

IR 1753

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December 2nd, 1944.

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of the

ORE DRESSING AND METALLURGICAL LABORATORIES.

Investigation No. 1753.

Flotation Tests on Samples of Copper-Nickel Ore  
from the Lakemount Mine at Hawk Junction, Ontario.

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Shipments:

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A shipment of 100 pounds of ore was received on July 10th, 1944. On September 2nd, 1944, a further shipment was received, consisting of two ore samples, one a high-copper ore and the other a high-nickel ore. On October 6th, four small specimens of split drill core were received for microscopic examination. The samples were submitted by F. E. Weldon, Chromium Mining and Smelting Corporation, Limited, 1010 Canada Cement Building, Montreal 2, Quebec.

Location:

The property from which these samples were taken is located at or near Hawk Junction, in the Algoma mining division of Ontario, about 125 miles north of Sault Ste. Marie.

Purpose of Tests:

These tests were conducted to find a convenient method of concentrating all of the sulphides in the ore, either in bulk or separately.

Sampling and Assaying:

The ore shipments were sampled, assayed, and reported as follows:

		SHIPMENT NO. 1,	SHIPMENT NO. 2,	
		RECEIVED JULY 11TH	RECEIVED SEPT. 2ND (A) High-Nickel Ore	(B) High-Copper Ore
Gold, oz./ton	-	Trace.	0.0025	0.0075
Silver, "	-	0.30	0.18	0.31
Platinum and palladium, cz./ton	-	0.039	0.027	0.035
Copper, per cent	-	0.55	0.16	1.15
Nickel, "	-	1.08	1.31	0.77
Iron, "	-	12.05	13.40	10.34
Sulphur, "	-	5.88	6.71	4.49

Experimental Tests:

A series of flotation tests was conducted on these ore samples and best results were obtained in a high-acid circuit, i.e., after the addition of 9 to 11 pounds of sulphuric acid per ton of ore. The nickel assays of the flotation tailings became progressively higher as various quantities of acid were added up to 7 pounds per ton, followed by a very sharp drop when the acid was increased to 9 pounds per ton for a pH reading of 4.1 and a further slight improvement at 11 pounds per ton. The next best results were obtained on the alkaline side, with about 6 pounds of soda ash used per ton of ore to give a pH value of around 8.

CONCLUSIONS:

The samples submitted were apparently taken from a zone of oxidation somewhere near the surface. This accounts for the presence of violarite in the samples submitted for test purposes. Violarite is a supergene replacement product of pentlandite or pyrrhotite and was not found in the drill core samples taken from depths of more than 300 feet. It is therefore not likely that the ore of the type submitted will constitute more than a small fraction of the ore to be treated, and its behaviour will be a matter of secondary importance in designing a mill to treat this ore.

The results of tests conducted on the samples submitted indicate that best results will be obtained by flotation in an acid circuit. They also show that the pH value of the pulp does not vary in direct proportion to the amount of acid added, since some of it reacts with pyrrhotite and evolves hydrogen sulphide gas. The tests conducted indicate that at least 9 pounds of acid should be used for each ton of ore and that better results will be obtained with larger amounts. If this circuit be used, some means of controlling the hydrogen sulphide gas will have to be used. A hood and ventilating system over the grinding circuit should be enough if all of the acid is added at this point.

In an alkaline circuit, using soda ash to pH 8.4, a nickel tailing of 0.25 per cent can be produced, but the total sulphur in the tailing will be quite high, perhaps 3 or 4 per cent.

However, when ore from depth is to be treated the foregoing is not to be considered applicable to it and further tests should be conducted on it.

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CHARACTER OF THE ORE:

Ore Received July 10th, 1944.

From a representative sample of the July 10th shipment, six polished sections were prepared and examined microscopically for the purpose of determining the character of the ore.

