# A Microscopic Examination of Ore

# from

# The Humming Bird Mine

# Ymir - Nelson Area, B.C.

A report submitted to the Department of Geology at the University of British Columbia in partial fulfilment of the requirements of the course Geology 409.

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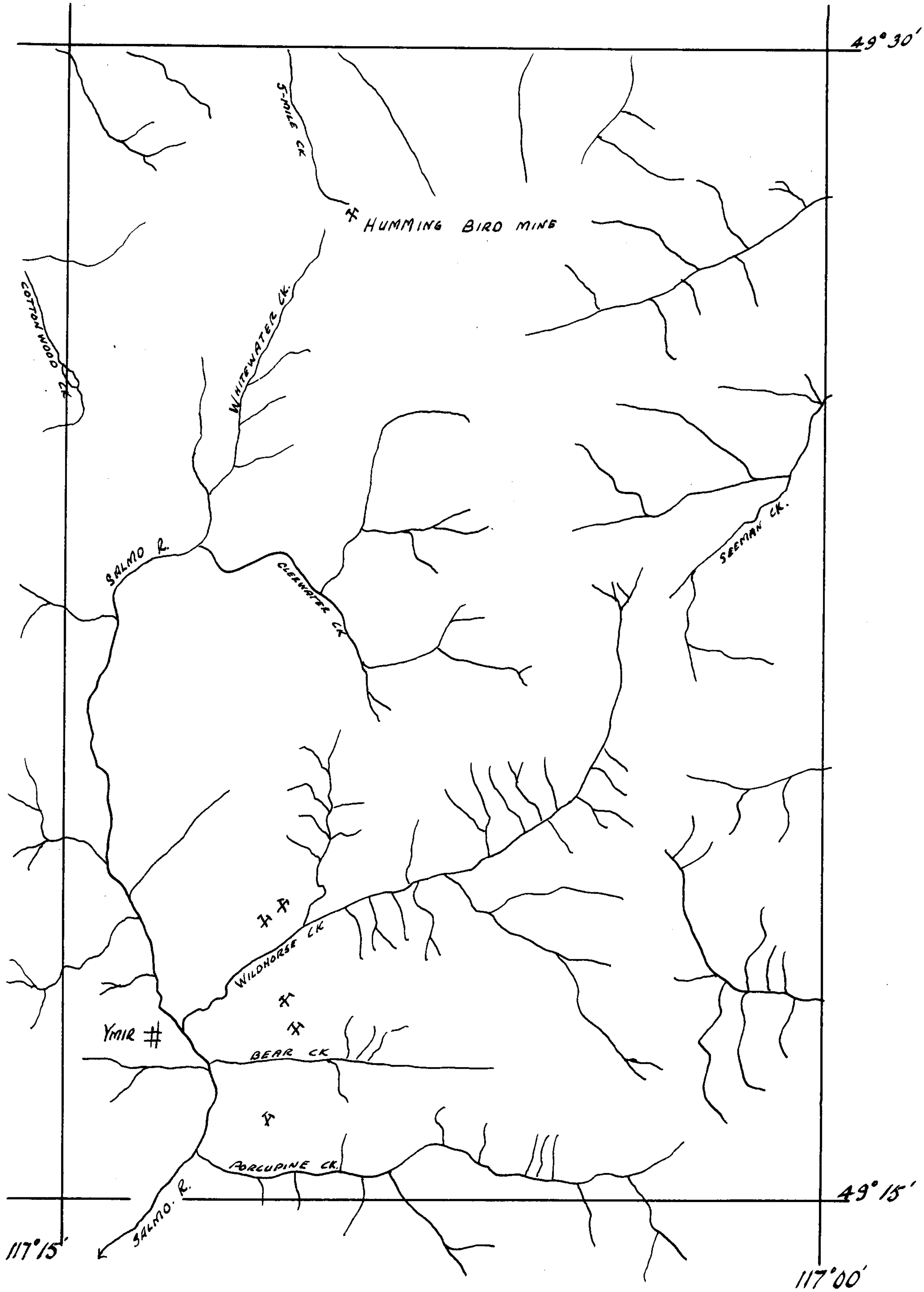
## Introduction

This report is the result of a microscopic examination of ore specimens from the Humming Bird mine. The purpose of the report was to determine the ore and gangue minerals, their paragenesis, and to report mineral associations which may be of value in the treatment of the ore. The report has been divided into two parts. The first part describes the location and geology of the mine followed by a megascopic and microscopic description of the mineralogy. This section is concluded by a discussion of the paragenesis. The second part of the report is largely diagramatic and presents the evidence for the conclusions reached in part #1. The diagrams are followed by a short detailed description of each polished section studied under the microscope. A small scale sketch map has been appended to show where specimens were taken in the field.




