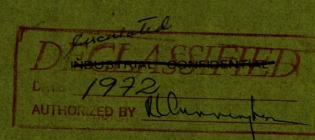
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CANADA

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

W. ARTHUR WALL AND R. W. BRUCE

by

MINERAL PROCESSING DIVISION

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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.

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INTR ODUCTI ON

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.

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TABLE 1

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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.

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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.

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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

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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.

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 %		l		
Cu	4.1	3.8	3.2	3.7
Ni	8.4	9.8	10.6	11.0
111	0.4	7.0	10.0	1

TABLE	3

Results of Flotation at Various Grinds

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

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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.

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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

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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

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APPENDIX A

<u>Test Data Sheets</u>

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
$\mathrm{Cu}\mathrm{SO}_4$	Copper Sulphate
CaO	Lime
A 238	Sodium Di-secondary Butyl Dithio-phosphate
Na_2SO_3	Sodium Sulphite
A 301	Sodium Secondary Butyl Xanthate
$\mathrm{H_2SO_4}$	Sulphuric Acid
SO_2	Sulphur Dioxide
Na O H	Sodium Hydroxide
A 350	Potassium Amyl Xanthate
3501	Aero Promoter 3501

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1

TEST NO. 1 SAMP	LE: Z	enmac	Limite	ed - N	icopor	Sample								<u>v 29, 1</u>	
OBJECT OF TEST: Pre	limina	ry Flo	tatio	1	-									2000-g	
														BY: WAW	
OPERATION	Time	.%	pH		Jnit	No. CO	1 7 6			gents	s, lb	per ton			
······································		Solids			ised	Na ₂ CO	3 2-0	AF 70	DF250		_			-	
Grind*	30	67		7x14	RM		<u> </u>	<u> </u>			_				
Condition (1)	7.0	45	7.9	2000	-g cell	4.0	0.03				_				
				1	8 0011		1			<u> </u>		•			1
Float No. I	1	30						0.014	`				-		1
Float No. II	2	30	7.9		<u>`,</u>		0.10	0.014							-
								-					·		
Float No. III	2	20	7.9		<u> </u>		<u> </u>	· · · · · · ·	0.02	·					
Float NoIV	2	20	7.8	<u> </u>	·		0.10	· · · · ·							
														·	
PRODUCT	W	T			ANAL	YSIS	% (3)		·			DISTE	RIBUTIC)N %	
PRODUCT	%	6		Cu	Ni	Fe	S					Cu	Ni	Fe	S
No. 1 conc		.94		.78	5.15		20.61					60.4	23.5	9.8	14.9
No. 2 conc		. 44		.57	3.51		23.25					30.3	55.2	39.3 11.9	58.0
No. 3 conc No. 4 conc	51	. 32		.69	2.06	40.55	17.28					1.1	2.9	4.0	5.1
Magnetic tailing ⁽²⁾	11	.53	1	.04	0.20	50.00						0.4	1.5	22.2	3.7
Non-magnetic tailing ⁽²⁾	55	. 34	c	.07	0.16	5.00	0.59					3.7	6.9	12.8	4.0
Rougher tailing (calcd)	64	. 87	. C	.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
													4		
	+ 0 = 7 =		70		0 maab			4				<u></u>	<u> </u>	<u></u>	
REMARKS: * Flotation (1) Flotation						onditio	ning								

(2) Rougher tailing magnetic fraction removed in Sala magnetic separator. (3) From Internal Report MS-AC-70-617.

TEST NO. 2 SAME															
OBJECT OF TEST:			7		7		1					CH	ARG	E: 2000-g	
	rerent		eaure s	same (Grind as	lest .	L •					ТЕ	STED	BY: WAW	
OPERATION	Time	%	рН		Jnit				Rea	igents	s, Ib	per ton			
	min	Solids		. L	ised	Na ₂ CO ₂	A15	Z-200	CuS04	Z-6	_				
Grind	3 0	67		7x14	RM										
		1.5		ļ											
Condition	5	45.0	8.8	2000	-g cell	5.00		0.05							ļ
					·····					ļ				•	ļ
Float No. 1 Float No. 2	1 2	<u>30</u> 30	8.6				-	0.07							
Fibat No. 2	<u> </u>	30	8.6			•		0.05							
Condition	5	30	8.1					<u> </u>	1.0	0.10	_				+
		- 30	0.1	<u> </u>					1.0	<u> </u>					
Float No. 3	2	30	8.1				0.05				1				1
Float No. 4	2.5	30	8.1				0.05			0.10					
PRODUCT	W	12			ANAL	YSIS	% *		<u> </u>			DISTE	RIBUT	10N %	
	%	6		Cu	Ni							Cu		Ni	
No. 1 conc	. 8	.0	6	.78	6.00							50.0		36.7	
No. 2 conc		.4		.78	4.68							32.7		33.7	
No. 3 conc	13			.73	1.60							8.8		15.9	
No. 4 conc	4	.9	0	.70	1.29							3.1		4.8	
Rougher tail	64	7		.09	0.18										
hought turi		• 1		.09	0.10							5.4		8,9	
Feed (calcd)	100	.0	1	.08	1.31							100.0		100.0	
Combined Mar 1 C Mar 2															
Combined No. 1 & No. 2 conc	17	A	-	.16	F 90							00.5			
conc	1 1	• 4	5	.10	5.29							82.7		70.4	
		-													
PENADKA					I			1	<u> </u>			<u> </u>	l	<u> </u>	
REMARKS: * From Inter	mal Re	eport N	IS-AC-	70-60	5			,							

