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CANADA

DEPARTMENT OF MINES AND TECHNICAL SURVEYS

OTTAWA

MINES BRANCH INVESTIGATION REPORT IR 66-62

PILOT PLANT INVESTIGATION OF NICKEL-COPPER ORE FROM THE STRATHCONA PROPERTY OF FALCONBRIDGE NICKEL MINES LIMITED, FALCONBRIDGE, ONTARIO

by

A. STEMEROWICZ

MINERAL PROCESSING DIVISION

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SUMMARY OF RESULTS

Typical hexagonal pyrrhotite concentrate produced in the pilot plant from the Strathcona contact ore by a combination of flotation and magnetic separation assayed 0.10% copper, 1.14% nickel and 31.15% sulphur. A quantity of this material was produced and shipped to Falconbridge for further process studies.

The best results obtained by the two processing methods investigated were on feed composed of 1/3 contact ore and 2/3 footwall ore and are given below:

	**Combined Concentrates			
	Assays - %		Recoveries - %	
	Cu	Ni	Cu	Ni
All flotation (Flowsheet No. 2)	3.54	10.08	96.6	82.8
Flotation-magnetic separation (Flowsheet No. 3)	3.20	8.70	94.0	77.1

**Copper-nickel rougher concentrate and cleaner scavenger concentrates.

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In the all flotation scheme the ore was ground to about 65% -250 mesh and a high grade copper-nickel concentrate was floated off with small amounts of xanthate. Larger amounts of xanthate were then added and a nickel scavenger concentrate was floated, reground to about 95% -325 mesh and cleaned once by flotation. In the flotation-magnetic separation scheme the same grinding and flotation procedure was employed but the nickel scavenger concentrate was run through a magnetic separator. The magnetics were reground to about 95% -325 mesh and cleaned once by flotation while the non-magnetics were cleaned once without prior regrinding.

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INTRODUCTION

Location of Property

The Strathcona mine is located in Levack Township on the north-west rim of the Sudbury Basin. It is owned by Falconbridge Nickel Mines Limited, Falconbridge, Ontario.

Shipment

A total of 144 tons of ore was shipped from the mine by truckload lot as required during the course of the investigation. Two types of ore were received: high sulphide contact ore and low sulphide footwall ore.

Purpose of Investigation

In a letter dated October 1, 1964, from Mr. W. L. W. Taylor, Asst. Manager-Technical Services, Falconbridge Nickel Mines Limited, the use of the Mines Branch pilot plant was requested for the purpose of producing a low magnetic susceptibility (hexagonal) pyrrhotite concentrate from the Strathcona ore.

In a subsequent communication dated October 21, 1964 from Mr. M. P. Sudbury, Senior Research Metallurgist, Falconbridge Nickel Mines Limited, it was stated that 1500 lbs of hexagonal pyrrhotite concentrate was required and it was to be produced from the Strathcona contact ore using a flowsheet which employed a combination of flotation and magnetic separation. The concentrate was to be shipped to the Falconbridge laboratories for upgrading studies and roasting tests. On the basis of lab batch tests done on similar feed, the concentrate was expected to assay 6 - 10% SiO_2, 1 - 2% Ni, 0.1 - 0.5% Cu, 50 - 55% Fe and 30 - 34% S.

When a sufficient amount of hexagonal pyrrhotite concentrate was produced, the further use of the pilot plant was requested to investigate two proposed methods for processing the Strathcona ore:

(1) An all flotation scheme to produce a copper-nickel rougher concentrate which when combined would make a suitable feed for the Falconbridge smelter.

(2) A scheme in which the same end product was produced but which utilized a combination of flotation and magnetic separation.

Initially, preliminary testing of the all flotation scheme was to be done on contact and footwall ores and then the two proposed schemes were to be investigated on feed composed of 2 parts footwall ore to 1 part contact ore which corresponds to the projected mining rate.

No firm specifications were given with regard to acceptable ranges of grades and recoveries for the smelter feed product but it was stated verbally that this product should assay at least 8% nickel with as high a nickel recovery as possible, preferably over 80%.

Ore Characteristics and Analysis

Since the mineralogy of the ore had been studied in detail, no request was made for a mineralogical investigation at the Mines Branch. It was stated that the Strathcona ore differed from the other Sudbury area nickel-copper ores being mined by Falconbridge in that it contained a high proportion of non-magnetic, hexagonal pyrrhotite in addition to the common magnetic or monoclinic variety of pyrrhotite.

TABLE 1

Head Sample Analysis

Ore Type	*Assays - %		
	Cu	Ni	S
Contact	0.37	1.37	20.4
Footwall	0.64	1.24	11.7
Composite - 2/3 footwall, 1/3 contact No. 1	0.45	1.20	14.7
" " " No. 2	0.58	1.41	16.0
" " " No. 3	0.58	1.37	16.0
" " " No. 4	0.49	1.57	18.5

*Falconbridge analysis - Averages of all Test Runs.

General Procedure

The flowsheets investigated in the pilot plant were based on lab test work carried out in the laboratories of Falconbridge Nickel Mines Ltd. and Lakefield Research Ltd. The investigation was directed and conducted by members of the Falconbridge staff. Mr. M. P. Sudbury was in charge of the investigation except for the period when the flotation-magnetic separation scheme was tried, at which time Mr. F. Pickard took charge. Mr. A. C. T. Bigg conducted the daily test runs during the entire investigation.

He was assisted by Messrs. McCarthy and Wyslouzil of Lakefield Research Ltd. in late November and early December 1964 when the Lakefield reagent scheme was being used.

The ore which was received as run-of-mine material was stage crushed to -3/8 inches to provide suitable feed for the ball mill. No head samples were cut from the crushed material. Instead, the flotation feed sample from each pilot plant test run served as the head sample for metallurgical balance calculations.

