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MINES BRANCH INVESTIGATION REPORT

IR 70-48 May, 1970

AN EVALUATION OF THE FLOTATION CHARACTERISTICS OF A COPPER-NICKEL ORE FROM DOBIE TOWNSHIP NEAR EMO, ONTARIO FOR LONG LAC MINERAL EXPLORATION LIMITED

by

A. Stemerowicz and R.W. Bruce

Mineral Processing Division

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Mines Branch Investigation Report IR 70-48

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SUMMARY OF RESULTS

The ore contains 0.18% copper, 0.25% nickel and 0.02% cobalt. The best results for bulk sulphide flotation were obtained at a grind of 64% minus 200 mesh and were as follows:

	Wt	Assays %					
	%	Cu	Ni	Co	Fe	S	Insol
Bulk cleaner conc	3.5	3.4	2.9	0.24	44.4	33.1	10.3

	Distribution %		
	Cu	Ni	Co
Bulk cleaner conc	63.8	43.5	40.1
Bulk cleaner tailings	16.5	22.4	

Selective flotation of copper and nickel concentrates directly from the ore gave results as tabulated below:

	Wt	Assays %			Distribution %		
	%	Cu	Ni	Co	Cu	Ni	Co
Copper conc	0.4	19.00	1.05	0.073	38.6	1.8	1.4
Copper cleaner tail	1.4	3.50	1.19		25.3	7.3	
Nickel conc	1.5	0.70	3.95	0.47	5.5	26.3	34.0
Nickel cleaner tail	7.6	0.36	1.06		14.3	35.3	

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*Engineer, and **Head, Non-Ferrous Minerals Section, Mineral Processing Division, Mines Branch, Department of Energy, Mines and Resources, Ottawa, Canada.

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INTRODUCTION

Location of Property

The property is located in Dobie Township near Emo in the northwestern area of Ontario.

Shipment

Two shipments of percussion drill cuttings were received as follows:

1. January 3, 1969 - 2 drums: net weight 385 lb
2. February 3, 1969 - 26 drums, gross weight 7500 lb

Shipment 1 was stated to be a representative sample of shipment 2 material.

Nature of Investigation Requested

In his letter of July 8, 1969, Mr. P.D. Timms, Manager of Long Lac Mineral Exploration Limited requested a bench-scale investigation on the sample to be followed by pilot-plant tests if the results of the bench-scale tests were favourable. Grades of concentrates to be produced from the sample were not specified but in a subsequent conversation it was stated that a bulk sulphide concentrate should contain a minimum of 8% total combined copper and nickel in order to be acceptable to a nickel smelter.

Sampling and Analysis

Shipment 1 was air-dried and riffled into quarters. One of these quarters was further riffled into 16 portions to provide representative material for investigative tests while the remaining quarters were stored for future use. One of the 16 portions was chosen at random as a head sample. Screen analysis of the head sample is given in Table 1 followed by the chemical analysis in Table 2 and a semi-quantitative spectrochemical analysis in Table 3.

TABLE 1

Screen Analysis of Head Sample

Tyler Mesh Size	Wt %
+35	4.4
+48	5.8
+65	10.6
+100	12.8
+150	14.7
+200	12.4
+325	15.2
-325	24.1
Total	100.0

TABLE 2

Chemical Analysis of Head Sample*

Copper (Cu)	-	0.18 %
Nickel (Ni)	-	0.25 "
Cobalt (Co)	-	0.021"
Iron (Total Fe)	-	6.48 "
Sulphur (S)	-	2.79 "
Platinum (Pt)	-	not detectable
Palladium (Pd)	-	0.002 oz/ton

*From Internal Reports MS-AC-69-186 and 189.

TABLE 3

Semi-Quantitative Spectrographic Analysis of Head Sample*

Range %	Elements
Principal constituents	Mg, Si, Fe, Al, Ca
1.0 to 0.1	Na, Cr, Ni, Ti
0.1 to 0.01	Cu, Mn, Co, V
Not detected	Ba, Sb, Mo, W, Pb, Sn, Bi Nb, Ta, In, Zr, Ag, Zn, Sr

*From Internal Report MS-AC-69-24.

Mineralogical Examination

Because of the fineness of the sample as received and its low sulphide content it was not thought worthwhile to submit it for mineralogical examination. To get a true picture of occurrences and textural relationships of sulphides and gangue minerals, it would be necessary to study mineralized sections of lump ore. However, a sample of bulk sulphide concentrate produced in a lab batch text was submitted for mineralogical examination a report of which is given in Appendix C.

OUTLINE OF INVESTIGATION

Most of the time spent on this investigation was devoted to the flotation of the sulphides into a single bulk concentrate. Both single-stage and two-stage bulk flotation was tried as follows:

(1) Single-stage bulk flotation - a rougher concentrate was floated off with amyl xanthate and frother after conditioning the pulp with copper sulphate. The rougher concentrate was upgraded by multi-stage cleaning.
(2) Two-stage bulk flotation - a rougher concentrate containing the quick floating copper and nickel minerals was floated off without the aid of copper sulphate. The pulp was then conditioned with copper sulphate to activate the slower floating sulphides and scavenger concentrate was floated off. Both concentrates were cleaned. Soda ash was added to grinding in all tests. Generally, soda ash has a beneficial effect on the flotation of sulphides, especially when it is used in conjunction with copper sulphate.

In the initial bulk flotation test it was noted that talc or some other slimed silicate mineral was floating with the sulphides. Therefore, the practice was adopted of conditioning with a slime depressant prior to the addition of copper sulphate and promoter. Caustic starch (aqueous solution of starch and caustic soda in the ratio 2:1) and Orzan A (Crown Zellerbach Corp. trade name for ammonium lignin sulphonate) were employed as slime depressants. In one test an attempt was made to float off the interfering slimes with an alcohol frother prior to the sulphide float.

Fineness of grind, as measured by the screen analysis of the rougher tailing, was varied from 49 to 94% minus 200 mesh.

In two tests an attempt was made to partially desorb or destroy the xanthate coating on mineral surfaces prior to the cleaning operation by first heating the rougher concentrate slurry to 90°C in one test and by boiling the slurry in the other test. In both cases the hot water was decanted off and replaced by fresh water for cleaning. It was hoped that this treatment would result in improved selectivity between copper and nickel minerals on the one hand and gangue minerals and barren pyrrhotite on the other.

Magnetic separation was tried on a sample of reground bulk concentrate with a view to upgrading the concentrate by removing barren pyrrhotite.

A sample of bulk concentrate was submitted for mineralogical examination to identify the copper and nickel minerals and to determine the degree of association between the nickel minerals and pyrrhotite.

Bulk rougher tailings from tests employing coarse and fine grinds (64% and 85% minus 2000 mesh) were screened and the size fractions were assayed in order to determine distribution of copper and nickel tailing losses.

The production of separate copper and nickel concentrates was tried in only two tests each utilizing a different method as follows:

Copper-nickel selective flotation directly on the ore - a copper rougher concentrate was selectively floated from the ore by employing lime as a depressant for the nickel minerals and Z-200 as a selective copper promoter. Copper sulphate was then added to activate the nickel minerals and a nickel rougher concentrate was floated off with amyl xanthate. Both copper and nickel rougher concentrates were cleaned twice - the former with lime and the latter without additional reagents.

Copper-nickel separation of bulk concentrate - the copper and nickel minerals in the bulk concentrate were separated by using lime as a depressant for the nickel minerals. The chalcopyrite, which was unaffected, was then removed as the froth product which was upgraded by cleaning twice with lime. The nickel concentrate (non-float product) was upgraded by subjecting it to magnetic separation to remove pyrrhotite.

Except as noted, all test products were analyzed by Willroy Mines Limited, an associated company.

Full details of all tests are given in Appendix B.

EVALUATION AND DISCUSSION OF RESULTS

Single-Stage Bulk Flotation

The best results obtained for single-stage bulk flotation (Test 4) are given below in Table 4. These results were obtained at a grind of 64% minus 200 mesh. Caustic starch was employed as a slime depressant and the rougher concentrate slurry was boiled prior to the cleaning operation with the view of improving selectivity by partially desorbing or destroying the xanthate coating on the mineral surfaces.

TABLE 4

Best Results for Single-Stage Bulk Flotation (Test 4)

Product	Wt %	Assays %*						Distribution %		
		Cu	Ni	Insol	Co	Fe	S	Cu	Ni	Co
Bulk cleaner conc	3.51	3.40	2.86	10.34	0.24	44.4	33.1	63.8	43.5	40.1
Bulk cleaner tail No. 2	0.73	1.03	1.80	23.12				4.1	5.7	
Bulk cleaner tail No. 1	2.97	0.78	1.30	35.11				12.4	16.7	
Final tailing	92.79	0.04	0.085		0.015	4.48	0.56	19.7	34.1	
Feed (calcd)	100.00	0.19	0.23		0.021			100.0	100.0	
Calculated assays										
1st stage bulk cl conc	4.24	2.99	2.68	12.54				67.9	49.2	
Bulk rougher conc	7.21	2.08	2.11	21.84				80.3	65.9	

*Co, Fe, and S assays from Internal Report MS-AC-70-108.