YMIR MAP AREA
SCALE — 2 MILES to 1 INCH

PART #1

Location of the Humming Bird mine

The Humming Bird mine is situated within the Ymir - Nelson area of southern B. C. at approximately latitude 49° 25′ and longitude 117° 10′. The mine workings are between elevations 5450 and 5800 feet on the divide between 5-mile creek and Whitewater creek. An additional claim is at elevation 6300 feet. The mine is easily accessible from Apex by a two and one half mile pack trail which follows Whitewater creek. Apex is a railway siding on the Great Northern Railway eight miles due south of the city of Nelson.

Historical Note

The Humming Bird Group of claims was staked by Robert Qua and R. G. Joy in 1921 following the discovery of rich gold bearing float in the bed of 5-mile creek at elevation 5800 feet. By ground sluicing and trenching they exposed two parallel quartz veins above the creek carrying gold values associated with galena, sphalerite, pyrite and arsenopyrite. Assay values obtained from a ten foot ore shoot were reported to be:-

| | |
|---|---|
| Au | 6.26 oz. |
| Ag | 3.9 oz. |
| Pb | 5.5 % |
| Zn | 1.9 % |

how wide?

Two more quartz veins, 500 feet in elevation above the Humming Bird veins, were also staked by Qua and Joy in 1921. The veins were well mineralized by pyrrhotite but gold values were too low to merit underground exploration.

The property remained relatively unexplored until the summer of 1932 when the Nelson Gold Mining syndicate optioned the property. During 1932 and 1933 they completed approximately 325 feet of drifts and cross-cuts on two levels and located one small ore shoot. From this ore shoot they shipped a few tons of ore but dropped the option in 1933. The mine has remained essentially idle ever since, however the present owners were planning an exploration program at the time of the writer's visit in September, 1948.

Acknowledgements

The writer was privileged to serve as field assistant with the Geological Survey of Canada under A. L. McAllister in the summer of 1948. Mr. McAllister generously provided the opportunity for the writer to study the geology of the Humming Bird mine and to collect a suite of ores. An expression of thanks is due to Dr. R. M. Thompson and to Dr. H. V. Warren for their assistance in the laboratory. The writer also wishes to thank Mr. J. A. Donnan for making several polished sections.

## General geology of the Ymir area

The important gold deposits of the Ymir mining camp occupy fault fissures cutting a formation of black argillaceous rocks. These rocks extend as a narrow belt to the north and south of the town of Ymir. The formation is called the Pend-d'Oreille Schist by Drysdale (1917)* and Cockfield (1936) but recent work by A. L. McAllister may define the formation more exactly. Rocks of the Rossland Volcanic group overlie the argillites to the west. The Nelson Batholith, to which the mineral deposits are related, intrudes the argillite to the east. The volcanics and argillites have been closely folded along NS axes and have been subjected to numerous periods of faulting. The most productive fault fissures in the area strike N 60° - 80° E and dip steeply to the north.

The mineralogy of the N 60° - 80° E fissure veins is typically simple. They are all gold deposits in which the gold is closely associated with pyrite, galena, and sphalerite. The presence of galena is considered to be the best indicator of gold values in the camp. Where pyrrhotite is encountered at depth, the gold values decrease rapidly. A structural and mineralogical study of the Humming Bird mine has led the writer to believe that it also belongs to this Ymir type of lode gold deposit.

## Geology of the Humming Bird mine

The sedimentary rocks which are hosts to the quartz veins at the Humming Bird mine represent the northern extension of the black argillite formation of the Ymir camp.

* See Bibliography - page 24

At the Humming Bird the rocks are not typical of the argillite but represent very siliceous facies of the formation. The most abundant rock of sedimentary origin is a uniformly grained argillaceous quartzite. It is typically light grey with numerous dark grey bands. Gneissic granodiorite of the Nelson Batholith occurs to the north, south and east of the Humming Bird claims.

Three sets of veins occur at the Humming Bird mine. They vary from barren quartz veins to those well mineralized by quartz, pyrite, sphalerite, galena, and in one case by pyrrhotite.

(1) The most important veins are bedded fault fissures. These have been developed by two adits and have yielded the total ore production. At the upper adit a single persistent quartz vein follows well defined walls of quartzite. It contains abundant sphalerite and galena. The lower adit follows several, small, discontinuous stringers instead of one well defined vein. Much of the ore here consists of brecciated wallrock which has been heavily mineralized by pyrite and sphalerite.

(2) A set of mineralized tension fractures also occurs in the quartzites. These have been well mineralized by quartz and galena but vein widths are too small to mine.

