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A Microscopic Examination of Sheep Creek Ores

by

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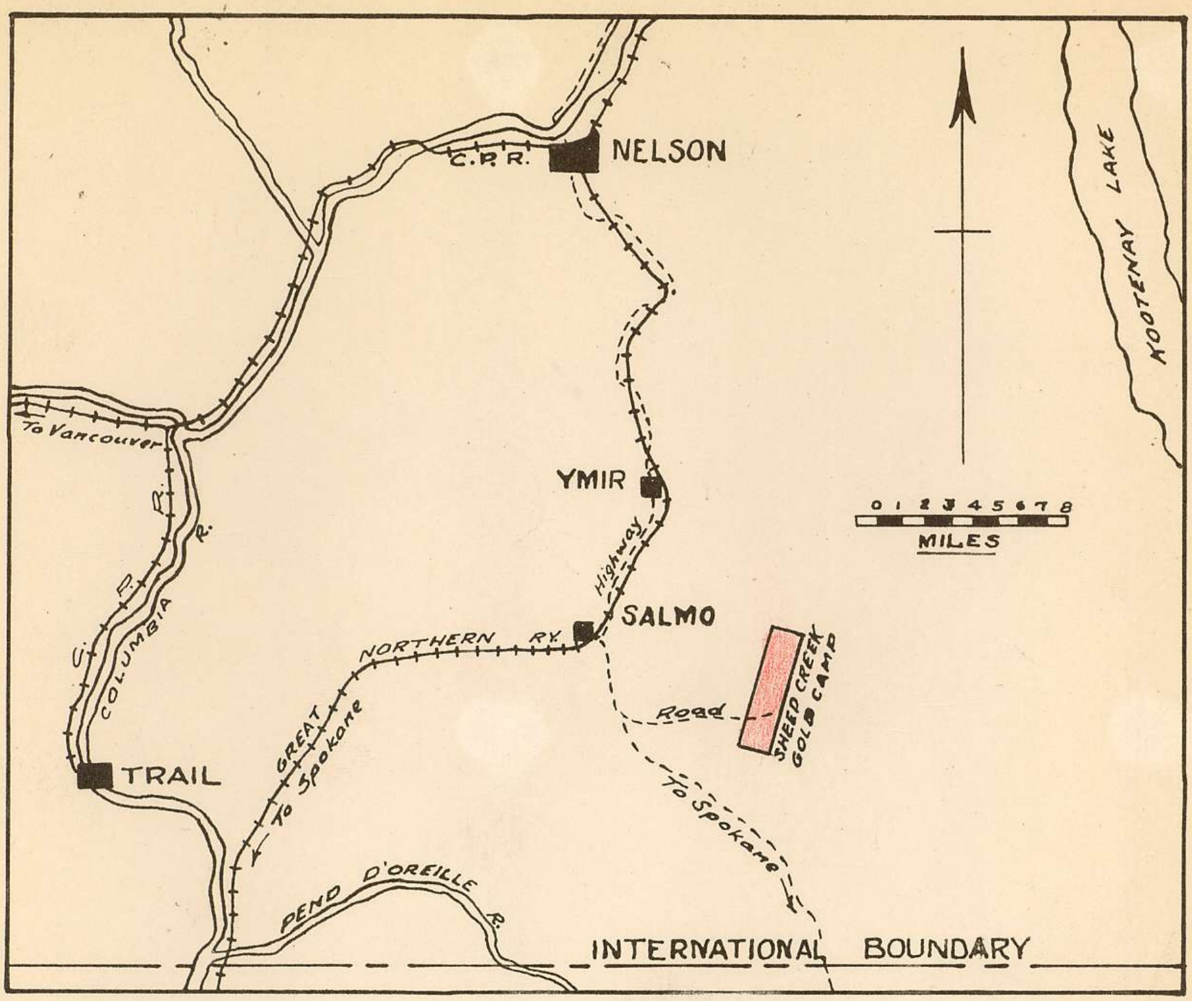


Sketch Map
Showing Location Of

SHEEP CREEK GOLD MINING CAMP

Southeastern British Columbia

A Microscopic Examination of Sheep Creek Ores

Abstract

This problem has been undertaken with the principal objectives of determining the minerals present in the Sheep Creek ores, their modes of occurrence, and possible order of deposition. Although mineralogical studies have been made of this ore in the past, a great deal of development work has been carried out since the last study was made. Specimens chosen for this study are of high grade ore from three closely spaced adjacent mines; the Gold Belt, the Kootenay Belle and the Queen.

Introduction

The Sheep Creek mining camp is situated about 30 miles due south of Nelson in the Kootenay district of British Columbia. It takes its name from Sheep Creek, a westerly flowing stream which enters the Salmo River at a point about four miles south of Salmo. The camp lies on the western slopes of the southern part of the Nelson (Quartzite) Range.

The whole camp takes in an area about six miles in length and two miles in breadth but only the most southerly part of the camp embracing an area three and one half miles in length and two miles in breadth will be concerned in this study.

The townsite of Sheep Creek, at an elevation of 3100 feet, is located at the junction of the south-westerly flowing Sheep Creek and the north-westerly flowing Waldie Creek. These streams conveniently divide the area into three sections. The area to be considered south of Waldie Creek lies on the north slope of Waldie Mountain which rises quite steeply to an elevation of about 5500 feet at the southern boundary of the map-area. Yellowstone Mountain between Waldie and Sheep Creeks rises precipitously with slopes up to 50 degrees to an elevation of about 6500 feet at the eastern boundary of the map-area. Reno Mountain to the north of Sheep Creek rises fairly steeply northward to an elevation of about 6500 feet at the northern boundary of the map-area.

The three mines under consideration were primarily gold producers although silver values were recovered. The Gold Belt Mine lies to the north of Sheep Creek on Reno Mountain, the Kootenay Belle Mine lies south of Sheep Creek on the north slope of Yellowstone Mountain and the Queen Mine lies south of Waldie Creek on Waldie Mountain.