Metallic Minerals -

In their order of decreasing abundance, the metallic minerals observed in the six polished surfaces are: pyrrhotite, violarite, chalcopyrite, pyrite, pentlandite, and "limonite".

Pyrrhotite, the most abundant metallic mineral, is disseminated through gangue as coarse to fine irregular grains and small masses in association with the other sulphides.

A nickel-iron mineral, identified as violarite  $((Ni,Fe)_3S_4)$ , is the next most abundant metallic. It occurs as tiny hazy veinlets and small masses of grains in pyrrhotite. The area of some of these granular masses is almost a square millimetre; the average size of the grains composing them is about 70 to 75 microns (approximately 200 mesh). Many grains exhibit minute branching fractures or veinlets which give them a characteristic crumbly appearance. This mineral contains occasional small inclusions of gangue and grains of pyrite and chalcopyrite (see Figure 1).

Chalcopyrite and pyrite are disseminated as coarse to fine grains and small masses in gangue and in pyrrhotite and violarite. The iron sulphide is often well crystallized and encloses rather numerous small grains of the copper mineral.

Pentlandite  $(Ni,Fe)S$  is present in small amount, largely as tiny, ragged, elongated particles in pyrrhotite.

A small quantity of "limonite" is visible as tiny grains and sinuous veinlets in gangue and against pyrrhotite.

(Continued on next page)

(Character of the Ore, cont'd) -

Gangue:

In the polished sections gangue is composed of soft, dark, fine-grained rock with occasional small patches and needles of hard mineral. In hand specimens (the sample was received crushed to about one-half inch size) it appears to be basic in nature, probably doleritic, and shows rather numerous, local, oxidation stains.

Conclusions from Microscopic Examination -

The microscopic examination of the six polished sections shows pyrrhotite, violarite, chalcopyrite and pyrite to be the chief ore minerals and, in general, these occur in intimate association with each other. However, the grain sizes are such that moderately fine grinding should release the bulk of them for concentration purposes, but some fine particles of each will likely remain tied up with the others. From the crumbly appearance of the violarite already mentioned, this mineral may powder (slime) easily during grinding.

If it is true, as Short<sup>e</sup> says, that violarite is usually a supergene replacement product of pentlandite or pyrrhotite, the relatively large amount of this mineral present in the sections examined would indicate that the sample received has undergone extensive surface alteration.

