

600078

A Microscopic Examination
of a
Suite of Ore
from
Pellaire Mine

R. D. Davies

April 1948

TABLE OF CONTENTS

	Page
Introduction	1
Location	2
General Geology	3
General Mineralogy	2
Ore Shoots	2
Megascopic Examination	3
Secondary Minerals	4
Detailed Mineralogy	6
Paragenesis	8
Treatment of Gold Telluride Ores	10
Conclusions	12
Bibliography	16

ILLUSTRATIONS

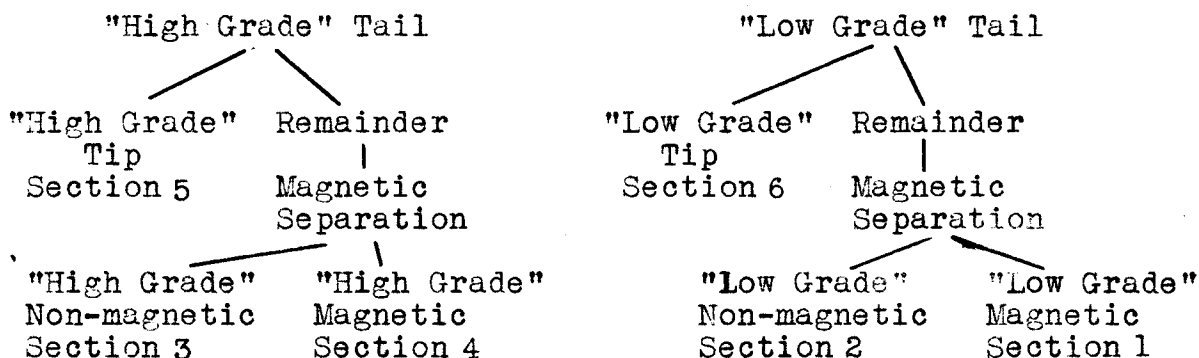
	Page
Figure 1 Limonite boxwork after chalcopyrite	4
2 Exsolution of hessite from pyrrhotite	13
3 Hessite in pyrrhotite	13
4 Sphalerite rimming pyrite and pyrrhotite	14
5 Gold veining hessite	14
6 Hessite in pyrrhotite	15

INTRODUCTION

Thirteen sections of ore from Pellaire Mine were prepared in an effort to determine the minerals present and their paragenesis. As the percentage of metallic minerals in the ore is small, it was necessary to crush the samples and concentrate the metallics. Six sections were made of the concentrates and seven sections were cut from uncrushed samples. The comminution and concentration were as follows:

- (1) Jaw crusher $\frac{1}{2}$ inch product
- (2) Rolls $\frac{1}{4}$ inch product
- (3) Disc pulverizer most material - 150 +200 mesh

The - 150 +200 mesh was concentrated on the Superpanner. Seven pounds each of "low grade" and "high grade" ore were concentrated separately and the products divided as follows:



LOCATION

Pellaire Mine is situated on Falls creek six miles southwest of the south end of Taseko lake in the Clinton mining division.

GENERAL GEOLOGY

The deposit consists of five parallel quartz veins that lie within the quartz diorite of the Coast Range batholith near the contact between the batholith and andesite flows of the Triassic Nicola formation. The batholith in this area is considered post-Lower Cretaceous. The contact strikes north-east and dips steeply south-east, while the veins strike north-east and dip approximately 45 degrees north-west. The veins, numbered one to five from south-east to north-west, appear to be hydrothermal fissure fillings, the fissures being formed by movements along irregular fault surfaces.

GENERAL MINERALOGYOre Shoots

The mineralization occurs in definite shoots that pitch down the dip of the veins. The quartz in the shoots is vuggy and minutely fractured and it is in these openings that the minerals have been deposited. The ore shoots appear to be controlled by the porosity of the quartz and are often found in the thicker portions of the veins. The percentage of metallic minerals in the ore shoots is less than three per cent, but in the massive portions of the veins there is

little or no mineralization. In No. 5 Adit on No. 5 Vein an ore shoot crosses the contact without any apparent change in mineralization. On the Charlie group, which lies nine miles to the north, similar quartz veins occur in andesite rocks of the Nicola formation. The mineralization² which consists of pyrite, chalcopyrite, galena, sphalerite, arsenopyrite, tetrahedrite, hessite, altaite, gold and wehrlite is somewhat similar to that at Pellaire. The veins on the Charlie group are narrower and comb structure is more highly developed, as it tends to be in narrow veins. The above evidence indicates that the mineralization is not affected by a change in wall rock from quartz diorite to andesite.