At the present time the Queen Mine is the only major producer. The Kootenay Belle Mine is being operated on a very small scale by leasers. The Gold Belt Mine, owing to adverse economic conditions, has been inactive since 1947.

Acknowledgements

The writer wishes to acknowledge the kindness of the managements of the Sheep Creek Gold Mines Ltd., the Gold Belt Mining Company Ltd., and leasers of the Kootenay Belle Mine, in permitting samples to be taken. Acknowledgements are also due to Dr. R.M. Thompson, Dr.H.V. Warren, and Mr. J.P. Donnqn for their assistance and advice in the examination and preparation of the polished sections.

General Geology

The Sheep Creek camp is underlain by sedimentary rocks which have recently been determined to be Cambrian in age. These sediments have been intruded in the western part of the camp by a granitic phase of the Nelson batholith. The sediments are also intruded by acidic dykes, mineralized quartz veins and basic dykes all of which are believed to be late differentiate phases of the Nelson batholith.

The sediments are upper members of the Windermere formation, namely; the Quartzite Range, the Reno, and the Pend d'Oreille Series. The sediments, which are all conformable, have been folded into two sharply folded anticlines with an intervening syncline. The main or easterly anticline which does not lie wholly within the camp is much the larger structure and overlies the smaller anticline to the west. The axes of both anticlines strike about N 15° E while their axial planes dip approximately 60° E.

The mineral deposits occur in sinuous shear fractures which traverse the structures in directions varying from N 55° E to N 80° E. All of these vein fractures dip vertically or steeply south. In all cases the south side of the vein fractures has moved westward and downward with respect to the north wall. In the section of the camp under discussion, quartz veins occur only where the shear fractures traverse competant quartzites of the Quartzite Range formation or lower Reno formation. Vein fault movement was taken up largely by crumpling rather than shearing in the less competant beds, and where shearing did occur in these beds, openings were not maintained for the mineralizing solutions. The ore deposits are also controlled to a large extent by structure. Sections through veins show the ore to be confined to the hooded anticlinal crests or uppermost parts of the anticlinal limbs.

An aplite sill 50 to 100 feet in width traverses the synclinal area from end to end and was apparently intruded after the vein fissuring had occurred. Lamprophyre dykes which cut all rocks and mineral deposits represent the last stage of igneous intrusion.

The Queen and Gold Belt deposits occur within the crestal portion of the western anticline, while the Kootenay Belle deposit is confined to thewestern limb of the eastern anticline.

The early day mining in the camp was carried out in rich oxidized upper portions of the veins but recent mining has all been carried out in lower primary sulphide ores. The camp has been noted for its deep oxidation zone which in some cases extended to a depth of 1000 feet.

All of the ore in the camp has bottomed in strong barren quartz veins. Some geologists have credited the proximity of underlying granite as being the cause of this bottoming.

Mineralogy

General statement

The samples taken are of primary sulphide ore and should be fairly representative of the minerals present in Sheep Creek ores. Since most of the veins in the camp have been mined out, no attempt was made to obtain ore samples representative of various horizons in ore shoots in the same and on different veins. Samples are representative of high grade ore from the Queen, the Kootenay Belle, and the Gold Belt mines.

Megascopic examination

The primary ore consists of medium to coarse grained bands of the common sulphides, namely: pyrite, sphalerite, galena, pyrrhotite, and chalcopyrite in a gangue of milky white quartz. The sulphides appear to occur along shears in the quartz filling which are approximately parallel to the vein walls. The width of the bands varies from a tight fracture to several inches.

Pyrite is the most abundant sulphide mineral and in many cases is the only visible sulphide. Pyrite usually occurs in well defined bands although small amounts are often scattered outside the main bands. The pyrite outside of the banding shows a definite tendency towards crystal development. In the wider productive veins of Sheep Creek, the pyrite bands are most commonly near the boundaries of the veins. Pyrite is commonly associated with sphalerite and galena.

After pyrite, sphalerite is probably the most abundant sulphide mineral. Sphalerite occurs in two ways; it may appear as bands of dark brown pure sphalerite, or as a light brown disseminated form associated with galena.

Crystal faces are not commonly seen in the sphalerite.

In some veins galena appears to be the most abundant sulphide; in these cases the mineral shows well developed crystal faces. The presence of sphalerite appears to reduce the tendency for good crystal development in the galena. Galena and sphalerite generally occur in less well defined bands than the pyrite and are most commonly seen in the central portions of veins where more intersecting fractures occur.

Chalcopyrite is not a commonly observed mineral in the ore but does occur as veinlets in the quartz or other sulphides. Pyrrhotite is more common than chalcopyrite but is not an abundant mineral in the ores of the southern part of the camp. Pyrrhotite is seen in the samples associated with sphalerite and pyrite.

Free gold is not seen megascopically in any of the samples but is occasionally seen in the ore. When seen megascopically the gold is usually closely associated with sphalerite and galena.

Assay Interpretations

Assay values were obtained for the gold, silver, lead, zinc, and iron content of a number of samples taken from the Queen and Kootenay Belle Mines. Some of these assay results are shown on page 7 . The assays are not necessarily those of any samples examined in this problem but do indicate the type of ore having the higher gold and silver values. Assay results indicate the higher values of gold and silver to be found in samples high in either lead or zinc or both. Results show also that samples low in lead and zinc and also low in iron have very low gold and silver values. Mining experience in the camp has indicated that sphalerite is generally the best indicator of gold but galena may also be a good indicator. Where pyrite occurs alone, gold and silver values are generally not high.