Test runs were generally from 6 to 7 hours duration with a 2 to 4 hour sampling period at the end of the run when conditions had stabilized.

As a control on product grades, approximate weights of certain key products were calculated hourly from a measurement of pulp flow and density and adjustments were made accordingly.

Assays of those pilot plant samples required to calculate metallurgical balances were done by Mines Branch personnel on an overtime basis following the completion of the test run. Splits of these samples were sent to Falconbridge for check analysis along with other special samples taken during the test run. Small unpulverized samples of certain products were also prepared daily and sent to Falconbridge for the purpose of making polished sections for mineralogical studies.

All high grade copper-nickel concentrates produced during the investigation were stored, filtered and shipped to the Falconbridge smelter.

DETAILS OF INVESTIGATION

Description of Flowsheets

The three flowsheets employed in this investigation differed only in the method of treating the nickel scavenger concentrates. The basic treatment of the ore was the same in all cases and was as follows:

(1) The ore was ground to about 65% -200 mesh in a single stage closed grinding circuit.

(2) A high grade copper-nickel rougher concentrate was floated with starvation amounts of amyl xanthate and frother. About 90% of the copper and 50 to 60% of the nickel was recovered in this concentrate.

(3) To recover the balance of the nickel, which was more or less closely associated with pyrrhotite, larger amounts of xanthate were added to the rougher tailing and a nickel scavenger concentrate was floated. In some tests copper sulphate was also added to the rougher tailing.

In Flowsheet 1 (Figure 1, page 5) which was used for the production of hexagonal pyrrhotite concentrate, the nickel scavenger concentrate was fed to a magnetic separator. The magnetics which were composed of the magnetic or monoclinic variety of pyrrhotite were given no further treatment while the non-magnetics which contained the non-magnetic hexagonal pyrrhotite were upgraded by one stage of cleaner flotation to produce the hexagonal pyrrhotite concentrate.

In Flowsheet 2 (Figure 2, page 7) the nickel scavenger concentrate was reground to about 95% -325 mesh and upgraded by one stage of cleaner flotation. The copper-nickel rougher concentrate and the cleaned nickel scavenger concentrate would then be combined for shipment to the smelter.

Flowsheet 3 (Figure 3, page 9) employed magnetic separation to separate the nickel scavenger concentrate into magnetic and non-magnetic fractions. Both magnetics and non-magnetics were upgraded in separate circuits by one stage of cleaner flotation. The magnetics were reground to about 95% -325 mesh before cleaning while the non-magnetics were cleaned without prior regrinding. The cleaned magnetics and non-magnetics would then be combined with the copper-nickel rougher concentrate to make up the smelter feed product.

