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MINERALOGRAPHIC REPORT

ON THE

SUNSHINE LARDEAU ORE BODIES

This report is submitted in partial fulfillment of the requirements for the course Geology 409.

by

EDDIE KIMURA

The University of British Columbia

1956

Nice job all round 1st Class.

Acadia Camp,
University of British Columbia,
Vancouver 8, British Columbia,
April 17, 1956.

Dr. R. M. Thompson,
Department of Geology,
University of British Columbia,
Vancouver 8, British Columbia.

Dear Sir:

In accordance with the requirements of the University of British Columbia for partial fulfilment of the course, Geology 409, I submit my report entitled Mineralographic Report on the Sunshine Lardeau Ore Bodies.

Yours truly,

Eddie Kimura

Eddie Kimura.

Introduction

This mineralographic report on the Sunshine Lardeau ore was undertaken to determine the origin of the silver values in the Spider and Eclipse ore bodies. Some significant textures which lead to suggest a paragenesis of the ore minerals were also studied.

The ore specimens were collected from the Spider and Eclipse ore bodies. These were studied megascopically and microscopically with the aid of a binocular microscope. The polished sections made from the specimens were examined with the aid of the reflecting microscope.

The writer wishes to thank Dr. R.M. Thompson and Mr. H. Bostock for their supervision and assistance in the laboratory. The writer also wishes to thank the mining engineer of the Sunshine Lardeau Mines for the ore specimens from the Eclipse ore body.

Previous Work

Geological mapping in the Lardeau map-area has been done by the Geological Survey of Canada and the British Columbia Department of Mines. A mineralographic examination on the Spider ore body has been undertaken by J.Rivett at the University of British Columbia in 1953. Many mining companies have done considerable amount of investigation and work on the various properties.

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Location, Topography and Assessibility

The mine is located on Pool Creek about seven miles from Beaton, British Columbia, which is at the head of the Upper Arrow Lakes, in the North Lardeau Revelstoke Mining Division. Two mines, the Spider and the Eclipse, are operated by the Sunshine Lardeau Mines, limited which have their main camp and concentrating mill at Camborne. The mine is accessible by two miles of steep road from the camp.

The Lardeau District is in the Selkirk Mountains and the general topography is a series of deep valleys and high mountains which are commonly snowcapped. The valleys are densely forested, and the higher elevations are often grassy. Roads in the district are limited to the valleys because of the steep-sided mountains. Many of the roads which lead up to the old mines in the district are very steep. Old pack trails are quite common throughout the district, but many of these are now overgrown.

General Geology

The Windermere formation covers a large area of the Lardeau map-area. It is a thick sequence of metamorphosed sediments which are divided into three parts -- the lowermost Hamill series, the Badshot formation, and the uppermost Lardeau Series. These metamorphosed sediments, which are largely argilletes, schists and quartzites, strike about N 30° W and dip predominantly steeply northeast.

The Sunshine Lardeau Mines are located along the richest and widest of the three mineral belts in the Windermere formation. This belt is characterized by a long plunging overturned fold which is called the Silver Cup Anticline. The rocks are jointed and faulted in many directions and these together with the bedding planes provided excellent avenues for the ascending mineralized solutions.

The geology in the vicinity of the mine consists of jointed and sheared, and strongly crumpled and folded sequences of green chlorite schist and another band of green brecciated rock. The rocks which are part of the Lardeau Series are striking N 30° W and dip about 75° NE.

Mineralization is along a strong shear zones which are almost north-south in direction and dip steeply to the east. The veins consist of quartz and carbonate-chrome mica alteration which have been mineralized. Besides the fractures and tight folds in the rock, the brecciated member is felt to be an important ore control. The vertical extent of the ore body in the Spider Mine is proven to be at least 950 feet.

History of the Mine

The early history of the mine was very similar to many of the small mines which were developed in the Lardeau District. It was never a large producer, and it was worked periodically for very short lengths of time. However, in the year 1950 with higher base metal prices an exploration and development program was started, and by the middle of 1952 the mine was in operation. By 1954 the Spider ore body had been developed by ten levels and it was in this year and the following one that an adjoining claim, the Eclipse, was developed by a nine hundred foot crosscut from the No. 10 adit. This crosscut was completed in the summer of 1955 and since then the new ore body has been developed on a higher level.

The ore from the mine is trucked two miles by a steep road to the concentrating mill, which is capable of handling about ninety tons of ore a day. The mill produces two concentrates -- a lead concentrate and a zinc concentrate, which are shipped to Kellogg, Idaho. Besides the lead and zinc and the silver values, they also are paid for the small amounts of copper and gold values. The grade of the ore at present is about 10% zinc, 10% lead, and averages about an ounce of silver per unit of lead.

Mineralogy

A megascopic examination of the hand specimens of the ore revealed a relatively simple mineralogy. Galena is by far the most abundant of the ore minerals and occurs in all the specimens. It occurs mainly as coarse crystalline masses always associated with pyrite and sphalerite. The galena may also occur as fine grained massive textured masses with other massive sulfides as pyrite, sphalerite and chalcopyrite. The coarse grained variety is very friable and crumbly in some specimens. Pyrite and sphalerite are also abundant ore minerals. Pyrite is very often corroded or rounded due to replacement by later sulfides and the size of the grains vary from microscopic to massive blebs. Sphalerite in the hand specimens has a dark resinous brown colour indicating the relative abundance of iron in its composition. It is also present in all the specimens examined and occurs largely as irregular masses. Tetrahedrite was identified in one hand specimen which was largely quartz gangue. The quartz in this particular specimen exhibits a very porous and vuggy characteristic. Two other ore minerals, chalcopyrite and covellite were noted in many specimens, but they are only minor in abundance. The covellite appears on only some specimens as films or coatings on sphalerite and chalcopyrite.