Assays of Samples Taken from the Queen and Kootenay Belle Mines

Sample No.	Sample Location	Gold oz. per ton	Silver oz. per ton	Lead %	Zinc %	Iron %
1	568 Drift E. Queen Mine	6.50	7.0	0.6	8.0	9.1
2	757-19 Stope Queen Mine	3.0	1.7	---	4.3	14.3
3	592 Drift E. Queen Mine	2.21	1.3	1.5	3.1	11.7
4	757-10 Stope Queen Mine	4.31	2.4	0.9	4.9	14.3
5	583-203 Stope Queen Mine	1.41	2.0	0.4	---	14.9
6	Muck Sample Kootenay Belle	2.96	0.9	---	13.0	6.1
7	283 Drift W. Queen Mine	5.33	5.0	1.5	0.26	4.2
8	281 Drift W. Queen Mine	1.03	0.5	---	---	16.2
9	581 Drift E. Queen Mine	0.56	---	tr	0.25	17.2
10	975 Drift E. Queen Mine	0.43	tr	---	---	23.2
11	483 Drift E. Queen Mine	0.14	---	tr	---	10.9
12	292 Drift E. Queen Mine	0.59	tr	---	---	16.9
13	276 Drift W. Queen Mine	0.28	0.3	---	---	21.6
14	576 Drift E. Queen Mine	0.04	0.2	---	---	5.2
15	981 Drift E. Queen Mine	0.73	tr	---	---	8.4

Microscopic Examination

Thirteen polished sections were made from the ore samples collected. Eight hypogene minerals were rocognized from the microscopic examination. These minerals in order of abundance are:

Quartz

Pyrite

Sphalerite

Galena

Pyrrhotite

Chalcopyrite

Arsenopyrite

Gold

The mode of occurrence and relations of the above minerals are described below.

Quartz

A milky white variety of quartz is the only important gangue mineral. One of the earliest minerals to be deposited, quartz has been fractured and in part replaced by later sulphides. Quartz appears to have been the most readily replaceable mineral - late minerals replace it in preference to other sulphides. The only mineral which shows any evidence of having been replaced by quartz is pyrite in which the replacement spreads outwards from fractures.

Pyrite

Pyrite is the most common sulphide mineral in the sections examined. It occurs as euhedral to anhedral grains in quartz or sulphide minerals or as irregular masses in quartz. Although pyrite commonly occurs along sheeting planes and fractures in the quartz, suggesting that it is younger than the quartz, boundary relations between the two minerals in polished sections usually indicate pyrite to be the older. There may be some doubt between age relations of pyrite and pyrrhotite but the pyrrhotite can most often be proved younger. Fractures in pyrite are seen filled with any of the later sulphides except pyrrhotite but remnants of quartz in these fractures suggest that quartz has first fulled the fractures to be later replaced by sulphides.

Sphalerite

Sphalerite is the second most common sulphide mineral in Sheep Creek ores. It occurs as irregular masses or as bands commonly associated with galena, pyrrhotite, and chalcopyrite and less commonly with pyrite. Sphalerite is cut by irregular replacement veinlets of galena or contains irregular masses of replacing galena within it. Rounded residuals of quartz or euhedral crystals of pyrite are frequently seen in sphalerite. Sphalerite was preceded by pyrite, quartz, and pyrrhotite and was succeeded by galena and at least in part by chalcopyrite.

Galena

Galena is the third most common sulphide mineral after pyrite and sphalerite. Galena occurs in the form of anhedral masses closely associated with sphalerite. This mineral is found veining the older minerals more commonly than is sphalerite. Galena veinlets replace and fill fractures in pyrite and irregular masses of galena embay pyrite. Euhedral crystals of pyrite are commonly seen in galena. Galena appears to replace quartz in preference to other sulphides - the veinlets of galena in fractured pyrite for the most part appear to result from a replacement of a previous quartz filling. Corroded residuals of chalcopyrite and pyrrhotite are found in galena.

Pyrrhotite

Pyrrhotite is not typically seen in hand specimens of the ore but occurs in three of the polished sections examined. Polished section studies indicate pyrrhotite to be definitely post-quartz in age since it veins and contains rounded residuals of that mineral. It is seen in association with pyrite, galena, chalcopyrite, and most commonly sphalerite. Contact relations between these minerals indicate that it is younger than pyrite but older than galena, chalcopyrite, and generally older than sphalerite. The presence of oriented inclusions of pyrrhotite in sphalerite probably results from the replacement of sphalerite along its cleavage planes. Since some pyrrhotite appears younger than the sphalerite with which it is in contact, there was probably an overlap in the time of deposition of the two.

Chalcopyrite

Chalcopyrite is not an abundant mineral but small amounts of it occur in most of the sections examined. Chalcopyrite occurs most commonly as blebs in sphalerite and less commonly in galena, pyrrhotite, and pyrite. Blebs of chalcopyrite were seen as oriented inclusions in sphalerite associated with similar inclusions of pyrrhotite - this may indicate a replacement of the sphalerite along its cleavage planes. Chalcopyrite commonly occurs as a filling along contacts of other adjacent minerals, especially along pyrite - pyrrhotite contacts, indicating that it is probably younger than either of these minerals. Chalcopyrite also occurs as small irregular masses or veinlets in quartz: this occurrence appears to be related to fractures and grain boundaries in the quartz.

Gold

Since gold is the valuable constituent of Sheep Creek ores, its mode of occurrence, relationships, and distribution is of prime importance. Gold is found most commonly in contact with the more abundant sulphide minerals, namely; pyrite, sphalerite and galena. It occurs along the mutual contacts of any combinations of quartz, pyrite, sphalerite, and galena or may be found isolated in any of these minerals. Isolated particles of gold were seen most often in sphalerite. The occurrence of gold as small isolated masses in quartz is probably related to invisible fractures or grain boundaries of that mineral. Gold occurs in fractures or as isolated blebs in pyrite. In all cases where gold was observed in quartz or pyrite, galena and sphalerite were closely associated with these minerals. Since gold occurs along the contacts of even the latest minerals, it is believed to be the last mineral introduced. The observed particles of gold ranged in size from approximately 15 to 200 microns, the average being about 25 microns.