Two-Stage Bulk Flotation

Two-stage bulk flotation was tried at grinds of 84.6% minus 200 mesh (Test 5), 75.4% minus 200 mesh (Test 6) and 93.6% minus 200 mesh (Test 7). In all three tests caustic starch was employed as a slime depressant. Results are shown in Table 5.

TABLE 5

Results for Two-Stage Bulk Flotation

Test No.	Product	Wt %	Assays %			Distribution %	
			Cu	Ni	Insol	Cu	Ni
5	Bulk cleaner conc	1.21	5.90	2.70	6.50	39.9	16.8
	Combined bulk cl tail	0.75	3.52	2.27	28.52	14.7	8.7
	Scavenger cleaner conc	2.16	0.85	1.80	6.73	10.3	20.0
	Combined scav cl tail	3.02	0.69	1.05	39.56	11.7	16.4
	Final tailing	92.86	0.045	0.08		23.4	38.1
	Feed (calcd)	100.00	0.18	0.19		100.0	100.0
	Bulk rougher conc (calcd)	1.96	4.99	2.54	14.93	54.6	25.5
6	Bulk cleaner conc	1.92	5.15	2.90	9.04	53.6	27.0
	Combined bulk cl tail	1.06	1.78	1.67	38.56	10.2	8.6
	Scavenger cleaner conc	2.05	0.65	1.70	7.88	7.2	16.9
	Combined scav cl tail	2.16	0.75	1.12	44.37	8.8	11.6
	Final tailing	92.81	0.04	0.08		20.2	35.9
	Feed (calcd)	100.00	0.18	0.21		100.0	100.0
	Bulk rougher conc (calcd)	2.98	3.95	2.46	19.55	63.8	35.6
7	Bulk cleaner conc	2.10	4.60	2.65	5.06	53.5	27.3
	Combined bulk cl tail	1.43	1.97	1.73	24.08	15.6	12.1
	Scavenger cleaner conc	1.29	0.40	1.70	5.16	2.9	10.7
	Combined scav cl tail	2.95	0.62	1.06	48.59	10.1	13.8
	Final tailing	92.23	0.035	0.08		17.9	36.1
	Feed (calcd)	100.00	0.18	0.20		100.0	100.0
	Bulk rougher conc (calcd)	3.53	3.54	2.28	12.77	69.1	39.4

By combining weights and assays of the numerous products produced in the two-stage bulk flotation tests it was possible to obtain a large number of grade:recovery combinations. These are plotted in Figure 1. Only one curve each for copper and nickel has been drawn through the points. Differences in locations of points for each test would allow the drawing of separate curves but these differences are not considered to be significant. For example, a difference in analysis of copper and nickel in the tailing of 0.005% and 0.01% respectively, which is within the limits of experimental error, would result in differences in recovery of 3% for copper and 5% for nickel.

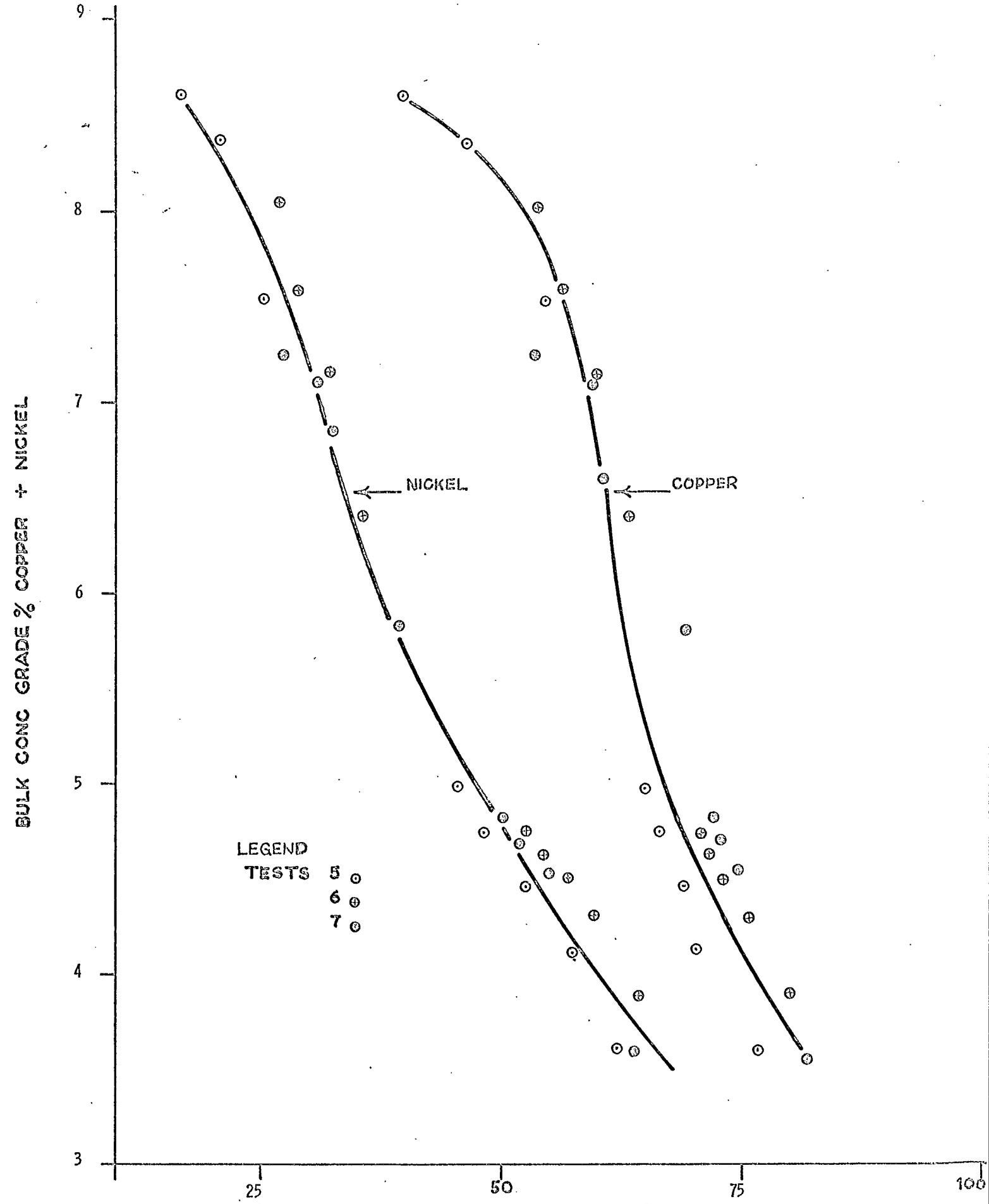

FIGURE 1. GRADE RECOVERY CURVES FOR TWO STAGE BULK FLOTATION TESTS 5, 6, AND 7

A comparison of the best results obtained for single-stage bulk flotation (Test 4) versus the results for two-stage bulk flotation as given by the curves in Figure 1 is shown in Table 6.

TABLE 6

Comparison of Results
Single-Stage vs Two-Stage Bulk Flotation

Product	Grade % Cu + Ni	Recovery by single-stage flotation, % Test 4		Recovery by two-stage flotation % from Figure 1 curves	
		Cu	Ni	Cu	Ni
Bulk cleaner conc	6.26	63.8	43.5	61.5	35.5
1st stage bulk cl conc	5.67	67.9	49.2	63.0	40.0
Bulk rougher conc	4.19	80.3	63.9	74.0	62.5

The above comparison shows that in most cases for the same concentrate grade a significantly higher copper and nickel recovery was obtained by single-stage bulk flotation.

Effect of Removal of Xanthate Prior to Cleaning

The removal of xanthate from mineral surfaces by heating the bulk rougher concentrate pulp prior to cleaning (Tests 3 and 4) resulted in an improvement in selectivity in the cleaning operation as evidenced by the superior results attained in Test 4. Boiling the pulp (Test 4) appeared to be more effective than heating to a lower temperature of 80°C (Test 3).

Effect of Slime Depressants

The results of bulk flotation with and without the addition of various amounts of the slime depressants Orzan A and caustic starch are compared in Table 7.

TABLE 7

Comparison of Bulk Flotation Results
Using Various Amounts of Orzan A and Caustic Starch

Test No.	Grind % -200 m	Slime Depressant	lb/ton	Bulk Rougher Conc				Tailing	
				Wt %	Assays %			Assays %	
					Cu	Ni	Insol	Cu	Ni
11	64.4	None		6.76	1.99	1.73	22.33	0.03	0.12
9	"	Orzan A	0.2	6.42	2.13	1.78	20.44	0.03	0.10
10	"	Orzan A	0.4	6.33	2.23	1.86	20.32	0.035	0.10
17	"	caustic starch	1.0	6.58	2.18	1.76	22.86	0.04	0.10

The most significant difference in results obtained in the one test above which was done without the addition of slime depressant (Test 11) was the higher nickel loss in tailing. A slightly lower grade of concentrate (copper + nickel content) was obtained in this test but after two cleaning stages the concentrate was upgraded to about the same cleaner concentrate grade as the other tests under comparison. More thorough testing would be required to definitely prove the need for employing slime depressants but was not carried out as the results would not materially affect the economics of processing this ore.

