CANADA

DEPARTMENT OF ENERGY, MINES AND RESOURCES

OTTAWA

MINES BRANCH INVESTIGATION REPORT IR 71-16

THE RECOVERY OF COPPER AND NICKEL FROM A SAMPLE OF ORE SUBMITTED BY ZENMAC METAL MINES LIMITED, SCHREIBER, ONTARIO

by

W. ARTHUR WALL AND R. W. BRUCE

MINERAL PROCESSING DIVISION

NOTE: THIS REPORT RELATES ESSENTIALLY TO THE SAMPLES AS RECEIVED. THE REPORT AND ANY CORRESPONDENCE CONNECTED THEREWITH SHALL NOT BE USED IN FULL OR IN PART AS PUBLICITY OR ADVERTISING MATTER.

COPY NO. 9

MAY 1971

Mines Branch Investigation Report IR 71-16

THE RECOVERY OF COPPER AND NICKEL FROM A SAMPLE OF ORE SUBMITTED BY ZENMAC METAL MINES LIMITED, SCHREIBER, ONTARIO.

by

W. Arthur Wall* and R. W. Bruce**

- - -

SUMMARY OF RESULTS

A satisfactory bulk copper-nickel concentrate can be floated from this ore as illustrated by Test 22. The concentrate assayed 4.00 per cent copper and 4.56 per cent nickel and contained 93.9 per cent of the copper and 79.1 per cent of the nickel in the feed.

Selective flotation resulted in the production of satisfactory copper and nickel concentrates as illustrated by Test 24 with satisfactory recoveries. The copper concentrate assayed 23.90 per cent copper and 1.00 per cent nickel and contained 69.6 per cent of the copper and 2.2 per cent of the nickel in the feed. The nickel concentrate assayed 1.00 per cent copper and 4.17 per cent nickel and contained 26.5 per cent of the copper and 84.5 per cent of the nickel in the feed.

A comparison of the results obtained from flotation tests carried out at different degrees of fineness indicate that the best results are obtained from ore ground to 85 per cent minus 200 mesh (see Table 3).

---

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

CONTENTS

TABLES

INTRODUCTION

Location of Property

The sample of ore was obtained from the Nicopor property of Zenmac Metal Mines Limited. The Nicopor property is located adjacent to the company's zinc mine a few miles from Selim Siding near Schreiber, Ontario.

Shipment

The shipment of ore weighing 293 pounds was received on May 4, 1970. The sample was culled from broken material blasted from the mineralized zone below the weathered surface exposure.

Purpose of Investigation

Mr. P. S. Broadhurst, General Manager, Zenmac Metal Mines Limited, in his letter of April 16, 1970, requested an investigation on the ore to develop a method of recovering the copper and nickel minerals.

Sampling and Analysis

Representative hand specimens were selected from the ore, as received, for microscopic examination. The remainder of the ore was crushed to minus one-half inch. One half of the crushed materials was further reduced to minus 10 mesh and split into 2000-gram portions. One 2000-gram sample, selected at random, was subdivided into fractions for microscopic examination, semi-quantitative spectrochemical analysis and chemical analysis.

The chemical analysis is tabulated in Table 1. The spectrochemical analysis is shown in Table 2.

TABLE 1

Chemical Analysis* of Head Sample

Copper	1.13 %
Nickel	1.34 %
Gold	< 0.005 oz/ton
Silver	0.16 oz/ton
Platinum	0.003 oz/ton
Palladium	0.008 oz/ton

* From Internal Reports MS-AC-70-607 and 893.

TABLE 2

Semi-Quantitative Spectrochemical Analysis* of Head Sample

Principal Constituents	> 1.0%		Si, Fe, Ca
Prominent Constituents	< 1.0%	> 0.1%	Mn, Al, Ni, Na, Cu, Mg
Minor Constituents	< 0.1%		Mo, Cr, Co, Ti, V

* From Internal Report MS-AC-70-494.

MINERALOGICAL EXAMINATION**

The ore consists essentially of small masses and grains of iron oxides and sulphide minerals, disseminated in a largely siliceous matrix. Copper occurs almost entirely as chalcopyrite, with only minute amounts present in the form of chalcocite and digenite. Nickel is present as a constituent of a number of sulphide minerals, largely as violarite and pyrrhotite and to a minor extent as heazlewoodite, pentlandite and smythite Trace amounts of a platinum-palladium-nickel bismuthotelluride and of molybdenite are also present in the ore.

**From Mines Branch Investigation Report IR 70-62 by D. Owens.

The principal ore minerals are pyrrhotite, pyrite and magnetite; chalcopyrite and violarite are present in much smaller amounts. There are very small to trace amounts of heazlewoodite, pentlandite, chalcocite, digenite, hematite, ilmenite, geothite, sphene, molybdenite and marcasite. The gangue minerals are mainly quartz and feldspar.

Pyrrhotite is the dominant nickel-bearing mineral in the ore. The pyrrhotite occurs essentially as aggregates of grains and as individual grains disseminated in the gangue. The pyrrhotite also occurs in combination with either chalcopyrite, magnetite, or pyrite in gangue, and is frequently present in intimate association with violarite. Small amounts of pyrrhotite also occur as inclusions in pyrite, chalcopyrite, violarite and magnetite. The pyrrhotite, itself, contains inclusions mainly of gangue but also of violarite, chalcopyrite, magnetite, pyrite and smythite as well as veinlets of gangue and to a lesser extent of chalcopyrite.

Enclosed within the pyrrhotite are very small particles of a mineral with a somewhat higher nickel content which is probably smythite. This tentative diagnosis could not be confirmed by X-ray diffraction analysis because of the fine grain size.

Violarite is much less prevalent than pyrrhotite although its nickel content is much higher. Violarite occurs largely as heavily fractured aggregates of grains, frequently assocaited with pyrrhotite, sometimes with chalcopyrite, and as disseminations in gangue. Minute amounts of violarite are present as inclusions in pyrite and magnetite. The fractures in the violarite are often filled with other minerals. These are mainly gangue and to lesser extent, chalcopyrite.

Only a few grains of pentlandite were observed and they were free in all instances. More heazlewoodite than pentlandite was present but the number of grains was quite small. Some of the grains were free but most occurred in combination with chalcocite and digenite.

Two individual grains of a platinum-palladium-nickel bismuthotelluride were observed during the examination. One grain, 30 microns in size, occurred as an inclusion in pyrite, and the other grain, about 90 microns in size, occurred partly enclosed by chalcopyrite in gangue.

Chalcopyrite occurs in approximately the same proportion as violarite. Except for a few grains of chalcocite and digenite, chalcopyrite is the only copper-bearing mineral in the ore. The chalcopyrite occurs essentially as grains and small masses disseminated in gangue. Some chalcopyrite occurs in association with violarite, as inclusions in pyrite, magnetite and pyrrhotite and as veinlets in magnetite and fracture fillings in violarite and as combinations with pyrrhotite and magnetite in gangue.

OUTLINE OF INVESTIGATION

A series of flotation tests was carried out on the ore to determine the grind, the flotation conditions and reagents required to produce the best grade of concentrate consistent with the highest copper-nickel recovery. The fineness of grind was varied from 50.7 per cent to 92.9 per cent minus 200 mesh. The flotation tests were carried out at pH's ranging from 7.2 to 13.5. Various combinations of promoters and frothers were used. The investigation was divided into three distinct phases to cover the recovery of the copper and nickel by bulk flotation, selective flotation, and magnetic separation.

Full details of all tests are shown in Mines Branch Flotation Test Reports in Appendix A.