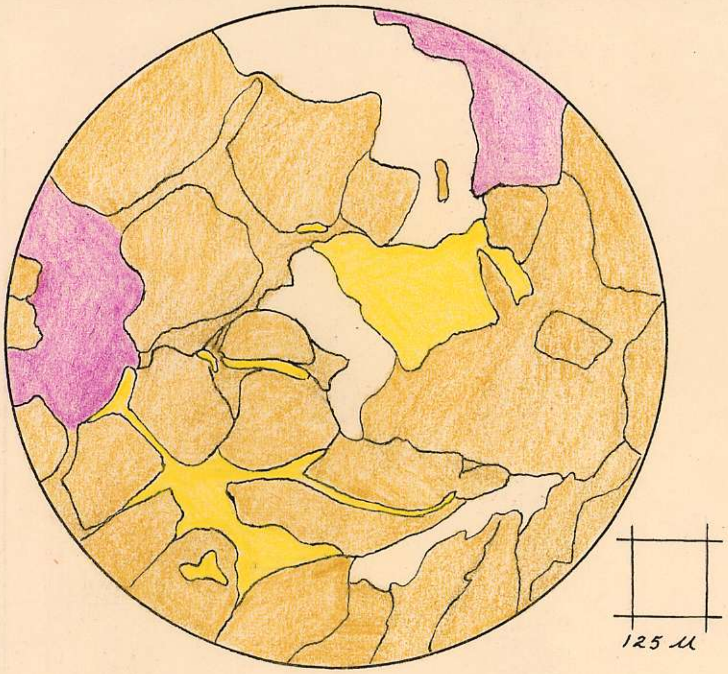
Arsenopyrite

Arsenopyrite was recognized only in one polished section. In the case observed it occurred as a euhedral grain in pyrrhotite with a diameter of approximately 200 microns. Under high power magnification several small inclusions of chalcopyrite were seen in the grain of arsenopyrite.

Paragenesis

1. Possible deposition of barren quartz followed by fracturing.
2. Deposition of pyrite followed by fracturing.
3. Introduction of quartz.
4. Introduction of pyrrhotite closely followed by sphalerite, the time of pyrrhotite deposition extending slightly beyond that of the sphalerite.
5. Introduction of chalcopyrite slightly overlapping the time of deposition of pyrrhotite.
6. Introduction of galena and gold, the gold being later than the galena but having a slight overlap.

SECTION NO. 2



Remarks

Gold in fractured pyrite closely associated with galena and sphalerite.

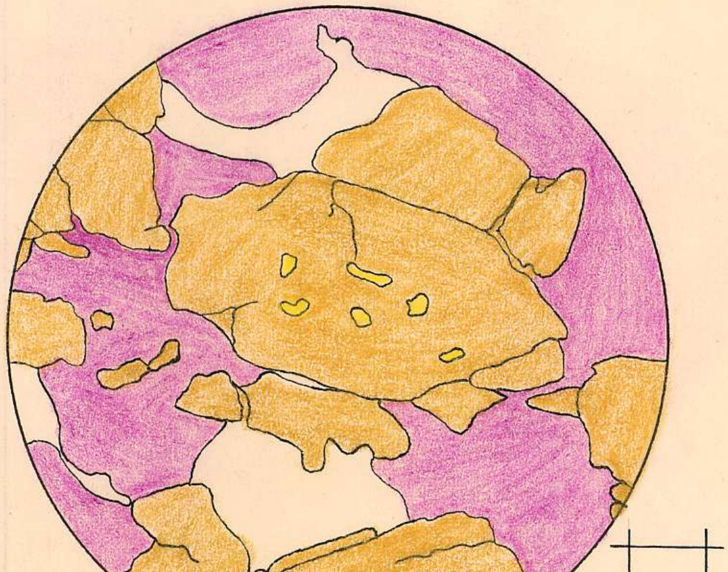
Pyrite

Sphalerite

Galena

Gold

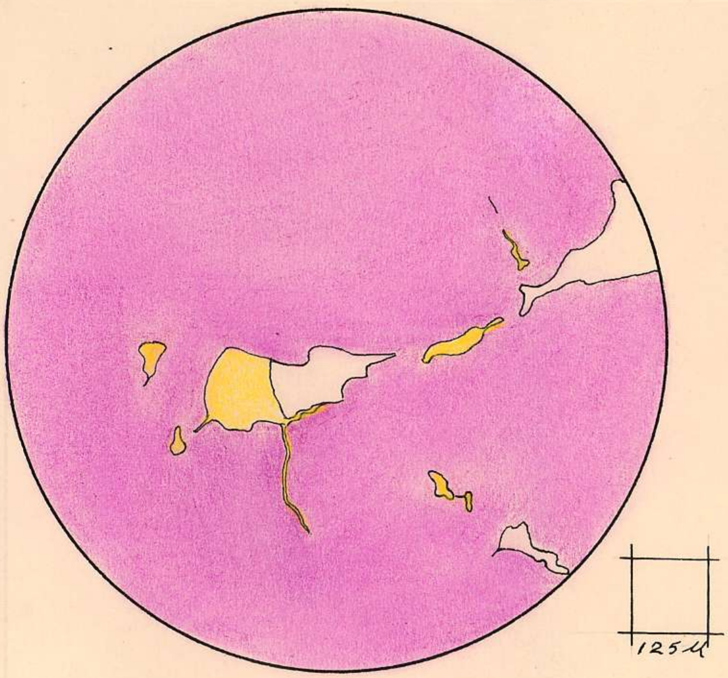
SECTION NO. 2



Remarks

Particles of gold inside a pyrite grain closely associated with galena and sphalerite.