Effect of Fineness of Grind

Bulk flotation was tried at grinds ranging from 49 to 93.6% minus 200 mesh. It was found that there was no advantage in grinding finer than about 64% minus 200 mesh. At a grind of 49% minus 200 mesh (Tests 1 and 16) there was a significant increase in copper and nickel losses in the tailing.

Flotation of Slimes Prior to Sulphide Flotation

In Test 2 the flotation of a slime concentrate was tried as a means of reducing the amount of slimes floating with the sulphides in the subsequent bulk sulphide float. The slimes were floated by the simple expedient of adding an alcohol frother and this was followed by bulk sulphide flotation using standard procedure. Results are in Table 8.

TABLE 8

Results of Slime Flotation Prior to Sulphide Flotation (Test 2)

Product	Wt %	Assays %			Distribution %	
		Cu	Ni	Insol	Cu	Ni
Slime conc	2.37	4.55	1.60	42.35	58.0	15.6
Bulk cl conc	4.08	0.90	2.55	6.81	19.7	42.7
Bulk cl tail	1.76	0.53	1.35	42.19	5.0	9.8
Final tailing	91.79	0.035	0.085		17.3	31.9
Feed (calcd)	100.00	0.19	0.24		100.0	100.0
Bulk rougher conc (calcd)	5.84	0.79	2.19	17.47	24.7	52.5

As can be seen from the results it was not possible to float off a slime concentrate without also floating a considerable amount of sulphides, especially chalcopyrite. Despite the removal of a considerable weight of slimes in the initial slime float there was no significant reduction in the amount of slimes floating with the sulphides.

Magnetic Separation of Bulk Concentrate

The results of magnetic separation of a sample of reground bulk concentrate are given in Table 9.

TABLE 9

Results of Magnetic Separation of Bulk Concentrate (Test 12)

Product	Wt %	Assays %*						Distribution %		
		Cu	Ni	Insol	Co	Fe	S	Cu	Ni	Co
Non-magnetics	63.0	4.00	2.80	13.37	0.29	40.2	32.4	96.5	84.1	95.0
Magnetics	37.0	0.25	0.90	4.35	0.026	55.4	34.5	3.5	15.9	5.0
Bulk cl conc (calcd)	100.0	2.61	2.10	10.04	0.19	45.8	33.2	100.0	100.0	100.0

*Co, Fe and S assays from Internal Report MS-AC-70-108.

As can be seen, 37% of the weight of the bulk concentrate was removed as magnetics resulting in an appreciable improvement in concentrate grade but this was accompanied by a substantial loss of nickel in the magnetics.

Mineralogical Examination of Bulk Concentrate

A mineralogical examination of a bulk concentrate (see report in appendix) identified the nickel minerals as nickeliferous pyrrhotite, pentlandite and violarite. It was concluded in the report that it would be difficult to concentrate the nickel effectively because of small, nickel-bearing inclusions in the pyrrhotite and the significant nickel content of the pyrrhotite itself (0.4% as measured with the electron probe).

Distribution of Copper and Nickel Losses in Tailing

Assay-size analyses of a sample of bulk flotation tailings (see Appendix A page 16) showed that the greatest loss of both copper and nickel was in the minus 500-mesh fraction (25 microns). At a grind of 64% minus 200 mesh (Test 17) 49% of the copper and 48% of the nickel was lost in the minus 500-mesh fraction while at a finer grind of 85% minus 200 mesh the losses in this fraction were increased to 62% and 58% respectively.

Flotation of Separate Copper and Nickel Concentrates

The results of flotation of separate concentrates by the two methods outlined, viz. selective flotation from the ore and separation of bulk concentrate, are given in Tables 10 and 11.

TABLE 10

Results of Selective Flotation Directly From Ore (Test 8)

Product	Wt %	Assays %*						Distribution %		
		Cu	Ni	Insol	Co	Fe	S	Cu	Ni	Co
Copper conc	0.39	19.00	1.05	12.81	0.073	33.3	27.7	38.6	1.8	1.4
Combined copper cl tail	1.39	3.50	1.19	51.04				25.3	7.3	
Nickel conc	1.52	0.70	3.95	7.87	0.47	44.2	38.1	5.5	26.3	34.0
Combined nickel cl tail	7.59	0.36	1.06	44.85				14.3	35.3	
Final tailing	89.11	0.035	0.075					16.3	29.3	
Feed (calcd)	100.00	0.19	0.23		0.021			100.0	100.0	

*Co, Fe and S assays from Internal Report MS-AC-70-108.

TABLE 11

Results of Copper-Nickel Separation of Bulk Concentrate (Test 13)

Product	Wt %	Assays %*						Distribution %		
		Cu	Ni	Insol	Co	Fe	S	Cu	Ni	Co
Copper conc	0.37	20.50	1.30	5.50	0.13	32.7	35.0	44.4	2.2	2.3
Combined copper cl tail	0.78	2.88	3.18	7.69				13.2	11.5	
Nickel conc (non-mags)	1.95	1.00	2.85	15.72	0.30	42.3	30.7	11.4	25.7	27.9
Magnetics	1.61	0.20	0.90	5.05	0.029	57.2	34.6	1.9	6.7	2.2
Combined bulk cl tail	1.85	1.05	1.15	52.25				11.4	9.8	
Final tailing	93.44	0.033	0.10					17.7	44.1	
Feed (calcd)	100.00	0.17	0.22		0.021			100.0	100.0	
Separation tail (calcd)**	3.57	0.64	1.97	10.90	0.18	49.0	32.5	13.3	32.4	30.1

*Co, Fe and S assays from Internal Report MS-AC-70-108.
**Nickel concentrate before magnetic separation.

The two methods gave similar copper results but selective flotation from the ore gave a better grade of nickel concentrate. The low-grade nickel concentrate obtained by subjecting the bulk concentrate to copper-nickel separation can be upgraded by magnetic separation, but, as was the case when this was tried on a bulk concentrate (Test 12), a substantial amount of nickel was lost in the magnetics.

CONCLUSIONS

A satisfactory grade of bulk concentrate could not be produced from the sample because of the intimate association of some of the nickel with pyrrhotite. The nickeliferous pyrrhotite can be rejected to produce concentrate grades with the required 8% combined copper + nickel content (See Figure 1) but only at the expense of a severe decrease in nickel recovery.

From the limited work done on selective flotation indications were that it would be possible to produce a copper concentrate containing only about 1% nickel but maximum nickel concentrate grade would be limited to about 4% nickel because of the presence of nickeliferous pyrrhotite.

It was not possible to obtain a tailing containing less than about 0.08% nickel. For most ores this would be considered to be a low value but on this low-grade sample it represents a loss of about 1/3 of the contained nickel.

Because of this, it is concluded that it would not be economical to treat this low-grade material. Hydrometallurgical methods might be feasible but these are beyond the scope of this investigation.

A comparison of the results of this investigation with the results of previous investigations, a summary of which is given in Appendix D, indicates that the mineralization of the sample submitted is similar to the high-grade sample investigated in Investigation No. MD 3201 (see page 43). In both cases a high-grade concentrate could not be produced because of the presence of nickeliferous pyrrhotite. The mineralization of the low-grade sample investigated in Investigation No. MD 3174 (see page 41) must differ substantially as there was no difficulty in producing a high-grade bulk concentrate once the problem of talc depression was solved.

ACKNOWLEDGEMENTS

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APPENDIX A

Screen Analyses of Final Tailings

10-min Rod Mill Grind - Test 1		
Tyler Mesh Size	Wt % Retained	Cumulative Wt % Retained
+48	0.2	0.2
+65	4.7	4.9
+100	14.4	19.3
+150	16.4	35.7
+200	15.3	51.0
+325	17.2	68.2
-325	31.8	100.0
Total	100.0	
30-min Rod Mill Grind - Test 2		
+65	0.1	0.1
+100	2.1	2.2
+150	14.8	17.0
+200	18.6	35.6
+325	22.4	58.0
-325	42.0	100.0
Total	100.0	
45-min Rod Mill Grind - Test 6		
+100	0.2	0.2
+150	6.1	6.3
+200	18.3	24.6
+325	26.8	51.4
-325	48.6	100.0
Total	100.0	
60-min Rod Mill Grind - Test 5		
+150	2.2	2.2
+200	13.2	15.4
+325	28.9	44.3
-325	55.7	100.0
Total	100.0	

60-min Ball Mill Grind* - Test 7		
+100	0.1	0.1
+150	0.9	1.0
+200	5.4	6.4
+325	24.4	30.8
-325	69.2	100.0
Total	100.0	

*with ceramic pebbles

Assay-Size Analyses of Final Tailings

Test 17

30-min Rod Mill Grind

Tyler Mesh Size	Wt %	Assays %		Distribution %	
		Cu	Ni	Cu	Ni
+150	18.0	0.03	0.05	14.7	8.3
+200	18.1	0.025	0.05	12.3	8.4
+270	12.3	0.025	0.10	8.4	11.4
+325	9.5	0.025	0.10	6.5	8.8
+400	5.1	0.02	0.10	2.7	4.7
+500	11.1	0.02	0.10	6.0	10.3
- -500	25.9	0.07	0.20	49.4	48.1
Total	100.0	0.037	0.11	100.0	100.0