Megascope Examination

The mineralized quartz tends to be vuggy, the vugs being lined with well developed quartz crystals that range in length from 1/8 to 1/2 inches. One specimen exhibited two sets of oriented crystals with a line of vugs formed at the junction of the two sets. This comb structure is similar to that found in the veins on the Charlie group. Chalcopyrite is the only hypogene mineral that was identified in hand specimens. The most apparent minerals are limonite, malachite, azurite, and a dark blue, sooty mineral believed to be chalcocite. The limonite is often in the form of limonite boxworks. Figure 1 is a sketch of a boxwork that closely resembles types B, quadrangular pattern, and C, average type, after chalcopyrite as illustrated by Blanchard and Boswell.¹ The rhombic

(4)

shapes are similar to type B and the strong continuous walls and the linear arrangement of the cells is characteristic of type C.

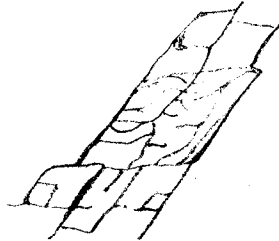


Figure 1.

Secondary Minerals

The main secondary mineral is limonite. Bornite is secondary often coating chalcopyrite. Malachite and azurite are common on the foot wall of the veins. Underground the chalcopyrite weathers to a sooty blue mineral believed to be secondary chalcocite. This material was spectragraphed and was found to contain the following elements:

- (1) Copper
- (2) Silver
- (3) Bismuth (trace)
- (4) Lead
- (5) Tellurium
- (6) Iron

The copper, tellurium, and iron were confirmed by micro-chemistry. The sooty mineral has a colour typical of manganese compound. However the spectrograph and soda bead gave negative tests for manganese. The presence of a small amount

of bismuth may indicate the presence of tetradymite, the bismuth telluride which has been found at the Harrison group² and at the Taylor Windfall property which is ten miles east of Pellaire. It may also indicate cosalite which is also found on the Harrison group². The presence of lead in small amounts may indicate altaite or galena although only altaite was identified in the sections. Altaite occurs in association with hessite and galena on the Charlie group². The bismuth and lead together indicate wehrlite ($\text{Bi}_2\text{Te}_3\text{Bi-Ag}$) which is only found at present on the Charlie group². There is little or no hessite in the surface exposures of the veins as the mineral is readily oxidized. The gold liberated upon the decomposition of hessite is extremely fine, the so called mustard gold, which cannot be panned and which readily floats on water by dint of surface tension. Surface samples generally assay less than do those taken from underground in the unoxidized ore. It therefore appears that there is less residual concentration of the gold in the outcrops than is usual with gold-quartz veins. With very fine gold, forces such as adhesion and surface tension become important relative to gravitational force and tend to prevent gravity concentration. The residual gold that is present in the surface exposures is the coarser gold that originally veined the decomposed hessite. The tellurium may possibly form tellurite (TeO_2), emmonsite (probably a hydrated ferric tellurite), and/or durdenite (Hydrous ferric

tellurite $\text{Fe}_2(\text{TeO}_3)_3 \cdot 4\text{H}_2\text{O}$) but these possibilities have not been investigated.

DETAILED MINERALOGY

The following minerals have been identified in the polished sections.

- (1) Chalcopyrite
- (2) Pyrrhotite
- (3) Sphalerite
- (4) Hessite
- (5) Pyrite
- (6) **Altaite**
- (7) Gold

Chalcopyrite. This is the most abundant mineral. It occurs massively in some specimens and this massive chalcopyrite weathers to a limonite boxwork.