SECTION NO. 2

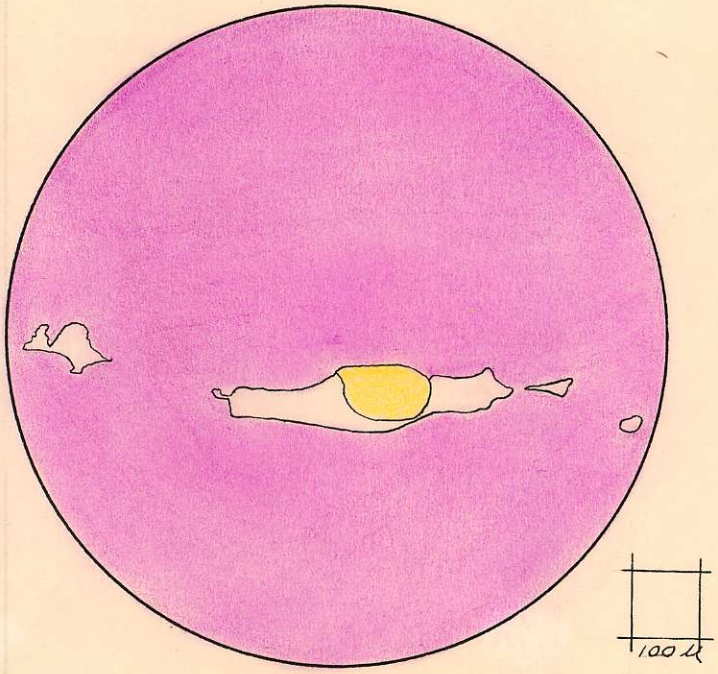


Remarks

Gold occurring as blebs and veins in sphalerite closely associated with galena

Sphalerite	
Galena	
Gold	

SECTION NO. 1

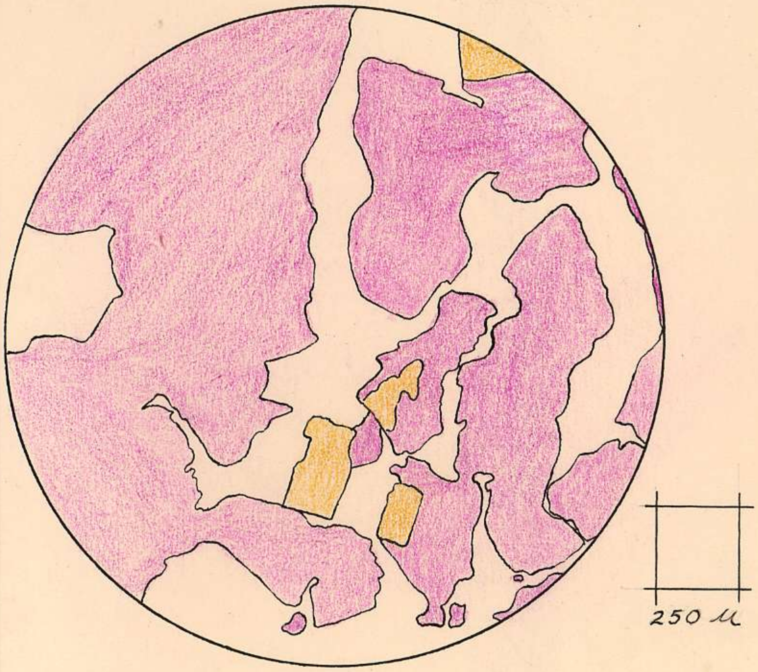


Remarks

Gold closely associated with blebs of galena in sphalerite.

PLATE 3.

SECTION NO. I

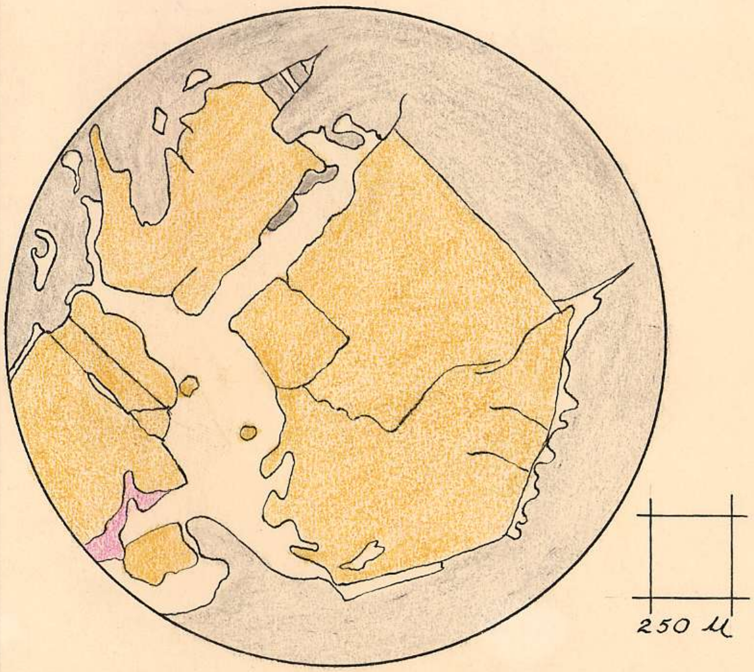


Remarks

Galena veining sphalerite. Grains of early pyrite embayed by sphalerite and galena.

Pyrite
Sphalerite
Galena
Quartz

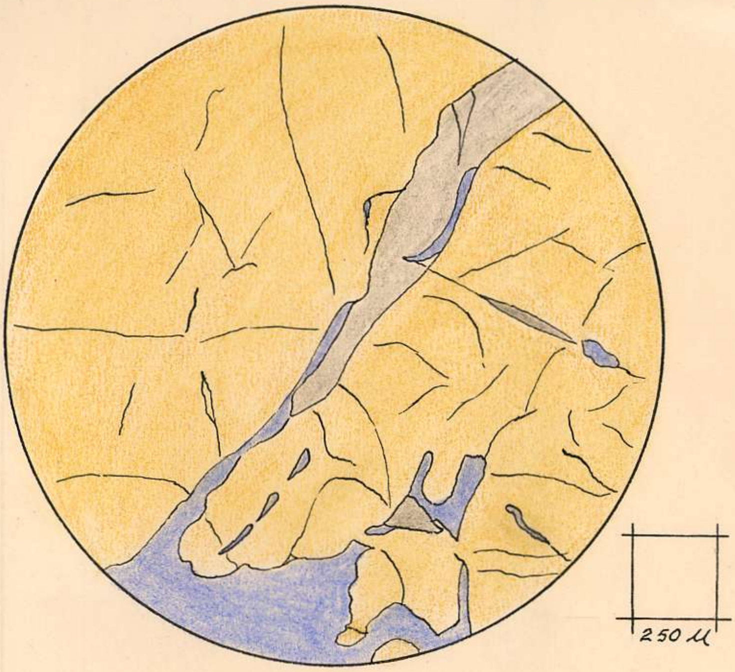
SECTION NO. II



Remarks

Galena replacing quartz in fractured pyrite and along pyrite-quartz boundaries.

