THE MINERALOGY OF THE MORNING ORE BODY IN THE NICKEL PLATE MINE

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Geology 9

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A C K N O W L E D G E M E N T

This report is submitted in partial fulfilment of the course in the fifth year of Metallurgical Engineering at the University of British Columbia. I would like to express my thanks to Dr. H. V. Warren for his kind words of encouragement. Thanks are also due to Professor F. A. Forward for allowing me to use the Leitz microscope in the Mining Building.

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Fred E. Kutquist.

I N D E X

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INTRODUCTION

LOCATION

"The Nickel Plate mine is in Nickel Plate Mountain, which is near the town of Hedley. It is in the Osoyoos mining division and lies about 27 miles north of the international boundary and 1½ miles west of the 120th meridian.

"Hedley, on a spur of the Great Northern Railway, is situated between Keremeos, 17 miles to the southeast, and Princeton, which is on the Kettle Valley line of the Canadian Pacific Railway and lies 25 miles to the northeast. The southern Trans-Canada highway affords excellent road connections between Hedley and Princeton and Hedley and the Okanogan Valley."[1]

GENERAL GEOLOGY

"The ore deposits lie in the upper portion of Nickel Plate Mountain where a series of inclined sedimentary beds of Triassic age have been intruded by large and complex bodies of basic igneous rock of late Mesozoic or Tertiary age. The ore is of the contact Metamorphic type and replacement has played an important part in determining the position and size of the many ore shoots.

"The ore consists essentially of disseminated

gold in arsenopyrite in a complex gangue composed largely of metamorphic silicates.

"Some sedimentary beds have apparently been more susceptible to replacement by ore-bearing solutions than others, but recent work shows that ore deposition has been controlled more particularly by structural features such as minor folding."[2]

Samples

Section No.	Name of Ore Body	Sample Designation	Gold content ounces/ton
@ 1	Morning	N 43 A-1	2.60
2	Orange	1001	0.65
3	Yellow	A 12.2	1.30
@ 4	Morning	N 44 A-3	2.80
5	Morning	N 44 A-6	1.00
@ 6	Morning	N 43 C	0.60
@ 7	Morning	N 43 C.EX	1.70
8	Yellow	6.0	1.00
@ 9	Morning	N 44 A-6	0.80
10	Morning	N 44 A-4	Not assayed

@ sections which were examined.

Only five of the above samples were prepared for this report, but the remainder have also been included, with their assays, for the benefit of anyone who may later wish to study this suite.

The following table is a list of the approximate compositions of the sections. The figures are based upon the relative amounts of the minerals, as seen through the microscope, and are thus merely rough estimates.

Sec.No.	% Arseno-pyrite	% Pyrrhotite	% Chalco-pyrite	% Gangue	% Safflorite-Loellingite
1	45	10	trace	45	
4	60			40	
6	20	20		60	trace
7	75	5		15	5
9	10	5	70	15	trace

EXAMINATION OF POLISHED SECTIONS

MINERAL OCCURRENCE

Section No. 1

Arsenopyrite, pyrrhotite, and minor amounts of chalcopyrite all lie close together in the gangue but there is no evidence of intermingling.

Some of the arsenopyrite is present as well-defined diamond-shaped cross sections and the remainder is in massive form and has irregular borders. The arsenopyrite is lined with fracture-fillings and inclusions of gangue. (Plate 1)

The pyrrhotite also has irregular borders, gangue inclusions and fracture-fillings. Some of the pyrrhotite grains have very marked signs of deformation (Plate 2). The pyrrhotite seems to have been subjected to a bending force and the resulting arc-shaped fractures have been filled with gangue at a later date.

Section No. 4

The arsenopyrite is very badly lined with gangue and the resulting mixture of gangue and arsenopyrite has a mottled appearance.

This sample contains a crumbly soft green gangue in addition to the complex gangue found in all the other sections. The green gangue was difficult to polish because of its crumbly nature and tendency to form a mud when washed.

Section No. 6

Diamond-shaped eross sections of arsenopyrite are quite common. The arsenopyrite contains some inclusions of pyrrhotite and gangue. Traces of safflorite-loellingite are found in the arsenopyrite.

The pyrrhotite is in spotty clumps throughout the gangue and contains small arsenopyrite inclusions (Plate 3). Some small stringers of pyrrhotite are seen in the arsenopyrite.