Test 18

60-min Rod Mill Grind

Tyler Mesh Size	Wt %	Assays %		Distribution %	
		Cu	Ni	Cu	Ni
+200	15.3	0.025	0.075	10.2	9.3
+270	16.6	0.02	0.075	8.9	10.2
+325	12.1	0.025	0.075	8.1	7.4
+400	5.7	0.02	0.075	3.0	3.5
+500	14.9	0.02	0.10	8.1	12.1
-500	35.4	0.065	0.20	61.7	57.5
Total	100.0	0.037	0.12	100.0	100.0

APPENDIX B

Abbreviations Used in Flotation Test Reports

RM	Rod mill
BM	Ball mill
SA	Soda ash
CS	Caustic starch - aqueous solution of caustic soda and starch in the ratio 1:2
Z-6	Dow Chemical Co. trade name for potassium amyl xanthate
DF 250	Dowfroth 250 - Dow Chemical Co. frother
MIBC	Methyl isobutyl carbinol - alcohol frother
Orz A	Orzan A, Crown Zellerbach trade name for ammonium lignin sulphonate

MINES BRANCH FLOTATION TEST REPORT

TEST NO. 1	SAMPLE: Long Lac Mineral Exploration Ltd.	DATE: Feb. 18/69
OBJECT OF TEST:	Preliminary bulk flotation test with 1.0 lb/ton caustic starch as talc depressant	CHARGE: 3000 g
		TESTED BY: A.S.

OPERATION	Time min	% Solids	pH	Unit used	Reagents, lb per ton									
					SA	CS	$CuSO_4$	Z-6	DF250					
Grinding	10	65		7 x 14 RM	1.0									
Conditioning				2000-g cell										
No. 1	5		*			1.0								
No. 2	5						0.2							
Bulk rougher				2000-g cell										
Stage 1	1							0.033	0.027					
Stage 2	1							0.033						
Stage 3	2							0.066						
Bulk cleaners														
No. 1	2			500-g cell					0.013					
No. 2	1½			250-g cell										
No. 3	1			" " "										

PRODUCT	WT %	ANALYSIS %							DISTRIBUTION %				
		Cu	Ni	Insol					Cu	Ni			
Bulk cleaner conc	4.66	2.63	2.50	6.96					67.7	46.9			
Bulk cleaner tail No. 3	0.38												
" " " No. 2	0.29	1.10	1.30	50.36					9.0	7.7			
" " " No. 1	0.80												
Final tailing	93.87	0.045	0.12						23.3	45.4			
Feed (calcd)	100.00	0.18	0.25						100.0	100.0			
Bulk rougher conc (calcd)	6.13	2.26	2.21	17.37					76.7	54.6			

REMARKS: Screen analysis of rougher tailing, 49.0% minus 200 mesh.
Rougher froth coated with dirty, grey slime.
*6.6 before addition of caustic starch. 7.5 after this reagent was added.

MINES BRANCH FLOTATION TEST REPORT

TEST NO. 2	SAMPLE: Long Lac Mineral Exploration Ltd.	DATE: Feb. 19/69
OBJECT OF TEST: To float a slime concentrate prior to sulphide flotation.		CHARGE: 3000 g
		TESTED BY: A.S.

OPERATION	Time min	% Solids	pH	Unit used	Reagents, lb per ton									
					SA	MIBC	CS	$CuSo_4$	Z-6	DF250				
Grinding	30	65		7x14 RM	2.0									
Slime flotation Stage 1	1		7.3	2000-g cell		0.027								
" " " 2	2					0.013								
Conditioning No. 1	5		8.3				1.0							
" No. 2	5							0.2						
Bulk rougher Stage 1	1								0.033					
" " " 2	1								0.033					
" " " 3	2								0.066					
Bulk cleaner No. 1	1½			500-g cell						0.013				
" " No. 2	1			250-g cell						0.003				
" " No. 3	1			" " "						0.003				

PRODUCT	WT %	ANALYSIS %							DISTRIBUTION %				
		Cu	Ni	Insol					Cu	Ni			
Slime conc	2.37	4.55	1.60	42.35					58.0	15.6			
Bulk cleaner conc	4.08	0.90	2.55	6.81					19.7	42.7			
Combined bulk cl tail	1.76	0.53	1.35	42.19					5.0	9.8			
Final tailing	91.79	0.035	0.085						17.3	31.9			
Feed (calcd)	100.00	0.19	0.24						100.0	100.0			
Bulk rougher conc (calcd)	5.84	0.79	2.19	17.47					24.7	52.5			

REMARKS: Screen analysis of rougher tailing, 64.4% minus 200 mesh.
Bulk rougher froth appeared to be cleaner than Test 1.

MINES BRANCH FLOTATION TEST REPORT

TEST NO. 3	SAMPLE: Long Lac Mineral Exploration Ltd.	DATE: Feb. 20/69
OBJECT OF TEST: Bulk flotation with 2.0 lb/ton caustic starch as talc depressant, also heated ro conc to 80°C before cleaning in order to desorb Z-6 from mineral surfaces		CHARGE: 3000 g
		TESTED BY: AS

OPERATION	Time min	% Solids	pH	Unit used	Reagents, lb per ton									
					SA	CS	$CuSO_4$	Z-6	DF250					
Grinding	30	65		7x14 RM	2.0									
Conditioning				2000-g cell										
No. 1	5					2.0								
No. 2	5		8.0				0.2							
Bulk rougher				2000-g cell										
Stage 1	½							0.033	0.026					
" 2	½							0.033						
" 3	1							0.066	0.013					
" 4	1							0.066						
Desorption*														
Bulk cleaner No. 1	1½			500-g cell					0.013					
" " No. 2	1			250-g cell										

PRODUCT	WT %	ANALYSIS %							DISTRIBUTION %					
		Cu	Ni	Insol					Cu	Ni				
Bulk cleaner conc	3.84	2.73	2.45	7.33					61.5	44.9				
Bulk cleaner tail No. 2	1.65	0.88	1.73	15.70					8.5	13.6				
" " " No. 1	0.99	1.38	1.40	51.60					8.0	6.6				
Final tailing	93.52	0.04	0.078						22.0	34.9				
Feed (calcd)	100.00	0.17	0.21						100.0	100.0				
1st stage cleaner conc**	5.49	2.17	2.23	9.85					70.0	58.5				
Bulk rougher conc**	6.48	2.05	2.11	16.23					78.0	65.1				

REMARKS: Screen analysis of final tailing, 64.4% minus 200 mesh.
* Bulk rougher conc was filtered, repulped with fresh water and heated for 10 min at 80°C. The hot water was then decanted off and replaced by cold, fresh water for cleaning.
** Calculated.

MINES BRANCH FLOTATION TEST REPORT

TEST NO. 4	SAMPLE: Long Lac Mineral Exploration Ltd.	DATE: Feb. 20, 1969
OBJECT OF TEST: Bulk flotation with 1.0 lb/ton caustic starch as talc depressant also desorbed Z-6 prior to cleaning by boiling rougher conc slurry.		CHARGE: 3000 g
		TESTED BY: A.S.

OPERATION	Time min	% Solids	pH	Unit used	Reagents, lb per ton									
					SA	CS	$CuSO_4$	Z-6	DF250					
Grinding	30	65		7 x 14 RM	1.0									
Conditioning				2000-g cell										
No. 1	5		7.5			1.0								
No. 2	5						0.2							
Bulk rougher				2000-g cell										
Stage 1	1							0.02	0.026					
" 2	1							0.02						
" 3	2							0.026	0.013					
Desorption *														
Bulk cleaners														
No. 1	1½			500-g cell					0.013					
No. 2	2			250-g cell					0.003					

PRODUCT	WT %	ANALYSIS %							DISTRIBUTION %				
		Cu	Ni	Insol	Co	Fe	S		Cu	Ni	Co		
Bulk cleaner conc	3.51	3.40	2.86	10.34	0.24	44.4	33.1		63.8	43.5	40.1		
Bulk cleaner tail No. 2	0.73	1.03	1.80	23.12					4.1	5.7			
" " " No. 1	2.97	0.78	1.30	35.11					12.4	16.7			
Final tailing	92.79	0.04	0.085		0.015	4.48	0.56		19.7	34.1			
Feed (calcd)	100.00	0.19	0.23		0.021				100.0	100.0			
1st stage cleaner conc**	4.24	2.99	2.68	12.54					67.9	49.2			
Bulk rougher conc**	7.21	2.08	2.11	21.84					80.3	65.9			

REMARKS: Screen analysis of final tailing, 64.4% minus 200 mesh
* Bulk rougher conc was filtered, repulped with fresh water and boiled for 5 min. The hot water was then decanted off and replaced by cold, fresh water for cleaning.

** Calculated

MINES BRANCH FLOTATION TEST REPORT

TEST NO. 5	SAMPLE: Long Lac Mineral Exploration Ltd.	DATE: March 13/69
OBJECT OF TEST:	To try two-stage bulk rougher float at a fine grind.	CHARGE: 3000 g
		TESTED BY: A.S.