DISCUSSION OF RESULTS

Bulk Flotation

Flotation tests (Nos. 1, 3, 4, and 22) were carried out to determine the grind required for the liberation of the valuable constituents. These tests were done under similar flotation conditions and reagents on pulps

ground to different degrees of fineness. From the results shown in Table 3, it can be seen that the best results were obtained in Test 4 in which the fineness of grinding was such that the flotation tailing contained 84.0 per cent minus 200-mesh material.

TABLE 3

Results of Flotation at Various Grinds

Test No	1	3	4	22
Grind, Per cent minus 200 m	50.7	70.4	84.0	86.1
Bulk concentrate				
Assay %				
Cu	3.64	4.34	4.00	4.00
Ni	3.88	4.50	4.20	4.56
Distribution %				
Cu	90.7	89.2	92.9	93.9
Ni	78.7	75.5	80.8	79.1
Cleaner tailing				
Assay %				
Cu	0.64	0.64	0.56	0.35
Ni	1.92	1.64	1.50	2.00
Distribution %				
Cu	5.2	7.0	3.9	2.4
Ni	12.9	14.7	8.6	9.9
Rougher tailing				
Assay %				
Cu	0.07	0.06	0.05	0.06
Ni	0.17	0.19	0.20	0.24
Distribution %				
Cu	4.1	3.8	3.2	3.7
Ni	8.4	9.8	10.6	11.0

Tests 2, 15, and 23 were carried out to determine the effect of varying pH on the flotation results. Test 2 was similar to Test 1 but flotation was carried out at a pH of 8.6 instead of 7.9. The higher pH resulted in a concentrate with higher copper and nickel assays but with a lower recovery. The concentrate produced in Test 23 at a pH of 8.5 had higher assays and lower recoveries than Test 22 at a pH of 7.6 Test 15

was a repeat of Test 4 but lime was used for alkalinity control instead of soda ash. The results indicate that soda ash is superior to lime for controlling the alkalinity.

The flotation conditions and reagents as used in Test 4 and 22 produced the best concentrate grades and recovery.

Selective Flotation

A series of Tests (Nos. 5, 8, 9, 10, 11, and 14) was carried out in an attempt to float a bulk copper-nickel concentrate and then depress the nickel in the bulk concentrate and float off the copper. Various combinations of grind, reagents, pH and aeration were investigated. None of these tests resulted in a satisfactory separation of the nickel from the copper.

Another series of Tests (Nos. 6, 12, 13, 16, 17, 18, 19, 20, 21, and 24) was carried out in which a copper concentrate was floated followed by a nickel concentrate. In all the above tests, the pulp was treated by aerative conditioning before flotation. Various combinations of grind, flotation conditions and flotation reagents were investigated. In each case, a copper concentrate and a nickel concentrate was produced.

The results of this series of tests indicated that the amount of reagent addition had a critical effect on selectivity. In Tests 17, 18 and 21 too much nickel floated with the copper. When the collector was reduced by over 50 per cent, good selectivity was obtained as shown by the results of Test 19.

In Test 13, the flotation reagents were added to the rod mill. In Test 21, the reagents were added to the conditioner. All other conditions were the same. The procedure used in Test 13 resulted in a much better copper nickel separation.

Tests 16 and 20 produced similar results and indicate that regrinding the concentrate as investigated in Test 20 did not result in any significant improvement of the grade of concentrate.

In Test 24, a copper concentrate assaying 1.00 per cent nickel and a nickel concentrate assaying 1.00 per cent copper was produced. However, the amount of copper in the nickel concentrate was considerably more than in Tests 16 and 20. The combined recovery in Test 24 was the highest of this series.

The flotation conditions and reagents are used in Tests 16, 20, and 24 produced satisfactory concentrate grades and recoveries.

Magnetic Separation

Test 7 was an investigation into the possibility of concentrating the nickel in a magnetic or non-magnetic concentrate. The results indicate that no concentration was achieved.

In Test 8, a magnetic concentrate was removed using a Sala magnetic separator. The non-magnetic portion of the sample was conditioned and a bulk concentrate removed by flotation. This bulk concentrate was cleaned and recleaned. The copper was floated from this recleaned bulk concentrate and the non-float constituted the nickel concentrate. The magnetic fraction contained too much nickel to discard. The removal of the magnetic portion did not improve the floatability of the non-magnetic fraction.

CONCLUSIONS

This investigation has shown that either a bulk copper-nickel concentrate or separate copper concentrate and nickel concentrate can be produced with satisfactory grades and recoveries.

The type of flowsheet to be selected for this ore will depend partially on the economics of smelting the two types of concentrates and partially on the concentration costs and recoveries.

The production of a bulk copper-nickel concentrate is illustrated by Test 22 in which the concentrate assayed 4.00 per cent copper and 4.56 per cent nickel and contained 93.9 per cent of the copper and 79.1 per cent

of the nickel in the feed. Test 24 is typical of the selective flotation tests in which a copper concentrate was produced assaying 23.90 per cent copper and 1.0 per cent nickel. A nickel concentrate was produced assaying 1.00 per cent copper and 4.17 per cent nickel. The combined recovery of copper was 96.1 per cent and of nickel 86.7 per cent of the feed.

The precious metal content of the ore is very low. The copper and nickel concentrates in Test 12 and 19 were assayed for gold, platinum and palladium. However, the concentration of these elements is low and of minor economic significants only.

The tests which resulted in the production of concentrates with the best assays and recoveries were carried out on pulps ground to produce a flotation tailing containing between 84 and 86 per cent minus 200-mesh material. The results of tests carried out on ore ground coarser or finer were not as satisfactory.

ACKNOWLEDGEMENTS

The authors wish to acknowledge the assistance of the following members of the Mineral Sciences Division: D. Owens who carried out the mineralogical examination, D. P. Palombo who did the spectrographic analysis and J. Cloutier, D. Cumming, R. Donahoe, J. Graham, J.C. Hole, B. Kobus, P. E. Maloughney, E. Nadeau and C. Smith who performed the chemical analysis.

- - -

WAW/RWB/ec

APPENDIX A

Test Data Sheets

Abbreviations Used in Data Report Sheets

RM	Rod Mill
Na_2CO_3	Sodium Carbonate
Z-6	Sodium Amyl Xanthate
AF 70	Aerofroth Frother 70
AF 71	Aerofroth Frother 71
DF 250	Dowfroth Frother 250
A 15	Aerofloat Promoter 15
Z-200	Dow Promoter 200
$CuSO_4$	Copper Sulphate
CaO	Lime
A 238	Sodium Di-secondary Butyl Dithio-phosphate
Na_2SO_3	Sodium Sulphite
A 301	Sodium Secondary Butyl Xanthate
H_2SO_4	Sulphuric Acid
SO_2	Sulphur Dioxide
NaOH	Sodium Hydroxide
A 350	Potassium Amyl Xanthate
3501	Aero Promoter 3501

MINES BRANCH FLOTATION TEST REPORT

TEST NO. 1	SAMPLE: Zenmac Limited - Nicopor Sample	DATE: May 29, 1970
OBJECT OF TEST: Preliminary Flotation		CHARGE: 2000-g
		TESTED BY: WAW

OPERATION	Time min	% Solids	pH	Unit used	Reagents, lb per ton									
					Na_2CO_3	Z-6	AF 70	DF250						
Grind*	30	67		7x14 RM										
Condition (1)	7.0	45	7.9	2000-g cell	4.0	0.03								
Float No. I	1	30					0.014							
Float No. II	2	30	7.9			0.10	0.014							
Float No. III	2	20	7.9					0.02						
Float No. -IV	2	20	7.8			0.10								

PRODUCT	WT %	ANALYSIS % (3)				DISTRIBUTION %			
		Cu	Ni	Fe	S	Cu	Ni	Fe	S
No. 1 conc	5.94	10.78	5.15	35.55	20.61	60.4	23.5	9.8	14.9
No. 2 conc	20.44	1.57	3.51	41.43	23.25	30.3	55.2	39.3	58.0
No. 3 conc	6.32	0.69	2.06	40.55	18.48	4.1	10.0	11.9	14.3
No. 4 conc	2.43	0.49	1.56	37.54	17.28	1.1	2.9	4.0	5.1
Magnetic tailing (2)	9.53	0.04	0.20	50.00	3.16	0.4	1.5	22.2	3.7
Non-magnetic tailing (2)	55.34	0.07	0.16	5.00	0.59	3.7	6.9	12.8	4.0
Rougher tailing (calcd)	64.87	0.066	0.17	11.60	0.97	4.1	8.4	35.0	7.7
Feed (calcd)	100.0	1.06	1.30	21.54	8.19	100.0	100.0	100.0	100.0
Ro conc No. 1 and No. 2	26.38	3.64	3.88	40.11	22.67	90.7	78.7	49.1	72.9

REMARKS: * Flotation tailing 50.7% minus 200 mesh.

