fractures.

Section No. 6

Both quartz and calcite are readily observable in this section. The calcite is surrounded by quartz but at the same time, surrounds several idiomorphic quartz crystals (Figure 1) and, for this reason, is thought to represent the filling of a vug in the quartz. The metallic minerals, sphalerite, chalcopyrite and ruby silver can be seen in fractures in both the quartz and the calcite.

Under the microscope, it is seen that there are several blebs of chalcopyrite and galena in the sphalerite.

Section No. 7

Upon a megascopic examination of this section, the metallic minerals, ruby silver and sphalerite in fractured quartz are apparent.

Upon a microscopic examination, it is seen that galena is present in the section in addition to the minerals observed with the naked eye.

Section No. 8

Sphalerite and galena are readily observed with the naked eye in the fractured quartz of this section.

Under the microscope, tetrahedrite is seen to be closely associated with the galena both as small blebs and fairly large grains with smooth contacts indicating that the two minerals were deposited contemporaneously.

In several places, smoothly curving contacts between galena and sphalerite are broken by cube-like projections of the former into the latter (Figure 8) which suggests that although these two minerals were deposited contemporaneously the galena had greater power of crystallization. It is common to observe in this section that, in addition to the mutual boundaries between galena, sphalerite and tetrahedirte, there are veinlets of galena and tetrahedrite definitely cutting the sphalerite as is shown in Figure 9. This shows that some of the galena and tetrahedrite continued to crystallize after the sphalerite had ceased.

Another interesting age relationship is sketched in Figure 10, which shows a minute veinlet of chalcopyrite cutting tetrahedrite. This indicates that part of the chalcopyrite remained fluid after the cyrstallization of the tetrahedrite was completed.

Pyrrhotite was observed in one place in this section. It was in contact with galena and chalcopyrite with boundaries suggesting that all three minerals were deposited at the same time.

VI Paragenesis

Because of the evidence observed in Specimen A and the polished sections described in the foregoing pages, the writer believes that the sequence of events in the deposition of the minerals of the Providence vein was as follows:

1. Deposition of quartz and pyrite in a fracture in the country rock.

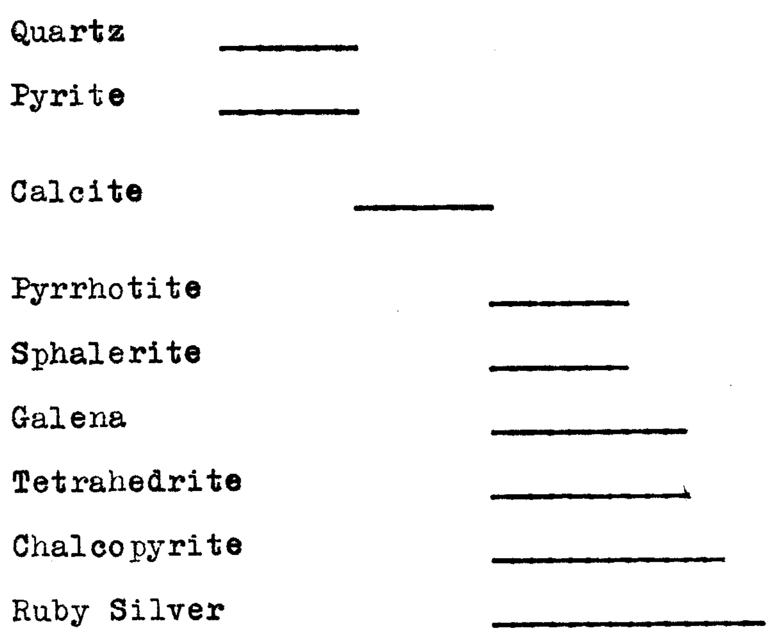
2. Fracturing of the quartz.

3. Deposition of calcite in fractures and vugs in the quartz vein.

4. Fracturing of the quartz and calcite.

5. Deposition of pyrrhotite, sphalerite, galena, tetrahedrite, chalcopyrite and ruby silver in fractures in the quartz and calcite.