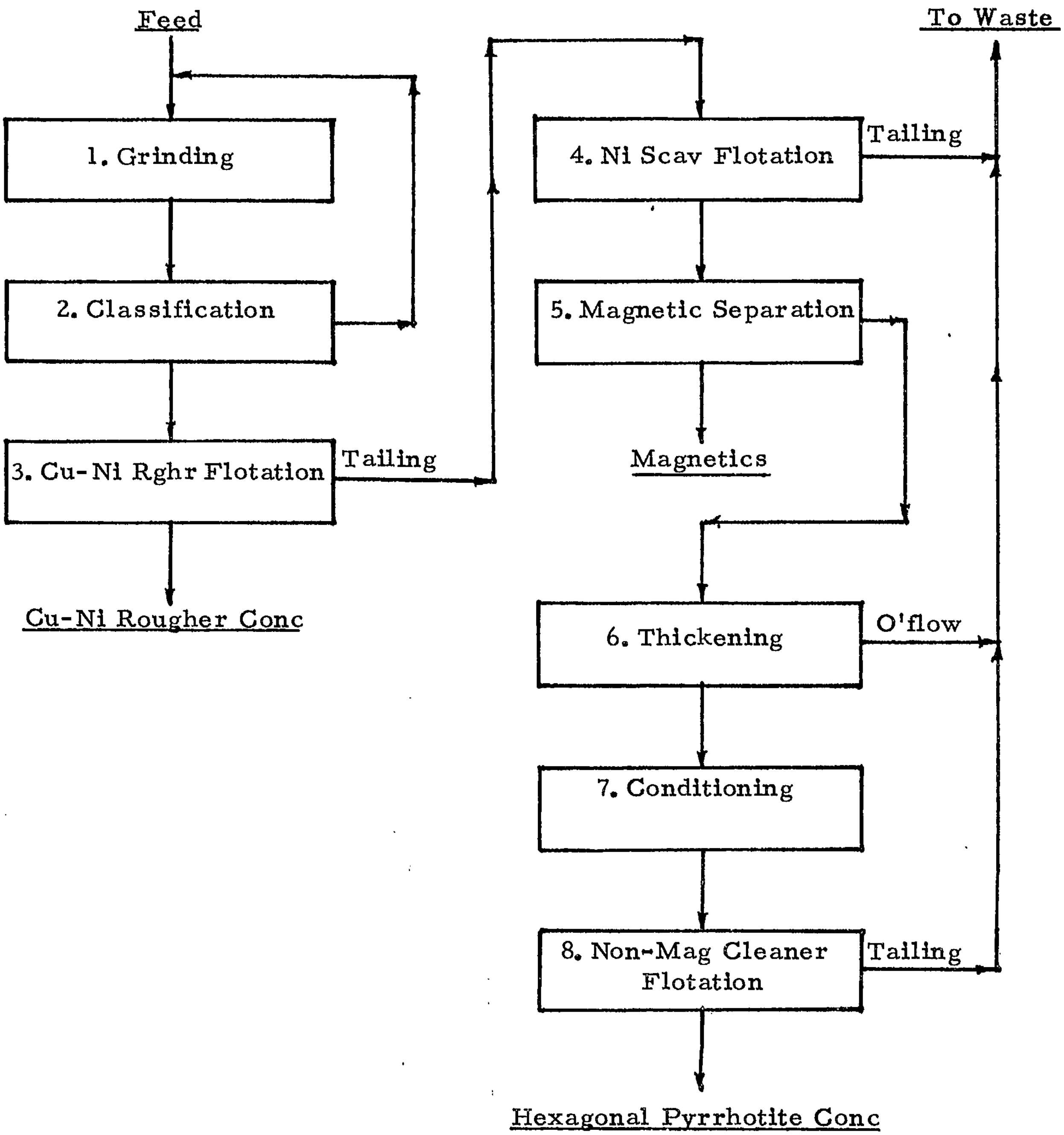

Figure 1. Flowsheet No. 1

Flowsheet No. 1

Equipment Used

1. Primary Grinding.	30" x 48" Denver ball mill.
2. Primary Classification:	30" dia. Sweco vibrating screen fitted with 60 mesh screen cloth.
3. Cu-Ni Rougher Flotation:	4 to 6 No. 7 Denver flotation cells.
4. Nickel Scavenger Flotation:	18 No. 7 Denver flotation cells with cells No. 1 and 6 acting as conditioners.
5. Magnetic Separation:	Dings magnetic drum separator -30" x 12"- 1 drum.
6. Thickening:	4' dia. conc thickener.
7. Conditioning:	18" x 24" Denver conditioner.
8. Non-magnetic Cleaner Flotation:	6 No. 5 Denver flotation cells.

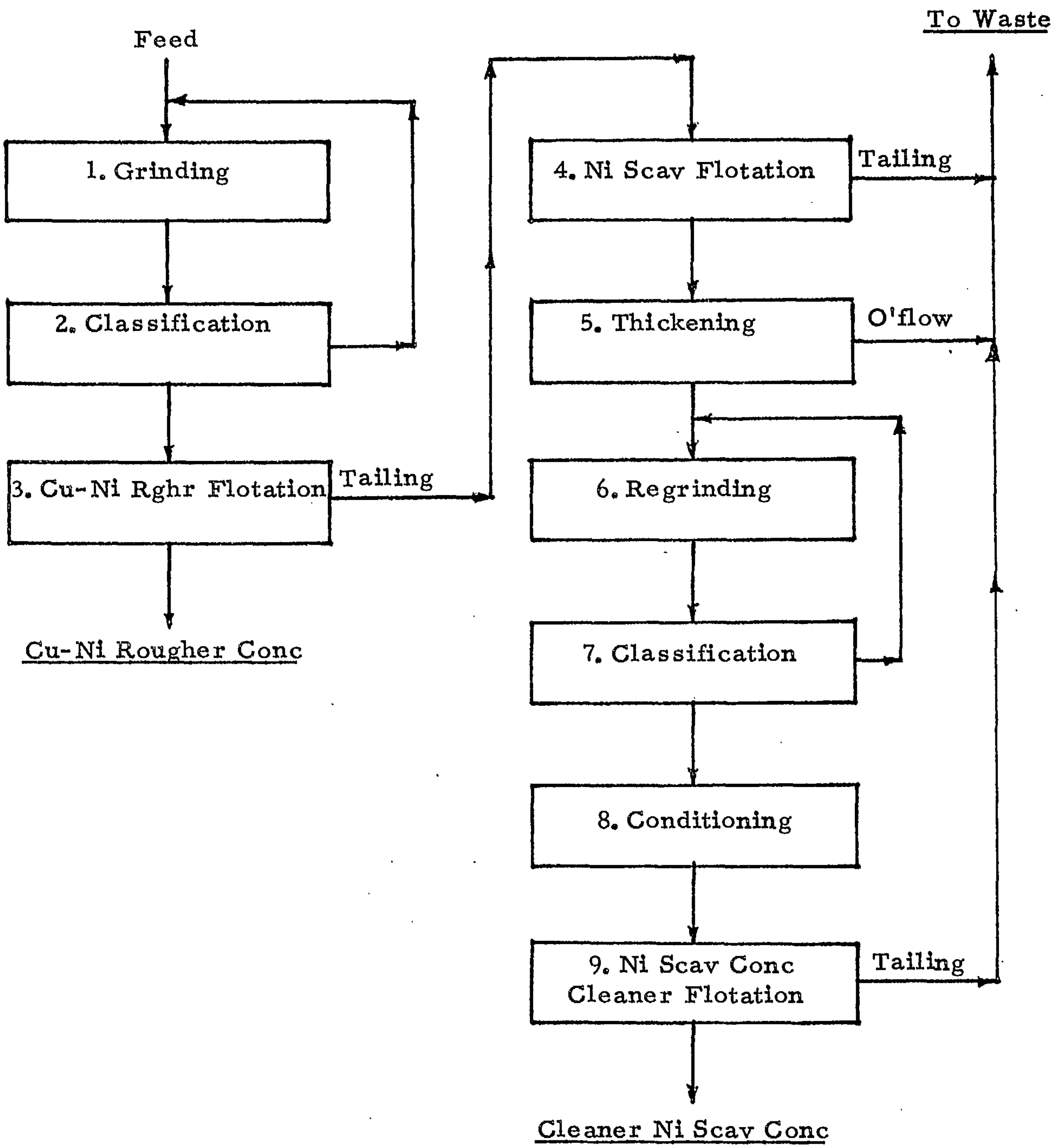

Figure 2. Flowsheet No. 2

Flowsheet No. 2

Equipment Used

1. Primary Grinding:	30" x 48" Denver ball mill.
2. Primary Classification:	30" dia. Sweco vibrating screen with 60 mesh screen cloth.
3. Cu-Ni Rougher Flotation:	1 to 5 No. 7 Denver flotation cells plus 1 cell acting as a conditioner.
4. Nickel Scavenger Flotation:	9 to 15 No. 7 Denver Flotation cells plus extra cells acting as conditioners when adding copper sulphate.
5. Thickening:	4' dia. conc thickener.
6. Regrinding:	2 ball mills - an 8" x 24" Hardinge conical mill connected in series with a Denver 20" x 30" ball mill.
7. Conditioning:	18" x 24" Denver conditioner.
8. Regrind Classification:	20" x 32" Hummer vibrating screen fitted with a 200 mesh screen cloth.
9. Nickel Scavenger Conc Cleaner Flotation:	4 to 10 No. 5 Denver flotation Cells.