Galena

Galena is the most abundant ore mineral representing about 45-50% of the total percentage of the ore minerals. It is usually associated with the other ore minerals and almost always has smooth rounded boundaries on the contacts with other minerals. Galena is one of the later minerals to crystallize, and therefore, it frequently has corroded remnants of pyrite, sphalerite and quartz developed within it. Caries texture, which is suggestive of replacement, is present when galena is in contact with sphalerite, tetrahedrite and chalcopyrite. The mineral is mostly coarsely crystalline, but it may be quite massive and fine grained and in such cases the galena, with other sulfides, is in bands which are either straight parallel bands or swirling with no preferred direction. The samples of ore from the Eclipse ore body exhibit evidences of shearing which is made obvious by the foliation of the galena. Microscopically the galena cleavages definitely illustrate that some post ore deformation has occurred.

Galena is a very consistent mineral throughout the different levels on the Spider ore body. However it is very noticeable that when the quartz vein becomes vuggy or essentially ore samples from the higher levels, the proportion of galena to the other sulfides somewhat decrease.

Where there is an abundance of pyrite, galena is invariably seen invading the fractures in pyrite and partially replacing the host.

The galena is one of the important argentiferous minerals in the mine. This fact is particularly noticed in the lower levels of the mine where the tetrahedrite is not an abundant mineral and yet the silver content of the ore is considerable.

Sphalerite

Sphalerite in the Sunshine Lardeau ore bodies is an abundant and consistent mineral through the various levels. It is seen in all the polished sections either as the main mineral or as blebby masses associated with other sulfides. It is noteworthy to mention that chalcopyrite seems to have an affinity for sphalerite, and therefore, is very closely associated with it. The mineral can be seen forming a mutual boundary relationship between galena, chalcopyrite and tetrahedrite and also as corroded rounded inclusions in the galena. This latter occurrence suggests that the sphalerite is definitely older and has been partially replaced by the galena. The mutual boundary relationship between the sphalerite and chalcopyrite plus the exsolution of chalcopyrite in sphalerite would indicate contemporaneous deposition. It is also noted that there are small inclusions of chalcopyrite in the sphalerite in most polished sections, but whether this texture is due to exsolution is difficult to say. It is important to note that tetrahedrite, which is the main silver mineral seldomly occurs as inclusions or exsolved in the sphalerite.

Sphalerite in the polished sections very frequently shows twinning intergrowths where the twin lamellae show up as differences in relief.

Tetrahedrite

Tetrahedrite is the main silver mineral in the ore. Its distribution varies considerably with the various levels in the mine. In the spider ore body the mineral occurs mainly as microscopic grains in very precious quantities in the lower levels, but as one approaches the higher limits of the ore body tetrahedrite occurs in megascopic quantities and is more predominant than the galena. Tetrahedrite in the ore from the No. 10 level is microscopic and takes various forms. In most cases it adheres as irregularly-shaped films or rims on sphalerite and projects into the galena. It also occurs as minute irregular shaped inclusions in galena and this occurrence appears to be due to exsolution of tetrahedrite in galena. One of the reasons for discounting the exsolution of tetrahedrite is that the small inclusions do not seem to have any particular orientation within the galena. If exsolution does not occur, then the third dimension of the polished section must be considered, and this would suggest that small bodies of the tetrahedrite are intruding up into the galena. From this investigation it is thought that the tetrahedrite is contemporaneous with the galena crystallization or may have been introduced during the very last stages of galena deposition.

The distribution of tetrahedrite varies from level to level. A specimen from the No. 6 level reveals that there is a significant increase in the amount of tetrahedrite present. They still occur in much the same manner as on No. 10 level with the exception that most of the grains are slightly larger. On higher levels of the mine tetrahedrite becomes one of the prominent ore minerals, forming about 50% of the total. Caries texture and inclusions of galena remnants are good evidences that tetrahedrite is younger than galena.

The tetrahedrite in the Eclipse ore body occurs in much the same behaviour as in the No. 10 level. It is reported that drill cores from deeper down in the Eclipse ore body revealed some tetrahedrite in megascopic quantities.

A microchemical test was carried out on the tetrahedrite and an excellent silver test was obtained. It is possible that the tetrahedrite is very close to freibergite in composition.

The grain size of the tetrahedrite which occur as inclusions or disseminations in galena varies from 20 to 200 microns with the average being about 75 microns. The average thickness of the tetrahedrite films which occur on the contacts of sphalerite is about 50 microns. These figures are typical for the ore from the No. 10 level and the Eclipse vein.

Pyrite

It was surprising to note that the percentage of pyrite in the Spider ore body is very high. In most hand specimens the percentage of pyrite appears to be about 15% of the ore minerals, but when polished sections are examined it is found that the percentage is very often twice as high. Much of the pyrite which is not seen in the hand specimen is microscopic and these contribute heavily to the overall abundance of the mineral in the ore.

Pyrite is found very commonly closely associated with quartz gangue and occurs as granular grains in the other sulfides. The grain size of the granules, which are mostly corroded and rounded, varies between 0.10 to 1.00 millimeter in diameter. In some specimens it is massive and in such cases the mineral has been highly fractured and invaded by later sulfides, namely chalcopyrite and galena.

Pyrite has two periods of mineralization. The first phase occurs as injections of pyrite in the fractured quartz veins. The pyrite of this phase is the first ore mineral to appear and very often it occurs as idiomorphic crystals, veinlets and stringers within the quartz. The second phase of pyrite mineralization occurs after or possibly contemporaneously with the sphalerite mineralization. This sequence of deposition is indicated by very small stringers of pyrite in the sphalerite masses. The latter phase of pyrite is only seen in some specimens from the No. 10 level of the Spider vein.

Pyrite is a fairly consistent mineral over the different levels in the mine except in the highest zones where it is definitely scarce. In the highly oxidized zones it is completely oxidized and disintegrated to limonite and native sulfur.

Ore specimens from the 8-59 Stope of the Spider Mine are mainly fine grained and massive sulphides, and the polished sections of these specimens reveal the highest pyrite content of all the specimens examined. All of the pyrite in these sections occur as rounded granules in galena and sphalerite, or as concentrated bands through the section. The percentage of pyrite is estimated to be as high as 35% for the specimens from this particular stope.

Chalcopyrite

Chalcopyrite is a minor ore mineral in the Sunshine Lardeau ore. It is largely responsible for the low copper values in the mill concentrates.

The mineral does occur as small masses with the other minerals, but it occurs largely as minute scattered inclusions in sphalerite and as stringers in pyrite. These minute inclusions of chalcopyrite in sphalerite are only about 25 microns in diameter. The chalcopyrite is also exsolved in sphalerite but this occurrence is rare.