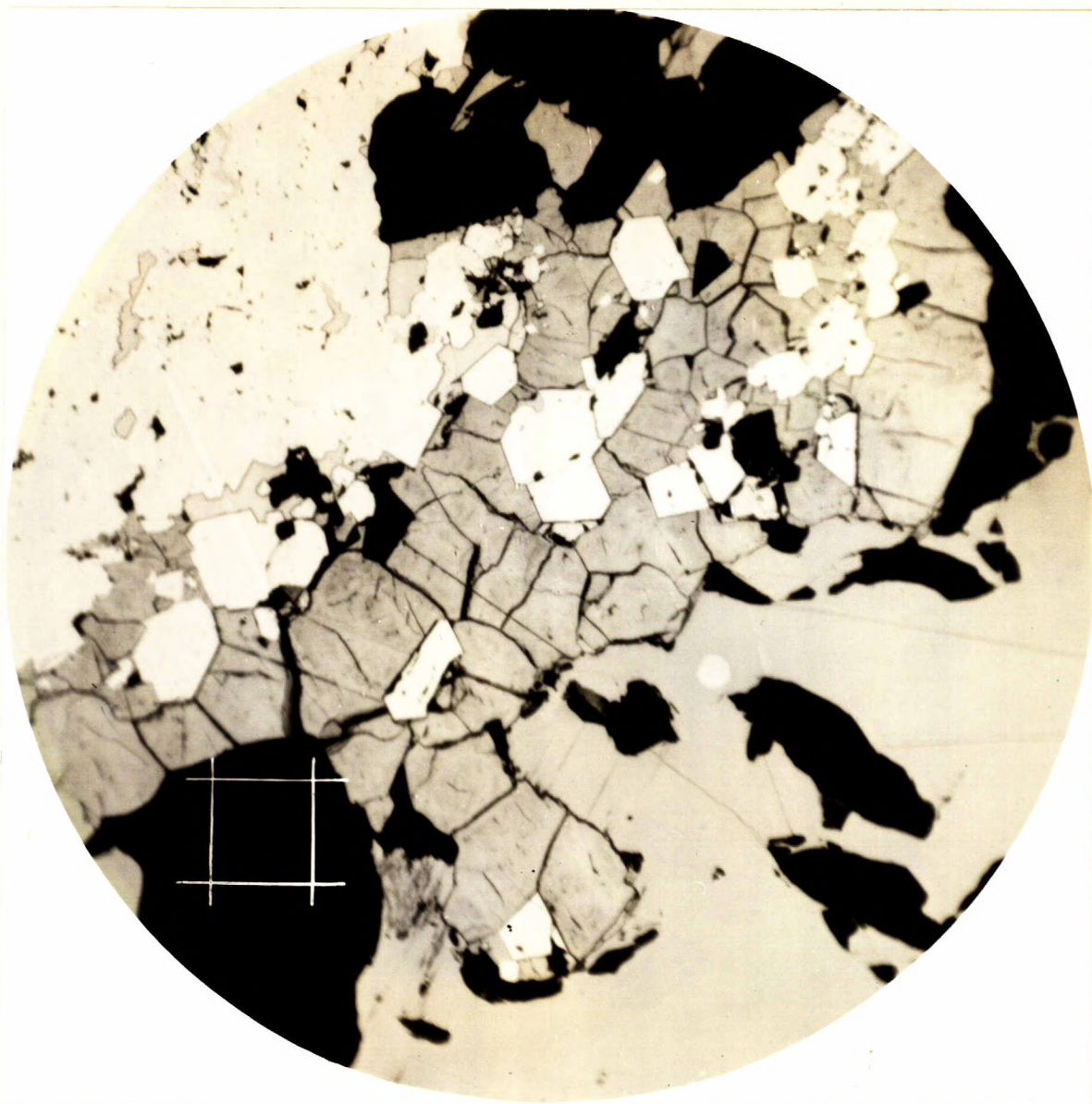
{ Figure 1 follows,  
on Page 6.  
Text continues  
on Page 7. }

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<sup>e</sup> Short, M. N., Microscopic Determination of the Ore Minerals, p. 123. Bulletin 914 (1940), U.S. Government Printing Office, Washington.

(Character of the Ore, cont'd) -

Figure 1.



PHOTOMICROGRAPH OF A POLISHED SURFACE, SHOWING  
THE GENERAL RELATIONSHIPS AND MODES OF  
OCCURRENCE OF THE CHIEF ORE MINERALS.

A 200-mesh opening is superimposed.

Pyrite	-	Py, white, high relief.
Pyrrhotite	-	Pht, very light grey, smooth surface.
Violarite	-	Vi, light grey, granular mass.
Chalcopyrite	-	Cp, light grey, smooth surface; here largely associated with pyrite.
Gangue	-	dark grey.
Pits	-	black.

Magnification, 200X.

(Character of the Ore, cont'd) -

Drill Cores Received October 6th, 1944.

The four split drill cores received from the Lakemount Mines property were designated as follows:

44 - 360'  
44 - 362' 6"  
36 - 322' 4"  
36 - 320' 4"

The drill cores were first examined and compared with lumps of the bulk samples by means of a binocular microscope and without the aid of a glass. Then four polished sections, one from each specimen, were prepared and examined under a reflecting microscope in order to check the metallic minerals, that is, to see if they were the same as described above.