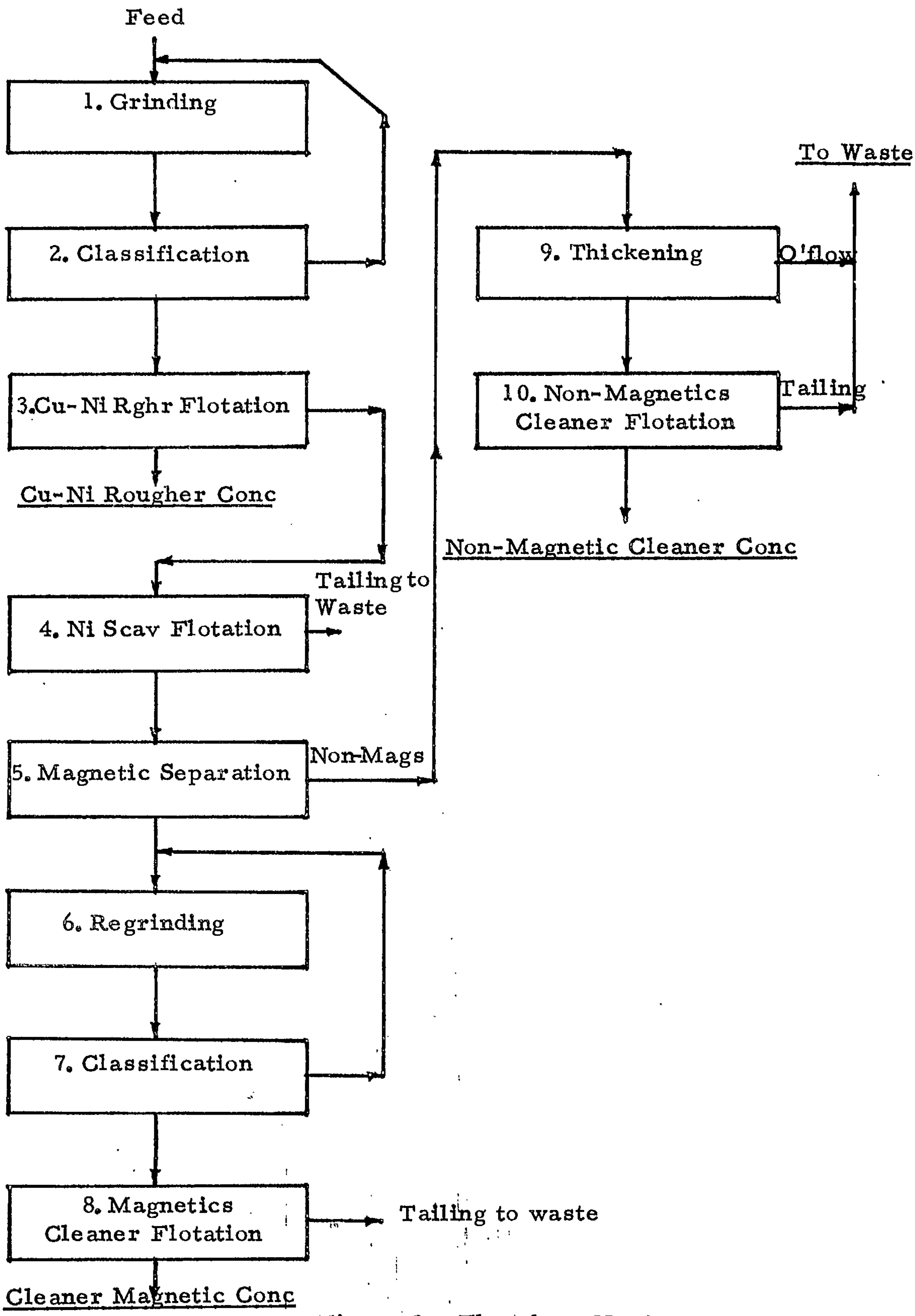

Figure 3. Flowsheet No. 3

Flowsheet No. 3

Equipment Used

1. Primary Grinding:	30" x 48" Denver ball mill.
2. Primary Classification:	30" dia. Sweco vibrating screen fitted with 60 mesh screen cloth.
3. Cu-Ni Rougher Flotation:	2 or 3 No. 7 Denver flotation cells plus 1 cell acting as a conditioner.
4. Nickel Scavenger Flotation:	15 or 16 No. 7 Denver flotation cells plus extra cells acting as conditioners when adding copper sulphate.
5. Magnetic Separation:	12" Crockett belt separator.
6. Regrinding:	2 ball mills - an 8" x 24" Hardinge conical mill connected in series with a Denver 20" x 30" ball mill.
7. Regrind Classification:	20" x 32" Hummer vibrating screen fitted with a 200 mesh screen cloth.
8. Magnetics Cleaner Flotation:	6 No. 5 Denver flotation cells.
9. Thickening:	4" dia. conc thickener.
10. Non-Magnetics Cleaner Flotation:	6 No. 5 Denver flotation cells.

Grinding and Classification

The pilot plant was first started up with a 14 x 8 in. Dorr rake classifier in closed circuit with a 30x48 in. ball mill. It was found that the classifier gave too fine an overflow even when the density of the overflow was raised to 45% solids. This was due to the rapid setting characteristics of the heavy sulphide ore which was intensified by the flocullating effect of lime fed to the ball mill.