(1) Flotation cell air valve open during conditioning.

(2) Rougher tailing magnetic fraction removed in Sala magnetic separator.

(3) From Internal Report MS-AC-70-617.

MINES BRANCH FLOTATION TEST REPORT

TEST NO. 2	SAMPLE: Zenmac Limited - Nicopor Sample	DATE: May 29, 1970
OBJECT OF TEST: Different Procedure same Grind as Test 1.		CHARGE: 2000-g
		TESTED BY: WAW

OPERATION	Time min	% Solids	pH	Unit used	Reagents, lb per ton									
					Na_2CO_3	A15	Z-200	$CuSO_4$	Z-6					
Grind	30	67		7x14 RM										
Condition	5	45.0	8.8	2000-g cell	5.00		0.05							
Float No. 1	1	30	8.6											
Float No. 2	2	30	8.6				0.05							
Condition	5	30	8.1					1.0	0.10					
Float No. 3	2	30	8.1			0.05								
Float No. 4	2.5	30	8.1			0.05			0.10					

PRODUCT	WT %	ANALYSIS % *						DISTRIBUTION %			
		Cu	Ni					Cu		Ni	
No. 1 conc	8.0	6.78	6.00					50.0		36.7	
No. 2 conc	9.4	3.78	4.68					32.7		33.7	
No. 3 conc	13.0	0.73	1.60					8.8		15.9	
No. 4 conc	4.9	0.70	1.29					3.1		4.8	
Rougher tail	64.7	0.09	0.18					5.4		8.9	
Feed (calcd)	100.0	1.08	1.31					100.0		100.0	
Combined No. 1 & No. 2 conc	17.4	5.16	5.29					82.7		70.4	

REMARKS: * From Internal Report MS-AC-70-605

MINES BRANCH FLOTATION TEST REPORT

TEST NO. 3	SAMPLE: Zenmac Limited - Nicopor Sample	DATE: June 18, 1970
OBJECT OF TEST: Finer Grind than Test 2		CHARGE: 2000-g
		TESTED BY: W.A.W.

OPERATION	Time min	% Solids	pH	Unit used	Reagents, lb per ton									
					Na_2CO_3	Z-6	AF71							
Grind	45	67		7x14 RM										
Conditioning (1)	10	45	7.9	2000-g cell	6.0	0.03								
No. 1 Float	1	30	7.9				0.02							
No. 2 Float	2	30				0.05	0.02							
No. 3 Float	1.5	30				0.05	0.02							
No. 4 Float	3.0	30	7.9			0.10								

PRODUCT	WT %	ANALYSIS % (3)			DISTRIBUTION %		
			Cu	Ni		Cu	Ni
Nos. 1 and 2 conc	21.6		4.34	4.50		89.2	75.5
No. 3 conc	2.8		0.46	1.65		1.2	3.6
No. 4 conc	8.7		0.70	1.64		5.8	11.1
Rougher tail (2)	66.9		0.06	0.19		3.8	9.8
Feed (calcd)	100.0		1.05	1.29		100.0	100.0

REMARKS: (1) Flotation cell Air valve open during conditioning
(2) Flotation tail 70.4% minus 200 mesh
(3) From Internal Report MS-AC-70-646

MINES BRANCH FLOTATION TEST REPORT

TEST NO. 4	SAMPLE: Zenmac Limited - Nicopor Sample	DATE: June 19, 1970
OBJECT OF TEST: Finer Grind than Test 3		CHARGE: 2000-g
		TESTED BY: W.A.W.

OPERATION	Time min	% Solids	pH	Unit used	Reagents, lb per ton									
					Na_2CO_3	Z-6	AF71							
Grind	60	67		7x14 RM										
Condition (1)	10	45	7.9	2000-g cell	6.0	0.05								
Flotation No. 1	1	30	7.9				0.02							
" No. 2	2.5	30				0.05	0.02							
" No. 3	1.5	30				0.05	0.02							
" No. 4	3	30	7.9			0.05	0.02							

PRODUCT	WT %	ANALYSIS % (3)							DISTRIBUTION %				
			Cu	Ni						Cu	Ni		
Nos. 1 + 2 conc	24.7		4.00	4.20						92.9	80.8		
Nos. 3 + 4 conc	7.3		0.56	1.50						3.9	8.6		
Rougher tail (2)	68.0		0.05	0.20						3.2	10.6		
Feed (calcd)	100.0		1.06	1.28						100.0	100.0		

REMARKS: (1) Flotation cell air valve open during conditioning
(2) Flotation tail 84.0% minus 200 mesh
(3) From Internal Report MS-AC-70-647

MINES BRANCH FLOTATION TEST REPORT

TEST NO. 5	SAMPLE: Zenmac Limited - Nicopor Sample	DATE: June 22, 1970
OBJECT OF TEST: Clean Cu-Ni concentrate and separate Cu and Ni		CHARGE: 2000-g
		TESTED BY: W.A.W.

OPERATION	Time min	% Solids	pH	Unit used	Reagents, lb per ton									
					Na_2CO_3	Z-6	AF71							
Grind	60	67		7x14 RM										
Condition (1)	20	45	8.5	2000-g cell	8.0	0.05								
Flotation	4	28	8.2			0.05	0.05							
Scavenge	5	25	8.2			0.10								
Clean Cu-Ni conc	2			1000-g cell										
Re-clean Cu-Ni conc	1			500-g cell										
Cu-Ni Sep	0.75		12.5	250-g cell	2.0									

PRODUCT	WT %	ANALYSIS % (3)			DISTRIBUTION %		
		Cu	Ni	Insol	Cu	Ni	Insol
Copper conc	2.1	23.21	6.03	1.40	47.2	10.0	0.1
Nickel conc	7.5	2.94	4.91	2.46	21.5	28.9	0.4
Cu-Ni reclean conc (calcd)	9.6	7.37	5.16	2.23	68.7	38.9	0.5
No. 1 cl tail	14.9	1.11	2.63	12.16	16.0	30.7	3.3
No. 2 cl tail	2.7	3.43	6.74	6.66	9.0	14.3	0.3
Rougher Cu-Ni conc (calcd)	27.2	3.55	3.93	8.11	93.7	83.9	4.1
Scavenger conc	6.0	0.53	1.32	32.40	3.1	6.2	3.6
Rougher tail (2)	66.8	0.05	0.19	74.88	3.2	9.9	92.3
Feed (calcd)		1.03	1.28	54.17	100.0	100.0	100.0

REMARKS: (1) Air Valve on flotation cell open during conditioning
(2) Flotation tail 84.0% minus 200 mesh
(3) From Internal Report MS-AC-70-692

MINES BRANCH FLOTATION TEST REPORT

TEST NO. 6	SAMPLE: Zenmac Limited - Nicopor Sample	DATE: June 23, 1970
OBJECT OF TEST: Float Copper followed by Nickel float		CHARGE: 2000-g
		TESTED BY: W.A.W.