Binocular and Megascopic Examination -

The rock in the drill cores is quite dark in colour and is solid and fresh-looking compared to that in the lumps of ore previously received for test work. In the latter the rock is lighter in colour, has a leached appearance, and is more or less friable and crumbly. The main difference apparent, however, is that in the drill cores the sulphides, where showing, are clean and bright, whereas in the test ore they are tarnished and stained.

It is highly improbable that the alteration of the peridotite, noted by F. E. Weldon in thin sections, has a detrimental effect in floating the ore minerals. It might cause some sliming if the alteration product is soft but, as previously stated, we believe that flotation will cause little or no difficulty when fresh ore is reached and the sulphides are not oxidized.

Mineragraphic Examination -

In the four polished surfaces prepared from the drill cores, metallization is probably not quite so strong as in the sections made from the ore sample. In their approximate order



(Character of the Ore, cont'd) -

of decreasing abundance the metallic minerals are: pyrrhotite, pentlandite, chalcopyrite, magnetite, and ilmenite.

Pyrrhotite and chalcopyrite occur in the same manner as already described. Pentlandite is comparatively abundant as small masses and tiny needles or elongated particles in pyrrhotite. In size, ranging up to almost one millimetre in diameter, and in associations, the masses of pentlandite correspond to the mineral previously identified as violarite (see Figure 2 and compare it with Figure 1). The surface of almost all of the pentlandite and much of the pyrrhotite has a broken or checked appearance, probably due to numerous small inclusions of gangue which have pulled out in polishing.

Magnetite and one or two grains of ilmenite, ranging from about 420 microns (35 mesh) down to only a few microns in size, are common in gangue, in some places closely associated with sulphides. No violarite, pyrite, or "limonite" was observed in the sections.

Conclusions from Microscopic Examination -

The fact that no violarite is visible in four polished sections prepared from drill cores is in accordance with Short's<sup>6</sup> statement that it is usually a supergene replacement product of pentlandite or pyrrhotite. Hence, if they are truly representative of the ore body at depth, the microscopic examination indicates that:

1. The nickel mineral will be pentlandite below the zone of active oxidation.
2. Pyrite, which is present in the first ore sample, appears to be absent in the drill cores.
3. Magnetite, a mineral not noticed in the sections prepared from the ore sample, is quite common