The mechanical classifier was then replaced by a 30 inch diameter Sweco vibrating screen fitted with a 60 mesh wire cloth which operated satisfactorily to give the desired grind of about 65% -200 mesh. A 65 mesh equivalent D. S. M. screen was also tried for a few test runs. It gave the desired classification but there were some problems in build-up of oversize material on the screen at low flow rates.

A 2 inch cyclone was used as a classifier in the scavenger concentrate regrind circuit from the start of the investigation of No. 2 flowsheet until December 15 when it was replaced by an 18 inch diameter Sweco screen fitted with a 200 mesh wire cloth. A 200 mesh, 20x32 in. Hummer vibrating screen was substituted for the Sweco on January 4, 1965 and remained in use for the balance of the investigation.

The cyclone overflow density was maintained at about 15% solids which gave a screen analysis of 85 - 90% -325 mesh. The 200 mesh separation obtained by the vibrating screens was equivalent to about 95% -325 mesh. The main advantage in using the vibrating screens was that pulp density control was independent of classification therefore allowing a wider choice of cleaner feed densities.

Flowsheet No. 1 - Production of Hexagonal Pyrrhotite Concentrate

After a two day tune-up period, 5 test runs were carried out on contact ore using this scheme to produce hexagonal pyrrhotite concentrate. In the first two runs on November 16 and 17, 1964 the rake classifier was in use in the grinding circuit and unsuccessful attempts were still being made to coarsen the overflow to the desired fineness of about 65% -200 mesh (see discussion under "Grinding and Classification"). Also, the addition of too much xanthate to the copper-nickel roughers resulted in too low a grade of copper-nickel rougher concentrate (4.70% and 5.52% nickel for the two runs). In the last three test runs on November 18, 19 and 20, 1964 the classification difficulties were overcome by replacing the mechanical classifier with a vibrating screen and the necessary reduction was made in xanthate feed rate to the roughers. There was an appreciable increase in copper-nickel rougher concentrate grade and in all tests the hexagonal pyrrhotite concentrate met specifications. Of the three test runs the steadiest conditions were obtained for the November 20 run and therefore results obtained can be considered representative.

Reagents and conditions and results for the November 20 test run are given in Tables 2 and 3 respectively.

TABLE 2

Reagents and Conditions

November 20, 1964 - Flowsheet No. 1

Operation	No. of cells	Point of reagent addition	Reagents added lb/ton			
			Lime	Z-6*	Copper Sulphate	Dowfroth 250
Primary grinding		Feed	2.4			
Copper-Nickel rougher flotation	4	No. 1 cell		0.018		as required
Nickel scavenging	18 - cells 1 and 5 acting as conditioners	No. 1 cell No. 3 " No. 5 " No. 9 " No. 13 "		0.024 0.024 0.024 0.024 0.024	0.21 0.08	as required
Scav concentrate cleaning	6	Conditioner	1.6			
Feed rate 800 lb/hour	pH Rougher feed - 9.5 Cleaner feed -10.5			% Solids Rougher feed - 35 Cleaner feed - 25		

*Potassium amyl xanthate

TABLE 3

Results

November 20, 1964 - Flowsheet No. 1

Product	Wt. %	*Assays - %			Distribution - %		
		Cu	Ni	S	Cu	Ni	S
Copper-nickel rougher conc	10.7	2.30	7.60	27.40	79.8	54.7	12.3
" " " tailing**	89.3	0.08	0.75	22.90	20.2	45.3	87.7
Nickel scavenger conc**	65.2	0.12	1.02	27.65	17.8	44.9	81.9
Magnetics	51.2	0.08	1.05	31.20	13.4	36.3	67.2
Non-magnetics**	14.0	0.11	0.91	28.95	4.4	8.6	14.7
Hexagonal pyrrhotite conc	11.1	0.10	1.14	31.15	3.6	8.5	14.5
Cleaner tailing	2.9	0.09	0.04	1.68	0.8	0.1	0.2
Nickel scavenger tailing	24.1	0.03	0.02	5.78	2.4	0.4	5.8
Feed (calcd)	100.0	0.31	1.48	23.80	100.0	100.0	100.0
Screen analysis - Rougher feed (screen undersize) - 64.7% -200 mesh							

* Falconbridge analysis
**Intermediate products

Representative lots of hexagonal pyrrhotite concentrate collected during the course of the investigation amounted to 12 - 45 gal drums of wet cake all of which was shipped to Falconbridge. Each drum was numbered and sampled as it was being filled and the dried samples were sent to Falconbridge.

Flowsheet 2 - All Flotation Scheme

The testing of this flowsheet comprised the major part of the investigation; 59 test runs were carried out on footwall contact and composite ores. Most of the test runs were based on the Falconbridge reagent scheme in which lime was used as an alkalinity regulator in the grind. Lime was also added to the scavenger concentrate cleaners to obtain selectivity. A much smaller number of test runs were done using the Lakefield reagent scheme in which a combination of soda ash and sodium silicate was used in the grind in place of lime,and caustic starch replaced lime in the scavenger concentrate cleaners. In both reagent schemes amyl xanthate was used as the sole promoter and Dowfroth 250 as the frother. Varying amounts of xanthate and Dowfroth 250 were added to the scavenger cleaners as required to control the weight of cleaner concentrate floated off. The lime circuit was tried with and without the addition of copper sulphate to the scavengers but all soda ash test runs were done without the use of copper sulphate.

In addition to those noted above, the following variations in reagents and conditions were tried also:

(1) Amount of xanthate and frother fed and point of addition in roughers and scavengers.

(2) Length of flotation contact time in roughers, scavengers and cleaners.

(3) pH of rougher and cleaner feed.

(4) Density of cleaner feed.