(3) The third vein set is represented by one quartz vein contained in the granodiorite, 2000 feet to the northeast of the main workings. (see sketch map) (PAGE 22) The vein has been traced for 300 feet along strike and attains a maximum width of four

feet. A 50-foot inclined shaft has been driven on a lense of massive pyrrhotite within the vein.

Megascopic mineralogy

The suite of ores was collected from the lower adit at elevation 5600 feet, from the upper adit at elevation 5775 feet, and from an inclined shaft on the vein at elevation 6300 feet. (see sketch map). (page 22) Differences in texture and mineralogy between the three collections are very noticeable in the hand specimens.

Specimens from the lower adit exhibit many large cubes and pyritohedrons of pyrite and a few prismatic crystals of arsenopyrite. These crystals occur in a white quartz gangue and in many instances seem to replace the brecciated wallrock. Sphalerite is also abundant. It occurs in the white quartz veins and as a fine grained, banded replacement in the quartzite wallrock. Galena is uncommon but occurs as a massive replacement of wallrock in some specimens.

Specimens from the upper adit are predominantly galena and sphalerite in a white quartz gangue. Euhedral crystals of quartz are common. Galena and sphalerite are associated with the quartz and do not occur as replacements of the wallrock. Pyrite does not occur as euhedral crystals. It is seen only as fine grained, highly oxidized, stringers through the ore.

Specimens from the inclined shaft at elevation 6300 feet exhibit fractured euhedral quartz crystals in massive pyrrhotite. A few inclusions of coarsely crystalline sphalerite are also visible in the pyrrhotite. Chalcopyrite can be seen as minute specs in most specimens.

# MICROSCOPIC MINERALOGY

## Lower adit

The minerals are discussed in their order of occurrence.

Pyrite and arsenopyrite:

Both pyrite and arsenopyrite occur as euhedral crystals up to 9 mm. in length. Pyrite is 20 times more abundant than arsenopyrite. Both minerals occur entirely as unsupported nuclii in quartz or as euhedral crystals replacing the wallrock. They were not seen to vein any earlier mineral. (figs. 1, 9 ). Pyrite has been severely fractured, veined, and replaced by quartz. (figs 1, 9 ) Arsenopyrite has been fractured but not veined or replaced by quartz. Pyrite is also actively replaced by sphalerite and galena.

Quartz:

Quartz is the most abundant mineral and is best seen veining fractured pyrite. (figs. 3, 9 ) It exhibits considerable variation in its tendency to replace pyrite. Quartz is actively replaced by all the sulphides with the exception of pyrite and arsenopyrite. It is replaced in preference to pyrite by the later sphalerite and galena.

Sphalerite:

Sphalerite veins and replaces both quartz and pyrite. It is however most conspicuously developed as a fine grained replacement of the quartzite wallrock. It was easily identified by its hardness and internal reflection.

Chalcopyrite:

Chalcopyrite was seen in only one section. (No. 12) It occurs in fractures in the pyrite where it possibly replaces quartz which originally filled the fracture. (fig. 3 ) Chalcopyrite shows no tendency to replace the pyrite. It was identified by its hardness and streak.

Galena:

Galena replaces quartz, pyrite, and sphalerite (figs. 2 ) It replaces quartz and sphalerite more readily than pyrite. Galena is also found as a replacement of the wallrock. It was identified by its hardness and triangular pits.

Main adit:

The minerals are discussed in their order of occurrence.

Quartz:

Quartz is the most abundant mineral often forming euhedral crystals. These crystals have been fractured and replaced by sphalerite and galena. Quartz was not seen to replace or vein any other minerals so is presumed to be the earliest mineral.

Sphalerite:

Sphalerite veins and replaces quartz. (fig. 6 ) It is easily recognized by minute blebs of pyrrhotite which it invariably contains. Since all the pyrrhotite is restricted to blebs in the sphalerite this may be an "emulsion" texture due to ex-solution. However, no orientation of the pyrrhotite was observed.

Galena:

Galena is the most abundant metallic mineral. It actively replaces quartz and sphalerite. Alteration of galena to a mixture of, possibly, anglesite and cerussite, has taken place along cleavage planes. It has produced a diagnostic angular pattern through much of the galena. (fig. 6 ) Microchemical tests on this alteration product yielded Pb and a slight test for $CO_3$.

Pyrite:

Fine grained pyrite with a poor lustre, veins quartz, sphalerite, and galena. (fig. 7 ) It has not noticeably replaced these minerals. In the hand specimen it has the appearance of colloform pyrite filling fractures through the ore. It is probably a secondary mineral.

Inclined shaft, elevation 6300 feet (pyrrhotite vein)

The minerals are discussed in their order of occurrence.