This sequence is represented graphically in the following table:



Since ruby silver may be either hypogene or supergene, special attention was given to the determination of its origin in the Providence deposit. Because of the lack of alteration of the minerals in the ore, it is considered that they have not been subjected to the action of descending meteoric waters and that, for this reason, the ruby silver is hypogene in origin. Since pyrrhotite is one of the first minerals to be attacked by oxidizing solutions, it is notable that is shows no evidences of alteration in the sections examined.

A very interesting association in the ore of the Providence Mine is that of pyrrhotite and primary ruby silver. Although most workers consider that pyrrhotite ie always deposited under hypothermal conditions, there are a few who believe that there are exceptions to this, and that in some cases, it may be deposited under conditions which are less extreme. The association of pyrrhotite with ruby silver, which is definitely a low temperature mineral, confirms the belief of the latter group of workers.

VII Conclusions

1. The ore of the Providence Mine is not amenable to cyanidation because of its copper content.

2. A sample of sphalerite containing a very small amount of tetrahedrite, galena and chalcopyrite assayed

7.82 ounces of silver per ton. Investigations regarding the relation of sphalerite and silver have always shown that the silver is not contained in the sphalerite itself, but in the impurities in the sphalerite, of which tetrahedrite is the most important. The tetrahedrite, galena and chalcopyrite in the sphalerite of the Providence ore could be freed by grinding to 80 or 100 mesh and then separated from the sphalerite by flotation, thereby avoiding the reduction in payment which the smelter makes for silver which is associated with zinc.

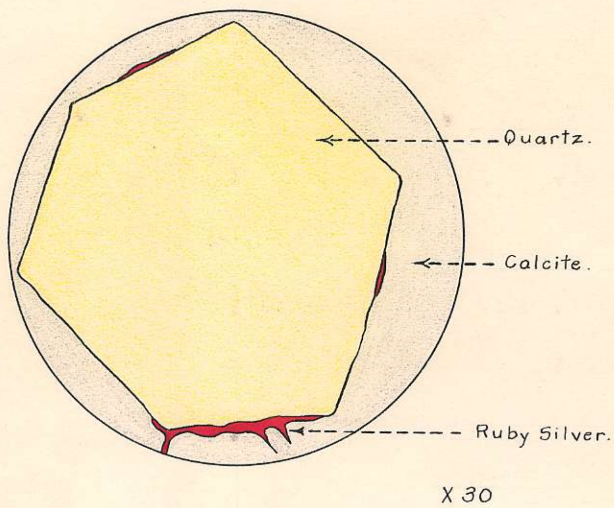


Fig. 1.
Spec. No. 6.

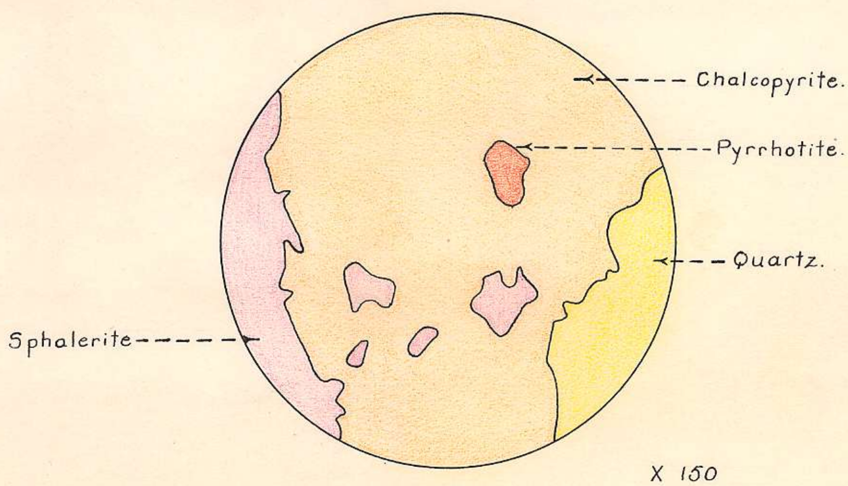


Fig. 2.
Spec. No. 3.