Chalcopyrite seems to have a great affinity for invading and replacing pyrite fractures. In the polished section this property is seen as a complicated network of chalcopyrite stringers "criss-crossing" through the pyrite. This property is not seen in the hand specimen because the stringers are only in the order of 100 microns in width. However their presence may often be indicated by the occasional coating or film of covellite on the pyrite.

Covellite

Covellite occurs in very minor quantities as a supergene mineral. It was principally found in the altered cleavage cracks of galena and as fine net-like strings in tetrahedrite. On one occasion it was found as a very thin film on Sphalerite. All of these occurrences are found in the specimens in the higher levels of the mine and in the oxidized zone. In the hand specimen it is sometimes observed as coatings on chalcopyrite, sphalerite, and pyrite.

Gangue Minerals

The main gangue minerals are quartz and the carbonate-chrome mica wall rock alteration. These have largely been replaced by the later ore minerals, and there are remnants of them still included in some specimens.

Besides the original quartz there are very good evidences of a later stage when quartz in minor quantities was again introduced. The quartz is seen in some fairly tight fractures in pyrite. In the hand specimen a druse of fine quartz crystals were observed in a cavity amongst the ore minerals. This would suggest that this quartz is post-ore mineralization and it is thought that it may have been introduced or "sweated" out during the post-ore deformation.

Two alteration products are also considered under gangue minerals. Anglesite was first noticed in the ore from the No. 6 level which is well oxidized and altered. Anglesite occurs in the cleavage cracks and around the borders of galena. Covellite is also associated with the anglesite. Native sulfur was noted on the hand specimen which was taken from the oxidized zone of the ore body. It occurs as a dirty greenish yellow powdery coating on galena and altered sphalerite. The origin of the sulfur is probably the result of the oxidation of the pyrite and then the precipitation of the sulfur.

Significant Textures

Mutual Boundary Relationships

This relationship is most typically developed by galena-tetrahedrite and sphalerite-chalcopyrite. This texture is suggestive of contemporaneous deposition especially when other evidences are also present.

The galena-tetrahedrite relationship was best observed in a section made from one of the upper level specimens. Under the microscope the boundaries are represented by smooth rounded contacts.

The sphalerite-chalcopyrite relationship also shows some development of caries. Taking into consideration that exsolution exists between these two minerals, the mutual boundary relationship is considered as good evidence of contemporaniety between the sphalerite and chalcopyrite.

Exsolution Texture

Exsolution of chalcopyrite in sphalerite was observed in one occasion. A small body of chalcopyrite is in contact with sphalerite, and adjacent to the contact there are numerous minute spherules of chalcopyrite peppered throughout the sphalerite.

This texture is fairly good evidence for indicating contemporaneous deposition between chalcopyrite and sphalerite.

Zonal Replacement

The alteration of galena has resulted in covellite replacing galena in microscopic zones which tend to be roughly concentric. A core of galena is surrounded by three alternate zones of covellite and galena. This texture is microscopic being only about 500 microns in diameter and was examined in a specimen from the oxidized zone.

Mineral Banding

Possibly the most interesting feature of the Spider ore, mineralographically, is the mineral banding which was examined in the two specimens from 8-59 Stope. The banding is made up of different sulfides which are fine grained in texture. These bands are either straight and parallel, or are swirling similar to flow bands. The flow type of banding was examined more completely and it was found that the main mineral was pyrite and then sphalerite and galena are layered on the pyrite with galena occupying the center of the band.

Some quartz occupies the intergranular spaces of pyrite. The sequence of deposition found from investigation of other specimens indicates that pyrite is first followed by sphalerite and galena, and this is the order of deposition found in this band. Edwards[1] says that a similar occurrence is due to replacement in a schist or slate, where the pyrite is the first mineral introduced and forms the most pronounced bands followed by sphalerite which replaces a less soluble rock, and finally galena replaces the remaining most resistant schist minerals. The bedding planes or schistosity controls the direction and orientation of the bands. In the Spider ore specimen there is a swirling band and this can possibly be explained by the ore minerals replacing the rock which was drag folded or crumpled. The straight and parallel bands would be those bands controlled by undisturbed schists.

Paragenesis

The paragenetic sequence of the minerals was determined by observing various textures and differences in occurrences and associations of the minerals with one another.

The first mineral in the sequence was the injection of the quartz veins in the shear zones of the country

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1 Edwards, A.B., Textures of the Ore Minerals, Australasian Institute of Mining and Metallurgy, 1954, pp. 29-31.

rock. Then the various ore minerals were deposited with pyrite being the first to replace much of the quartz. Sphalerite and chalcopyrite followed the pyrite with the second phase of pyrite mineralization possibly overlapping the final stages of the deposition. Galena follows the sphalerite mineralization. The tetrahedrite in the lower levels of the mine seems to be contemporaneous with the galena or overlap the final stages of galena deposition. In the oxidized zones the tetrahedrite shows good evidences of being quite definitely later than galena.

After all the ore minerals were deposited there was some shearing and a small quantity of quartz was precipitated.

Covellite and anglesite are supergene minerals as a result of the alteration of the ore minerals.

Classification of the Deposit

The classification of the Spider and Eclipse ore bodies was determined after many characteristics of it were considered. Considerations made:

(a) Mineralogy, paragenesis and textures.

(b) Vertical extent of the veins.

(c) Igneous activity in the area.

(d) Regional and local geological structure.

(e) Wall rock alteration.

It was concluded that the deposit is a medium temperature hydrothermal replacement deposit. This deposit is somewhat similar to the lead-zinc-silver ores with a quartz and siderite gangue in the Slocan silver camp, British Columbia.

Alteration

Hydrothermal wall rock alteration is earlier than the first quartz deposition along the north-south shear zones. The wall rock has been altered to carbonates and chromium mica which shows up as green micaceous flakes in the rock.