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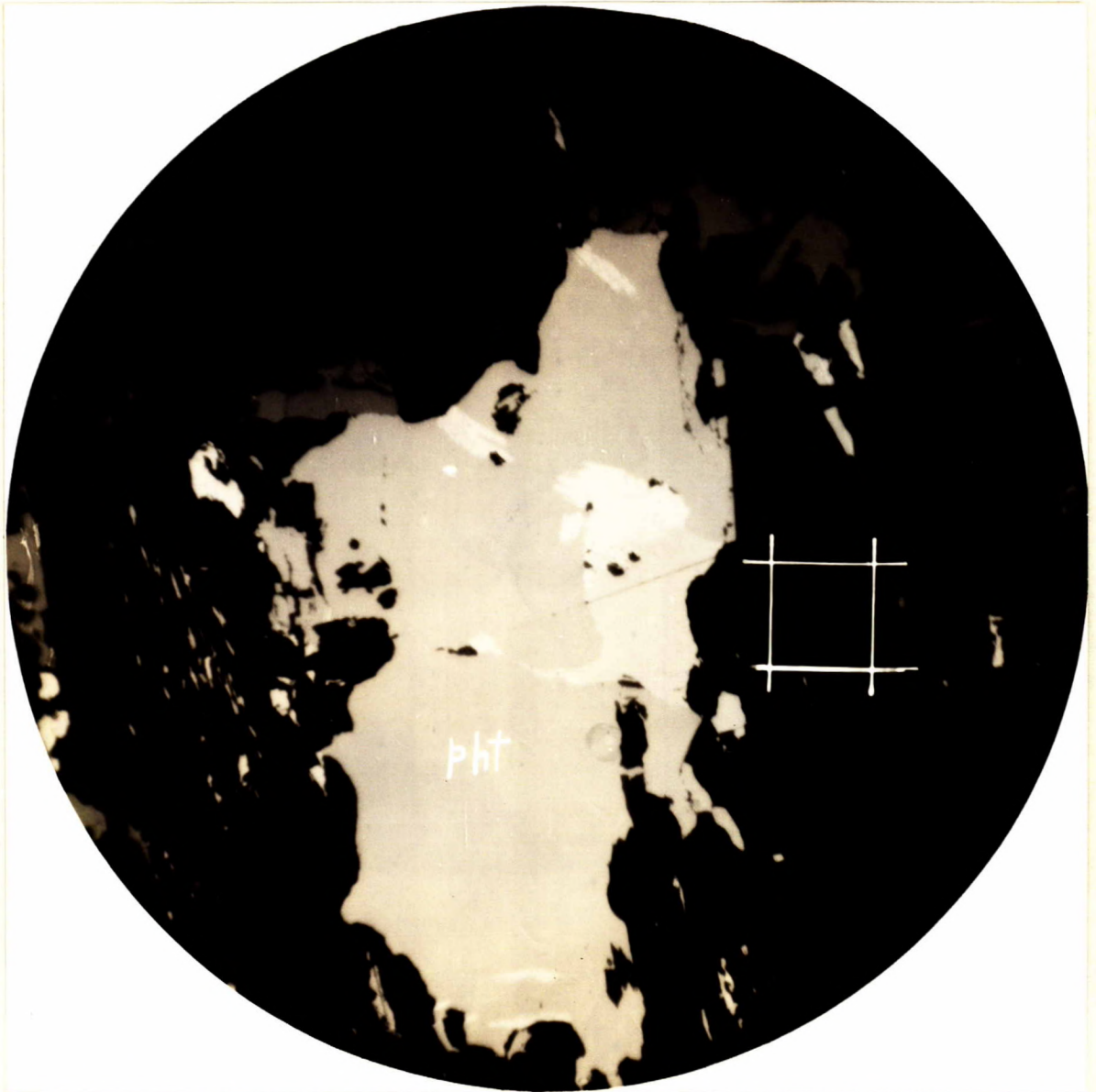
<sup>6</sup> Short, M. N., Microscopic Determination of the Ore Minerals, p. 123. Bulletin 914 (1940), U.S. Government Printing Office, Washington.

(Character of the Ore, cont'd) -

in those prepared from the drill cores.

4. No "limonite" or other sign of oxidation is visible in the four polished sections.

Figure 2.



PHOTOMICROGRAPH OF POLISHED SECTION MADE  
FROM DRILL CORES FROM LAKE MOUNT MINES,  
SHOWING PENTLANDITE IN PYRRHOTITE.

Pentlandite	-	Pl, very light grey, almost white.
Pyrrhotite	-	Pht, light grey.
Magnetite	-	Mg, medium grey.
Gangue	-	dark grey.
Pits	-	black.

Magnification, 200X.

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DETAILS OF EXPERIMENTAL TESTS:

Test No. 1. - Flotation in Alkaline Circuit.

This test was conducted on the sample of ore received on July 10th and is the best of a series.

The following oil mixture was prepared and used in the complete series of tests:

Water gas tar - 60 per cent.  
 Coal tar creosote - 20 "  
 Cresylic acid - 20 "

Charge to Ball Mill -

Ore - 2,000 grams.  
 Water - 1,500 "  
 Soda ash - 8 lb./ton.  
 Oil mixture - 0.30 "

Reagents to Cell -

Amyl xanthate - 0.20 lb./ton.  
 Pine oil - 0.10 "

A screen test of the flotation tailing showed the sample to be 82 per cent finer than 200 mesh.