In practically all test runs a primary grind of 65 - 70% -200 mesh was employed along with regrinding of nickel scavenger concentrate to about 95% -325 mesh,but a few tests were tried using a coarser primary grind and regrind.

Flowsheet modifications investigated were as follows:

(1) Recirculation of cleaner scavenger tailing to head of nickel scavengers.

(2) "Bulk float" i.e. copper-nickel rougher concentrate combined with nickel scavenger concentrate for regrinding and cleaning with and without the recirculation of the cleaner tailing to the head of the nickel scavengers.

(3) Regrinding only the oversize fraction of the nickel scavenger concentrate.

A breakdown of Flowsheet 2 test runs according to ore types treated and reagent schemes is given in Table 4.

TABLE 4

Breakdown of Test Runs

Flowsheet No. 2

Ore Type	Date Tested	No. of Test Runs with Lime circuit	No. of Test Runs with Soda ash circuit	No. of Test Runs Total
Contact	Nov. 24-27/64 (incl)	4	4	8
Footwall	Nov. 29-Dec. 1/64 "	3	1	4
No. 1 composite	Dec. 1-8/64 "	5	3	8
No. 2 "	Dec. 9/64-Jan. 7/65	10	0	10
No. 3 "	Jan. 8-27/65 "	14	0	14
No. 4 "	Feb. 1-12/65 and Mar. 1-15/65 "	15	0	15

Test Runs on Contact, Footwall and No. 1 & 2 Composite Ores

None of the results up to the completion of the testing of No. 2 composite ore met the minimum requirement of 8% nickel in the concentrate. Some of the better results obtained on the various ores are given in Table 5.

TABLE 5

Best Results Using Flowsheet No. 2
for Contact, Footwall & Nos. 1 and 2 Composite Ores

Ore Type	Date of Test run	Sampling Period	Circuit used	Combined Concentrates Weight %	Assays - %* Cu	Assays - %* Ni	Distribution - % Cu	Distribution - % Ni
Contact	Nov. 25/64	3-7pm	Lime	26.7	1.52	3.74	87.8	78.1
"	Nov. 27/64	12.30-3 pm	Soda ash	32.0	1.07	3.58	89.8	80.7
Footwall	Nov. 30/64	4-7 pm	Lime	24.4	3.94	6.94	92.3	82.8
No.1 comp	Dec. 4/64	11 am-3 pm	Lime	18.7	2.53	5.19	90.7	81.4
No.1 "	Dec. 1/64	5 - 7 pm	Soda ash	17.3	2.44	5.31	93.3	80.2
No.2 "	Jan. 6/65	11.30am-3.30	Lime	16.0	3.78	6.82	93.2	77.7

*All Falconbridge analysis except January 6 which was from MB Internal Report MS-AC-65-10

Test Runs on Nos. 3 and 4 Composite Ores

Much improved results were obtained when composite ores Nos. 3 and 4 were tested. These results were obtained using substantially the same reagent feed rates and conditions employed previously on the other ore samples. The best results obtained in individual test runs for the two composite ores, both of which exceeded the minimum requirements for grade and recovery are shown in Tables 7 & 9. The reagents and conditions are shown in Tables 6 & 8.

TABLE 6

Reagents and Conditions
January 12, 1965
Flowsheet No. 2 - No. 3 Composite Ore

Operation	No. of cells	Point of Reagent addition	Reagents added - lb/ton		
			Lime	Z-6	Dowfroth 250
Primary grinding			5.2		
Copper-nickel rougher flotation	6-No. 1 cell acting as conditioner	No. 1 cell		0.022	
		No. 2 "			0.043
		No. 4 "		0.009	
Nickel scavenging	10	No. 1 "		0.049	0.009
		No. 4 "		0.038	0.09
		No. 7 "		0.036	0.005
Regrinding		Conditioner	4.9		
Scav concentrate cleaning	6	No. 1 cell		0.008	
		No. 3 "		0.006	
Feed rate: 400 lb/hour	pH Rougher feed - 10.8 Cleaner feed - 10.9		%Solids: Rougher feed 36 Cleaner " 16		

TABLE 7

Results
January 12, 1965
Flowsheet No. 2 - No. 3 Composite Ore

Product	Wt %	*Assays - %		Distribution - %	
		Cu	Ni	Cu	Ni
Copper-nickel rougher conc	9.4	5.86	9.34	88.5	61.0
Copper-nickel rougher tailing**	90.6	0.064	0.62	11.5	39.0
Nickel scavenger conc**	20.9	0.16	1.62	7.0	23.5
Cleaner nickel scav conc	3.7	1.08	7.66	6.5	19.8
Cleaner nickel scav tailing	17.2	0.02	0.31	0.5	3.7
Nickel scav tailing	69.7	0.04	0.32	4.5	15.5
Feed (calcd)	100.0	0.62	1.44	100.0	100.0
Combined conc (calcd)***	13.1	4.50	8.86	95.0	80.8

* From Internal Report MS-AC-65-22.
**Intermediate products.
***Copper-nickel rougher conc + nickel scavenger conc.