Besides the wall rock alteration there has been some post ore alteration and oxidation notably in the higher oxidized zones. Galena is found to be altering along its cleavage directions. Anglesite and covellite occupy the cleavage fractures, the grain boundaries of the galena, and also penetrate into the adjacent sphalerite on many occasions. Much of the galena in such cases has a fine stipled texture suggesting that this may be the first stages of alteration. Galena was also observed once to be replaced by thin covellite zones giving a good zoned replacement texture.

Tetrahedrite is altered to covellite. The covellite occurs in the mass of tetrahedrite as a sort of small nucleus with fine strings of covellite forming a complicated network around it. The fine network shows no controlled orientation. It was also noted that for minerals in contact with one another, the galena alters most readily, followed by tetrahedrite and lastly sphalerite.

The pyrite in the oxidized zones is altered to limonite and native sulfur. The occurrence of native sulfur in this behavior is due to the complete oxidation of pyrite, the migration of the iron, and then the precipitation of the native sulfur on galena and sphalerite.

Conclusions

Tetrahedrite is the main silver mineral in the Sunshine Lardeau ore. The mineral is more plentiful in the upper oxidized zones of the ore body and therefore the higher assays of silver were produced from the oxidized ore. Galena is also an important silver carrier in the ore.

The paragenetic sequence for the minerals was studied and determined. It was found that the silver minerals were the last hypogene minerals to be deposited, and the ore deposit classified as an intermediate temperature hydrothermal replacement deposit.

The copper values in the concentrates are mainly due to the small amount of chalcopyrite which is present in the ore. Tetrahedrite may also contribute some copper. Gold values are reported to be about 0.40 to 0.45 ounces per ton in the concentrates. No native gold was seen in the polished section and it is presumed that it is present in very minute quantities in the sulfides or possibly in the quartz gangue.

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   1950, p. 150.
   1951, p. 178.
   1952, pp. 182-183.
   1953, pp. 143-144.
   1954, p. 143.