OPERATION	Time min	% Solids	pH	Unit used	Reagents, lb per ton									
					SA	CS	Z-6	MIBC	DF250	$CuSO_4$				
Grinding	60	65		7 x 14	1.33									
Conditioning	10		6.9*	2000-g cell		2.0	0.053	0.04	0.013					
Bulk rougher				" "										
Stage 1	2													
" 2	2						0.033							
Conditioning	5		7.6							0.50				
Scavengers														
Stage 1	2						0.066							
" 2	2						0.066							
(continued on Sheet 2)														

PRODUCT	WT %	ANALYSIS %							DISTRIBUTION %				
		Cu	Ni	Insol					Cu	Ni			
Bulk cleaner conc	1.21	5.90	2.70	6.50					39.9	16.8			
Bulk cleaner tail No. 2	0.27	4.45	2.80	15.80					6.7	3.9			
" " " No. 1	0.48	3.00	1.95	35.67					8.0	4.8			
Scavenger cleaner conc	2.16	0.85	1.80	6.73					10.3	20.0			
Scav cleaner tail No. 4	0.37	0.75	1.40	13.14					1.6	2.7			
" " " No. 3	0.57	0.75	1.45	16.60					2.4	4.3			
" " " No. 2	0.79	0.85	1.25	34.29					3.7	5.1			
" " " No. 1	1.29	0.55	0.65	60.50					4.0	4.3			
Final tailing	92.86	0.045	0.08						23.4	38.1			
Feed (calcd)	100.00	0.18	0.19						100.0	100.0			

REMARKS:
Screen analysis of final tailing, 84.6% minus 200 mesh.
*before addition of reagents.

MINES BRANCH FLOTATION TEST REPORT

TEST NO. 5	SAMPLE: Long Lac Mineral Exploration Ltd.	DATE: March 13/69
OBJECT OF TEST:		CHARGE:
		TESTED BY:

OPERATION	Time min	% Solids	pH	Unit used	Reagents, lb per ton									
									DF250					
Bulk cleaners														
No. 1	1½			500-g cell					0.007					
No. 2	1½			250-g cell					0.007					
Scavenger cleaners														
No. 1	1½			500-g cell					0.007					
No. 2	1			250-g cell					0.003					
No. 3	1			" "					0.003					
No. 4	1			" "					0.003					

PRODUCT	WT %	ANALYSIS % *							DISTRIBUTION %				
		Cu	Ni	Insol					Cu	Ni			
1st stage bulk cl conc	1.48	5.64	2.72	8.20					46.6	20.7			
Bulk rougher conc	1.96	4.99	2.54	14.93					54.6	25.5			
3rd stage scav cl conc	2.53	0.84	1.74	7.67					11.9	22.7			
2nd stage scav cl conc	3.10	0.82	1.69	9.31					14.3	27.0			
1st stage scav cl conc	3.89	0.83	1.60	14.38					18.0	32.1			
Scavenger conc	5.18	0.76	1.36	25.87					22.0	36.4			
Bulk cl & Scav cl conc	3.37	2.66	2.12	6.65					50.2	36.8			
Bulk rougher & Scav conc	7.14	1.92	1.69	22.86					76.6	61.9			

REMARKS:

* Calculated

MINES BRANCH FLOTATION TEST REPORT

TEST NO. 6	SAMPLE: Long Lac Mineral Exploration Ltd.	DATE: March 13, 1969
OBJECT OF TEST: Two-stage bulk rougher float as in Test 5 but (1) coarser grind (45 min vs 60 min) and (2) caustic starch cut from 2.0 to 1.0 lb/ton		CHARGE: 3000 g
		TESTED BY: A.S.

OPERATION	Time min	% Solids	pH	Unit used	Reagents, lb per ton									
					SA	CS	Z-6	DF250	$CuSO_4$					
Grinding	45	65		7 x 14 RM	2.0									
Conditioning	10		7.0*	2000-g cell		1.0	0.053	0.026						
Bulk rougher				" " "										
Stage 1	2													
" 2	2							0.013						
Conditioning	5		7.2						0.50					
Bulk scavenger														
Stage 1	2						0.066							
" 2	2						0.066							
(continued on Sheet 2)														

PRODUCT	WT %	ANALYSIS %							DISTRIBUTION %					
		Cu	Ni	Insol					Cu	Ni				
Bulk cleaner conc	1.92	5.15	2.90	9.04					53.6	27.0				
Bulk cleaner tail No. 3	0.25	2.00	2.05	21.81					2.7	2.5				
" " " No. 2	0.30	2.15	1.90	31.95					3.5	2.8				
" " " No. 1	0.51	1.45	1.35	50.68					4.0	3.3				
Scavenger cleaner conc	2.05	0.65	1.70	7.88					7.2	16.9				
Scav cleaner tail No. 4	0.24	0.55	1.55	18.34					0.7	1.8				
" " " No. 3	0.33	0.85	1.45	25.44					1.5	2.3				
" " " No. 2	0.52	0.90	1.25	40.80					2.5	3.1				
" " " No. 1	1.07	0.70	0.85	57.78					4.1	4.4				
Final tailing	92.81	0.04	0.08						20.2	35.9				
Feed (calcd)	100.00	0.18	0.21						100.0	100.0				

REMARKS: Screen analysis of final tailing, 75.4% minus 200 mesh
* before addition of reagents.

MINES BRANCH FLOTATION TEST REPORT

TEST NO. 6	SAMPLE: Long Lac Mineral Exploration Ltd.	DATE: March 13, 1969
OBJECT OF TEST:		CHARGE:
		TESTED BY:

OPERATION	Time min	% Solids	pH	Unit used	Reagents, lb per ton									
								DF250						
Bulk cleaners														
No. 1	1			500-g cell				0.007						
No. 2	1			250-g cell				0.003						
No. 3	1			" " "				0.003						
Scavenger cleaners														
No. 1	1			250-g cell				0.007						
No. 2	1			" " "				0.003						
No. 3	1			" " "				0.003						
No. 4	1			" " "				0.003						

PRODUCT	WT %	ANALYSIS %*							DISTRIBUTION %				
		Cu	Ni	Insol					Cu	Ni			
2nd stage bulk cl conc	2.17	4.79	2.80	10.51					56.3	29.5			
1st " " " "	2.47	4.47	2.69	13.12					59.8	32.3			
Bulk rougher conc	2.98	3.95	2.46	19.55					63.8	35.6			
3rd stage scav cl conc	2.29	0.64	1.68	8.97					7.9	18.7			
2nd " " " "	2.62	0.66	1.65	11.05					9.4	21.0			
1st " " " "	3.14	0.70	1.59	15.98					11.9	24.1			
Scavenger conc	4.21	0.70	1.40	26.60					16.0	28.5			
Bulk cl + Scav cl conc	3.97	2.83	2.28	8.44					60.8	43.9			
Bulk rougher + Scav conc	7.19	2.05	1.84	23.68					79.8	64.1			

REMARKS: * calculated

MINES BRANCH FLOTATION TEST REPORT

TEST NO. 7 | SAMPLE: Long Lac Mineral Exploration Ltd. | DATE: March 18/69

OBJECT OF TEST: Two-stage float as in Test 6 but employed pebble grinding | CHARGE: 3000 g | TESTED BY: A.S.

OPERATION	Time min	% Solids	pH	Unit used	Reagents, lb per ton									
					SA	CS	Z-6	DF250	$CuSO_4$					
Grinding	60	65		12-in. BM	2.0									
Conditioning	10		7.2*			1.0	0.053							
Bulk rougher														
Stage 1	2							0.013						
" 2	2													
Conditioning	5								0.50					
Scavenger														
Stage 1	2						0.066							
" 2	2						0.066							
(continued on Sheet 2)														

PRODUCT	WT %	ANALYSIS %							DISTRIBUTION %				
		Cu	Ni	Insol					Cu	Ni			
Bulk cleaner conc	2.10	4.60	2.65	5.06					53.5	27.3			
Bulk cleaner tail No. 3	0.30	3.55	2.55	7.39					5.9	3.8			
" " " No. 2	0.17	1.25	1.85	15.08					1.2	1.5			
" " " No. 1	0.96	1.60	1.45	30.90					8.5	6.8			
Scavenger cleaner conc	1.29	0.40	1.70	5.16					2.9	10.7			
Scav cleaner tail No. 3	0.22	0.60	1.65	14.98					0.7	1.8			
" " " No. 2	0.39	0.80	1.45	34.03					1.7	2.8			
" " " No. 1	2.34	0.60	0.80	54.17					7.7	9.2			
Final tailing	92.23	0.035	0.08						17.9	36.1			
Feed (calcd)	100.00	0.18	0.20						100.0	100.0			

REMARKS: Screen analysis of rougher tailing, 93.6% minus 200 mesh.
* before addition of reagents.