TEST NO. 3 SAMP	LE: Z	enmac	Limite	ed - N	licopor	Sample			<u></u>			DA	TE: Jun	e 18, 1	L970
													ARGE: 2		
											. <u> </u>			Y: W.A	.W.
ODERATION	Time	%	nH ·				•		Rea	gents,	lb p	per ton			
OPERATION	min	Solids		ι ι	ised	Na2CO3	Z- 6	AF71							
Grind	45	67	•	7x14	RM										
				ļ	<u>.</u>			<u> </u>							<u></u>
Conditioning (1)	10	45	7.9	2000-	g_cell	6.0	0.03	<u> </u>		<u> </u>					
		20	7 0					0.02			<u> </u>				+
			1.3	<u> </u>		<u> </u>	0.05	<u>↓</u>							+
No. 2 Float	<u> </u>			+	·····	·····	0.05	0.02							
No. 3 Float	1.5	30			<u> </u>		0.05	0.02							
No. 4 Float	3.0	30	7.9				0.10								
					·····			<u></u>							
		1	4	ļ		1								N 94	<u> </u>
PRODUCT			·										<u> </u>	N 70	
		•		Cu	Ni			<u> </u>	<u> </u>		_	Cu	<u>.N1</u>		
Nos. 1 and 2 conc	21	.6		4.34	4.50							89.2	75.5		
												1 0			
No. 3 conc	2	•8	(.46	1.65							1.2	3.0		÷
No. 4 conc	8	.7	0	.7 0 [.]	1.64		-					5.8	11.1		
Rougher tail (2)	66	.9		0.06	0.19							3.8	9.8		
	1 1 00				1 30							TOO O	100.0		
Feed (calcd)	1100	.0		1.05	1.29		· · · ·					100.0	100.0		
,															
OPERATION Time min % Solida PH Unit Used Reagents, ib per ton 3rind 45 67 7x14 RM 6 4 6 1 6 1															
REMARKS: (1) Flotat	ion ce	11 Air	valve	e oper	n during	condit	ioning	3				•			
(2) Flotat	lon ta nterpa	1 Repo	46 M11 rt MS.	us 20 AC-70)-646										

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TEST NO. 4 SAM	PLE: Z	enmac 1	Limite	d - N	icopor S	Sample							ne 19,	
OBJECT OF TEST: Fir	er Gri	nd than	n Test	3									2000 - g	
				. <u>.</u>									3Y: W.A	.W.
OPERATION	Time	%	рН		Jnit		1	1	Rea	gents,	lb per tor	l 		
	min	Solids			ised	Na ₂ CO ₃	Z-6	AF71						
Grind	60	67		7 <u>x14</u>	RM									
	+ 10	15	7.0	2000	1 1		0.05							
Condition (1)	10	45	7.9	2000	g cell	6.0	0.05							
Flotation No. 1	1	30	7.9	<u> </u>				0.02]			••	
" No. 2	2.5			1		+	0.05							
" No. 3	1.5	30					0.05							
" No. 4	3	30	7.9				0.05	0.02						
		ļ	ļ	<u> </u>		<u> </u>								
					· · · · · · · · · · · · · · · · · · ·									
·														
	l W	<u> </u> 	[<u> </u>	ΔΝΙΔΙ	YSIS	04 (3)		1	<u>_</u>			NI 94	
PRODUCT	11	6		Cu	Ni	1010	/0 (3)		<u> </u>		Cu	Ni Ni		
												1		
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		
	-													
				ĺ			_							
									-					
					<u> </u>							<u> </u>		
REMARKS: (1) Flotat (2) Flotat (2) From J	ion tai	il 84.0)% min	us 200) mesh	condit	ioning						-	
(3) From I	nternal	L Kepor	C MS-/	HU-/U-	-04/									