Results of Test No. 1:

Product	Weight,		Assays, per cent				Distribution,	
	per	cent	Cu	Ni	Fe	Insol.	Cu	Ni
Flotation conc.	19.24	3.34	4.48	32.66	25.52	95.21	81.64	
Flotation tailing	80.76	0.04	0.24	5.83		4.79	18.36	
Feed (cal.)	100.00	0.67	1.06	10.99		100.00	100.00	

The addition of Emulsol X-1 to the cell increased the recovery of pyrrhotite but made no difference to the nickel.

Examination of the products of this and other tests under a binocular microscope seemed to indicate that the nickel minerals were almost entirely free from the pyrrhotite. Samples of pyrrhotite recovered by magnetic concentration from samples of flotation tailing failed to give a microchemical test for nickel.

A sample of the flotation tailing was screened down

(Details of Experimental Tests, cont'd) -

to 200 mesh and the fraction finer than 200 mesh was infrasized. The sized fractions were assayed for copper, nickel and sulphur, as follows:

Size	Assays, per cent		
	Cu	Ni	S
+ 65 mesh	0.065	0.16	0.63
- 65+100 "	0.03	0.19	0.81
-100+150 "	0.02	0.19	1.57
-150+200 "	0.01	0.28	1.95
-200 mesh +56 microns	0.01	0.35	6.20
- 56 " +40 "	0.01	0.10	0.67
- 40 " +28 "	0.01	0.11	0.33
- 28 " +20 "	0.01	0.19	0.33
- 20 " +14 "	0.025	0.23	0.31
- 14 " +10 "	0.02	0.50	0.37
- 10 " "	0.09	0.57	0.71

These results indicate that there is no definite relationship between the total sulphur and either the nickel or the copper. This condition is probably due to the weathering and leaching to which these samples have been subjected, the microscopic examination of the drill core samples having indicated a somewhat closer association of pentlandite with pyrrhotite in them.

Tests Nos. 2-8. - Flotation in an Acid Circuit.

A series of tests was conducted in acid circuit, starting with a natural circuit at pH 4.6 and going through a series in which varying quantities of sulphuric acid were added to the pulp. When 5 pounds per ton or more of sulphuric was added to the pulp, hydrogen sulphide gas was liberated in quantities sufficient to cause an offensive odour.

Owing to the reaction that resulted in the liberation of H<sub>2</sub>S, an increased quantity of acid added to the pulp was not accompanied by a corresponding change in pH value.

The following table gives the tailing assays for each

(Details of Experimental Tests, cont'd) -

set of conditions:

	H <sub>2</sub> SO <sub>4</sub> , lb./ton	pH reading	Tailing Assays, per cent	
			Ni	S
	Nil.	4.60	0.67	0.49
	1.8	4.50	0.61	0.48
	3.6	4.40	0.75	0.37
	5.4	4.40	0.83	0.27
	7.2	4.40	1.09	0.24
	9.0	4.30	0.18	0.31
	9.0	4.30	0.17	0.22
	10.8	4.10	0.11	0.16

In the last test of this series the results were as follows:

Product	Weight, per cent	Assays, per cent				Distribution, per cent	
		Cu	Ni	S	Insol.	Cu	Ni
Concentrate	21.55	1.08	4.94		18.60	94.92	88.87
Cleaner tailing	7.68	0.07	0.63			1.94	4.04
Flotation tailing	70.77	0.01	0.11	0.16		3.14	7.09
Feed (cal.)	100.00	0.25	1.20			100.00	100.00

Recoveries in this test are the highest yet obtained and the tailing assays are the lowest yet obtained in copper, nickel and sulphur. While this circuit holds promise of the best results the high acid liberates enough hydrogen sulphide gas to cause an offensive odour and it would be necessary to build a hood with ventilating fan over the grinding unit to carry the gas away if this circuit is to be used in practice.

This, of course, only applies to the oxidized ore from near the surface. When ore from depth is being treated further test work should be conducted on samples of it but it is highly probable that the present difficulty will disappear.

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