MINES BRANCH FLOTATION TEST REPORT

TEST NO. 7	SAMPLE: Long Lac Mineral Exploration Ltd.	DATE: March 18/69
OBJECT OF TEST:		CHARGE:
		TESTED BY:

OPERATION	Time min	% Solids	pH	Unit used	Reagents, lb per ton									
								DF250						
Bulk cleaners														
No. 1	1			500-g cell				0.007						
No. 2	1			250-g cell				0.007						
No. 3	1			" "										
Scavenger cleaners														
No. 1	1			500-g cell				0.007						
No. 2	1			250-g cell				0.003						
No. 3	1			" "				0.003						

PRODUCT	WT %	ANALYSIS %*							DISTRIBUTION %				
		Cu	Ni	Insol					Cu	Ni			
2nd stage bulk cl conc	2.40	4.47	2.64	5.35					59.4	31.1			
1st " " " "	2.57	4.26	2.59	6.00					60.6	32.6			
Bulk rougher conc	3.53	3.54	2.28	12.77					69.1	39.4			
2nd stage scav cl conc	1.51	0.43	1.69	6.60					3.6	12.5			
1st stage scav cl conc	1.90	0.51	1.64	12.23					5.3	15.3			
Scavenger conc	4.24	0.56	1.18	35.37					13.0	24.5			
Bulk cl & scav cl conc	3.39	3.00	2.29	5.10					56.4	38.0			
Bulk rougher & scav conc	7.77	1.91	1.68	25.10					82.1	63.9			

REMARKS:

* calculated

MINES BRANCH FLOTATION TEST REPORT

TEST NO. 8	SAMPLE: Long Lac Mineral Exploration Ltd.	DATE: March 18, 1969
OBJECT OF TEST: To try copper-nickel selective flotation using Z-200 as copper promoter and lime as a depressant for nickel minerals.		CHARGE: 3000 g
		TESTED BY: A.S.

OPERATION	Time min	% Solids	pH	Unit used	Reagents, lb per ton									
					Lime	CS	Z-200	$CuSO_4$	Z-6	DF250				
Grinding	60	65		12-in. B.M.*	2.0									
Conditioning	10		8.5**	2000-g cell		1.0	0.04							
Copper rougher Stage 1	1			" " "										
" " " 2	1						0.026							
Conditioning	5		8.4					0.5						
Nickel rougher Stage 1	2								0.066					
" " " 2	1								0.066					
" " " 3	1								0.066					
Copper cleaner No. 1	1		11.7	250-g cell	0.5					0.003				
" " No. 2	1		11.9	" " "	0.3					0.003				
Nickel cleaner No. 1	1			500-g cell						0.007				
" " No. 2	1			250-g cell										

PRODUCT	WT %	ANALYSIS %							DISTRIBUTION %				
		Cu	Ni	Insol	Co	Fe	S		Cu	Ni	Co		
Copper conc	0.39	19.00	1.05	12.81	0.073	33.3	27.7		38.6	1.8	1.4		
Copper cleaner tail No.2	0.34	7.80	2.05	28.10					13.8	3.1			
" " " No.1	1.05	2.10	0.90	58.47					11.5	4.2			
Nickel conc	1.52	0.70	3.95	7.87	0.47	44.2	38.1		5.5	26.3	34.0		
Nickel cleaner tail No.2	1.79	0.40	1.75	24.78					3.7	13.7			
" " " No.1	5.80	0.35	0.85	51.04					10.6	21.6			
Final tailing	89.11	0.035	0.075						16.3	29.3			
Feed (calcd)	100.00	0.19	0.23						100.0	100.0			
1st Stage Cu cl conc ***	0.73	13.78	1.52	19.93					52.4	4.9			
Copper rougher conc	1.78	6.89	1.16	42.66					63.9	9.1			
1st Stage Ni cl conc	3.31	0.54	2.76	17.01					9.2	40.0			
Nickel rougher conc	9.11	0.42	1.54	38.67					19.8	61.6			
Cu ro + Ni ro conc	10.89	1.48	1.48	39.33					83.7	70.7			

REMARKS: Screen analysis of final tailing, 94.2% minus 200 mesh
* with ceramic pebbles
** before addition of reagents.
*** all intermediate products calculated

MINES BRANCH FLOTATION TEST REPORT

TEST NO. 9	SAMPLE: Long Lac Mineral Exploration Ltd.	DATE: April 22, 1969
OBJECT OF TEST: To try 0.2 lb/ton Orzan A as talc depressant		CHARGE: 3000 g
		TESTED BY: A.S.

OPERATION	Time min	% Solids	pH	Unit used	Reagents, lb per ton									
					SA	Orz A	$CuSO_4$	Z-6	DF250					
Grinding	30	65		7 x 14 RM	2.0									
Conditioning				2000-g cell										
No. 1	5		6.9			0.2								
No. 2	5						0.2							
Bulk rougher				2000-g cell										
Stage 1	1							0.033	0.027					
" 2	1							0.033						
" 3	2							0.033	0.013					
Bulk cleaners														
No. 1	1			500-g cell					0.007					
No. 2	1			250-g cell					0.003					

PRODUCT	WT %	ANALYSIS %							DISTRIBUTION %				
		Cu	Ni	Insol					Cu	Ni			
Bulk cleaner conc	4.78	2.50	2.00	9.93					72.5	37.5			
Combined bulk cl tail	1.64	1.05	1.15	51.08					10.4	7.4			
Final tailing	93.58	0.03	0.15						17.1	55.1			
Feed (calcd)	100.00	0.16	0.25						100.0	100.0			
Bulk rougher conc (calcd)	6.42	2.13	1.78	20.44					82.9	44.9			

REMARKS: Clean and bright froth in cleaners.

MINES BRANCH FLOTATION TEST REPORT

TEST NO. 10	SAMPLE: Long Lac Mineral Exploration Ltd.	DATE: April 22, 1969
OBJECT OF TEST:	To try 0.4 lb/ton Orzan A as talc depressant	CHARGE: 3000 g
		TESTED BY: A.S.

OPERATION	Time min	% Solids	pH	Unit used	Reagents, lb per ton									
					SA	Orz A	$CuSO_4$							
Grinding	30	65		7 x 14 RM	2.0									
Conditioning				2000-g cell										
No. 1	5		6.9			0.4								
No. 2	5						0.2							
Bulk rougher } as in														
Bulk cleaners } Test 9														

PRODUCT	WT %	ANALYSIS %							DISTRIBUTION %				
		Cu	Ni	Insol					Cu	Ni			
Bulk cleaner conc	4.41	2.65	2.10	9.47					67.3	43.8			
Combined bulk cl tail	1.92	1.25	1.30	45.23					13.8	11.8			
Final tailing	93.67	0.035	0.10						18.9	44.4			
Feed (calcd)	100.00	0.17	0.21						100.0	100.0			
Bulk rougher conc (calcd)	6.33	2.23	1.86	20.23					81.1	55.6			

REMARKS: Froth appeared to be cleaner than that obtained in Test 9.

MINES BRANCH FLOTATION TEST REPORT

TEST NO. 11	SAMPLE: Long Lac Mineral Exploration Ltd.	DATE: Apr. 22, 1969
OBJECT OF TEST: Comparison for Tests 9 and 10 - no Orzan A added		CHARGE: 3000 g
		TESTED BY: A.S.

OPERATION	Time min	% Solids	pH	Unit used	Reagents, lb per ton									
					SA	$CuSO_4$								
Grinding	30	65		7 x 14 RM	2.0									
Conditioning				2000-g cell										
No. 1	5		6.9											
No. 2	5					0.2								
Bulk rougher (as in Test 9)														
Bulk cleaners (as in Test 9)														

PRODUCT	WT %	ANALYSIS %							DISTRIBUTION %				
		Cu	Ni	Insol					Cu	Ni			
Bulk cleaner conc	4.13	2.55	2.00	9.75					64.9	32.2			
Combined bulk cl tail	2.63	1.10	1.30	42.08					17.8	13.3			
Final tailing	93.24	0.03	0.15						17.3	54.5			
Feed (calcd)	100.00	0.16	0.26						100.0	100.0			
Bulk rougher conc (calcd)	6.76	1.99	1.73	22.33					82.7	45.5			

REMARKS:
Fairly clean float despite absence of slime depressant.

MINES BRANCH FLOTATION TEST REPORT

TEST NO. 12	SAMPLE: Long Lac Mineral Exploration Ltd.	DATE: April 23, 1969
OBJECT OF TEST: To try magnetic separation on reground bulk cleaner conc		CHARGE: 2 x 3000 g
		TESTED BY: A.S.

OPERATION	Time min	% Solids	pH	Unit used	Reagents, lb per ton									
						Orz A								
Grinding as in														
Bulk rougher Test 10														
Bulk cleaner														
Bulk cl conc regrinding	15	50		**		0.2*								
Magnetic separation				***										

PRODUCT	WT %	ANALYSIS %							DISTRIBUTION %				
		Cu	Ni	Insol	Co	Fe	S		Cu	Ni	Co		
Non-magnetics	3.00	4.00	2.80	13.37	0.29	40.2	32.4		69.1	32.2	41.4		
Magnetics	1.76	0.25	0.90	4.35	0.026	55.4	34.5		2.5	6.1	2.2		
Combined bulk cl tail	1.79	1.05	1.15	52.24	0.076	22.8	12.7		10.8	7.9	6.5		
Final tailing	93.45	0.033	0.15						17.6	53.8			
Feed (calcd)	100.00	0.17	0.26						100.0	100.0			
Bulk cleaner conc (calcd)	4.76	2.61	2.10	10.04					71.6	38.3			
Bulk rougher conc (calcd)	6.55	2.19	1.84	21.57					82.4	46.2			

REMARKS: Two 3000g batches were ground and floated separately - cleaner concentrates were combined for regrinding and magnetic separation.