OPERATION	Time min	% Solids	pH	Unit used	Reagents, lb per ton									
					Na_2CO_3	Z-6	A238	AF71	CaO					
Grind	60	67		7x14 RM										
Condition (1)	10	45	8.5	2000-g cell	8.0	0.03	0.03	0.03						
Copper float	4	30	8.5			0.01	0.01	0.03						
Nickel float	5	30	8.5			0.15								
Nickel conc clean	1.5		9.5	1000-g cell					0.25					
Nickel conc reclean	1.0			500-g cell					0.20					

PRODUCT	WT %	ANALYSIS % (3)						DISTRIBUTION %				
		Cu	Ni					Cu	Ni			
Rougher Cu conc	11.1	8.69	6.98					86.6	59.9			
Reclean Ni conc	4.0	0.70	2.28					2.5	7.0			
Clean Ni tail	8.9	0.53	1.48					4.2	10.2			
Reclean Ni tail	6.6	0.48	2.36					2.9	12.1			
Rougher Ni conc (calcd)	19.5	0.55	1.94					9.6	29.3			
Rougher tail (2)	69.4	0.06	0.20					3.8	10.8			
Feed (calcd)	100.0	1.11	1.29					100.0	100.0			

REMARKS: (1) Flotation cell Air Valve open during conditioning
(2) Flotation tailing 84.0% minus 200 mesh
(3) From Internal Report MS-AC-70-691

MINES BRANCH FLOTATION TEST REPORT

TEST NO. 7	SAMPLE: Zenmac Limited - Nicopor Sample	DATE: June 29, 1970
OBJECT OF TEST: Magnetic Concentration		CHARGE: 2000-g
		TESTED BY: W.A.W.

OPERATION	Time min	% Solids	pH	Unit used	Reagents, lb per ton									
Grind	30	67		7x14 RM										
Sala Magnet														
Jones Magnet	set at 3.0		Amps											

PRODUCT	WT %	ANALYSIS %*					DISTRIBUTION %				
		Cu	Ni	Fe	S	Insol	Cu	Ni	Fe	S	Insol
Sala magnetics	25.9	0.26	0.93	50.00	17.31	16.74	6.1	19.1	58.9	42.3	7.9
Sala non-mag (calcd)	74.1	1.38	1.38	12.20	8.27	67.91	93.9	80.9	41.1	57.7	92.1
Jones magnetics	13.0	0.79	2.80	14.00	8.32	62.00	9.5	28.9	8.3	10.2	14.8
Jones middlings	30.4	1.47	1.29	12.73	8.33	68.73	41.0	31.1	17.6	23.9	38.2
Jones non-magnetics	30.7	1.54	0.86	10.91	8.18	69.60	43.4	20.9	15.2	23.6	39.1
Feed (calcd)	100.0	1.09	1.26	21.99	10.61	54.66	100.0	100.0	100.0	100.0	100.0

REMARKS: *From Internal Report MS-AC-70-722

MINES BRANCH FLOTATION TEST REPORT

TEST NO. 8	SAMPLE: Zenmac Limited - Nicopor Sample	DATE: July 14, 1970
OBJECT OF TEST: Remove Magnetics, Float Non-Magnetics		CHARGE: 2000-g
		TESTED BY: W.A.W.

OPERATION	Time min	% Solids	pH	Unit used	Reagents, lb per ton									
					Na_2CO_3	Z-6	A238	DF250	CaO					
Grind	60	67		7x14 RM										
Magnetic Sep				Sala										
Condition	10	45	8.6	2000-g cell	4.0	0.05	0.02							
Flotation	7	30	8.4					0.05						
Clean	1.75	30												
Reclean	1.25	30												
Condition conc (1)	20	30	12.5	1000-g cell					3.0					
Float Cu	4			500-g cell										
Clean	1			250-g cell										
Reclean	1			250-g cell										

PRODUCT	WT %	ANALYSIS % (3)							DISTRIBUTION %					
			Cu	Ni						Cu	Ni			
Cu conc	2.3		22.32	7.78						48.4	14.3			
Cu clean tail	1.3		12.38	10.47						15.2	10.8			
Cu reclean tail	0.7		9.83	12.95						6.5	7.2			
Ro cu conc (calcd)	4.3		17.28	9.43						70.1	32.3			
Ni conc	7.1		0.88	2.64						5.9	14.9			
Cu-Ni conc (calcd)	11.4		7.07	5.20						76.0	47.2			
Cu-Ni clean tail	5.1		1.72	2.37						8.3	9.6			
Cu-Ni reclean tail	3.3		2.78	7.22						8.7	19.0			
Ro Cu-Ni conc (calcd)	19.8		4.97	4.81						93.0	75.8			
Magnetics	21.6		0.13	0.92						2.6	15.6			
Rougher tails (2)	58.6		0.08	0.18						4.4	8.4			
Feed (calcd)	100.0		1.06	1.26						100.0	100.0			

REMARKS: (1) Flotation cell air valve open during conditioning
(2) Flotation tailing 84.0% minus 200 mesh
(3) From Internal Report MS-AC-70-734

MINES BRANCH FLOTATION TEST REPORT

TEST NO. 9	SAMPLE: Zenmac Limited - Nicopor Sample	DATE: July 15, 1970
OBJECT OF TEST: Rougher flotation, clean and separate Cu-Ni		CHARGE: 2000-g
		TESTED BY: W.A.W.

OPERATION	Time min	% Solids	pH	Unit used	Reagents, lb per ton									
					Na_2CO_3	Z-6	A238	CaO	DF250					
Grind	30	67		7x14 RM	3.0		0.02							
Condition	10	50	8.7	2000-g cell	3.0	0.05	0.02	2.0						
Bulk flotation	8	30	8.1			0.15	0.04		0.01					
Clean	2		7.7	1000-g cell										
Reclean	2		7.6											
Condition bulk conc	20		12.5	1000-g cell				3.0						
Float Cu	3													
Clean	2													
Reclean	1.5													

PRODUCT	WT %	ANALYSIS % (3)						DISTRIBUTION %					
			Cu	Ni						Cu	Ni		
Reclean Cu conc	2.4		23.88	4.72						53.7	8.8		
Cu clean tail	1.0		7.94	8.10						7.4	6.3		
Cu reclean tail	0.8		8.61	8.38						6.5	5.2		
Ro cu conc (calcd)	4.2		17.17	6.21						67.6	20.3		
Ni conc	15.8		1.09	3.72						16.1	45.6		
Reclean Cu-Ni conc (calcd)	20.0		4.46	4.25						83.7	65.9		
Clean Cu-Ni tail	4.9		0.87	2.00						4.0	7.6		
Reclean Cu-Ni tail	7.1		1.00	2.52						6.6	13.9		
Ro Cu-Ni conc (calcd)	32.0		3.15	3.52						94.3	87.4		
Rougher tail (2)	68.0		0.09	0.24						5.7	12.6		
Feed	100.0		1.07	1.29						100.0	100.0		

REMARKS: (1) Compressed Air added to cell during conditioning
(2) Flotation tailing 50.7% minus 200 mesh
(3) From Internal Report MS-AC-70-723

MINES BRANCH FLOTATION TEST REPORT

TEST NO. 10	SAMPLE: Zenmac Limited - Nicopor Sample	DATE: July 14, 1970
OBJECT OF TEST: Bulk float - Grind concentrate, clean and reclean		CHARGE: 2000-g
		TESTED BY: W.A.W.