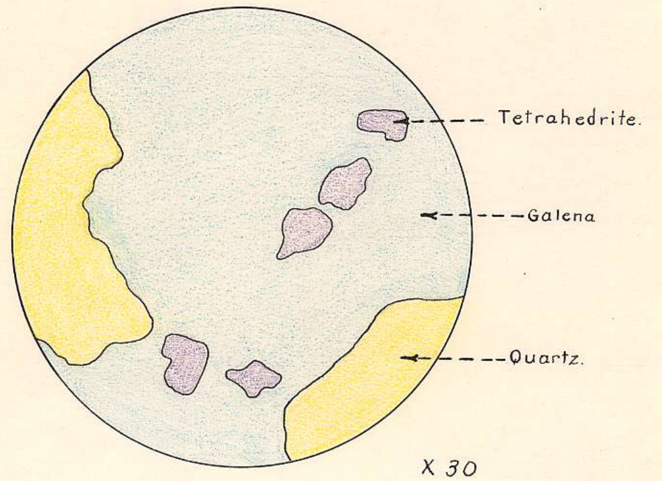


Fig. 3
Spec. No. 5.

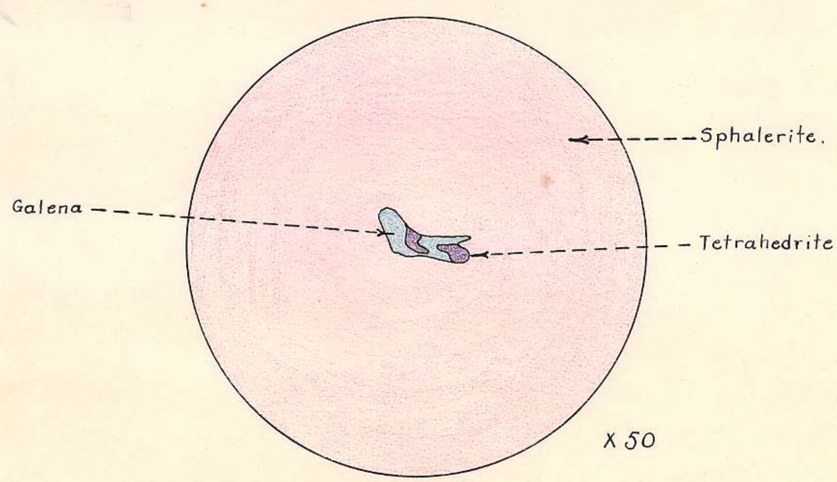


Fig. 4.
Spec. No. 1.

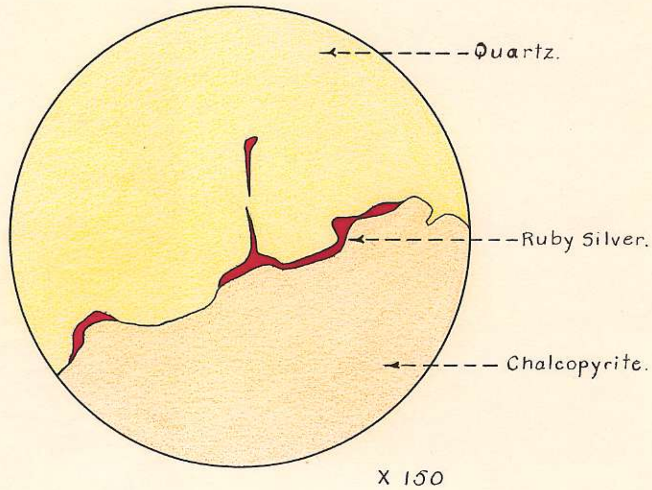


Fig. 5.
Spec. No. 3.