TABLE 8

Reagents and Conditions
February 1, 1965
Flowsheet No. 2 - No. 4 Composite Ore

Operation	No. of cells	Point of Reagent addition	Reagents added - lb/ton		
			Lime	Z-6	Dowfroth 250
Primary grinding		Feed	3.3		
Copper-nickel rougher flotation	4-No. 1 cell acting as conditioner	No. 1 cell		0.022	
		No. 2 "			0.043
		No. 4 "		0.009	
Nickel scavenging	15	No. 1 cell		0.050	0.009
		No. 4 "		0.036	0.009
		No. 7 "		0.035	0.006
		No. 11 "		0.035	0.009
Regrinding		Feed	5.5		
Scav concentrate cleaning	10	No. 1 cell		0.009	
		No. 3 cell		0.010	
		No. 7 cell		0.006	0.003
Feed rate: 400 lb/hour	pH: Rougher feed - 11.0 Cleaner feed - 10.9		%Solids: Rougher feed 36.0 Cleaner " 31.0		

TABLE 9

Results
February 1, 1965
Flowsheet No. 2 - No. 4 Composite Ore

Product	Wt %	*Assays - %		Distribution - %	
		Cu	Ni	Cu	Ni
Copper-nickel rougher conc	9.3	5.14	10.70	91.8	57.5
Copper-nickel rougher tailing	90.7	0.054	0.80	8.2	42.5
Nickel scavenger conc	29.2	0.16	2.77	5.5	31.3
Cleaner nickel scav conc	4.9	0.51	8.92	4.8	25.3
Cleaner nickel scav tailing	14.3	0.024	0.73	0.7	6.0
Nickel scav tailing	71.5	0.02	0.27	2.7	11.2
Feed (calcd)	100.0	0.52	1.73	100.0	100.0
Combined concentrates (calcd)	14.2	3.54	10.08	96.6	82.8
Screen analysis:					
Rougher feed (screen undersize) - 68.9% -200 mesh					
Cleaner feed (reground scav conc) - 94.8% -325 mesh					

*From Internal Report MS-AC-65-146

Effect of Copper Sulphate

The addition of a small amount of copper sulphate (.05 - .10 lb/ton) to the nickel scavengers was tried in a number of test runs on various ores. It did not appear to have any pronounced effect on results. The best results were generally obtained without the use of copper sulphate.

Bulk Flotation

When testing No. 4 composite ore several tests were carried out in which the copper-nickel rougher concentrate was combined with the nickel scavenger concentrate to form a "bulk concentrate" which was reground and cleaned once by flotation. Bulk flotation was tried with and without recirculation of cleaner tailing to the head of the nickel scavengers. Except for a slightly finer primary grind, reagents and conditions were identical to those employed in the February 1 run (see Table 8). In Table 10 results are compared with those obtained using the standard flowsheet.

TABLE 10

Comparison of Results
Bulk Flotation vs Two-Stage Flotation
Flowsheet No. 2 - No. 4 Composite Ore

Date of Test Run	Flowsheet Modification	Concentrate Produced					Primary Grind
		Weight *%	*Assays - %		Distribution - %		% -200 M
			Cu	Ni	Cu	Ni	
Feb. 2/65	Standard flowsheet (2 stage flotation)	13.9	3.54	8.55	96.5	74.4	72.4
Feb. 3/65	Bulk flotation - cleaner tailing discarded	13.6	2.40	9.76	93.3	78.1	74.6
Feb. 4/65	Bulk flotation - cleaner tailing re-circulated to nickel scavengers	17.1	2.78	8.20	96.0	82.4	72.0

*From Internal Reports MS-AC-65-148, 155 and 159.

Modified Regrind Circuit

Two tests were tried on the No. 4 composite ore in which only the oversize portion of the scavenger concentrate was reground. This modification to the regrind circuit is shown in Figure 4.

Figure 4

Flowsheet of Modified Regrind Circuit

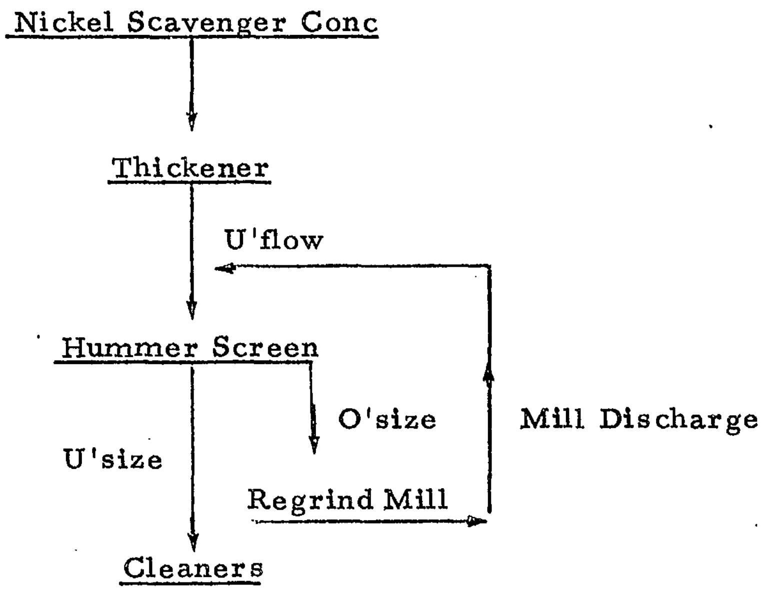

Table 11 compares results with those obtained using the standard flowsheet.

TABLE 11

Comparison of Results
Modified Regrind vs Standard Regrind
Flowsheet No. 2 - No. 4 Composite Ore

Date of Test Run	Regrind Circuit	Reagents and Conditions	Concentrate Produced				
			Wt %	*Assays - %		Distribution - %	
				Cu	Ni	Cu	Ni
Mar. 2/65	Standard (see Fig. 3)	As in Table 8 but added extra 0. 009 lb/ton xanthate to roughers.	14. 1	3. 00	8. 29	96. 0	79. 0
Mar. 3/65	Modified (see Fig. 4)	" "	13. 6	3. 21	8. 82	95. 8	78. 0
Mar. 1/65	Standard	As for Mar. 2 but added 0. 09 lb/ton copper sulphate to scav.	13. 8	3. 63	9. 04	94. 8	77. 8
Mar. 5/65	Modified	" "	15. 9	2. 74	6. 66	95. 0	78. 9

*From Internal Reports MS-AC-65-368, 370, 366 and 382.

Reproducibility of Results

Table 12 compares results obtained when identical test procedure was used on different composite ores. Table 13 compares results obtained when test runs were duplicated on the same composite ore.