OPERATION	Time min	% Solids	pH	Unit used	Reagents, lb per ton									
					Na_2CO_3	Na_2SO_3	DF250	A238	Z-6	CaO				
Grind	30	67	7.0	7x14 RM	6.0	1.0								
Condition	7	50	7.8	2000-g cell	2.0		0.03	0.10	0.10					
Bulk float	5	30	7.8				0.03	0.05	0.05					
Filter conc														
Grind conc	15			7x14 RM						5.0				
Clean No. 1	2		11.2	1000-g cell										
Condition with air	5													
Reclean	1.5		12.2	500-g cell										

PRODUCT	WT %	ANALYSIS % (2)						DISTRIBUTION %				
			Cu	Ni					Cu	Ni		
Cu reclean conc	1.1		30.00	1.90					32.4	1.5		
Clean Cu tail	31.2		1.37	3.23					42.0	73.5		
Reclean Cu tail	3.1		6.29	4.83					19.2	10.9		
Rougher tail (1)	64.6		0.10	0.30					6.4	14.1		
Feed (calcd)	100.0		1.02	1.37					100.0	100.0		

REMARKS: (1) Flotation tailing 50.7% minus 200 mesh
(2) From Internal Report MS-AC-70-723

MINES BRANCH FLOTATION TEST REPORT

TEST NO. 11	SAMPLE: Zenmac Limited - Nicopor Sample	DATE: July 16, 1970
OBJECT OF TEST:	Repeat of Test 9 at finer grind	CHARGE: 2000-g
		TESTED BY: W.A.W.

OPERATION	Time min	% Solids	pH	Unit used	Reagents, lb per ton									
					Na_2CO_3	Z-6	A238	CaO	DF250					
Grind	60	67	7.5	7x14 RM	6.00	0.05	0.02							
Condition	10	50	7.7	2000-g cell		0.05	0.02	1.0						
Cu float No. 1	1	30	7.7											
Bulk float	6	30				0.10	0.02		0.06					
Clean No. 1 Cu conc	1.5		7.2	250-g cell										
Reclean No. 1 Cu conc	1.5		12.2					1.0						
Clean bulk conc (1)	2		8.1	1000-g cell										
Reclean bulk conc	2		7.8											
Cond reclean conc (2)	20													
Cu conc No. 2	2		12.1											
Clean Cu conc No. 2	1.5													

PRODUCT	WT %	ANALYSIS % (4)							DISTRIBUTION %				
		Cu	Ni						Cu	Ni			
No. 1 Reclean Cu conc	1.2	30.87	2.66						36.9	2.4			
No. 2 cl cu conc	0.8	29.00	1.84						23.1	1.1			
Copper conc (calcd)	2.0	30.10	2.35						60.0	3.5			
Ni conc	11.0	0.63	4.67						6.9	38.2			
Bulk conc clean tail	9.2	1.49	2.12						13.6	14.5			
Bulk conc reclean tail	11.3	1.00	3.64						11.2	30.5			
No. 2 Cu conc clean tail	0.3	14.32	6.73						4.3	1.5			
Rougher tail (3)	66.2	0.06	0.24						4.0	11.8			
Feed (calcd)	100.0	1.00	1.35						100.0	100.0			

REMARKS: (1) No. 1 Cu cleaner and recleaner tails added to Bulk concentrate before cleaning. (2) Conditioned with compressed air. (3) Flotation tailing 84.0% minus 200 mesh. (4) From Internal Report MS-AC-70-728.

MINES BRANCH FLOTATION TEST REPORT

TEST NO. 12	SAMPLE: Zenmac Limited - Nicopor Samples	DATE: July 22, 1970
OBJECT OF TEST: Grind-Aerate-Float		CHARGE: 2000-g
		TESTED BY: W.A.W.

OPERATION	Time min	% Solids	pH	Unit used	Reagents, lb per ton									
					Na_2CO_3	CaO	Z-6	A238	DF250	H_2SO_4				
Grind	60	67	7.4	7x14 RM	3.0	3.0	0.10	0.05	0.06					
Aerate	20			Aerator										
Condition	20		12.1	2000-g cell	3.0	11.0								
Copper float	2		12.0											
Copper clean	1			250-g cell										
Copper reclean	1													
Condition Cu tails	5		8.0	2000-g cell						7.0				
Ni float	5		8.0				0.10	0.05						
Ni conc clean	1													
Ni conc reclean	1													

PRODUCT	WT %	ANALYSIS (2)						DISTRIBUTION %				
			Cu%	Ni %	Au oz/t	Pt oz/T	Pd oz/T		Cu	Ni		
Cu conc	2.6		31.97	1.29	0.090	0.013	0.019		71.9	2.5		
Ni conc	7.2		1.73	11.01	0.034	0.013	0.055		10.8	58.8		
Cu clean tail	0.3		15.00	1.69					3.9	0.4		
Cu reclean tail	0.1		16.19	2.00					1.4	0.2		
Rougher Cu conc (calcd)	3.0		29.73	1.37					77.2	3.1		
Ni clean tail	1.8		1.30	2.18					2.0	2.9		
Ni reclean tail	2.6		1.48	4.14					3.3	8.0		
Rougher Ni conc (calcd)	11.6		1.60	8.10					16.1	69.7		
Rougher tail (1)	85.4		0.09	0.43					6.7	27.2		
Feed (calcd)	100.0		1.16	1.35					100.0	100.0		

REMARKS: (1) Flotation tailing 84.0% minus 200 mesh.
(2) From Internal Reports MS-AC-70-750 and 1149.

MINES BRANCH FLOTATION TEST REPORT

TEST NO. 13	SAMPLE: Zenmac Limited - Nicopor Sample	DATE: July 25, 1970
OBJECT OF TEST: Repeat of Test 12 with different reagents.		CHARGE: 2000-g
		TESTED BY: W.A.W.

OPERATION	Time min	% Solids	pH	Unit used	Reagents, lb per ton									
					Na_2CO_3	CaO	A238	A301	DF250	A350	H_2SO_4	$CuSO_4$		
Grind	60	67		7 x 14 RM	3.0	3.0	0.05	0.10	0.06					
Aerate	30		7.4	Aerator										
Condition	10	45	12.0	2000-g cell		11.0								
Copper float	2.5	30	11.8											
Conc clean	1.5			250-g cell										
Conc reclean	1.5													
Ni condition	5		8.0	2000-g cell						0.05	7.0			
Ni float	5		7.9							0.10				
Ni conc clean	2			500-g cell										
Ni conc reclean	2			250-g cell										
Scav conc	2.5		7.8	2000-g cell				0.10				1.35		

PRODUCT	WT %	ANALYSIS % (1)		DISTRIBUTION %	
		Cu	Ni	Cu	Ni
Cu reclean conc	2.6	28.59	1.48	67.1	2.9
Cu clean tail	0.4	19.45	1.87	7.0	0.5
Cu reclean tail	0.5	11.22	2.14	5.0	0.8
Cu rough conc (calcd)	3.5	25.06	1.60	79.1	4.2
Ni reclean conc	14.0	0.49	5.28	6.2	55.6
Ni clean tail	5.8	0.74	2.66	3.9	11.6
Ni reclean tail	6.0	0.42	2.54	2.3	11.4
Ni rougher conc (calcd)	25.8	0.53	4.05	12.4	78.6
Cu-Ni ro conc (calcd)	29.3	3.46	3.76	91.5	82.8
Scav conc	2.8	1.18	2.37	3.0	5.0
Bulk conc (calcd)	32.1	3.26	3.64	94.5	87.8
Rougher tail (2)	67.9	0.09	0.24	5.5	12.2
Feed (calcd)	100.0	1.11	1.33	100.0	100.0

REMARKS: (1) From Internal Report MS-AC 70-869
(2) Flotation tail grind 84.0 per cent minus 200-mesh.