Section No. 7

The arsenopyrite is massive and has gangue inclusions and fracture-fillings.

Minor amounts of pyrrhotite lie in the gangue.

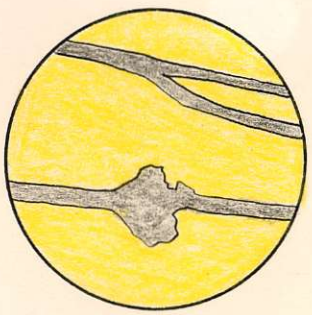
This section contains a small amount of safflorite-loellingite which seems to be in small clusters, partly in the gangue and partly in the arsenopyrite (Plate 4). The safflorite-loellingite resembles arsenopyrite closely except that its surface is much flatter and pit-free and its color is gray-white whereas arsenopyrite is galena-white. When etched with nitric acid, the safflorite-loellingite stains black and the surrounding arsenopyrite stains irridescent.

Section No. 9

The arsenopyrite is massive, has an irregular outline, and has the usual gangue inclusions and fracture-fillings.

Minute pieces of safflorite-loellingite lie in the gangue.

Some of the chalcopyrite is in large massive pieces and contains very clear-cut fracture-fillings and inclusions of gangue. Some instances of combined fracture-filling and replacement by gangue are seen in the chalcopyrite as in the accompanying sketch.



x460

The remainder of the chalcopyrite is in an intimate mixture of small "islands" of chalcopyrite and pyrrhotite in a gangue matrix (Plate 5).

Gangue

The gangue is complex and contains some hard dark-colored silicate minerals in addition to quartz and calcite. In all sections, the dark gangue seems like a matrix for the sulphides. The gangue which is commonly present in fracture-fillings is softer and has a purplish-blue color. The latter gangue effervesces with acids and

PARAGENISIS CHARTS

Metamorphic silicates

Arsenopyrite and safflorite-loellingite

Pyrrhotite and chalcopyrite

Late gangue

Gold

Iron

Arsenic

Sulphur

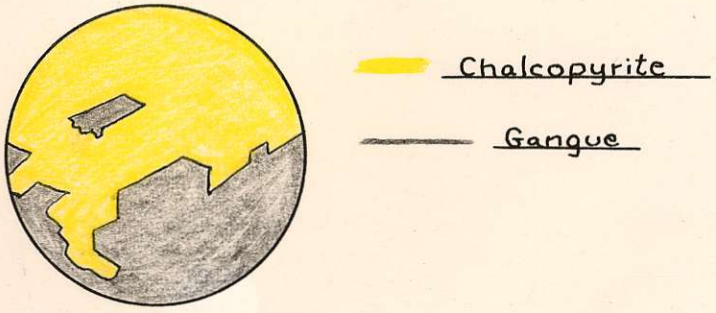
Silica

Copper

Cobalt

Calcium

thus calcite is known to be present. However, in section No. 9, there is definite evidence of gangue replacing chalcopyrite as well as filling its fractures so this late gangue must contain other minerals besides calcite. This gangue has some interesting cross sections which are similar to those of the amphiboles (the sides meet at angles of approximately 120°).



X 460

Probably the original silicate gangue was surrounded by sulphides and was later replaced by this purplish-blue gangue. Thin sections would probably show whether or not these crystals outlines are pseudomorphs.

PARAGENISIS OF ORE

The hard dark-colored gangue was, without a doubt, the first mineral present and was then partly replaced by the sulphides. Arsenopyrite is the most abundant of the sulphides and has only a few inclusions of pyrrhotite and chalcopyrite whereas the latter sulphides have several inclusions of arsenopyrite. The safflorite-loellingite seems to be closely related to the arsenopyrite and was probably deposited at the same time. The

pyrrhotite and chalcopyrite are intimately mixed, expecially in section No. 9, and were probably deposited at the same time, shortly after the arsenopyrite. The purplish gangue, containing calcite and possibly quartz, was definitely the last group of minerals to solidify, since it runs in stringers through all the other minerals.

The order of occurrence is, then:

1. Complex hard gangue.
2. Arsenopyrite and safflorite-loellingite.
3. Pyrrhotite and chalcopyrite.
4. Softer gangue, containing calcite, possibly quartz, and other minerals.