		LIMIC	ea - r	licopor	Sample							e 22, 1	
n Cu-N:	i conce	entra	te and	l separa	ate Cu a	und Ni							
						<u> </u>						3Y: W.A	.W.
Time	%	ън					· · · · · · · · · · · · · · · · · · ·	Reag	ents, il	b per ton			
miņ	Solids			used	Na ₂ CO ₃	Z-6	AF71						
60	67		7x14	RM	•								
	· .												
20	45	8.5	2000)-g cell	8.0	0.05	<u> </u>			· .			
		<u>. </u>					·				·		
4	28	8.2				0.05	0.05						
				<u>.</u>		0.10			·			·	
	.25	8.2	+			0.10	[]						
2			1000										
1													
0.75		12.5	250-	g cell	2.0								
W-	Т			ANA	LYSIS	% (3)				DISTE	RIBUTIC	N %	
%	5		Cu	Ni	Insol	· · ·		<u>.</u>		Cu	Ni	Insol	
2.	.1		23.21	6.03	1.40	• .				47.2	10.0	0.1	
	11		2.94	4.91	2.46						1	0.4	
	44					·				1		1	
FI	11				1 1								
			0.40		0.00						14.0	0.0	
.d] 27.	.2		3.55	3.93	8.11					93.7	83.9	4.1	, ,
6.	.0		0.53	1.32	32.40	•				3.1	6.2	3.0	
66.	.8		0.05	0.19	74.88			· · ·		3.2	9.9	92.3	
													•
			1.03	1.28	54.17					100.0	100.0	100.0	
	<u> </u>		.1 1					l	11		1	<u> </u>	
e on r n tail	.10caci .84.0%	on ce minu	:⊥⊥ op is 200	mesh	ing cond	10101	ng					·	
	Time min 60 20 4 5 2 1 0.75 2 1 0.75 2 1 0.75 2 1 2 0.75 4 9. 14. 2. 7. 6. 66. 66. 66. 66.	Time % min Solids 60 67 20 45 4 28 5 25 2 1 0.75 WT % 2.1 7.5 d 9.6 14.9 2.7 d 27.2 6.0 66.8 e on flotati n tail 84.0%	Time % pH 60 67 20 45 8.5 4 28 8.2 5 25 8.2 2 1 1 0.75 12.5 12.5 WT % 1 0.75 12.5 12.5 WT % 1 2.1 7.5 1 9.6 14.9 2.7 14.9 2.7 6.0 66.8 66.8 1 e on flotation central 84.0% minution 1	Time min % Solids pH 60 67 7x14 20 45 8.5 2000 4 28 8.2	Time min % Solids pH Unit used 60 67 $7x14 \text{ RM}$ 20 45 8.5 $2000-g \text{ cell}$ 4 28 8.2 $$	Time % pH Unit Na2C03 60 67 7x14 RM	min Solids PH used Na ₂ CO ₂ Z-6 60 67 7x14 RM	Time % pH Unit Na2C02 Z-6 AF71 60 67 $7x14 \text{ RM}$ - -	Time % pH Unit Reag 60 67 $7x14 \text{ RM}$ - - </td <td>Time min Solids ρH Unit used Reagents, II 60 67 7x14 RM 1 1 20 45 8.5 2000-g cell 8.0 0.05 1 20 45 8.5 2000-g cell 8.0 0.05 1 4 28 8.2 0.05 1 1 5 25 8.2 0.10 1 1 2 1000-g cell 1 1 1 1 5 25 8.2 0.10 1 1 2 1000-g cell 1 1 1 1 5 25 250-g cell 2.0 1 1 1 0.75 12.5 250-g cell 2.0 1 1 1 0.75 12.5 250-g cell 2.0 1 1 1 1 0.75 12.5 250-g cell 2.0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1<td>Time % Time % pH Unit used Na_2C03 Z-6 AF71 60 67 7x14 RM </td><td>Time % pH Unit Reagents, lb per ton 20 45 8.5 2000-g cell 8.0 0.05 1 1 4 28 8.2 0.05 1 1 1 1 5 25 8.2 0.10 1 1 1 1 20 45 8.5 2000-g cell 8.0 0.05 1 1 4 28 8.2 0.10 1<!--</td--><td>TESTED BY: W.A Time % pH Unit Reagents. Ib per ton 60 67 7x14 RM 20 45 8.5 2000-g cell 8.0 0.05 20 45 8.5 2000-g cell 8.0 0.05 4 28 8.2 0.05 5 25 8.2 0.10 2 1000-g cell 0.10 3 25 8.2 0.10 1 500-g cell 2.0 0.75 12.5 250-g cell 2.0 1 500-g cell 2.0</td></td></td>	Time min Solids ρH Unit used Reagents, II 60 67 7x14 RM 1 1 20 45 8.5 2000-g cell 8.0 0.05 1 20 45 8.5 2000-g cell 8.0 0.05 1 4 28 8.2 0.05 1 1 5 25 8.2 0.10 1 1 2 1000-g cell 1 1 1 1 5 25 8.2 0.10 1 1 2 1000-g cell 1 1 1 1 5 25 250-g cell 2.0 1 1 1 0.75 12.5 250-g cell 2.0 1 1 1 0.75 12.5 250-g cell 2.0 1 1 1 1 0.75 12.5 250-g cell 2.0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 <td>Time % Time % pH Unit used Na_2C03 Z-6 AF71 60 67 7x14 RM </td> <td>Time % pH Unit Reagents, lb per ton 20 45 8.5 2000-g cell 8.0 0.05 1 1 4 28 8.2 0.05 1 1 1 1 5 25 8.2 0.10 1 1 1 1 20 45 8.5 2000-g cell 8.0 0.05 1 1 4 28 8.2 0.10 1<!--</td--><td>TESTED BY: W.A Time % pH Unit Reagents. Ib per ton 60 67 7x14 RM 20 45 8.5 2000-g cell 8.0 0.05 20 45 8.5 2000-g cell 8.0 0.05 4 28 8.2 0.05 5 25 8.2 0.10 2 1000-g cell 0.10 3 25 8.2 0.10 1 500-g cell 2.0 0.75 12.5 250-g cell 2.0 1 500-g cell 2.0</td></td>	Time % Time % pH Unit used Na_2C03 Z-6 AF71 60 67 7x14 RM	Time % pH Unit Reagents, lb per ton 20 45 8.5 2000-g cell 8.0 0.05 1 1 4 28 8.2 0.05 1 1 1 1 5 25 8.2 0.10 1 1 1 1 20 45 8.5 2000-g cell 8.0 0.05 1 1 4 28 8.2 0.10 1 </td <td>TESTED BY: W.A Time % pH Unit Reagents. Ib per ton 60 67 7x14 RM 20 45 8.5 2000-g cell 8.0 0.05 20 45 8.5 2000-g cell 8.0 0.05 4 28 8.2 0.05 5 25 8.2 0.10 2 1000-g cell 0.10 3 25 8.2 0.10 1 500-g cell 2.0 0.75 12.5 250-g cell 2.0 1 500-g cell 2.0</td>	TESTED BY: W.A Time % pH Unit Reagents. Ib per ton 60 67 7x14 RM 20 45 8.5 2000-g cell 8.0 0.05 20 45 8.5 2000-g cell 8.0 0.05 4 28 8.2 0.05 5 25 8.2 0.10 2 1000-g cell 0.10 3 25 8.2 0.10 1 500-g cell 2.0 0.75 12.5 250-g cell 2.0 1 500-g cell 2.0