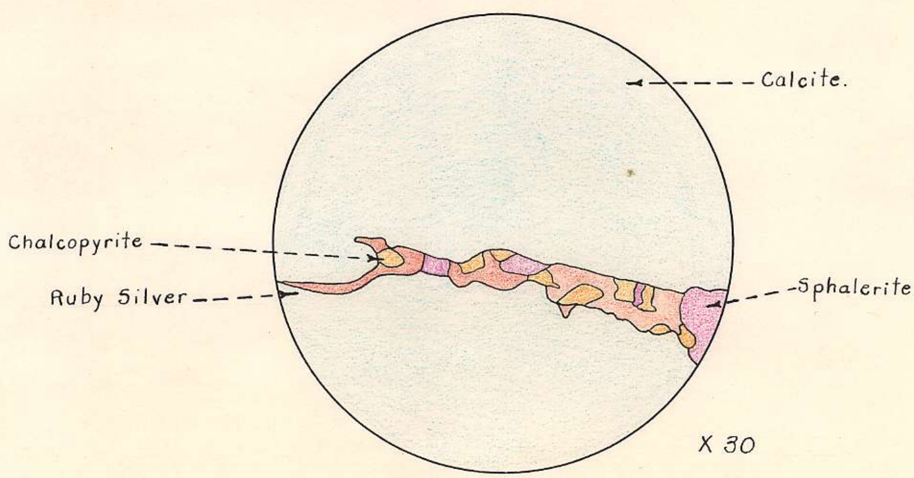


Fig. 6
Spec. No. 4.

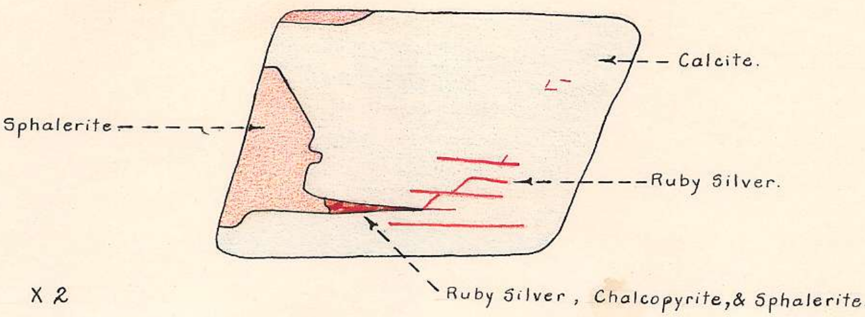


Fig. 7.
Spec. No. 4.