MINES BRANCH FLOTATION TEST REPORT

TEST NO. 14	SAMPLE: Zenmac Mines Limited - Nicopor Sample	DATE: Sept. 1, 1970
OBJECT OF TEST: Bulk float - Aeration of bulk conc - Cu Ni separation		CHARGE: 2000-g
		TESTED BY: W.A.W.

OPERATION	Time min	% Solids	pH	Unit used	Reagents, lb per ton									
					Na_2CO_3	CaO	Z-6	A238	A301	AF71	$CuSO_4$			
Grind*	60	67		7x14 RM										
Condition	20	45	7.7	2000-g cell	8.0	3.0	0.10	0.05	0.05					
Flotation	3	28	7.9				0.05			0.05				
Scavenging	5	25	8.0				0.10				1.00			
Aerate bulk conc	20													
Condition bulk conc	2	25	12.1		8.0	8.0								
Cu float	1.5	25												
Cu clean	1													
Cu reclean	1													
Ni float	2.5													
Ni clean	1													
Ni reclean	1													

PRODUCT	WT %	ANALYSIS % (1)							DISTRIBUTION %				
			Cu	Ni						Cu	Ni		
Reclean Cu conc	5.6		10.72	3.70						50.6	16.1		
Clean Cu tail	3.7		2.55	5.84						7.9	16.8		
Reclean Cu tail	3.0		6.92	5.16						17.5	12.0		
Rougher Cu conc (calcd)	12.3		7.33	4.70						76.0	44.9		
Reclean Ni conc	8.5		1.82	4.60						13.1	30.4		
Clean Ni tail	1.8		0.72	2.34						1.1	3.3		
Reclean Ni tail	2.9		0.47	1.82						1.2	4.1		
Rougher Ni conc (calcd)	13.2		1.37	3.68						15.4	37.8		
Rougher Cu-Ni conc (calcd)	25.5		4.25	4.17						91.4	82.7		
Cu-Ni Sep. tail	2.6		0.49	1.27						1.1	2.6		
Scav conc	4.2		1.00	1.78						3.5	5.8		
Rougher tail	67.7		0.07	0.17						4.0	8.9		
Feed (calcd)	100.0		1.19	1.29						100.0	100.0		

REMARKS: *Flotation tailing 84.0% minus 200 mesh. (1) From Internal Report MS-AC-70-879.

MINES BRANCH FLOTATION TEST REPORT

TEST NO. 15 | SAMPLE: Zenmac Mines Limited - Nicopor Sample | DATE: Sept. 8, 1970

OBJECT OF TEST: Repeat of Test 4 using CaO instead of Na_2CO_3 | CHARGE: 2000-g

TESTED BY: W.A.W.

OPERATION	Time min	% Solids	pH	Unit used	Reagents, lb per ton									
					CaO	Z-6	AF71							
Grind*	60	67		7x14 RM										
Condition	10	45	7.9		8.0	0.05								
Float No. 1	3.5	30	7.9			0.05	0.04							
Float No. 2	1.5					0.05	0.02							
Float No. 3	3.0					0.10	0.02							

PRODUCT	WT %	ANALYSIS % (1)							DISTRIBUTION %				
			Cu	Ni						Cu	Ni		
Concentrate No. 1	18.5		4.96	5.08						86.6	72.2		
Concentrate No. 2	6.4		0.61	1.80						3.7	8.8		
Concentrate No. 3	5.6		0.72	1.56						3.8	6.7		
Rougher tail	69.5		0.09	0.23						5.9	12.3		
Feed (calcd)	100.0		1.06	1.30						100.0	100.0		

REMARKS: *Flotation tailing 84.0% minus 200 mesh. (1) From Internal Report MS-AC-70-875.

MINES BRANCH FLOTATION TEST REPORT

TEST NO. 16	SAMPLE: Zenmac Metal Mines Limited - Nicopor Sample	DATE: Sept. 9, 1970
OBJECT OF TEST: Repeat of Test 12		CHARGE: 2000-g
		TESTED BY: WAW

OPERATION	Time min	% Solids	pH	Unit used	Reagents, lb per ton									
					CaO	Z-6	A238	DF250	H_2SO_4	$CuSO_4$				
Grind (1)	60	67		7 x 14 RM	10.0	0.10	0.05							
Aerate	30		12.1	Aerator										
Condition	20	35	12.1	2000-g cell	8.0			0.05						
Cu float	2.0	25	12											
Ni condition	5	25	8.1						7.0					
Ni float	5					0.15	0.05							
Scav float	2					0.10	0.05			1.50				
Cu clean	1			250-g cell										
Cu reclean	0.5													
Ni clean	1			500-g cell										
Ni reclean	1			250-g cell										
Ni re-reclean	0.75			250-g cell										

PRODUCT	WT %	ANALYSIS % (2)		DISTRIBUTION %	
		Cu	Ni	Cu	Ni
Cu reclean conc	2.2	28.30	1.61	56.4	2.4
Cu reclean tail	0.8	14.55	2.22	10.5	1.3
Cu clean tail	0.6	17.10	1.87	9.3	0.8
Cu ro conc (calcd)	3.6	23.39	1.78	76.2	4.5
Ni re-reclean conc	10.1	1.13	4.87	10.3	34.3
Ni re-reclean & reclean tail	3.9	0.42	3.50	1.5	9.5
Ni clean tail	11.5	0.62	4.57	6.4	36.7
Ni ro conc (calcd)	25.5	0.79	4.53	18.2	80.5
Cu-Ni ro conc (calcd)	29.1	3.58	4.19	94.4	85.0
Scav conc	4.2	0.22	0.87	0.8	2.5
Rougher tail	66.7	0.08	0.27	4.8	12.5
Combined Scav & ro tail	70.9	0.09	0.30	5.6	15.0
Feed	100.0	1.11	1.44	100.0	100.0

REMARKS: (1) Flotation tailing 84.0 per cent minus 200 mesh.
(2) From Internal Report MS-AC-70:885

MINES BRANCH FLOTATION TEST REPORT

TEST NO. 17 | SAMPLE: Zenmac Metal Mines Limited - Nicopor Sample | DATE: Sept. 29, 1970

OBJECT OF TEST: Repeat of Test 16 using Na_2CO_3 in place of CaO | CHARGE: 2000-g | TESTED BY: WAW

OPERATION	Time min	% Solids	pH	Unit used	Reagents, lb per ton								
					Na_2CO_3	Z-6	A238	CaO	Z-200	H_2SO_4	DF250	$CuSO_4$	
Grind (1)	60	67		7 x 14 RM	10.0	0.10	0.05						
Aerate	30	50		Aerator									
Condition	20	45	12	2000-g cell	10.0			20.0					
Cu float	2	25							0.02				
Condition	5	25	8.3							7.0			
Ni float	4	25				0.15	0.05						
Scavenger float	2					0.10	0.05				0.03	1.50	
Copper conc clean	1			250-g cell									
Copper conc reclean	0.5												
Ni clean No. 1	1.0			500-g cell									
Ni clean No. 2	1.0			500-g cell									
Ni clean No. 3	0.75			250-g cell									

PRODUCT	WT %	ANALYSIS % (2)		DISTRIBUTION %	
		Cu	Ni	Cu	Ni
Cu clean conc	3.3	20.94	6.63	65.5	16.7
Cu clean tail	1.9	2.50	4.60	4.5	6.6
Cu reclean tail	1.9	7.98	8.23	14.4	11.9
Cu rougher conc (calcd)	7.1	12.53	6.51	84.4	35.2
Ni clean conc	5.0	0.30	1.32	1.4	5.0
No. 1&2 Ni clean tail	16.5	0.48	2.98	7.5	37.5
No. 3 Ni clean tail	1.3	0.89	6.66	1.2	6.7
Ni rougher conc (calcd)	22.8	0.46	2.82	10.1	49.2
Bulk Cu-Ni conc (calcd)	29.9	3.33	3.70	94.5	84.4
Scav conc	1.8	0.60	1.83	1.0	2.5
Rougher tail	68.3	0.07	0.25	4.5	13.1
Feed (calcd)	100.0	1.06	1.31	100.0	100.0

REMARKS: (1) Flotation tailing 84.0 per cent minus 200 mesh.
(2) From Internal Report MS-AC-70-906.