TEST NO. 6 SAMP	PLE: Z	enma	c Limit	ed -	Nicopor S	Sample	*****					DA	TE: Jui	ne 23,	1970
OBJECT OF TEST: Floa	t Copp	er fo	ollowed	by 1	Nickel flo	oat						СН	ARGE: 2(000-g	
												TES	STED B	Y: W.A.	W.
OPERATION	Time	%	pН	Τ	Unit				Rea	agents,	lb per	ton			
	min	Solic	ds Pi		used	Na ₂ CO ₂	Z- 6	A238	AF71	Ca0					
Grind	60	67		7x1	L4 RM										
·····															
Condition (1)	10	45	8.5	200)0-g_ce11	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	ļ			0.15								
Nickel conc clean	1.5		9.5	100	0-g cell					0.25					
Nickel conc reclean	1.0)-g cell					0.20					
				<u> </u>											
PRODUCT	W W				ANAL	YSIS	% (3)				DI	STR	BUTIO	N %	
	%			Cu	Ni						Cu	L	Ni		
Rougher Cu conc	11	.1	8	.69	6.98						6	36.6	59.9		
Reclean Ni conc Clean Ni tail		.0		.70	2.28							2.5	7.0		
Reclean Ni tail		.6	1	.48	2.36							4.2 2.9	10.2		
				• • •	2.50							2.9	12.1		
Rougher Ni conc (calcd)	19	.5	C	.55	1.94							9.6	29.3		
Rougher tail (2)	69	.4	c	.06	0.20							3.8	10.8		
Feed (calcd)	100	.0	1	.11	1.29			•			10		100.0		
				• 4 4	1.027						TO	0.0	100.0		
															:
														į	
REMARKS: (1) Flotatio	n cell	. Air	Valve	open	during c	onditi	oning								
(2) Flotatio	on-tail	ing	84.0% m	inus	200 mesh	L	0			~					
(3) From Int	ernal	Керо	rt MS-A	.c-70	-691 .										
												-			