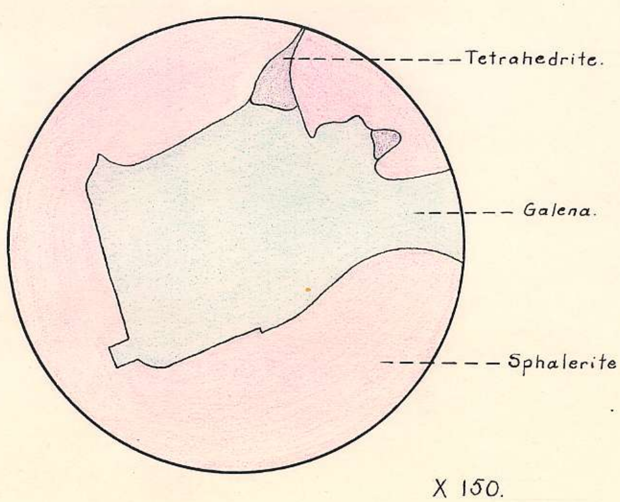
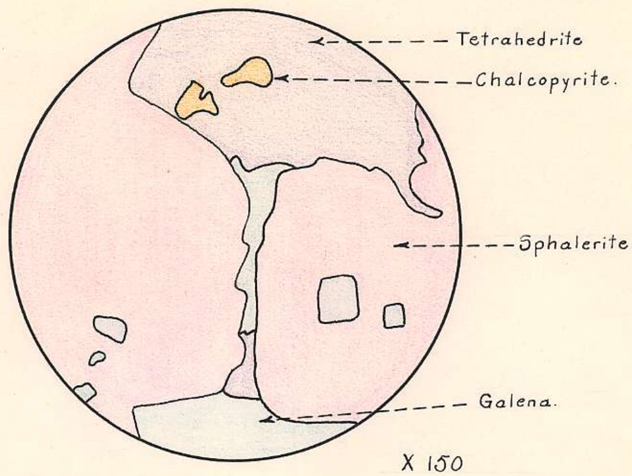
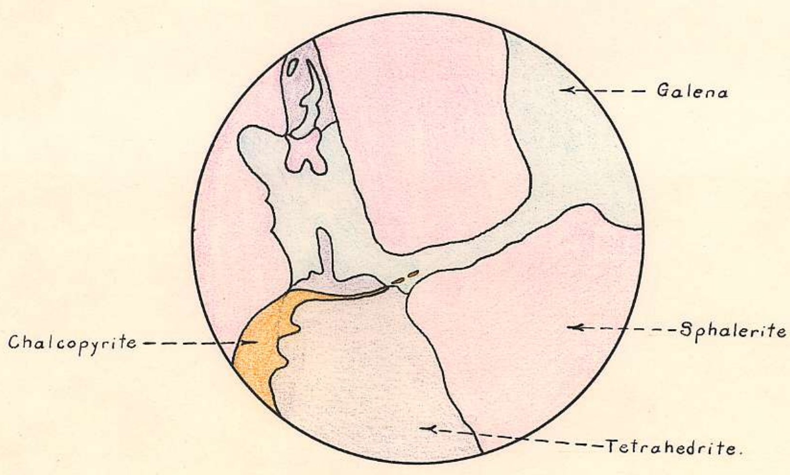


Fig. 8.
Spec. No. 8.



X 150

Fig. 9.
Spec. No. 8.



X 150

Fig. 10.
Spec. No. 8

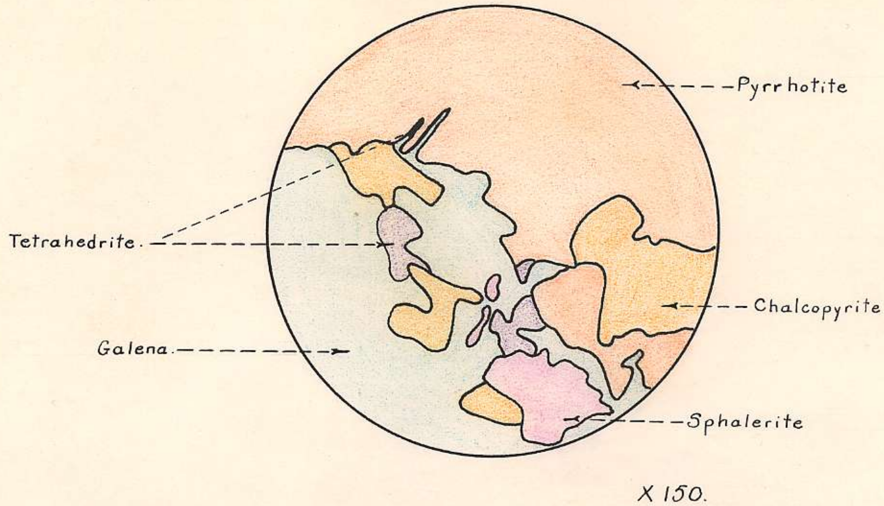


Fig. 11.
Spec. No. 5.

Figure 12.   (Section 4).

Photomicrograph showing ruby silver (R.Ag.) containing chalcopyrite (Cu) in cleavage planes of calcite. 65 mesh grid superimposed. Magnification : 120 diameters.