*Added to disperse slimes

**8-in.-dia Abbé porcelain mill with steel ball charge

***12-in. Sala drum separator.

MINES BRANCH FLOTATION TEST REPORT

TEST NO. 13	SAMPLE: Long Lac Mineral Exploration Ltd.	DATE: April 30, 1969
OBJECT OF TEST:	To try copper-nickel separation on bulk cleaner conc followed by magnetic separation of nickel conc	CHARGE: 2 x 3000 g
		TESTED BY: A.S.

OPERATION	Time min	% Solids	pH	Unit used	Reagents, lb per ton									
					Lime	DF250								
Grinding } as in														
Bulk rougher } Test 10														
Bulk cleaners														
Bulk cl conc regrinding	15	50		*	0.66									
Copper-nickel separation				500-g cell										
Stage 1	1		11.8		0.80	.0013								
" 2	1					.0006								
Copper cleaners														
No. 1	1 1/2		11.8	250-g cell	0.40	.0006								
No. 2	1 1/2		11.9	" " "	0.40	.0006								
Magnetic Separation				12-in. Sala										

PRODUCT	WT %	ANALYSIS %							DISTRIBUTION %				
		Cu	Ni	Insol	Co	Fe	S		Cu	Ni	Co		
Copper conc	0.37	20.50	1.30	5.50	0.13	32.7	35.0		44.4	1.8	2.3		
Copper cleaner tail No. 2	0.25	4.75	3.05	7.36					7.0	2.9			
" " " No. 1	0.53	2.00	3.25	7.85					6.2	6.6			
Non-mags (nickel conc)	1.95	1.00	2.85	15.72	0.30	42.3	30.7		11.4	21.3	27.9		
Magnetics	1.61	0.20	0.90	5.05	0.029	57.2	34.6		1.9	5.6	2.2		
Combined bulk cl tail	1.85	1.05	1.15	52.25					11.4	8.2			
Final tailing	93.44	0.033	0.15						17.7	53.6			
Feed (calcd)	100.00	0.17	0.26						100.0	100.0			
Separation tailing **	3.56	0.64	1.97	10.90					13.3	26.9			

REMARKS: Two 3000-g batches were ground and floated separately - cleaner concentrates were combined for regrinding and copper-nickel separation. Before regrinding, the concentrates were filtered and repulped with fresh water.

* 8-in.-dia. Abbé porcelain mill with steel ball charge.

** Nickel conc before magnetic separation.

MINES BRANCH FLOTATION TEST REPORT

TEST NO. 14	SAMPLE: Long Lac Mineral Exploration Ltd.	DATE: May 1, 1969
OBJECT OF TEST:	Bulk rougher float similar to Test 11 but using a finer grind along with a 100% increase in promoter addition.	CHARGE: 3000 g
		TESTED BY: A.S.

OPERATION	Time min	% Solids	pH	Unit used	Reagents, lb per ton									
					SA	$CuSO_4$	Z-6	DF250						
Grinding	60	65		7 x 14 RM	2.0									
Conditioning				2000-g cell										
No. 1	5		6.9											
No. 2	5					0.2								
Bulk rougher														
Stage 1	1						0.066	0.027						
" 2	1						0.066							
" 3	2						0.066	0.013						
Bulk cleaners														
No. 1	1			500-g cell				0.007						
No. 2	1			250-g cell				0.003						

PRODUCT	WT %	ANALYSIS %							DISTRIBUTION %				
		Cu	Ni	Insol					Cu	Ni			
Bulk cleaner conc	4.35	2.55	2.20	8.94					67.5	43.2			
Combined bulk cl tail	2.85	0.90	1.15	46.17					15.6	14.8			
Final tailing	92.80	0.03	0.10						16.9	42.0			
Feed (calcd)	100.00	0.16	0.22						100.0	100.0			
Bulk rougher conc (calcd)	7.20	1.90	1.78	23.68					83.1	58.0			

REMARKS: Screen analysis of final tailing, 84.6% minus 200 mesh vs 64.4 % minus 200 mesh for 30-min grind in Test 11.

MINES BRANCH FLOTATION TEST REPORT

TEST NO. 15	SAMPLE: Long Lac Mineral Exploration Ltd.	DATE: May 1, 1969
OBJECT OF TEST:	Repeat of Test 14 but with 0.4 lb/ton Orzan A added as talc depressant	CHARGE: 3000 g
		TESTED BY: A.S.

OPERATION	Time min	% Solids	pH	Unit used	Reagents, lb per ton									
					SA	Orz A	$CuSO_4$							
Grinding	60	65		7 x 14 RM	2.0									
Conditioning														
No. 1						0.4								
No. 2							0.2							
Bulk rougher } as in														
Bulk cleaners } Test 14														

PRODUCT	WT %	ANALYSIS %							DISTRIBUTION %				
		Cu	Ni	Insol					Cu	Ni			
Bulk cleaner conc	4.77	2.20	2.05	9.62					62.9	43.6			
Combined bulk cl tail	2.96	1.00	1.15	46.50					17.7	15.2			
Final tailing	92.27	0.035	0.10						19.4	41.2			
Feed (calcd)	100.00	0.17	0.22						100.0	100.0			
Bulk rougher conc (calcd)	7.73	1.74	1.71	23.74					80.6	58.8			

REMARKS:

MINES BRANCH FLOTATION TEST REPORT

TEST NO. 16	SAMPLE: Long Lac Mineral Exploration Ltd.	DATE: May 27, 1969
OBJECT OF TEST: To try bulk flotation at a coarse grind along with caustic starch as a talc depressant		CHARGE: 3000 g
		TESTED BY: A.S.

OPERATION	Time min	% Solids	pH	Unit used	Reagents, lb per ton									
					SA	CS	$CuSO_4$	Z-6	DF250					
Grinding	10	65		7 x 14 RM	1.0									
Conditioning				2000-g cell										
No. 1	5		7.1			1.0								
No. 2	5						0.5							
Bulk roughers														
Stage 1	1							0.033	0.027					
" 2	1							0.033						
" 3	2							0.066						
Bulk cleaners														
No. 1	1			500-g cell					0.013					
No. 2	1			" " "					0.003					

PRODUCT	WT %	ANALYSIS %							DISTRIBUTION %					
		Cu	Ni	Insol					Cu	Ni				
Bulk cleaner conc	3.67	3.30	1.95	10.82					67.0	25.4				
Combined bulk cl tail	2.94	0.60	0.80	56.35					9.7	8.3				
Final tailing	93.39	0.045	0.20						23.3	66.3				
Feed (calcd)	100.00	0.18	0.28						100.0	100.0				
Bulk rougher conc (calcd)	6.61	2.10	1.44	31.07					76.7	33.7				

REMARKS: Screen analysis of final tailing, 49.0% minus 200 mesh.

MINES BRANCH FLOTATION TEST REPORT

TEST NO. 17	SAMPLE: Long Lac Mineral Exploration Ltd.	DATE: May 27/69
OBJECT OF TEST: Repeat of Test 16 but grinding time increased from 10 to 30 min.		CHARGE: 3000 g
		TESTED BY: A.S.

OPERATION	Time min	% Solids	pH	Unit used	Reagents, lb per ton SA									
Grinding	30	65		7 x 14 RM	1.0									
Conditioning } as in														
Bulk rougher } Test 16														
Bulk cleaners }														

PRODUCT	WT %	ANALYSIS % Cu	Ni	Insol					DISTRIBUTION % Cu	Ni			
Bulk cleaner conc	4.44	2.80	2.10	9.46					68.7	44.6			
Combined bulk cl tail	2.14	0.90	1.05	50.67					10.7	10.8			
Final tailing	93.42	0.04	0.10						20.6	44.6			
Feed (calcd)	100.00	0.18	0.21						100.0	100.0			
Bulk rougher conc (calcd)	6.58	2.18	1.76	22.86					79.4	55.4			

REMARKS: Screen analysis of final tailing, 63.9% minus 200 mesh

MINES BRANCH FLOTATION TEST REPORT

TEST NO. 18	SAMPLE: Long Lac Mineral Exploration Ltd.	DATE: May 27, 1969
OBJECT OF TEST:	Repeat of Test 16 but grinding time increased from 10 to 60 min.	CHARGE: 3000 g
		TESTED BY: A.S.