Quartz:

Quartz in abundance appears to be the earliest mineral. Much of the quartz has formed large euhedral crystals. It has been fractured, veined, and replaced by later pyrrhotite and sphalerite but much of it has retained its euhedral crystal form. (fig. 11 )

Sphalerite:

Dark, coarse grained sphalerite, veins and replaces quartz. Sphalerite is easily recognized by its invariable inclusions of minute blebs of pyrrhotite, chalcopyrite, and sometimes galena. Where the grain size of the sphalerite is particularly coarse, (up to 1 cm.), slender lath-shaped intergrowths of pyrrhotite are visible. They occur along three directions at approximately 60 degrees to one another in each grain. (figs. 10 ) Chalcopyrite and galena are also enclosed within the sphalerite but do not form the well oriented laths like the pyrrhotite.

Pyrrhotite:

Pyrrhotite definitely veins and replaces sphalerite (figs. 4, 5 ) although doubtful evidence to the contrary is easily found. Pyrrhotite and sphalerite may have been deposited contemporaneously but the deposition of pyrrhotite persisted longer. The occurrence of pyrrhotite as an intergrowth with sphalerite has already been described. Small blebs of pyrrhotite are also found arranged peripherally about large grains of sphalerite. These may be attributed to replacement or to an aggregation of the ex-solution pyrrhotite along grain boundaries. The presence of galena along these same grain boundaries may favour the replacement origin for the pyrrhotite.

Chalcopyrite:

Chalcopyrite is the most difficult mineral to date. It occurs as irregular blebs in the sphalerite and pyrrhotite but is most often found along the contact between pyrrhotite and sphalerite. Chalcopyrite along the contact between sphalerite or pyrrhotite and a euhedral quartz crystal is also common. This may be due to an aggregation following ex-solution from sphalerite or pyrrhotite. However, the absence of evidence for ex-solution favours the possibility of contemporaneous deposition or the replacement of chalcopyrite along favourable grain boundaries.

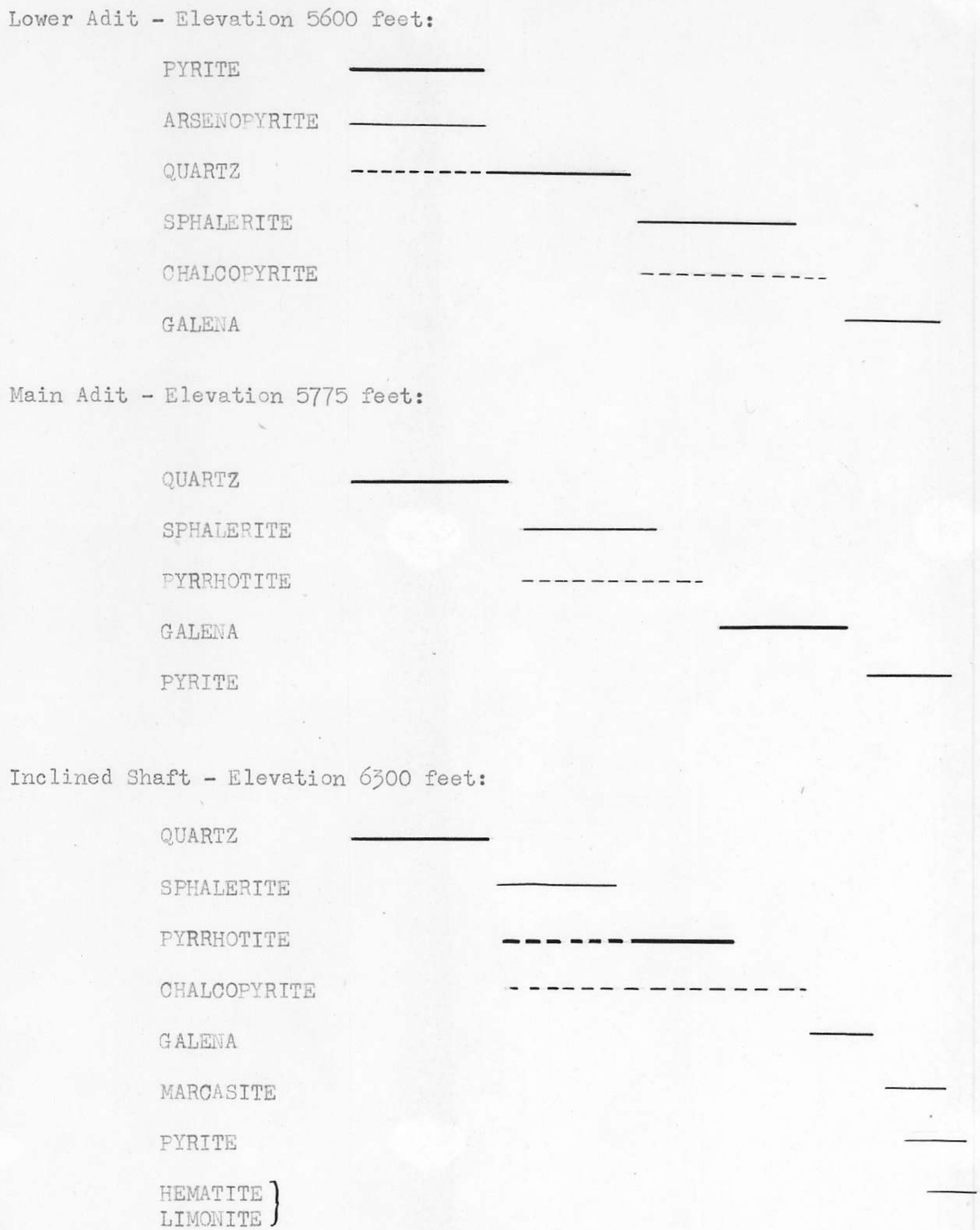
Galena:

Galena is a rare mineral in these specimens. It occurs only as minute blebs (100μ long), intimately associated with pyrrhotite, surrounding the grain boundaries of sphalerite (fig. 12 ).

Secondary minerals:

The pyrrhotite in all sections examined has undergone a complex series of alterations. All gradations from unaltered pyrrhotite through a complete series of new minerals can be observed. (figs. 13, 14) Alteration has occurred along fractures and the new minerals have formed as narrow bands along these. Pyrrhotite has first broken down to yield a rim of marcasite. Marcasite has in turn reverted to pyrite. The excess iron liberated in the change from pyrrhotite, through marcasite, to pyrite has led to the formation of hematite and limonite. These minerals form thin bands near the center of the fractures. Hematite and limonite are easily confused with sphalerite. However, where hematite has been deposited in fractures cutting sphalerite the minerals are readily distinguished. Marcasite was distinguished from pyrite under the polarizing microscope.

# PARAGENESIS



## Conclusions

### Temperature of formation

Laboratory experiments to determine the temperature of formation of the Humming Bird veins were attempted by the writer. Specimens of sphalerite exhibiting blade-like intergrowths of pyrrhotite were polished and examined microscopically. These were heated in an electric furnace for three hours at 800° F (427° C). Upon the advice of Mr. Paul Richardson* the specimens were covered with borax glass to prevent surface oxidation. After heating, the specimens were quenched and reexamined. No textural or mineralogical changes were discovered. Experiments were discontinued when it was realized that an extensive laboratory program was required to study the effects of temperature, time, and chemical environment on these specimens.

The character of the veins, the mineralogy, and the texture of the ores place the Humming Bird deposit in the high temperature mesothermal group. The smooth-walled veins and slickensides are characteristic of mesothermal vein deposits. Abundant pyrrhotite in one vein and minor arsenopyrite in another indicate a higher temperature of formation than for typical mesothermal deposits.

### Changes of mineralogy

The three veins from which specimens were collected have been previously described and their mineralogical and textural differences neted.

* Fourth year Geological Engineering student at the University of B.C.

The lower adit: Quartz, pyrite, arsenopyrite, galena, and sphalerite.
The main adit: Quartz, galena, and sphalerite.
Pyrrhotite vein: Quartz, pyrrhotite, and sphalerite.

The lower adit is 175 feet in elevation below the main adit and believed to be driven on the same vein. The portal of the lower adit is 125 feet from the granodiorite contact (see map #2 (page 22)). This contact, near the main adit, is completely covered. The presence of pyrite and arsenopyrite in the lower adit may bear some relation to the proximity of the intrusive contact.

The pyrrhotite vein differs in mineralogy, wall-rock, and attitude from the other veins on the property. Abundant pyrrhotite indicates a higher temperature of formation. The presence of this high temperature mineral in the granodiorite and lower temperature minerals in the quartzites to the south suggests a zonal arrangement. The granodiorite and quartzite may therefore represent rocks of the "hood" and "roof" respectively, as described by W. H. Emmons*. This difference in mineralogy may however be attributed to the difference in wall-rock or to structural controls.

Mineral dressing considerations

No gold was seen in polished section although assays of 6.26 oz. per ton have been reported. In common with deposits in the Ymir camp the assay results indicate gold in close association with galena and sphalerite and not with pyrite. Since the best gold assays at the Humming Bird mine were obtained from the main adit where there is no arsenopyrite or primary pyrite, it may be concluded that the gold is in the

* See bibliography page 24.

free state. Tellurides and selenides are unknown in the area. The low silver content of the ore (less than 4.0 oz. per ton) is undoubtedly in solid solution with galena.