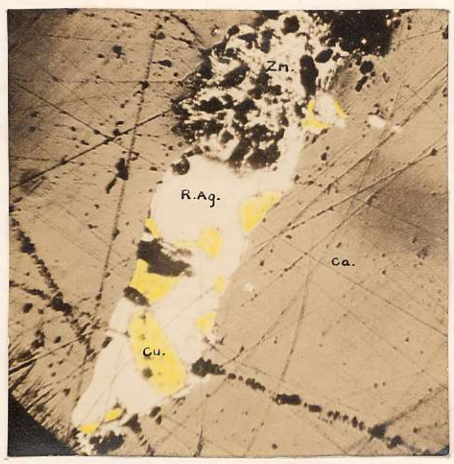


Figure 13.   (Section 4).

Photomicrograph showing ruby silver (R.Ag.) chalcopyrite (Cu) and sphalerite (Zn) occupying a fracture in calcite (Ca). Size of photograph =- opening of 28 mesh screen. Magnification : 100 diameters.

from Watson's article on Providence mine

no

Figure 14.   (Section 4).

Photomicrograph showing veinlet of ruby silver (R.Ag.) containing chalcopyrite (Cu.) and pyrrhotite, in calcite. 35 mesh grid superimposed. Magnification : 115 diameters.

Our figure !

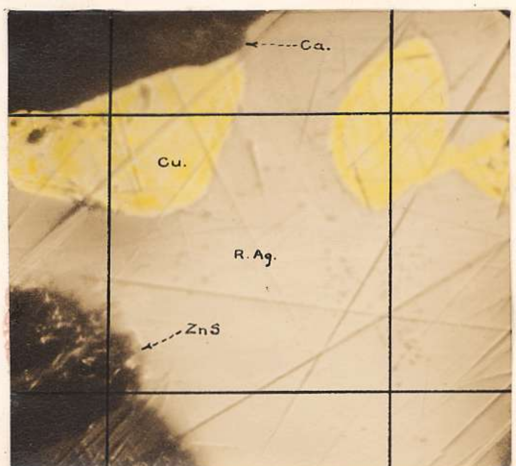


Figure 15.   (Section 4).

Photomicrograph showing the smooth fresh contacts between chalcopyrite (Cu) and ruby silver (R.Ag.) Zn S -- sphalerite.   Ca -- calcite.   200 mesh grid superimposed. Magnification : 500 diameters.

p. 20 from Watson's article on Providence

Our figure 2

Figure 16. (Section 5).

Photomicrograph showing galena (PbS) chalcopyrite (Cu), pyrrhotite (Fe), ruby silver (R.Ag.) and sphalerite (ZnS). 200 mesh grid (.074 mm. opening) superimposed. Magnification : 430 diameters.

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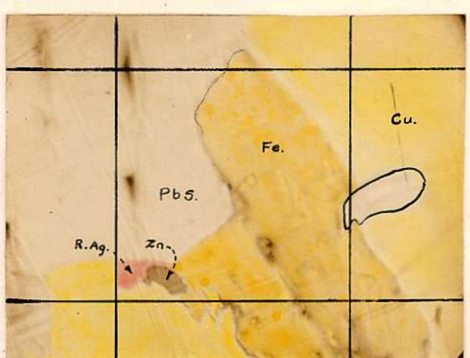

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Figure 17. (Section 5).

Photomicrograph showing galena (PbS) chalcopyrite (Cu), pyrrhotite (Fe), ruby silver (R.Ag.) and sphalerite (Zn.). 200 mesh grid (.074 mm. opening) superimposed.

Magnification : 420 diameters.