TEST NO. 7 SAMP	LE: 2	Zenmac	Limi	ited -	Nicopor	Sample	3					ATE: JI		
OBJECT OF TEST: Magne	etic (Concen	trati	ion							·	IARGE:		
												STED E	Y: W.A	.W.
OPERATION	Time	%	-tq	1 }	Unit				Reag	gents, I	b per tor	i		
	min	Solid	5		used									
Grind	30	67		7x1	4 RM									
Sala Magnet														
									- ·					· · ·
Jones Magnet	set a	t 3.0	Amps	6										
													····	
			· · · ·								······			
	····		1											
				<u>.</u>	- <u>., au.</u>									-
	1		<u> </u>	1			<u> </u>							
PRODUCT	W 9/		·····	Cu	Ni Ni	LYSIS Fe	%* S	Insol		Cu	Ni	RIBUTIO Fe	S S	Insol
Sala magnetics	25	5.9		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	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	0.0		1.09	1.26	21.99	10.61	54.66		100.0	100.0	100.0	100.0	100.0
						-								
REMARKS: *From Interna	1 Rep	ort M	S-AC-	70-722										
		-	. •				-							
														1

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OBJECT OF TEST: Remove Magnetics, Float Non-Magnetics CHARGE: 2000-g TESTED BY: W.A.W. OPERATION Time % min Solids pH Unit used Reagents, Ib per ton Grind 60 67 7x14 RM Image: Charge state st	•													
OPERATION Time % pH Unit Reagents, Ib per ton Min Solids PH Used Na2C03 Z=6 A238 DF250 Ca0 Image: Calify the second se	•													
OPERATION min Solids PH used Na2CO3 Z-6 A238 DF250 Ca0														
min Solids used Na ₂ CO ₃ Z-6 A238 DF250 CaO														
Grind 60 67 7x14 RM														
Magnetic Sep Sala Sala														
Condition 10 45 8.6 2000-g cel1 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 cel1														
Reclean 1 250-g cell														
PRODUCT WT ANALYSIS % (3) DISTRIBUTION %														
Reclean 1 250-g cell														
Cu conc 2.3 22.32 7.78 48.4 14.3	1													
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														
Rocu conc (calcd) 4.3 17.28 9.43 70.1 32.3	1													
Ni conc 7.1 0.88 2.64 5.9 14.9	ļ													
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														
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	ĺ													
	l													
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														

TEST NO. 9 SAME	LE: Z	enmac	Limit	ed - N	licopor S	Sample						DA	TE: July	y 15, 1	970
OBJECT OF TEST: Roug	her f	lotati	on. c	lean a	nd separ	ate Cu	-Ni					СН	ARGE: 2	2000-g	
	51101 1	TOCHCT	un c	19411 9	ine bepui				•			TES	STED B	Y: W.A	.W.
	Time	%		1 1	Jnit	T			Rea	agents,	lb pe	r ton			
OPERATION		Solids	рН	1	used	Na ₂ CO ₃	Z- 6	A238	CaO	DF250				ŀ	
Grind	30	67		7x14	RM	3.0		0.02							
Condition	10	50	8.7		-g cell		0.05	0.02	2.0	1					·
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		2.5	1000	-g cell			2	3.0						
Float Cu	3								<u></u>						
Clean		· · ·		_	` 										
Reclean	1.5													-	
-		<u> </u>	<u> </u>			<u> </u>				<u> </u>	L				
PRODUCT	W	11			ANAL	YSIS	% (3)	·	·		D	ISTR	IBUTIO	N %	
	9/	6		Cu	Ni						C	u	_Ni		
Reclean Cu conc	2	•4		23.88	4.72							53.7	8.8		
Cu clean tail	11	.0		7.94	4 I							7.4	6.3		
Cu reclean tail	11	.8		8.61	8.38							6.5	5.2		
Ro cu conc (calcd)		2		17.17	6.21						4	67.6	20.3		.
Ni conc	15	.8		1.09	3.72						1	16.1	45.6		
Reclean Cu-Ni conc (cald				4.46								83.7	65.9		
Clean Cu-Ni tail	11	.9		0.87	2.00						-	4.0	7.6		
Reclean Cu-Ni tail	7			1.00	, ,							6.6		•	
Ro Cu-Ni conc (calcd)	32			3.15		· · ·						94.3			· ·
Rougher tail (2)	68			0.09	0.24	ĺ			1			5.7	12.6	•	
Feed	100	.0		1.07	1.29	ł					. 1	00.0	100.0		
									1						
		<u> </u>			<u> </u>										l
REMARKS: (1) Compress	sed Ai	r adde	d to	cell d	uring co	onditio	ning			•			•		
(2) Flotatio (3) From Int	on tai. Fernal	Report	6.7% 1 t MS-	minus AC-70-	200 mesi 723	L									
				• •	+							2. 			