MINES BRANCH FLOTATION TEST REPORT

TEST NO. 18	SAMPLE: Zenmac Metal Mines Limited - Nicopor Sample	DATE: Oct. 2, 1970
OBJECT OF TEST: Flotation with different reagents and coarse sample.		CHARGE: 2000-g
		TESTED BY: WAW

OPERATION	Time min	% Solids	pH	Unit used	Reagents, lb per ton									
					CaO	3501	Z-200	H_2SO_4	Z-6					
Grind (1)	30	67		7 x 14 RM	10									
Aerate	30	50		Aerator										
Condition	15	40	12	2000-g cell	15	0.10	0.06							
Copper float	3	25	12											
Condition	10	25	7.3					7.0	0.10					
Nickel float	4	25	7.2											
Cu conc clean No. 1	2		11.7	1000-g cell										
" " " " 2	1.5			250-g cell										
" " " " 3	1.0													
" " " " 4	1.0													
Ni conc clean No. 1	2			1000-g cell										
" " " " 2	1			500-g cell										
" " " " 3	1			250-g cell										

PRODUCT	WT %	ANALYSIS % (2)				DISTRIBUTION %			
		Cu		Ni		Cu		Ni	
Cu clean conc	2.2	27.69		3.58		57.6		5.5	
No. 1 Cu clean tail	2.6	3.41		2.82		8.4		5.1	
No.2,3&4 Cu clean tail	2.2	8.53		3.50		17.8		5.3	
Ro cu conc (calcd)	7.0	12.66		3.27		83.8		15.9	
Ni clean conc	7.6	0.57		5.20		4.1		27.3	
No. 1 Ni clean conc	7.1	0.54		2.31		3.6		11.3	
No. 2 Ni clean conc	8.5	0.37		3.98		2.9		23.4	
No. 3 Ni clean conc	2.1	0.55		6.20		1.1		9.0	
Ro Ni conc (calcd)	25.3	0.49		4.06		11.7		71.0	
Ro Cu-Ni conc (calcd)	32.3	3.13		3.89		95.5		86.9	
Rougher tail	67.7	0.07		0.28		4.5		13.1	
Feed (calcd)	100.0	1.06		1.44		100.0		100.0	

REMARKS:
(1) Flotation tail 60.5 per cent minus 200 mesh.
(2) From Internal Report MS-AC-70-982.

MINES BRANCH FLOTATION TEST REPORT

TEST NO. 19	SAMPLE: Zenmac Metal Mines Limited - Nicopor Sample	DATE: Oct. 6, 1970
OBJECT OF TEST: Repeat of Test 18 with CaO and Promoters in Rod Mill.		CHARGE: 2000-g
		TESTED BY: WAW

OPERATION	Time min	% Solids	pH	Unit used	Reagents, lb per ton									
					CaO	3501	DF250	Z-200	H_2SO_4	$CuSO_4$				
Grind (1)	30	67		7 x 14 RM	10.0	0.05								
Aerate	30	50		Aerator										
Condition	15	40	13.5	2000-g cell	15.0		0.02							
Cu float No. 1	1.5	25	13.5											
Cu float No. 2	0.5	25	11.0					0.02	7.0					
Condition	10	25	7.9						6.0	1.5				
Ni float	5	25				0.05		0.04						
Combined Cu conc clean	2			500-g cell										
Combined Cu conc reclean	1.5			250-g cell										
Nickel clean No. 1	1.5			1000-g cell										
" " " 2	1.0			500-g cell										
" " " 3	0.5			250-g cell										

PRODUCT	WT %	ANALYSIS (2)					DISTRIBUTION %	
		Cu%	Ni%	Au oz/T	Pt oz/T	Pd oz/T	Cu	Ni
Cu clean conc	2.2	27.80	1.48	0.096	0.011	0.031	58.7	2.3
No. 1 Cu cl tail	1.1	12.38	2.43				13.0	1.9
No. 2 Cu cl tail	0.3	16.10	2.30				4.6	0.5
Rougher Cu con (calcd)	3.6	22.11	1.86				76.3	4.7
Ni clean conc	7.6	1.11	7.18	0.050	0.020	0.037	8.1	38.1
No. 1 Ni clean tail	7.6	0.73	2.50				5.3	13.2
No. 2 Ni clean tail	7.4	0.48	2.74				3.4	14.2
No. 3 Ni clean tail	3.6	0.63	5.00				2.2	12.6
Rougher Ni conc (calcd)	26.2	0.76	4.27				19.0	78.1
Cu-Ni ro conc (calcd)	29.8	3.33	3.98				95.3	82.8
Rougher tail	70.2	0.07	0.35				4.7	17.2
Feed (calcd)	100.0	1.04	1.43				100.0	100.0

REMARKS: (1) Flotation tail 60.5 per cent minus 200 mesh.
(2) From Internal Reports MS-AC-70-992 and 1149.

MINES BRANCH FLOTATION TEST REPORT

TEST NO. 20	SAMPLE: Zenmac Metal Mines Limited - Nicopor Sample	DATE: October 20, 1970
OBJECT OF TEST: Repeat of Test 12 plus regrind of concentrates before cleaning.		CHARGE: 2000-g
		TESTED BY: WAW

OPERATION	Time min	% Solids	pH	Unit used	Reagents, lb per ton									
					Na_2CO_3	CaO	A301	DF250	H_2SO_4	A238	Z-6	$CuSO_4$		
Grind (1)	60	67		7 x 14 RM	3.0	3.0	0.10	0.06		0.05				
Aerate	30	50	7.5	Aerator										
Condition	20	40	12.1	2000-g cell		11.0								
Copper float	2	25	11.6											
Nickel float	7.5		7.1				0.10		7.0	0.05	0.10	1.5		
Copper conc grind	15			Pebble Mill										
Copper cleaning	1.5		12.0	250-g cell										
Copper re-cleaning	1.5		12.0											
Nickel conc grind	20			Pebble Mill										
Nickel cleaning	2		7.5	500-g cell										
Nickel re-cleaning	1			250-g cell										
Nickel re-recleaning	1													

PRODUCT	WT %	ANALYSIS % (2)		DISTRIBUTION %	
		Cu	Ni	Cu	Ni
Cu clean conc	1.6	39.25	0.70	54.6	0.8
Cu clean tail	1.1	13.23	2.71	12.6	2.2
Cu reclean tail	0.5	24.27	2.16	10.5	0.8
Rough Cu conc (calcd)	3.2	27.94	1.62	77.7	3.8
Ni clean conc	7.4	0.77	5.18	5.0	28.5
Ni clean tail	14.9	0.53	3.18	6.9	35.3
Ni reclean tail	3.2	0.90	4.45	2.5	10.6
Ni re-reclean tail	1.7	0.90	4.45	1.3	5.7
Rough Ni conc (calcd)	27.2	0.66	3.95	15.7	80.1
Rough Cu-Ni conc(calcd)	30.4	3.53	3.71	93.4	83.9
Rougher tail	69.6	0.11	0.31	6.6	16.1
Feed (calcd)	100.0	1.15	1.34	100.0	100.0

REMARKS:
(1) Float Tailing 92.9 per cent minus 200 mesh.
(2) From Internal Report MS-AC-70-1028.