SECTION NO. 6



Remarks

Galena and quartz in fractured pyrite. Galena has probably replaced pre-existing quartz to a greater extent than pyrite.

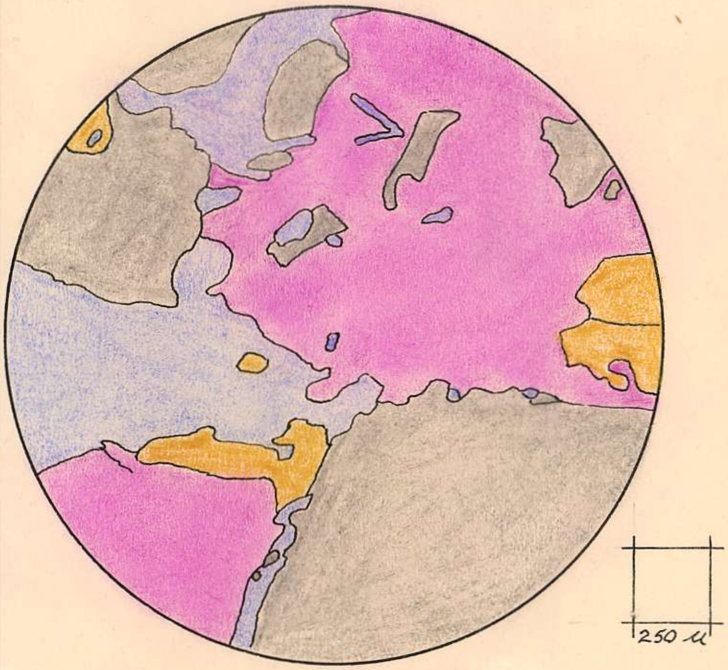
Pyrite

Sphalerite

Galena

Quartz

SECTION NO. 5

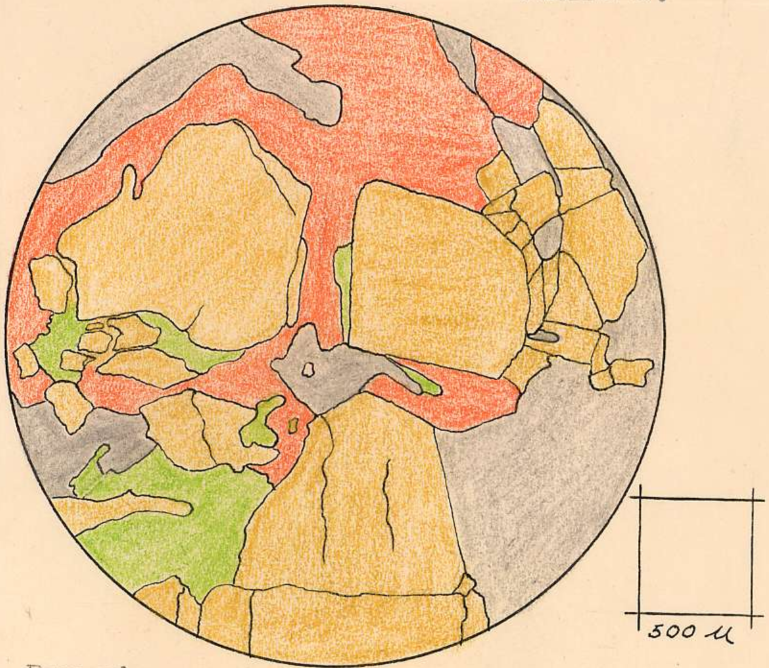


Remarks

Galena occurring to a large extent at quartz-sphalerite boundaries. Replacement residuals of pyrite and quartz in sphalerite.

PLATE 5.

SECTION NO. 7



Remarks

Pyrrhotite embaying pyrite and quartz. Chalcopyrite appearing for the most part in fractured pyrite and at pyrrhotite-pyrite boundaries.

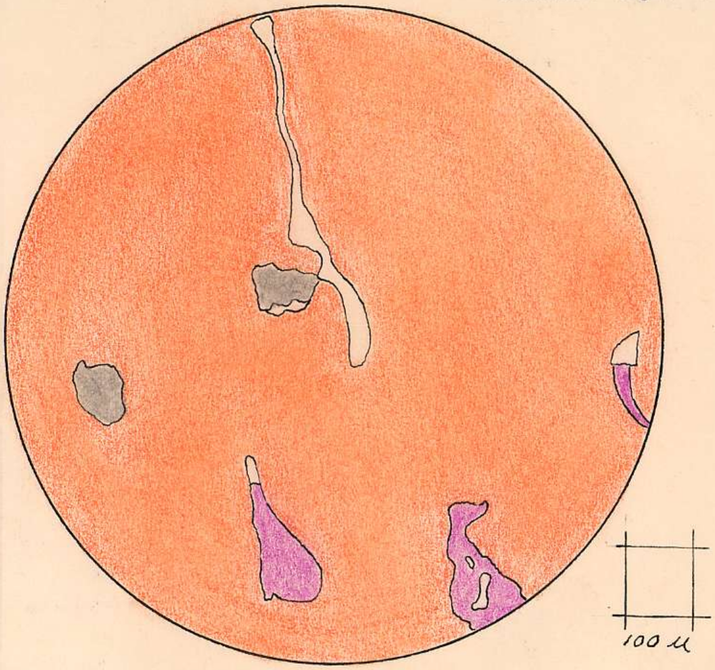
- Pyrite
- Sphalerite
- Galena
- Pyrrhotite
- Chalcopyrite
- Quartz

SECTION NO. 12

Remarks

Galena appears at quartz-pyrrhotite boundaries by the replacement of these earlier minerals.