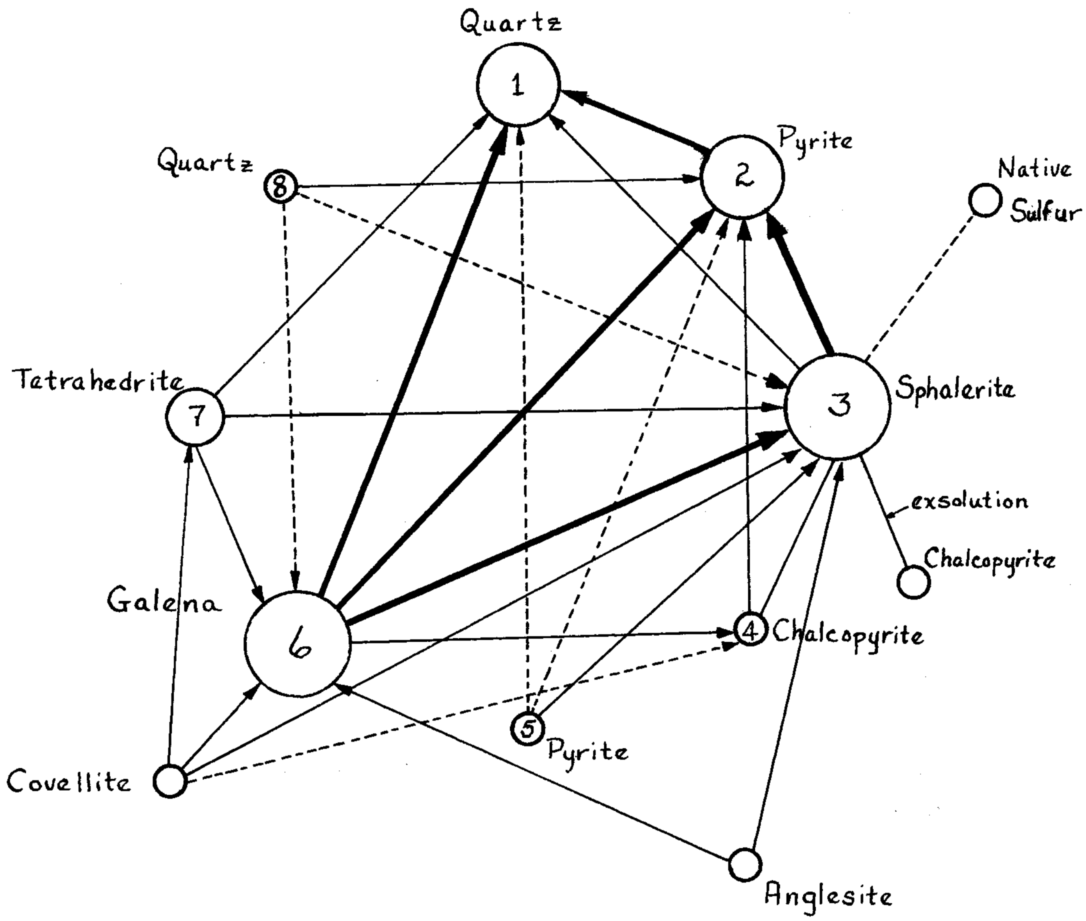


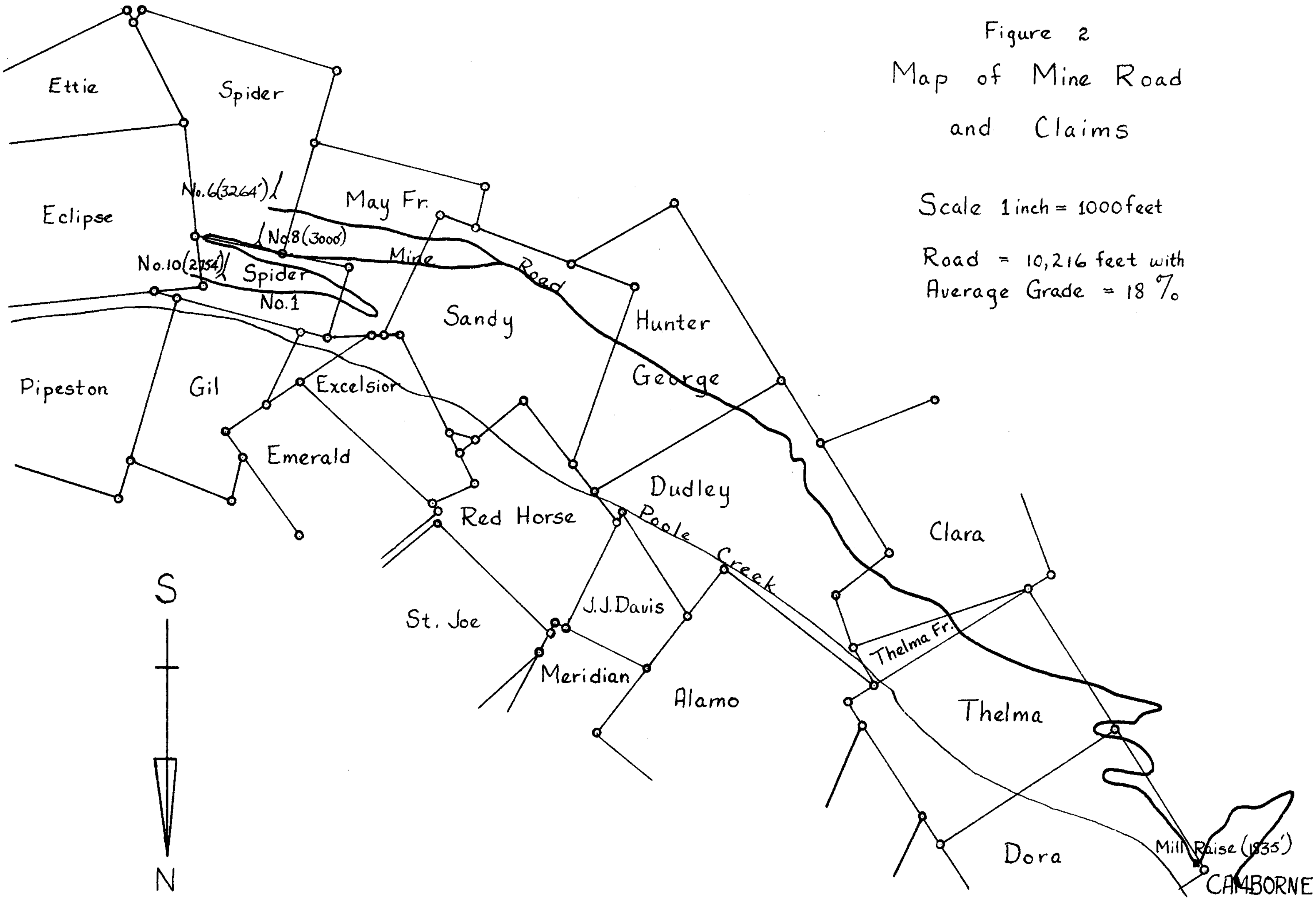
Figure 1 Paragenetic Relations of Minerals

Order of crystallization of hypogene minerals is clockwise beginning at the top. Supergene minerals are represented outside the hypogene circle.