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Zenmac Limited - Nicopor Sample DATE: July 14, 1970 TEST NO. 10 SAMPLE: CHARGE: 2000-g OBJECT OF TEST: Bulk float - Grind concentrate, clean and reclean TESTED BY: W.A.W. Reagents, Ib per ton Time % Unit OPERATION pН used Na₂CO₃Na₂SO₄ DF250 A238 Z-6 CaO min Solids 6.0 1.0 7.0 7x14 RM 30 Grind 67 0.03 2.0 7 50 7.8 2000-g_cell 0.10 0.10 Condition 7.8 0.03 0.05 0.05 Bulk float 5 30 Filter conc 7x14 RM 15 5.0 Grind conc 2 11.2 1000-g cell Clean No. 1 Condition with air 5 1.5 12.2 500-g cell Reclean ANALYSIS % (2) WT DISTRIBUTION % PRODUCT % Cu Ni Cu Ni Cu reclean conc 30.00 1.90 32.4 1.5 1.1 31.2 1.37 3.23 Clean Cu tail 42.0 73.5 3.1 6.29 4.83 19.2 10.9 Reclean Cu tail Rougher tail (1) 64.6 0.10 0.30 6.4 14.1 Feed (calcd) 100.0 100.0 100.0 1.02 1.37 REMARKS: (1) Flotation tailing 50.7% minus 200 mesh (2) From Internal Report MS-AC-70-723

MINES BRANCH FLOTATION TER REPORT

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TEST NO. 11 SAMP	LE: Ze	enmac I	Limite	d - N	icopor S	Sample							TE: Jul		1970
	eat of	F Test	9 at	finer	grind							CH	ARGE: 2	2000-g	
l contra transmission and the met	cac of		, 46.	LIICA	gr me				•			TES	STED B	Y: W.A	.W.
	Time	%		1	Jnit	T	·		Rea	igents,	lb pe	er ton			
OPERATION		Solids	рН	1	used	Na ₂ CO ₃	Z-6	A238	Ca0	DF250					T
															-
Grind	_60	67	7.5			6.00	0.05	0.02	1 0						
Condition	<u>10</u> 1	50 30	7.7	2000	<u>-g cell</u>		0.05	0.02	1.0						
Cu float No. 1		30	1.1		·		0.10	0.02		0.06			· · · · · ·		
Bulk float Clean No. 1 Cu conc	6 5	30.	7.2	250-	g cell		0.10	0.02		0.00					
				250-	<u>g</u> cerr	· · ·	·		1 0						
Reclean No. 1 Cu conc	1.5		12.2	1.000	-g cell				1.0						-
<u>Clean bulk conc (1)</u> Reclean bulk conc	2	<u> </u>	7.8	1000	-g cerr		·····	-					·		
Reclean Bulk Conc			7.0		· · · · · · · · · · · · · · · · · · ·	·				•					
	20							· .							-
Cond reclean conc (2) Cu conc No. 2	<u>20</u> 2		12.1												-
······································	1.5		12.1												
Clean Cu conc No. 2		11	l	1		YSIS	$\alpha(h)$!		<u> </u> }	Г			N %	
PRODUCT	W V	11		• • • •	T	-1212	% (4)	1				<u> </u>	1		
				Cu	Ni							Cu	Ni	· · · · · · · · · · · · · · · · · · ·	
No. 1 Reclean Cu conc		L.2		0.87	2.66		•				·	36.9	2.4		
No. 2 cl cu conc	11	0.8		9.00	1.84	· .						23.1	1.1		
Copper conc (calcd)		2.0	- 30	0.10	2.35		•					60.0	3.5		
				0 60	4.67						Ì	6.9	38.2	· · ·	
Ni conc		L.0	6	0.63 1.49	2.12							13.6	14.5		
Bulk conc clean tail Bulk conc reclean tail	11	9.2 L.3		1.00	3.64		· .				· ·	11.2	30.5	-	
Bulk conc reclean call				1.00	5.04						· ·				
No. 2 Cu conc clean tail		0.3	11	4.32	6.73							4.3	1.5		
Rougher tail (3)	66	5.2		0.06	0.24	[4.0	11.8		
-											.			•	
Feed (calcd)	100	0.0		1.00	1.35							100.0	100.0		
														•	
				·- · · · · ·	1 1	1		<u> </u>	<u> </u>	1			(2)	Condite	ionod
REMARKS: (1) No. 1 Cu with compre	clear	ner and	1 recl	eaner	tails a	idded t	o Buik O% min	conce	ntrate mesh.	befor (4)	e cie From	anıng Inter	nal Rei	ort MS	-
AC-70-728.	sseu a	3 I I I I I I I I I I I I I I I I I I I	(3) 11	Juari	UN CALLI		070 III II								
110-70-7200					``````````````````````````````````````										