Galena and sphalerite of shipping grade are found only in the main adit. Specimens of almost pure quartz-galena and pure quartz-sphalerite are easily sorted by hand. Where the minerals are intimately associated a reduction of size to -75 microns (approx. -200 mesh) will be required to free the components. Minute blebs of pyrrhotite and chalcopyrite ( -10 microns) occur throughout the sphalerite.

PART #2

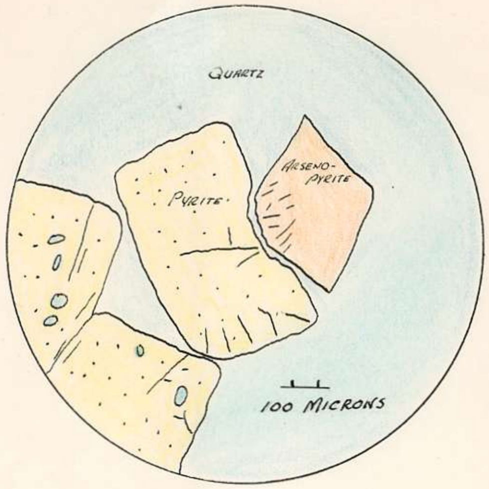



Fig. 1

Lower adit:
Euhedral crystals of arsenopyrite and pyrite enclosed by quartz and only slightly replaced.

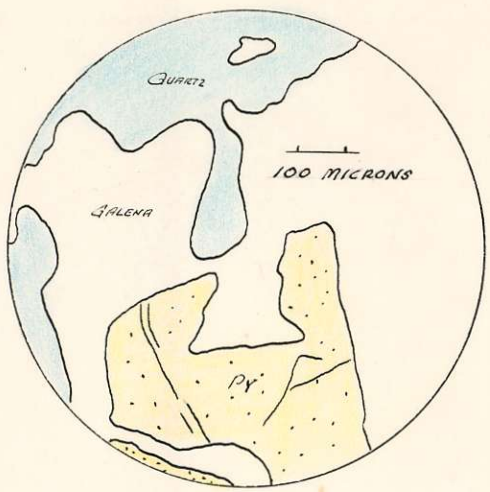



Fig. 2

Lower adit:
Galena replacing pyrite and quartz.

Lower adit:
Chalcopyrite veining pyrite without replacement.

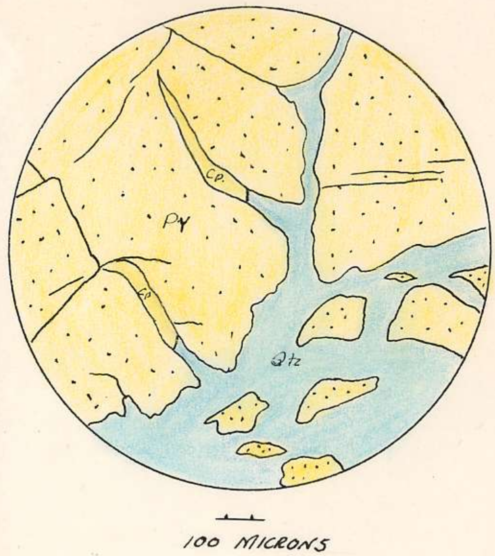



Fig. 3

Inclined shaft - El. 6300 feet.
Pyrrhotite veining and replacing sphalerite.

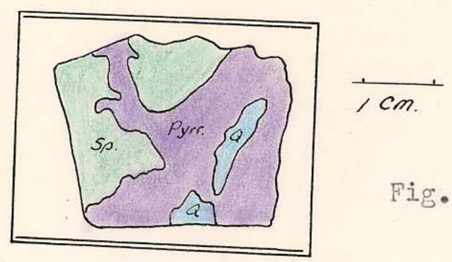



Fig. 4

Inclined shaft - El 6300 feet.
Pyrrhotite veining and replacing sphalerite.