OPERATION	Time min	% Solids	pH	Unit used	Reagents, lb per ton SA									
Grinding	60	65		7 x 14 RM	1.0									
Conditioning } as in														
Bulk rougher } Test 16														
Bulk cleaners }														

PRODUCT	WT %	ANALYSIS % Cu	Ni	Insol					DISTRIBUTION % Cu	Ni			
Bulk cleaner conc	4.20	2.85	2.25	10.80					69.2	44.3			
Combined bulk cl tail	2.57	0.80	1.00	49.22					11.9	12.0			
Final tailing	93.23	0.035	0.10						18.9	43.7			
Feed (calcd)	100.00	0.17	0.21						100.0	100.0			
Bulk rougher conc (calcd)	6.77	2.07	1.78	25.39					81.1	56.3			

REMARKS: Screen analysis of final tailing, 84.7% minus 200 mesh.

APPENDIX C

MINERAL SCIENCES DIVISION

Mineralogy Section

INTERNAL REPORT MS 69-44

Title: A Mineralogical Examination of a Copper-Nickel Bulk Concentrate for Long Lac Mineral Exploration Ltd.

Sample: A sample of the ore was received from Mr. A. Stemerowicz of the Mineral Processing Division on May 28, 1969.

The sample consisted of a concentrate* which had been floated from low-grade percussion-drill cuttings (0.18% Cu, 0.25% Ni) from the Long Lac copper-nickel prospect near Emo, in Dobie Twp., Rainy River District, Ontario.

Purpose: To identify the copper and nickel minerals and to determine the degree of association between the nickel minerals and the pyrrhotite.

Results: The minerals identified in the sample are chalcopyrite, pentlandite, $(Fe, Ni)_9S_8$, Violarite, (Ni_2FeS_4) nickeliferous pyrrhotite, pyrite, galena and magnetite. Electron probe analysis of the pyrrhotite gave 0.4% Ni. The violarite was identified by X-ray diffraction and the composition checked with the electron probe.

Pyrrhotite is the most abundant of the metallic minerals, followed by chalcopyrite, pyrite, pentlandite and violarite. Galena, magnetite and gangue occur in minor amounts.

The concentrate contains grains of different size with the larger grains (40 microns) of pyrrhotite containing inclusions of pentlandite, violarite and chalcopyrite, which range from 3-10 microns. Due to the fine-grained nature of the sample, it is impossible to determine the degree of association of the nickel minerals with the pyrrhotite.

Conclusions: Nickeliferous pyrrhotite, pentlandite and violarite are the nickel-bearing minerals in the concentrate. Chalcopyrite is the only copper mineral. Pyrrhotite is the most abundant sulphide in the sample. The small nickel-bearing inclusions in the pyrrhotite and the significant nickel content of the pyrrhotite itself suggest that it will probably be difficult to concentrate the nickel effectively.

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*Bulk cleaner conc Test 10, Cu 2.65%, Ni 2.10%, Insol 9.47%.

APPENDIX D

SUMMARY OF PREVIOUS INVESTIGATIONS

Two previous investigations have been carried out on samples from the same deposit, Investigation No. MD3174 (January 23, 1957) and Investigation No. MD3201 (June 24, 1957).

Investigation No. MD3174

Head Sample Analysis

Copper	-	0.28 %
Nickel	-	0.24 "
Cobalt	-	0.012"
Iron	-	5.00 "
Sulphur	-	2.40 "
Insolubles	-	83.26

Mineralogy

Metallic mineralization is not very prevalent in this sample and is represented by pyrrhotite, chalcopyrite, magnetite, pyrite and pentlandite, named in approximate order of decreasing abundance. In general ore minerals are largely liberated but are associated in places. This is particularly true of pentlandite, all of which, in the sections examined is associated with pyrrhotite as comparatively tiny particles.

The gangue consists largely of pyroxene and plagioclase with some quartz.

Bulk Flotation

Although no mention of it was made in the mineralogical report, talc was evident in the froth and its presence constituted one of the main problems in flotation.

At a grind of 62% minus 200 mesh the following results were obtained:

Product	Wt %	Assays % Cu	Ni	Insol	Distribution % Cu	Ni
Bulk rougher conc	4.1	5.58	3.76	46.9	82.6	76.5
Scavenger conc	6.1	0.34	0.47	40.2	7.6	14.5
Tailing	89.8	0.03	0.02		9.8	9.0
Feed (calcd)	100.0	0.27	0.20		100.0	100.0

Note the very high insoluble content in the concentrates despite the addition of Guar as talc depressant.

When both bulk and scavenger concentrates were cleaned at an acid pH with sulphur dioxide the insoluble content was lowered to give a substantial improvement in concentrate grades. Results of a test using this scheme were as follows:

Product	Wt %	Assays % Cu	Ni	Insol	Distribution % Cu	Ni
Bulk cleaner conc	1.7	11.50	7.73	13.2	75.1	72.5
Bulk cleaner tail	1.5	0.80	0.83	74.6	4.6	7.0
Scav cleaner conc	1.2	0.59	0.66	12.0	2.7	4.3
Scav cleaner tail	2.5	0.32	0.27	71.6	3.1	3.8
Magnetics	1.7	0.09	0.26	54.4	0.6	2.4
Tailing	91.4	0.04	0.02		13.9	10.0
Feed (calcd)	100.0	0.26	0.18		100.0	100.0

In this test the flotation tailing was run through a magnetic separator to recover the remaining pyrrhotite.

Copper-Nickel Separation of Bulk Concentrate

Only one copper-nickel separation test was reported with the following results:

Product	Wt %	Assays %					Distribution %	
		Cu	Ni	Fe	S	Insol	Cu	Ni
Magnetics	4.2	0.28	0.86	46.3	26.5	18.8	4.0	16.0
Copper conc	0.6	26.10	1.98	25.1	25.8	15.4	49.9	4.9
Copper cl tail	0.5	7.12	3.24	15.1	14.4	50.4	11.2	6.6
Nickel conc	2.7	1.72	4.62	26.5	21.5	37.4	16.1	56.2
Tailing	92.0	0.06	0.04	1.9	0.57		18.8	16.3
Feed (calcd)	100.0	0.29	0.23	4.62	2.43		100.0	100.0

The magnetics were obtained by feeding the ground ore to a magnetic separator prior to bulk flotation.

Investigation No. MD 3101

Head Sample Analyses

The samples investigated were of higher-grade material occurring in No. 1 and 2 zones and were obtained from two of the pits existing at that time.

Two shipments were received with the following analysis:

	No. 3 (14 tons)	No. 4 (245 lb)
Copper	0.55 %	0.72 %
Nickel	1.23 "	0.98 "
Cobalt	0.078"	-
Iron	20.80 "	19.44 "
Sulphur	12.90 "	13.00 "
Insolubles	55.80 "	52.60 "

Mineralogy

Examination of No. 4 sample showed that metallic mineralization consisted mostly of pyrrhotite and chalcopyrite. Violarite was the chief nickel mineral and occurred always associated with pyrrhotite and/or chalcopyrite. Some pentlandite was present as occasional to rare small particles associated with pyrrhotite.

Gangue was found to consist of a medium coarse-grained intergrowth of hypersthene and other pyroxenes along with a little finely disseminated talc.

Bulk Flotation

On the No. 3 sample lab batch flotation of successive bulk concentrates at a grind of 57% minus 200 mesh gave the following results:

Product	Wt %	Assays %			Distribution %	
		Cu	Ni	Insol	Cu	Ni
Bulk conc No. 1	14.6	3.53	3.86	11.0	86.2	55.6
" " No. 2	9.4	0.30	2.15	5.0	4.7	19.9
" " No. 3	8.8	0.16	1.37	6.4	2.4	11.9
Tailing	67.2	0.06	0.19		6.7	12.6
Feed (calcd)	100.0	0.60	1.01		100.0	100.0
Bulk conc No. 1+2 (calcd)	24.0	2.26	3.19	8.6	90.9	75.5
" " No. 1+2+3 (calcd)	32.8	1.71	2.69	8.1	93.3	87.4

The above results were confirmed in a 4-day pilot-plant investigation carried out on the No. 3 sample at a feed rate of 625 lb/hour.

On the No. 4 sample lab flotation of successive bulk concentrates gave individual concentrates that were higher grade than those obtained from No. 3 sample but the end result was the same, i.e. grades and recoveries for combined concentrates were similar (2.00% copper, 2.15% nickel with copper and nickel recoveries of 91.9% and 85.2% respectively).

Copper-Nickel Separation of Bulk Concentrate

Copper-nickel separation was tried in the pilot plant on No. 3 sample but satisfactory grades of copper and nickel concentrates could not be produced. However, on sample No. 4 which had been submitted specifically for further work on copper-nickel separation the following results were achieved in a batch test:

Product	Wt %	Assays %			Distribution %	
		Cu	Ni	Insol	Cu	Ni
Copper conc	1.6	27.40	0.51	4.6	64.9	0.8
Copper cl tail	0.3	8.41	1.57	31.5	3.3	0.4
Separation tail	5.1	1.76	3.86	16.3	12.9	19.0
Scav conc	19.6	0.44	3.10	5.3	12.5	59.1
Tailing	73.4	0.06	0.29		6.4	20.7
Feed (calcd)	100.0	0.69	1.03		100.0	100.0
Final nickel conc*	24.7	0.71	3.26	7.5	25.4	78.1

*Separation tailing + scavenger concentrate.