TEST NO. 12 SAMP	LE: 2	Zenmac	Limit	ed -	Nicopor	Sample	S					1	TE: Jul		L970
OBJECT OF TEST: Gri	nd-Aer	ate-Fl	loat				<u></u>					CH	ARGE:	2000 - g	
1				_								TES	STED B	Y: W.1	A.W.
	Time	%			Jnit				Rea	agents,	lb per	ton			
OPERATION		Solids	рН		used	Na2CO3	CaO	Z-6	A238	DF250	H2SO				
Grind	60	67	7.4	7x1	4 RM	3.0	3.0	0.10	0.05	0.06	<u></u>	1			
Aerate	20				ator		1					1			
Condition	20		12.1		0-g cell	3.0	11.0								
										-					
Copper float	2		12.0									1			
Copper clean	1			250	-g cell										•
Copper reclean	_1			-								ļ			
0.11.1.0			0.0	- 200	0 11						7.0				
Condition Cu tails Ni float	<u>5</u>		8.0	200	0-g_cel1	-		0.10	0.05		7.0				
			0.0					0.10	0.05						
Ni conc clean	$\frac{1}{1}$			+		-								+	
Ni conc reclean		l		<u> </u>			(0)			<u> </u>		<u> </u>			
PRODUCT	W W	1				YSIS	(2)	(- <u>F</u>			STR	IBUTIO	<u> </u>	
		»		Cu%	Ni %	Au oz/t	Rt oz/T	Pd oz/	r¦ 		<u> </u>	<u>u</u>	<u>Ni</u>		
Cu conc	2	.6	3	1.97	1.29	0.090	0.013	0.019			7	71.9	2.5		
Ni conc		.2		1.73	11.01	1	0.013	0.055				10.8			
				~											
Cu clean tail	11	.3		5.00	1.69					1		3.9	0.4	1	
Cu reclean tail	11	.1		6.19	2.00							1.4		1	
Rougher Cu conc (calcd)	3	•0	2	9.73	1.37							77.2	3.1		
Ni clean tail	1	.8		1.30	2.18							2.0	2.9		
Ni reclean tail		.6	1	1.48	4.14						Į	3.3	8.0		
Rougher Ni conc (calcd)	11	.6		1.60	8.10							16.1	1		
														1	
Rougher tail (1)	85	•4		0.09	0.43							6.7	27.2		
Feed (calcd)	100	.0		1.16	1.35						1	00.0	100.0		
								<u> </u>	<u> </u>						
REMARKS: (1) Flotati (2) From In	on tai ternal	ling 8 Repor	34.0% ts MS -	ninus AC-70	200 mes -750 and	sh. 1 1149.									