SECTION NO. 9



Sphalerite

Galena

Pyrrhotite

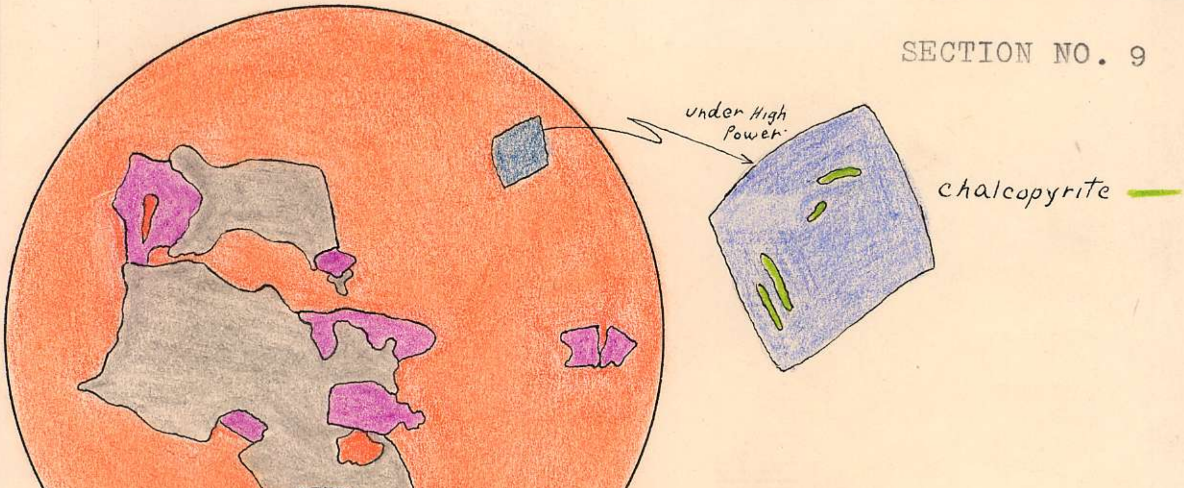
Quartz

Arsenopyrite

Remarks

Galena veining pyrrhotite. Residuals of quartz and sphalerite in pyrrhotite. Galena replacing sphalerite.

SECTION NO. 9

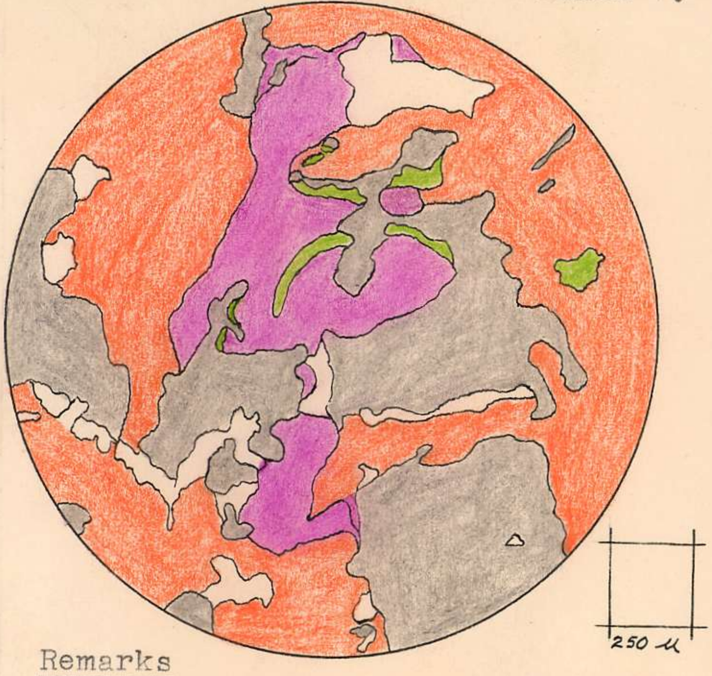


Remarks

Pyrrhotite replacing quartz and sphalerite? A grain of arsenopyrite appears as an unsupported nuclei in pyrrhotite.

PLATE 7.

SECTION NO. 12



Remarks

Galena appears along boundaries of earlier minerals.Chalcopyrite appears for the most part along earlier quartz-sphalerite boundaries.