GOLD OCCURRENCE

The majority of Hedley gold is very fine-grained and only one particle was found which could be satisfactorily photographed (Plate 6). It lies in the gangue and is separated from arsenopyrite by a small particle of pyrrhotite. When etched with nitric acid, the arsenopyrite was seen to contain minute particles of gold which, at a magnification of 460X, were the size of pin-heads. These minute particles were in craters, as mentioned in the report by Warren and Cummings.[1]

From the report by Warren and Thompson[2], "Gold particles as large as twenty and thirty microns may often be seen, but in general they run from ten microns down to the limit of microscopic resolution."

METALLURGY

The following table shows the relationships between the micron size of fine gold particles and the corresponding mesh size.

Mesh		Micron	
- 200	+ 270	- 74	+ 56
270	380	56	40
380	530	40	28
530	750	28	20
750	1060	20	14
1060	1500	14	10
1500		10	

Before a gold particle can be dissolved by cyanide its surface must be exposed by grinding, but slime problems are caused by excessive grinding.

The finest particles of Hedley gold are imbedded in the arsenopyrite and may be called "old gold". The coarser particles came into the ore body later with the calcite gangue and may be called "young" or "veining" gold. The "young" gold is extracted by cyanide and the "old" gold is recovered in a flotation concentrate of arsenopyrite.

List of Plates and Related Data

Plate	Sec.No.	Plates	Objective	Ocular	Plate Positn	Magnif'n.
1	1	Wratten	24 mm.	6.4X	top	100
2	1	M	4 mm	"	btm.	460
3	6		24 mm	"	top	100
4	7		24 mm	"	top	100
5	9		24 mm	"	btm.	75
6	7		4 mm	"	btm.	460

Yellow filter and 25 sec. exposure on all plates.
The Leitz microscope in the Mining Building was used for taking the pictures.

Bibliography

(1) Warren, Harry V., and Cummings, John M., "The Miner", May 1936, pages 27-28.

(2) Warren, Harry V., and Thompson, Robert M., "Western Miner", May 1945, pp. 34-41 incl.

(3) Short, M. N., "Microscopic Determination of the Ore Minerals". United States Geological Survey Bulletin 914.