TABLE 12

Comparison of Results
for Identical Procedure on
Different Composite Ores

Date of Test Run	Ore Tested	Reagents and Conditions	Concentrate Produced				
			Weight %	*Assays - %		Distribution - %	
				Cu	Ni	Cu	Ni
Jan. 7/65	No. 2 Comp	See Note	10.2	5.11	9.56	92.6	73.2
Jan. 8/65	No. 3 "	" "	9.0	7.13	11.26	92.7	74.7
Jan. 26/65	No. 3 "	As in Table 6	17.7	2.82	6.69	94.6	81.1
Feb. 1/65	No. 4 "	" " " "	14.2	3.54	10.08	96.6	82.8

Note:

Reagents and conditions for the Jan. 7 and 8 runs were similar to those employed for Feb. 1 except:
(1) Only 9 scavenger cells used as against 15
(2) " 4 cleaner " " " " 10
(3) About 25% less xanthate added to scavengers.

*From Internal Reports MS-AC-65-10, 14, 135 and 146.

TABLE 13

Comparison of Results
for Identical Procedure on
the Same Composite Ore

Date of Test Run	Ore Tested	Reagents and Conditions	Weight %	*Assays - %		Distribution - %	
				Cu	Ni	Cu	Ni
Feb. 1/65	No. 4 Comp	Feb. 1 Table 8	14.2	3.54	10.08	96.6	82.8
Feb. 8/65			13.5	4.09	9.74	96.7	81.0
Feb. 11/65			17.4	3.14	8.43	96.5	82.5

*From Internal Reports MS-AC-65-146, 171 and 178.

Flowsheet No. 3 - Flotation and Magnetic Separation

A total of 8 test runs all on No. 4 composite ore were carried out using this flowsheet. The same flotation procedure with variations was employed as that used in the testing of Flowsheet No. 2. The best grade for the combined concentrates was obtained in the first test run on February 16, 1965 in which reagents and conditions were identical to those employed for the Flowsheet No. 2, February 1 Test run (see Table 8). The results for this run are given in Table 14.

TABLE 14

Results
February 16, 1965
Flowsheet No. 3 - No. 4 Composite Ore

Product	Weight %	*Assays - %		Distribution - %	
		Cu	Ni	Cu	Ni
Copper-nickel rougher conc	9.3	4.92	9.86	85.8	51.8
" " " tailing**	90.7	0.082	0.94	14.2	48.2
Nickel scavenger conc**	32.4	0.18	2.11	12.3	38.7
Magnetics**	12.5	0.10	1.68	2.4	11.9
Non-Magnetics**	19.9	0.24	2.38	9.9	26.8
Cleaner magnetic conc	1.7	0.60	7.70	1.9	7.4
" " tailing	10.8	0.024	0.74	0.5	4.5
Cleaner non-magnetic concentrate	4.7	0.72	6.76	6.3	17.9
" " tailing	15.2	0.11	1.03	3.1	8.9
Nickel scavenger tailing	58.3	0.022	0.29	2.4	9.5
Feed (calc'd)	100.0	0.53	1.77	100.0	100.0
Combined concentrates (calc'd)***	15.7	3.20	8.70	94.0	77.1
Screen analysis: Rougher feed (screen undersize) - 67.7% -200 mesh; Reground magnetics - 96.2% -325 mesh					

* From Internal Report MS-AC-65-333
** Intermediate products
*** Copper-nickel rghr conc + cleaner mag conc + cleaner non-mag conc

"Bulk flotation" was also tried twice using the No. 3 Flowsheet. In these tests the copper-nickel rougher concentrate was combined with the nickel scavenger concentrate which was then given the same treatment as shown for the scavenger concentrate on the standard flowsheet. The non-magnetic cleaner tailing was recirculated to the head of the nickel scavengers while the magnetic cleaner tailing was discarded to waste. The best of these tests gave a concentrate grade of 2.86% copper and 6.84% nickel with recoveries of 96.5% and 79.7% respectively.

In other test runs attempts were made to increase nickel recovery but the higher recoveries were accompanied by too great a drop in concentrate grades. Results ranged from 4.8 to 6.4% nickel in the concentrate with from 84.3 to 89.8% nickel recovery.

CONCLUSIONS AND DISCUSSIONS

The most efficient method for processing the ore is the all flotation scheme. The flotation-magnetic separation scheme gave inferior results due perhaps to the fact that only the magnetic portion of the nickel scavenger concentrate was reground. It also has the disadvantage of being more complex.

The standard all flotation flowsheet as shown in Figure 2 without modifications, and the flotation reagents and conditions used in the February 1, 1965 test run (Table 8) gave the best results. There was no particular advantage in recirculating nickel scavenger cleaner tailings or in combining rougher and scavenger concentrates for regrinding and cleaning. Regrinding the oversize portion of the nickel scavenger concentrate (Figure 4) as against regrinding all of the scavenger concentrate (standard flowsheet) gave equivalent results in one set of tests and inferior results in another (see Table 11).

Since the soda ash circuit as used in the Lakefield lab tests was not investigated as fully as the lime circuit, no valid conclusions can be drawn. However in the early part of the investigation when soda ash was used it gave equivalent results to those obtained with the lime circuit (see Table 5).

One of the most significant test variables was the composition of the feed. Widely differing results were obtained when identical procedure was applied on the various composite ores (see Table 12). There was also an appreciable difference in concentrate grades when test procedures were duplicated on the same feed (see Table 13).

Flowsheet No. 1 which was used for the production of the hexagonal pyrrhotite concentrate can also be considered as an alternative processing method. The copper-nickel rougher concentrate would be shipped to the smelter while the hexagonal pyrrhotite concentrate and magnetics would presumably be treated by other methods to recover the contained metals.

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