Pyrrhotite. Some of the pyrrhotite appears to have different orientations within a single grain or perhaps inclusions of another mineral for they do not stain or etch uniformly. Most of the pyrrhotite contains inclusions of hessite. The smaller hessite particles are lath-shaped and have a linear orientation, as in Figure 2. The larger inclusions are in the form of rounded blebs with smooth boundaries, Figure 3. The intermediate sized inclusions are more angular, but there appears to be a gradation between the small angular laths and the larger rounded blebs. The smallest hessite inclusion is readily tested with potassium cyanide

which stains the hessite black. The lath-shaped hessite inclusions and their linear orientation in the pyrrhotite is indicative of exsolution. Hessite is isometric above 149.5 degrees centigrade and monoclinic below. Above this inversion point the similarity of the isometric and hexagonal systems would allow the two minerals to exist in solid solution, but upon cooling of the pyrrhotite below 149.5 degrees, the dissimilarity of the monoclinic and hexagonal systems would possibly bring about the unmixing of the two minerals.

Sphalerite. This mineral is found rimming pyrite and pyrrhotite. The sphalerite is dark brown indicating the presence of considerable iron. The internal reflection of the mineral with inclined light is weak.

Hessite. Hessite has two occurrences. Most commonly it is included in pyrrhotite as small linearly oriented laths or in rounded blebs varying from 50 to 100 microns along the major axis. Less often the hessite fills in fractures in quartz. In the latter occurrence the hessite is associated only with gold which occurs in the hessite as small veinlets less than 5 microns wide. The hessite is auriferous with a gold to silver ratio² of one to five and is therefore close to petzite which has a one to three, gold to silver ratio. The hessite is recognized under the microscope by its purple tinge.

Pyrite. Pyrite is rare. It was only observed in the

concentrate sections as anhedral, fractured grains, rimmed with sphalerite.

Altaite. Several small tin-white fragments were observed in the concentrate sections. Only one of these fragments was large enough to extract for a microchemical test. A positive test for lead and tellurium was obtained.

Gold. Native gold was only found associated with the hessite that occupies fractures in the quartz. The hessite contained in the pyrrhotite is not associated with native gold although it is auriferous. The native gold in the hessite occurs as veinlets which vary in width from 1 to 5 microns. Other investigators² have noted the presence of particles of gold in pyrite but this occurrence is of minor importance. The gold content of the hessite is released upon decomposition, but the gold is extremely fine mustard gold that does not form residual concentrations.

²Antimony. This mineral has been identified in a single specimen by means of X-ray powder photography. In the single occurrence it was associated with hessite.

PARAGENESIS

Investigation of the paragenesis is difficult because of the small content of metallic minerals. However, the following relations have been established:

- (1) Centripetal replacement of pyrite and pyrrhotite by sphalerite.

- (2) Hessite is contemporaneous with the pyrrhotite.
- (3) There has been a late deposition of hessite in fractures and vugs.
- (4) Native gold is later than the second deposition of hessite.
- (5) Quartz with no visible mineralization contains some gold and silver.

If Lindgren's succession of minerals³ is followed in which he states "Exceptions from this sequence are rare", then the stages of mineral deposition may be as follows:

- (1) Quartz with some gold and silver.
- (2) Pyrite and quartz.
- (3) Pyrrhotite, hessite, and quartz.
- (4) Sphalerite
- (5) Chalcopyrite
- (6) Altaite
- (7) Hessite
- (8) Gold and silver

The altaite because of its higher melting point is placed before hessite.

Experiments⁴ have been conducted to determine the relationship between native gold and tellurides. These experiments have shown that regardless of the form in which gold is transported it will in all cases be precipitated when the transporting medium comes in contact with a telluride or

native tellurium. This action explains the veining of tellurides by gold.

The sequence of elements is as follows:

SiO ₂			
Fe			
Zn			
Cu			
Pb			
Te			
Au			
Ag			

TREATMENT OF GOLD TELLURIDE ORES

There are three main methods of treatment⁵ of gold telluride ores. The roast method is used at South Kalgoorlie and Cripple Creek. The crushed ore is roasted to volatilize the tellurium and to free the gold and silver. However, considerable loss of gold and silver result as the volatilizing tellurium carries off the noble metals. The calcines are treated with sodium cyanide as in the normal cyanidation process. The silver and gold are taken into solution as is any tellurium that remains in the calcines. These metals are precipitated with zinc and the resulting slimes are roasted to

remove the remaining tellurium. In the second method, the ore is finely ground and leached with sodium cyanide using an excess of lime. Experiments, conducted at Kirkland Lake, have shown that finely ground tellurides will yield their gold and silver to a cyanide solution. (For maximum extraction the tellurides should be 1600 mesh.) Tellurium is also taken into solution by the cyanide and is precipitated along with the noble metals by zinc. The slimes are then leached with nitric acid to remove the tellurium. In the third method the normal cyanidation process is carried out except that bromide compounds are added to the sodium cyanide solution to form bromocyanide (CNBr), which rapidly dissolves the gold and silver from the tellurides. This method is used at the Kalgoorlie Ore Treatment Plant.