Plate 1
X 100
Gangue Network in Arsenopyrite

A Arsenopyrite
G Gangue

Plate 2
X 460
Gangue Filling Fractures in Stressed Pyrrhotite

G Gangue
P Pyrrhotite

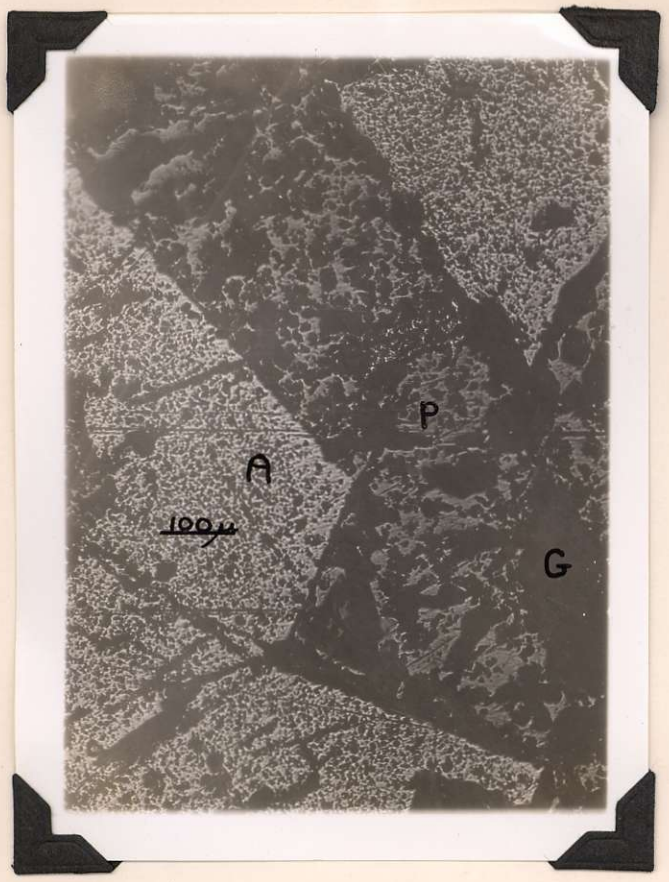


Plate 3
X 100
Pyrrhotite and Arsenopyrite in Gangue

A Arsenopyrite
G Gangue
P Pyrrhotite

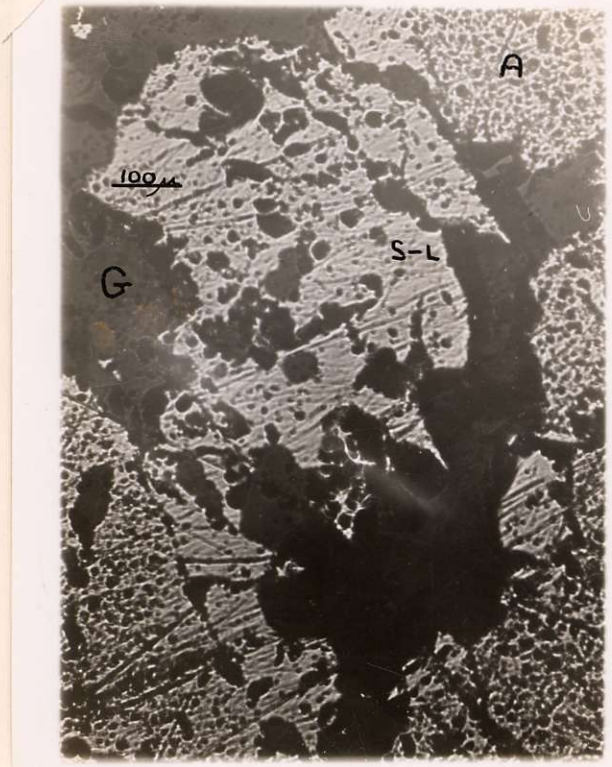


Plate 4
X 100
Clusters of Safflorite-Loellingite in
Gangue and Arsenopyrite

A Arsenopyrite
G Gangue
S-L Safflorite-Loellingite

Plate 5
X 75
"Islands" of Pyrrhotite and Chalcopyrite
in Gangue

C Chalcopyrite
G Gangue
P Pyrrhotite

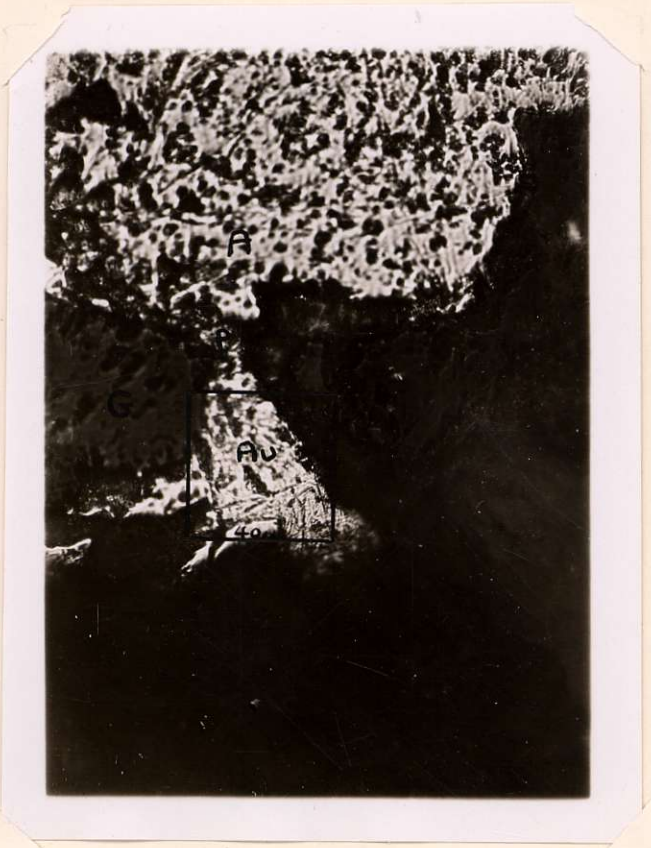


Plate 6
X 460
Mesh 380 Superimposed.
Gold in Gangue near Arsenopyrite
and Pyrrhotite

A Arsenopyrite
Au Gold
G Gangue
P Pyrrhotite