Figure 2
Map of Mine Road and Claims

Scale 1 inch = 1000 feet

Road = 10,216 feet with Average Grade = 18 %



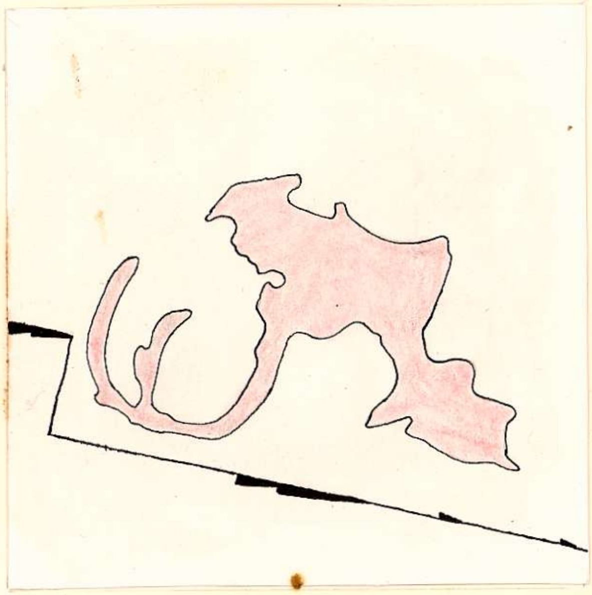


Figure 3 X170

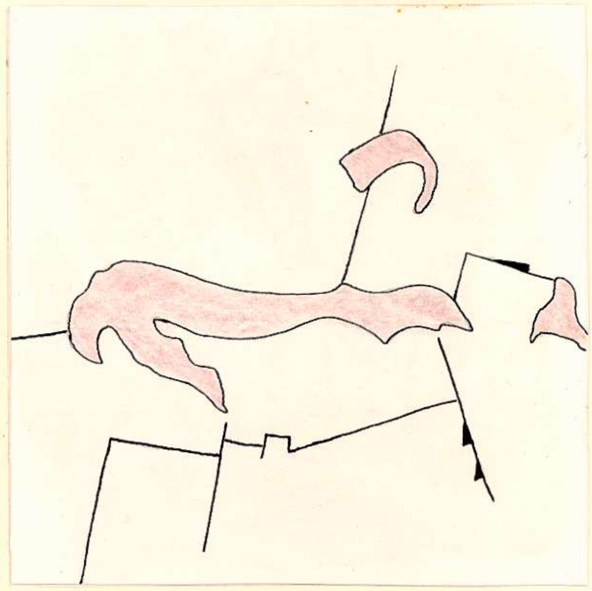


Figure 4 X175

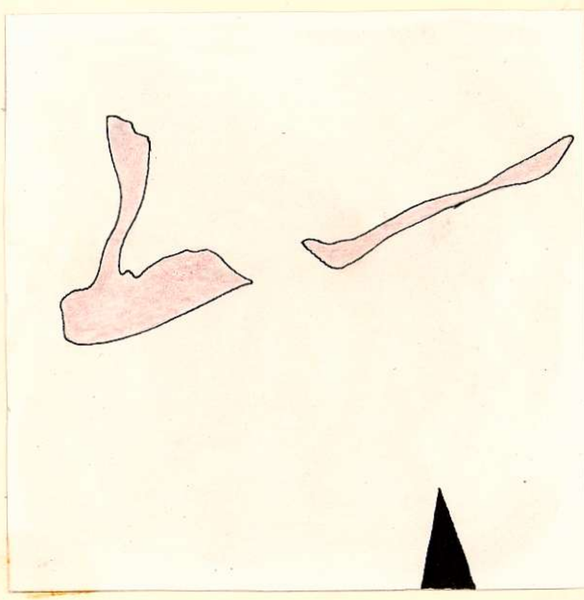


Figure 5 X125

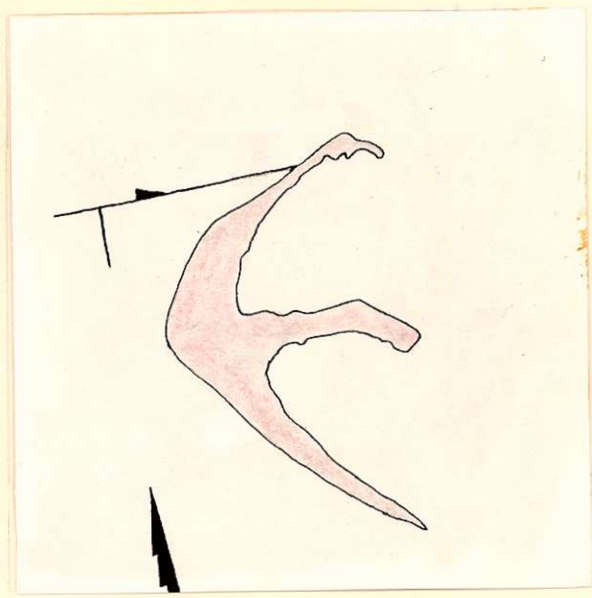


Figure 6 X240

Figures 3, 4, 5 and 6

Various forms of tetrahedrite (pinkish gray) which occur as inclusions or intergrowths in galena (white). They may suggest exsolution, contemporaneous deposition or later deposition than galena. Galena cleavage is shown in black.

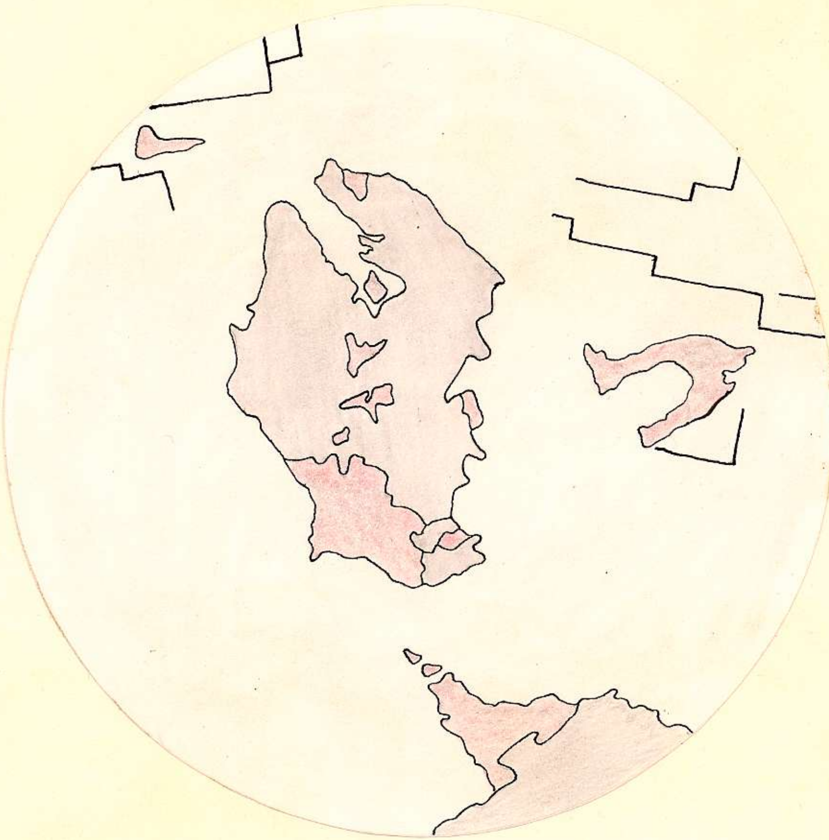


Figure 7

Ore from No. 10 Level

Sphalerite-galena-tetrahedrite relationship. The tetrahedrite (pinkish gray) which is adhering or included in the sphalerite (gray) will not be recovered in the milling process. X 125.

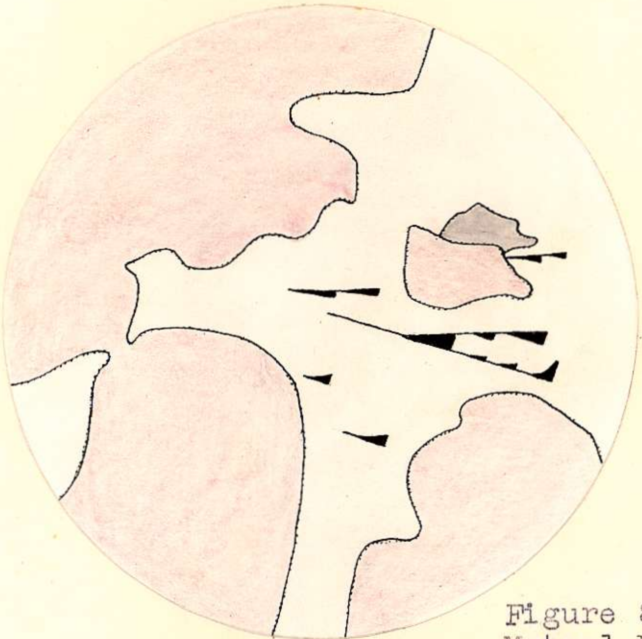


Figure 8.
Mutual boundary relationships between galena (white) and tetrahedrite (pinkish gray). Quartz gangue is dark gray. X 85.

Figure 9
Zonal replacement texture where the zone of supergene covellite (blue) are replacing the galena (white) and tetrahedrite (pinkish gray). Quartz gangue is dark gray. X 200.