CONCLUSIONS

The mineralogy does not greatly aid the classification of the deposit. The presence of pyrrhotite may indicate a mesothermal deposit. Lindgren states that pyrrhotite is never found in an epithermal deposit, however, some geologists believe that pyrrhotite precipitates instead of pyrite if there is a deficiency of sulphur in the mineralizing solutions and that the mineral is therefore not exclusive to the higher temperature deposits. Chalcopyrite, Sphalerite, and pyrite, the most abundant minerals, are not diagnostic. The tellurides hessite and altaite are found in high and low temperature deposits alike. The gold appears to be of low silver content as it is in the mesothermal and hypothermal deposits. The presence of native antimony indicates an epithermal deposit but it is not unknown in the mesothermal type. The regular, tabular shape of the veins, the absence of banding and crustifications, and the general massiveness of the quartz, point to a mesothermal deposit. The vugs and poorly developed comb structure in the ore shoots and the small content of metallic minerals are characteristic of epithermal deposits. The deposit may be considered then, to be mesothermal tending to epithermal.

The gold is almost entirely associated with the hessite and because of this close association it will probably be necessary to roast the ore prior to cyanidation or to apply the bromocyanide process.

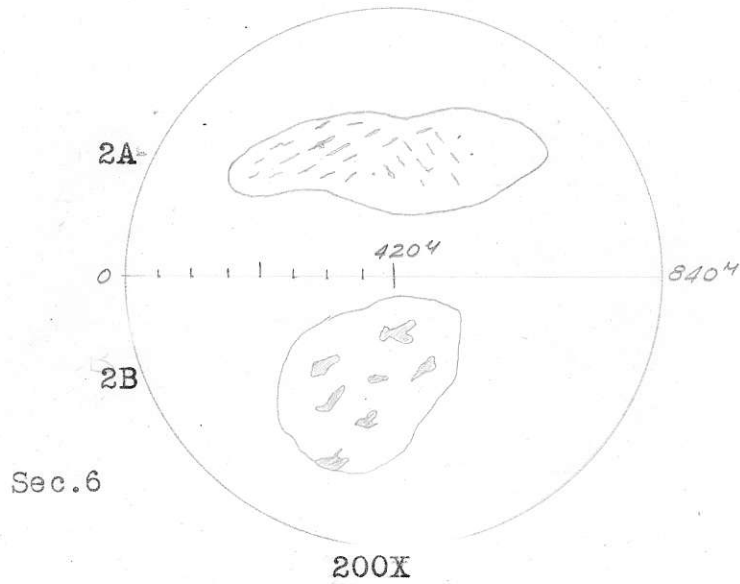


Figure 2A showing hessite laths in pyrrhotite, indicative of exsolution.

Figure 2B subangular blebs of hessite in pyrrhotite.

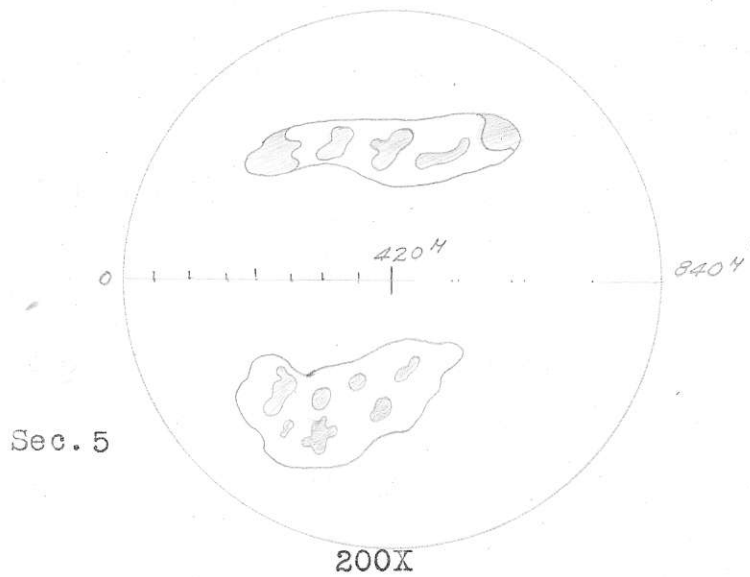


Figure 3 showing large rounded blebs of hessite in pyrrhotite.