MINES BRANCH FLOTATION TEST REPORT

TEST NO. 21	SAMPLE: Zenmac Metal Mines Limited - Nicopor Sample	DATE: Oct. 28, 1970
OBJECT OF TEST:	Repeat of Test 20 at coarser grind with no reagents in grind.	CHARGE: 2000-g
		TESTED BY: WAW

OPERATION	Time min	% Solids	pH	Unit used	Reagents, lb per ton									
					Na_2CO_3	CaO	A238	A301	DF250	H_2SO_4	Z-6	$CuSO_4$		
Grind (1)	50	67		7 x 14 RM										
Aerate	30	50		Aerator										
Condition	20	40	11.5	2000-g cell	3.0	20.0	0.05	0.10	0.06					
Cu float	2	25	11.5											
Ni condition	5		7.0							7.0				
Ni float	8	25	7.3				0.05	0.10			0.05	1.50		
Cu conc grind	15			Pebble Mill										
Cu clean	1.5		12.0	500-g cell		2.0								
Cu reclean & re-reclean	1.5		12.0	250-g cell										
Ni conc grind	25			Pebble Mill										
Ni clean	2		7.9	500-g cell										
Ni reclean & re-reclean	1			250-g cell										

PRODUCT	WT %	ANALYSIS % (2)		DISTRIBUTION %	
		Cu	Ni	Cu	Ni
Cu clean conc	1.8	28.73	3.47	48.2	4.4
Cu clean tail No. 1	7.7	1.38	3.22	9.9	17.4
Cu clean tail No. 2	0.9	7.46	5.00	6.2	3.2
Cu clean tail No. 3	0.4	10.39	6.45	3.9	1.8
Ro Cu Conc (calcd)	10.8	6.78	3.53	68.2	26.8
Ni clean conc	3.5	3.43	8.46	11.2	20.8
Ni clean tail No. 1	14.7	0.83	3.07	11.4	31.8
Ni clean tail No. 2	1.6	1.38	4.85	2.0	5.5
Ni clean tail No. 3	1.1	1.49	5.16	1.5	4.0
Ro Ni conc (calcd)	20.9	1.34	4.22	26.1	62.1
Ro Cu-Ni conc (calcd)	31.7	3.19	3.98	94.3	88.9
Rougher tail	68.3	0.09	0.23	5.7	11.1
Feed (calcd)	100.0	1.07	1.42	100.0	100.0

REMARKS:
(1) Float tailing 84.1 per cent minus 200 mesh.
(2) From Internal Report MS-AC-70-1037.

MINES BRANCH FLOTATION TEST REPORT

TEST NO. 22	SAMPLE: Zenmac Metal Mines Limited - Nicopor Sample	DATE: Nov. 19, 1970
OBJECT OF TEST: Repeat of Test 4.		CHARGE: 2000-g
		TESTED BY: W.A.W.

OPERATION	Time min	% Solids	pH	Unit used	Reagents, lb per ton									
					Na_2CO_3	Z-6	CaO	AF71						
Grind	50	67		7x14 RM										
Condition (1)	10	45	7.6	2000-g cell	8.0	0.05	2.0							
Flotation	7.5	25	7.9			0.20		0.05						
Clean	2.0			1000-g cell										

PRODUCT	WT %	ANALYSIS % (2)						DISTRIBUTION %				
			Cu	Ni					Cu	Ni		
Clean bulk conc	25.5		4.00	4.56					93.9	79.1		
Clean bulk tail	7.3		0.35	2.00					2.4	9.9		
Ro bulk conc (calcd)	32.8		3.19	3.99					96.3	89.0		
Ro tail (3)	67.2		0.06	0.24					3.7	11.0		
Feed (calcd)	100.0		1.09	1.47					100.0	100.0		

REMARKS: (1) Flotation cell air valve closed. (2) From Internal Report MS-AC-70-1157.
(3) Flotation tailing 86.1% -200 mesh.

MINES BRANCH FLOTATION TEST REPORT

TEST NO. 23	SAMPLE: Zenmac Metal Mines Limited - Nicopor Sample	DATE: Nov. 20, 1970
OBJECT OF TEST: Flotation of bulk float.		CHARGE: 2000-g
		TESTED BY: W.A.W.

OPERATION	Time min	% Solids	pH	Unit used	Reagents, lb per ton									
					Na_2CO_3	Z-6	AF71	SO_2	CaO					
Grind	50	67		7x14 RM										
Condition (1)	15	45	8.7	2000-g cell	12.0	0.05								
Float No. 1	1	25	8.7				0.015							
Float No. 2	1		8.5			0.05	0.015							
Float No. 3	1		8.3			0.05	0.030							
Float No. 4	1		7.5			0.10		5.0						
Combined conc														
No. 1 clean	2		9.4						3.0					
No. 2 clean	1.5		12.1						3.0					
No. 3 clean	1		11.9						1.0					
No. 4 clean	1		11.8						1.0					

PRODUCT	WT %	ANALYSIS % (2)				DISTRIBUTION %			
		Cu		Ni		Cu		Ni	
Clean conc	5.7	12.14		3.00		63.1		11.5	
No. 1 clean tail	4.2	1.33		2.55		5.1		7.2	
No. 2 clean tail	11.4	1.00		3.65		10.4		28.0	
No. 3 clean tail	3.6	2.00		7.75		6.6		18.7	
No. 4 clean tail	4.1	2.55		7.37		9.6		20.3	
Bulk conc (calcd)	29.0	3.58		4.40		94.8		85.7	
Rougher tail (3)	71.0	0.08		0.30		5.2		14.3	
Feed (calcd)	100.0	1.10		1.49		100.0		100.0	

REMARKS: (1) Flotation cell air inlet open.
(2) From Internal Report MS-AC-70-1157.
(3) Flotation tailing 86.1% -200 mesh.

MINES BRANCH FLOTATION TEST REPORT

TEST NO. 24	SAMPLE: Zenmac Metal Mines Limited - Nicopor Sample	DATE: Nov. 26, 1970
OBJECT OF TEST: Production of Copper Conc and Nickel Conc.		CHARGE: 2000-g
		TESTED BY: WAW

OPERATION	Time min	% Solids	pH	Unit used	Reagents, lb per ton									
					Na_2CO_3	Z-6	AF71	CaO	NaOH	SO_2				
Grind	50	67		7x14 RM	6.0	0.05	0.015							
Aerate	20	45		Aerator										
Condition	15	35	12.1	2000-g cell				15.0	6.0					
Copper float	4	25	12.0			0.05	0.015							
Nickel condition	5	25	8.2							15.0				
Nickel float	5					0.10	0.03							

PRODUCT	WT %	ANALYSIS % (1)				DISTRIBUTION %			
		Cu		Ni		Cu		Ni	
Copper conc	3.1	23.90		1.00		69.6		2.2	
Nickel conc	28.2	1.00		4.17		26.5	x	84.5	
Cu-Ni conc (calcd)	31.3	3.27		3.86		96.1		86.7	
Rough tail (2)	68.7	0.06		0.27		3.9		13.3	
Feed (calcd)	100.0	1.06		1.39		100.0		100.0	

REMARKS: (1) From Internal Report MS-AC-70-1168. (2) Flotation tailing 86.1% -200 mesh.