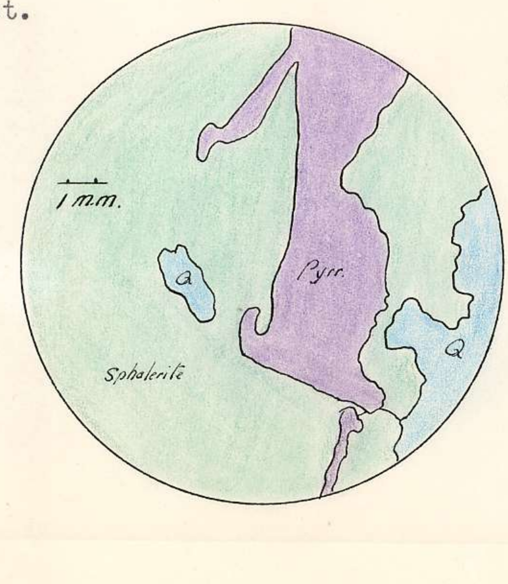



Fig. 5

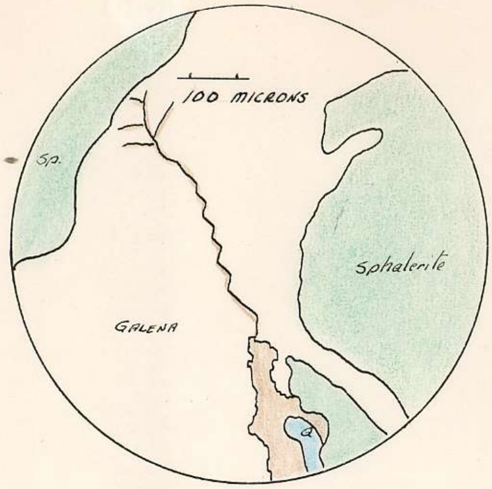



Fig. 6

Main adit:
Galena veining and replacing sphalerite. Anglesite and cerussite developed along cleavage in galena.

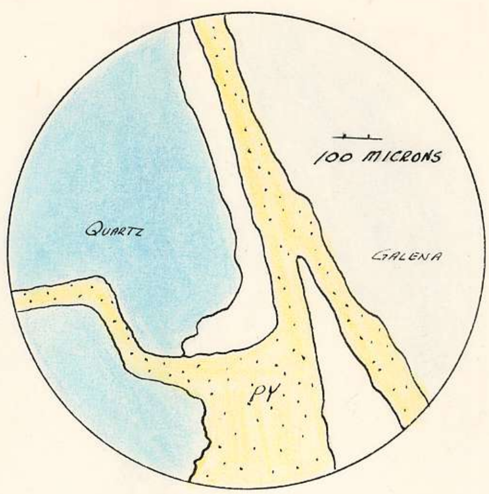



Fig. 7

Main adit:
Late pyrite veining quartz and galena.

100 MICRONS

FIG. 9

Section #12, lower adit.

Fractured pyrite veined by quartz (black).

100 MICRONS

FIG. 10

Section #32, Pyrrhotite vein, inclined shaft.

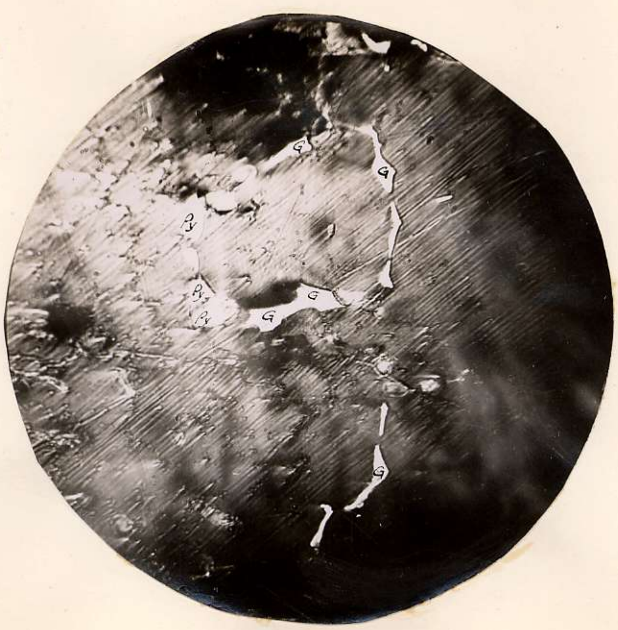
Ex-solution intergrowth of pyrrhotite lamellae (white) in sphalerite.

100 MICRONS

FIG. 11

Section #32, Pyrrhotite vein, inclined shaft.

Euhedral quartz crystal (black) slightly replaced by pyrrhotite.
Pyrrhotite highly altered to marcasite and pyrite.




100 MICRONS

FIG. 12

Section #33, Pyrrhotite vein, inclined shaft.

Blebs of galena and pyrrhotite outlining grains of sphalerite.

100 MICRONS

FIG. 13

Section #32, Pyrrhotite vein, inclined shaft.

Early stage in the alteration of pyrrhotite to marcasite and pyrite along fractures.