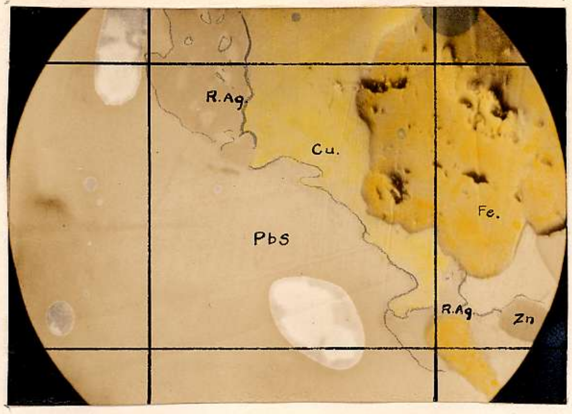

Figure 18. (Section 5).

Photomicrograph showing galena (PbS), chalcopyrite (Cu), pyrrhotite (Fe), ruby silver (R.Ag.) and sphalerite (Zn). 150 mesh grid (.104 mm. opening) superimposed, Magnification : 360 diameters.

Sketch showing typical relationships between galena, sphalerite, and ruby silver. X 40

(Figure 4)

$\frac{1\frac{1}{2}}{4} \times 40$

$\frac{3}{2} \times \frac{1}{4} \times 40$

5
10
15

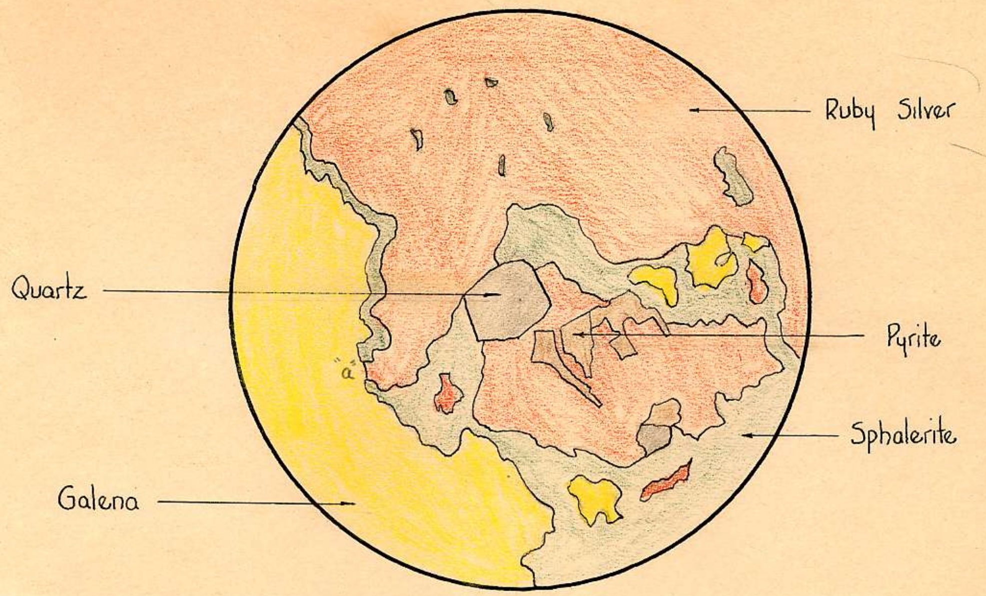

Figure 3 ----X 40

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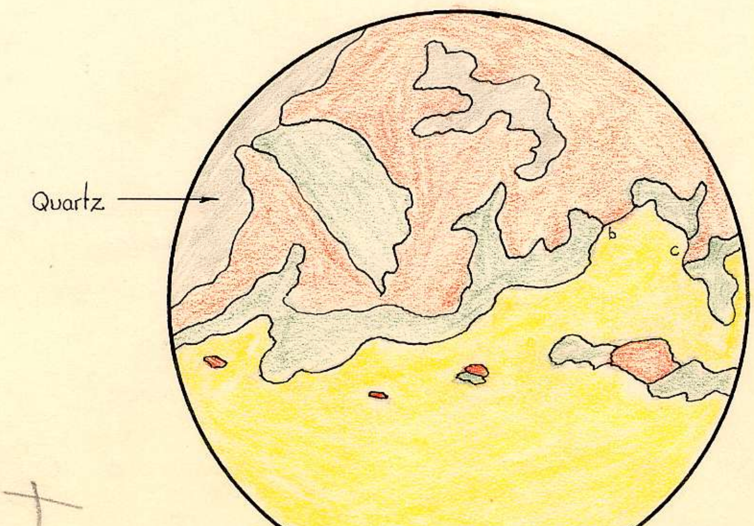