Sphalerite

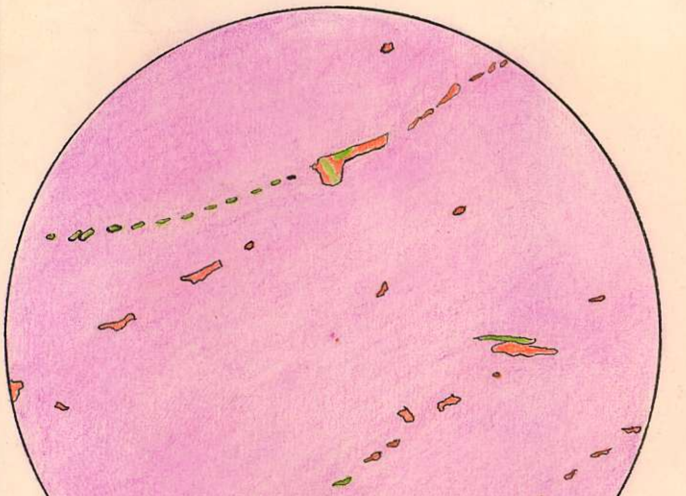
Galena

Pyrrhotite

Chalcopyrite

Quartz

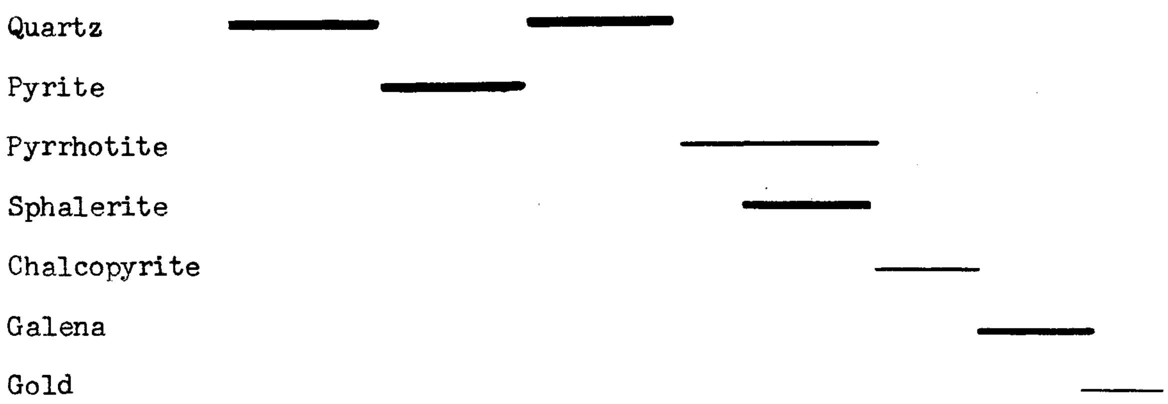
SECTION NO. 9



Remarks

Oriented blebs of pyrrhotite in sphalerite are probably a result of replacement by pyrrhotite along cleavage planes of sphalerite. Chalcopyrite blebs are a later replacement.

Graphical Illustration of Paragenesis



Conclusions

Gold is associated with sphalerite, pyrite, quartz, and galena in that order of decreasing importance. When gold occurs in pyrite or quartz, galena and sphalerite are usually closely associated with these minerals. Assay results indicate the higher values of gold and silver to be found in samples high in either lead or zinc or both. Samples having low assay values of lead, zinc, and iron are usually very low in gold and silver values. No silver minerals were seen in polished sections but it is probable that the silver is contributed largely by the galena.

The Sheep Creek deposits are probably of a higher temperature mesothermal type. The order of deposition shows a tendency to progress from higher to lower temperature minerals, the higher temperature minerals being deposited earliest.

Since much of the gold occurs as microscopic particles, the ore must be finely ground to facilitate good recovery by cyanidation. The minor amounts of chalcopyrite, pyrrhotite and arsenopyrite present in the ore will not affect the efficient use of the cyanidation process of gold recovery.

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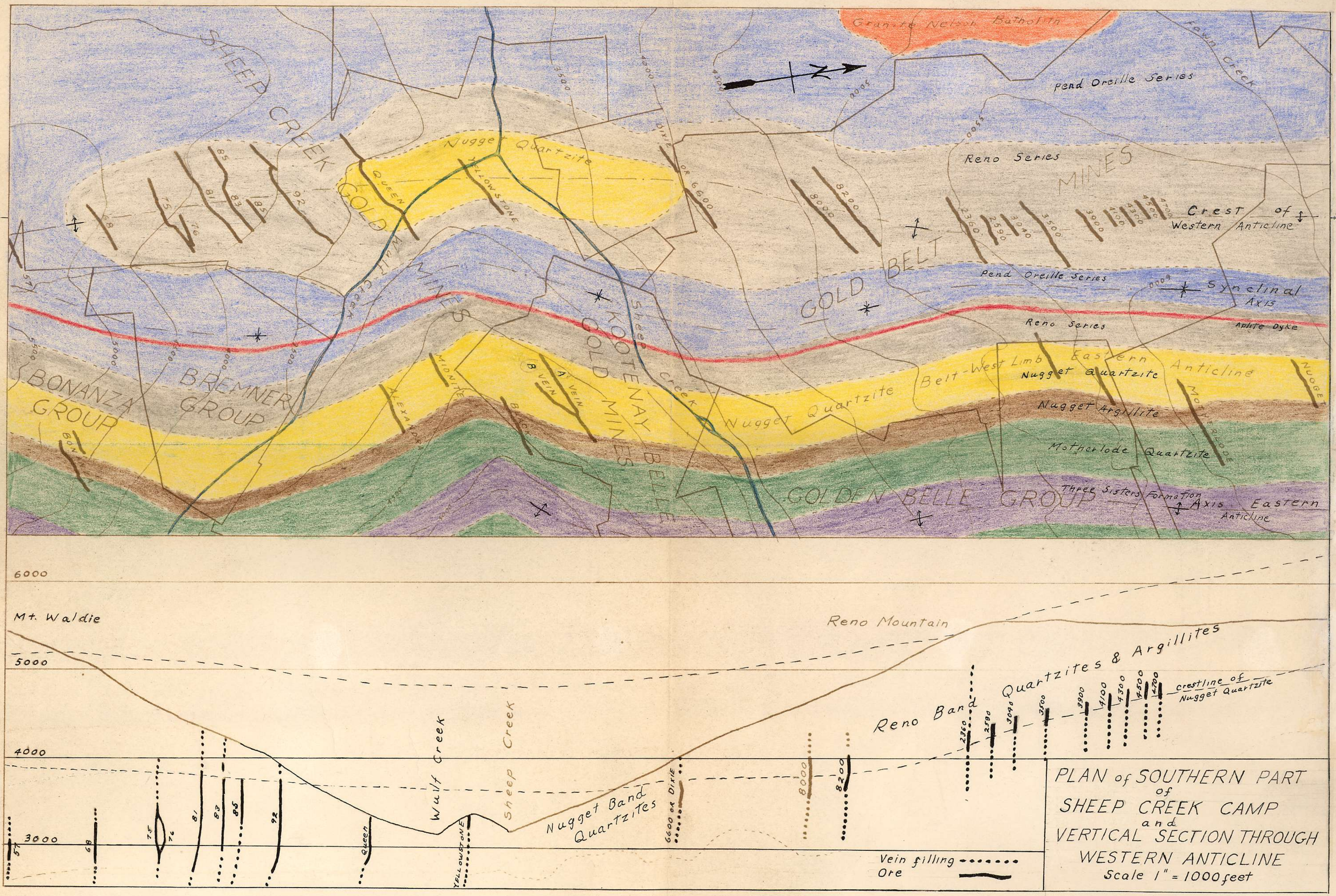

PLAN of SOUTHERN PART of SHEEP CREEK CAMP and VERTICAL SECTION THROUGH WESTERN ANTICLINE

Scale 1" = 1000 feet