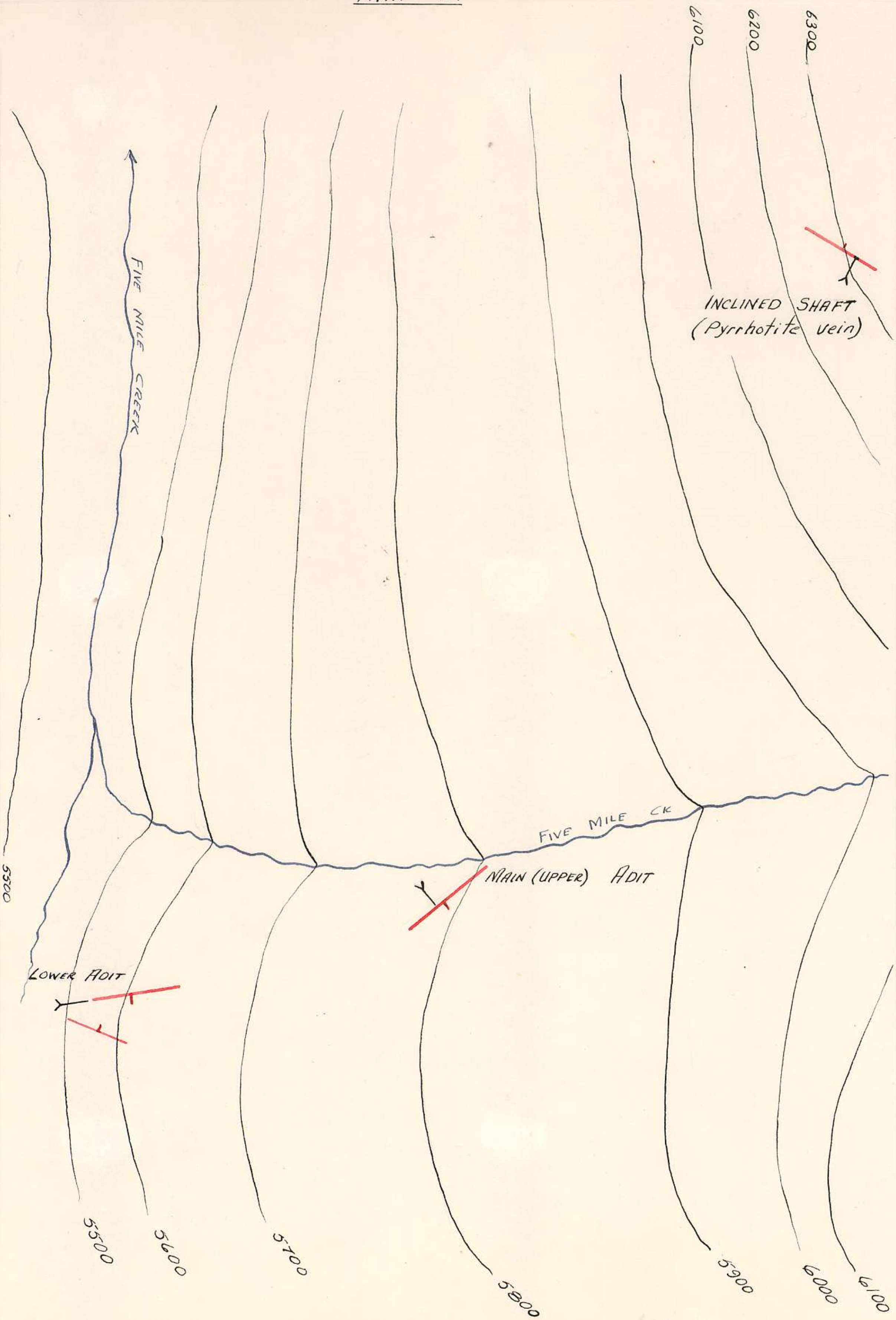
100 MICRONS

FIG. 14

Section #31, Pyrrhotite vein, inclined shaft.

Advanced stage in the alteration of pyrrhotite to marcasite and pyrite along intersecting fractures.

MAP #2.




SKETCH MAP OF THE HUMMING BIRD CLAIMS
SCALE 400 FEET TO 1 INCH

## Description of Sections

#11, Lower adit: Section shows replacement of quartzite wallrock by fine grained galena and sphalerite.

#12; Lower adit: Section shows small quartz vein containing large pyrite crystals, fine grained galena and sphalerite.

#13, Lower adit: Section shows contact between white quartz vein and wallrock. Euhedral pyrite, fine grained galena and sphalerite occur in both vein and wallrock.

#14, Lower adit: Section shows wallrock mineralized by quartz, pyrite and arsenopyrite.

#21, Main adit: Section shows quartz veined by massive sphalerite and minor galena.

#31. Pyrrhotite vein: Section shows massive pyrrhotite highly altered to marcasite and pyrite. Relic quartz crystals and small blebs of chalcopyrite are numerous.

#32, Pyrrhotite vein: Section shows relic quartz crystals in massive pyrrhotite and sphalerite. Pyrrhotite is highly altered to marcasite and pyrite.

#33, 34, 35, Pyrrhotite vein: These are polished fragments of coarsely crystalline sphalerite which exhibit a microscopic intergrowth of pyrrhotite and sphalerite.

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