Figure 4 ----X 40

Our Figure 4

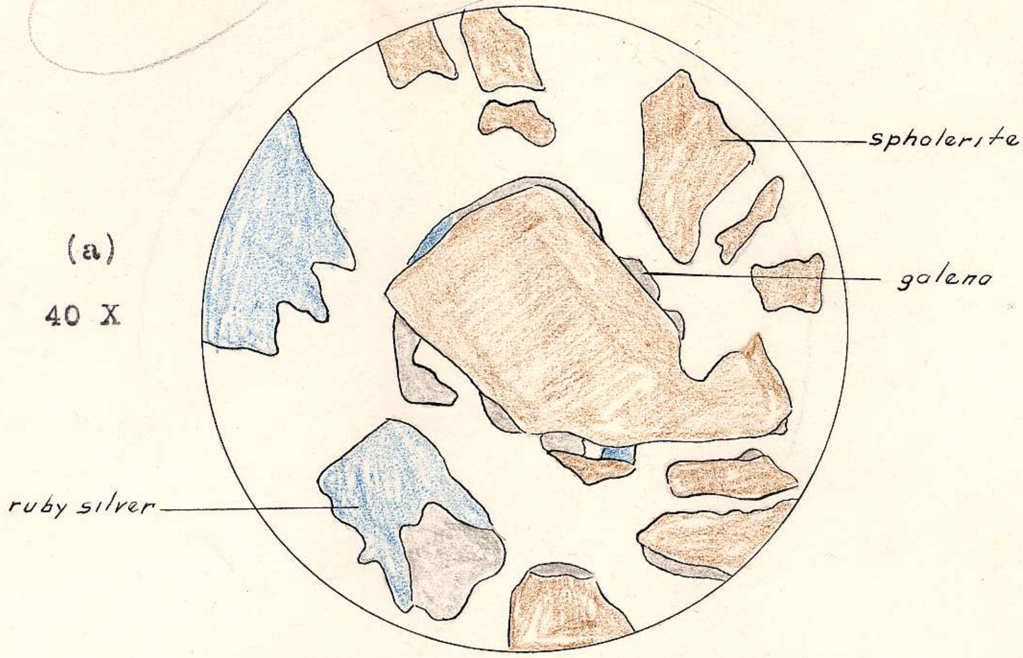
from Cleveland's article on Sally.

Our Figure 3

Figure 9 (a & b).

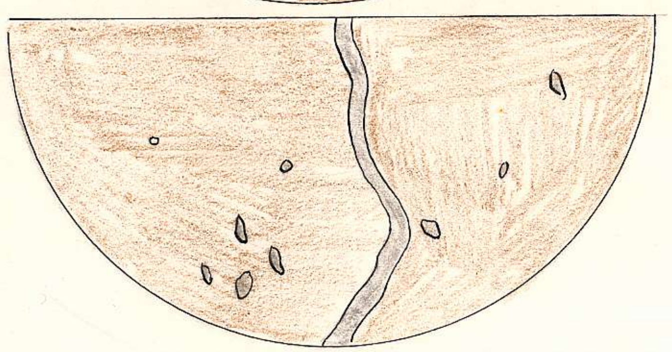
(a)

40 X



(b)

100 X



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Section of ore from the Beaverdell area, showing

(a) Ruby silver and galena encircling sphalerite which shows [demonstrates] the order of deposition, namely sphalerite followed closely by galena and ruby silver with no break between deposition of different minerals.

(b) Galena veining sphalerite.

in essay on Sally by Clarke insert following Fig 8

LEGEND

RUBY SILVER | QUARTZ

SPHALERITE | GALENA