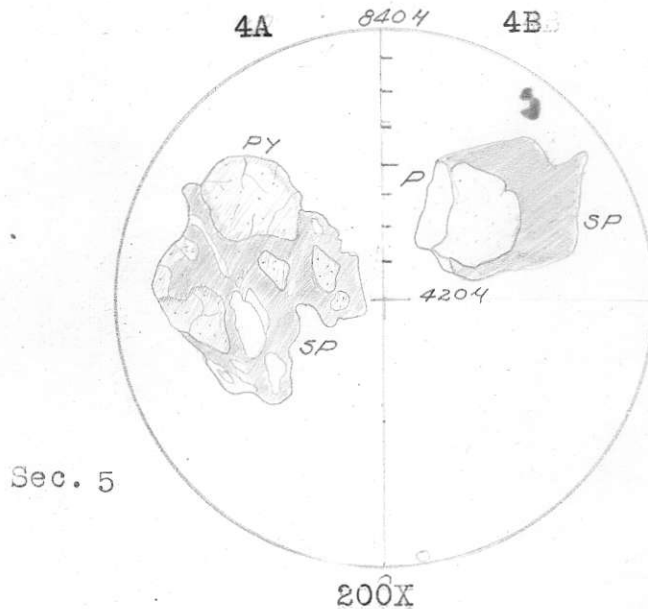


Figure 4A centripetal replacement of pyrite (PY) by sphalerite (SP).

Figure 4B centripetal replacement of pyrrhotite (P) by sphalerite.

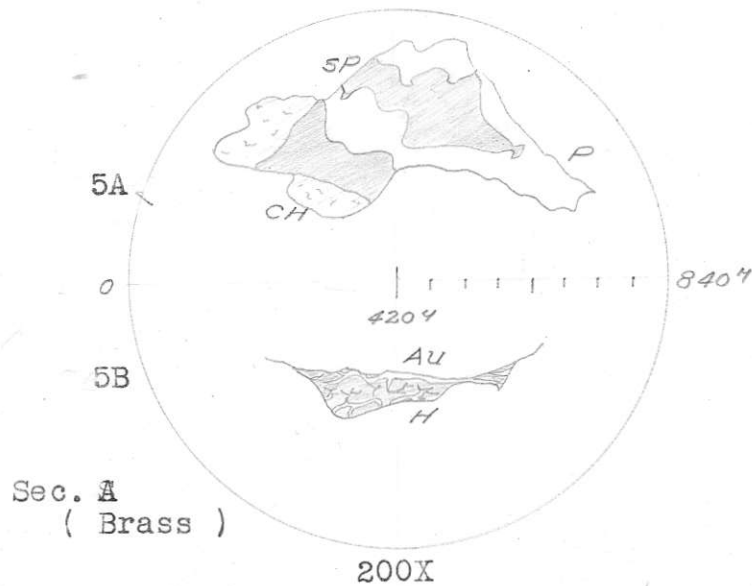


Figure 5A mineral relationship between sphalerite (SP) chalcopyrite (CH) and pyrrhotite (P).

Figure 5B gold veining hessite (H).

(15)



600 X

Figure 6, Microphotograph of hessite (H) in pyrrhotite (P).

BIBLIOGRAPHY

- (1) Blanchard, R. "Limonite Boxworks"
Boswell, P. F. Econ. Geol.,
Vols. 22, 25, 29, 30 1925-1935
- (2) Warren, H. V. "A New Type of Gold Deposit
in British Columbia" Trans.
of Royal Soc. of Canada,
Third Ser., Sec. IV, Vol. XLI 1947
- (3) Lindgren, W. "Mineral Deposits"
McGraw-Hill, N. Y. 1933
- (4) Lehner, V. "Some observations on the
Tellurides". Econ. Geol.,
Vol. 4 1915
- (5) Eissler, T. "The Metallurgy of Gold"
Crosby Lockwood, London 1920
- (6) Dana, E. S. "A ~~Text~~book of Mineralogy"
(Ford, W. E.) John Wiley 1932