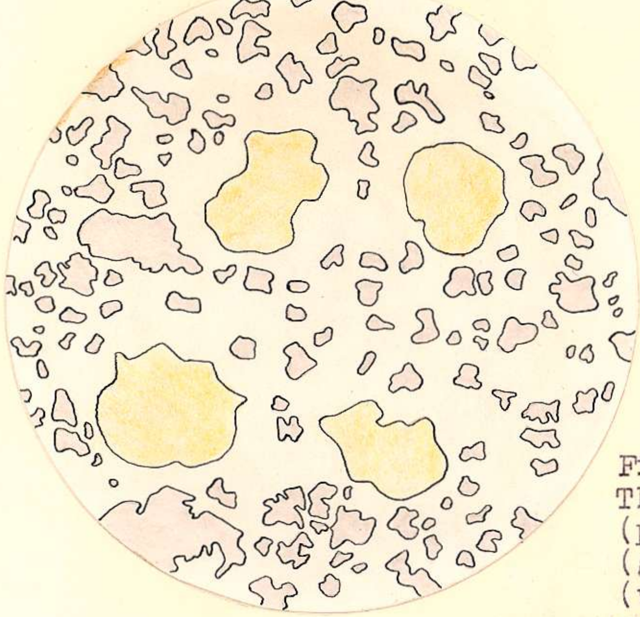


Figure 10
The earlier sulfides, pyrite (pale yellow) and sphalerite (gray) are replaced by galena (white) and they now occur as rounded and corroded remnants. X 180

Figure 11
Ore from No. 6 Level. Chalcopyrite (yellow) has invaded and partially replaced the network of fractures in pyrite (pale yellow). Some tetrahedrite (pinkish gray) and galena (white) also occur in the fractures. X 40

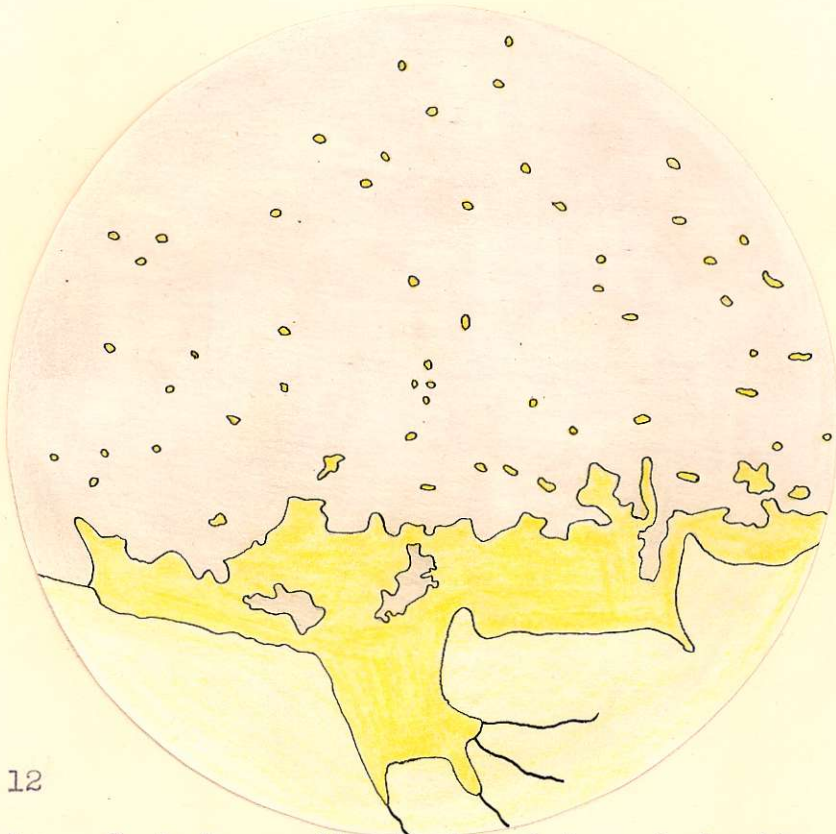


Figure 12

Exsolution of chalcopyrite (yellow) in sphalerite (gray) to give a mottled or emulsion texture. Pyrite is pale yellow. X 120.

Figure 13. Ore from No. 10 Level.
Pyrite (dark gray and granular) occurring as stringers cross-cutting the sphalerite (white). The pyrite has probably entered the irregular fractures in sphalerite and therefore occur as very irregular veinlets. The gray mass at the lower edge is quartz. X 50.

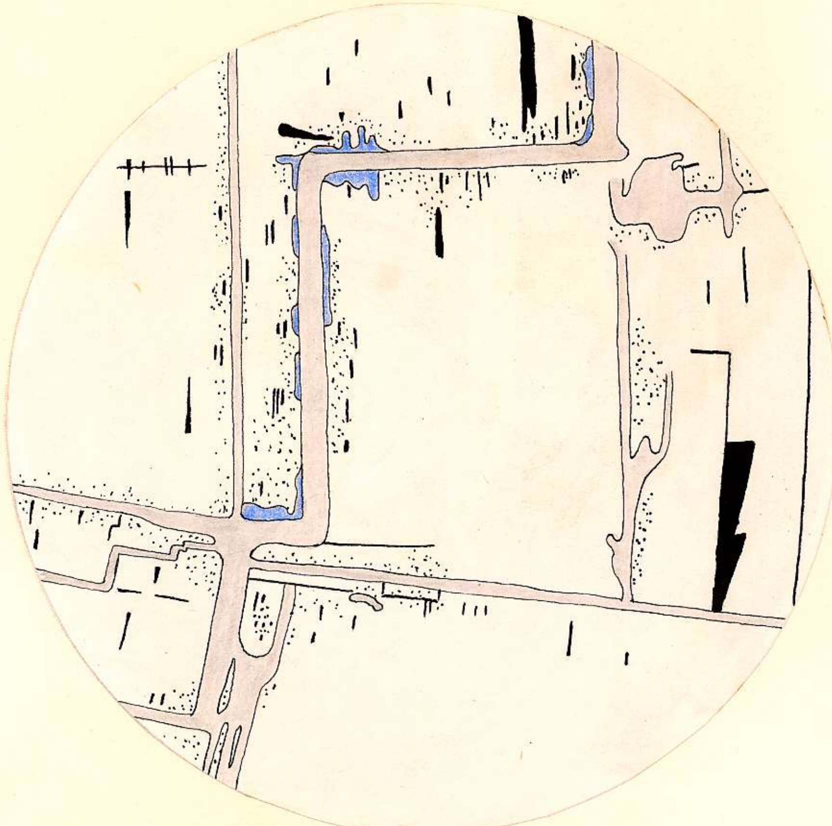


Figure 14

Ore from No. 6 Level

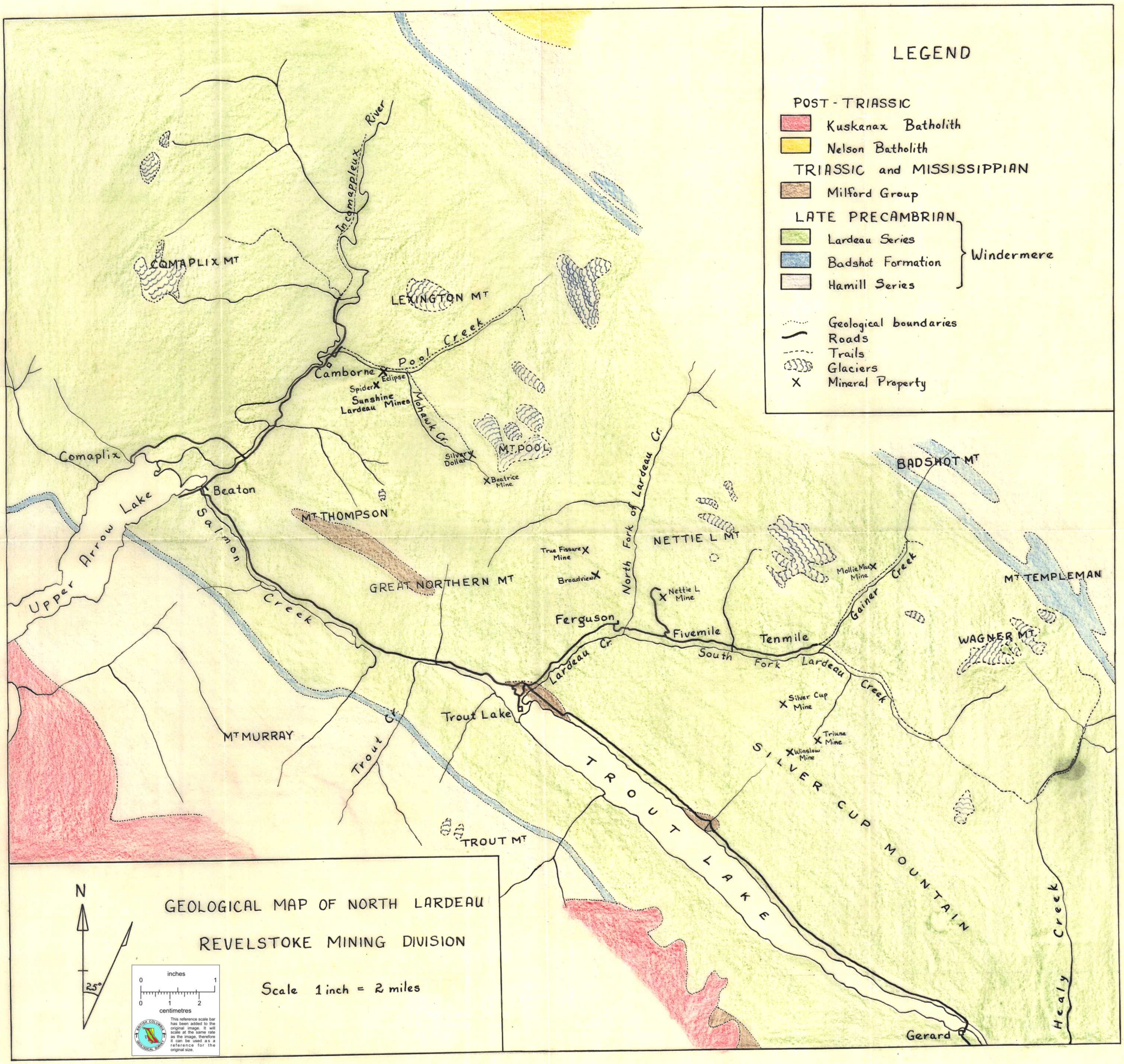
Anglesite (gray) and covellite (blue) replacing galena cleavages. Note that the galena (white) has a pitted appearance adjacent to its cleavages, and this is probably the beginnings of the alteration. X 55.

Figure 15

Geological Map of North Lardeau

Revelstoke Mining Division

Scale 1 inch = 2 miles.



LEGEND
POST - TRIASSIC
Kuskanax Batholith
Nelson Batholith
TRIASSIC and MISSISSIPPIAN
Milford Group
LATE PRECAMBRIAN
Lardeau Series
Badshot Formation
Hamill Series
Windermere
Geological boundaries
Roads
Trails
Glaciers
Mineral Property
GEOLOGICAL MAP OF NORTH LARDEAU
REVELSTOKE MINING DIVISION
Scale 1 inch = 2 miles
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This reference scale bar has been added to the original image. It will scale at the same rate as the image, therefore it can be used as a reference for the original size.
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COMAPLIX MT
LEXINGTON MT
Pool Creek
Camborne
Eclipse
Spider
Sunshine Lardeau Mines
Mohawk Cr.
Silver Dollar
Beatrice Mine
MT. POOL
Comaplix
Beaton
Upper Arrow Lake
Salmon Creek
MT THOMPSON
GREAT NORTHERN MT
True Fissure Mine
Broadview
North Fork of Lardeau Cr.
NETTIE L MT
Nettie L Mine
Ferguson
Fivemile
Tenmile
Lardeau Cr.
South Fork Lardeau Creek
Gainer Creek
Mollie Mac Mine
BADSHOT MT
MT TEMPLEMAN
WAGNER MT
Silver Cup Mine
Triune Mine
Winslow Mine
SILVER CUP MOUNTAIN
Trout Lake
TROUT LAKE
Trout Cr.
MT MURRAY
TROUT MT
Healy Creek
Gerard