TEST NO. 13 SAMP	LE:	Zenma	c Lim	ited -	Nicopo	r Samp	1e					DATE		y 25, 1	1970
OBJECT OF TEST: Re	peat o	of Test	12 w	ith di	fferent	reage	nts.					CHAR	GE: 2		
	1						· ·					L	ED BY	: W.A.	.W.
	Time	%		υ	nit	1			Rea	igents,	lb per	ton			
OPERATION		Solids	pН	u	sed	Na ₂ CO	β CaO	A238	A301	DF250	<u>A350</u>	H ₂ SO4	CuSO ₄		
Grind	60	67			4 RM ·	3.0	3.0	0.05	0.10	0.06					
Aerate	30			Aerat			[
Condition	10	45	12.0	2000-	g cell		11.0					·	·.		
Copper float	2.5	30	11.8											· · · · · · · · · · · · · · · · · · ·	ļ
Conc clean	1.5			250-g	cell_		ļ				·				
Conc reclean	1.5			· · · ·		<u> </u>	<u> </u>						ļ	· · · · · · · · · · · · · · · · · · ·	
Ni condition	5			2000-	g_cell_		·					-7.0			
Ni float	5	· ·	7.9		· · · · ·		ļ	<u>`</u>			0,10				
Ni conc clean	2	۰.		<u>500-g</u>			· .				L				
Ni conc reclean	2			250-g										·	
Scav conc	2.5		7.8	2000-	g cell				0.10				1.35		ļ
· · · ·	·									<u> </u>					<u> </u>
	W	т			ANAL	YSIS	% (1)				DI	STRIB	UTION	%	
PRODUCT	%	6		Cu		Ni					(Cu		Ni	
Cu reclean conc	2	.6	. 2	28.59		1.48					67	7.1		2.9	
Cu clean tail	0	.4	1 1	L9.45		1.87						7.0		0.5	
Cu reclean tail	0 0	.5	1	1.22		2.14						5.0		0.8	
Cu rough conc (calcd)	3	.5	2	25.06		1.60						9.1		4.2	
Ni reclean conc	11	.0		0.49		5.28						5.2		55.6	
Ni clean tail	5	.8		0.74		2.66	,	1				3.9		11.6	
Ni reclean tail		.0		0.42		2.54					r i	2.3		11.4	
Ni rougher conc (calcd)	25	.8		0.53		4.05					12	2.4		78.6	
Cu-Ni ro conc (calcd)	20	.3		3.46		3.76						L.5		82.8	
Scav conc	11	.8		1.18		2.37						3.0		5.0	
Bulk conc (calcd)	11	.1	· ·	3.26		3.64						4.5		87.8	
Rougher tail (2)		.9		0.09	1	0.24						5.5		12.2	
									-						
Feed (calcd)	100	.0		1.11		1.33					100	0.0		100.0	
•								-	<u> </u>				<u> </u>		
REMARKS: AN -					<u> </u>							· · · · ·			
REMARKS: (1) From Inte	ernal	Report	MS-A(: 70-8	69		1								
(2) Flotation	n tail	grind	84.0	per c	ent min	us 200-	-mesh.								

•

TEST NO. 14 SAMPL	E: Z	enmac l	Mines	Limit	ed - Nia	copor S	amplė					DA	ГЕ: Ѕер	ot. 1,	1970
OBJECT OF TEST: Bulk	floa	t - Ae	ration	of b	ulk cone	- Cu	Ni ser	aratic	<u>ີ</u>		<u></u>	CHA	ARGE:	2000-g	
Durk Durk	1104	c 210.	246201	02 0			512 D - F					TES	TED B	Y: W.A	.W.
	Time	%	[1	Jnit	1			Rea	agents,	lb per				
OPERATION		Solids	рН	1 -	used	Na ₂ CO ₂	0-0	Z-6	· · · · · · · · · · · · · · · · · · ·	A301	AF71	CuS		1	1
						Na2003		2-0	AZJO	ASUL	AF/1				
Grind*	60	67		7x14		ļ									
Condition	20	45	7.7	2000	-g cell	8.0	3.0	0.10	0.05	0.05		<u> </u>			_
Flotation	3	28	7.9			ļ		0.05		ļ	0.05	ļ			
Scavenging	5	25	8.0					0.10				1.0	0		
Aerate bulk conc	20			<u> </u>								<u> </u>			
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		Ì	1		1									
Ni clean	1														
Ni reclean	1		1			1									
	l w	т			ANAL	YSIS	% (1)			1	DI	STR	BUTIO	N %	
PRODUCT	%	· .		Cu	Ni	1		1	1		Cı	.	Ni		
	+			<u>vu</u>	N1				-						
Reclean Cu conc	5	.6	1	0.72	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							7.5	12.0		
Rougher Cu conc (calcd)	12		1	7.33	4.70							76.0	44.9		
Reclean Ni conc	11	.5		1.82	4.60					1	1	3.1	30.4		
Clean Ni tail	11	.8		0.72	2.34							1.1	3.3		
Reclean Ni tail	11	.9		0.47	1.82							1.2	4.1		
Rougher Ni conc (calcd)	13		1	1.37							1	5.4	37.8		
Rougher Cu-Ni conc (calco		11		4.25							9	91.4	82.7		
Cu-Ni Sep.tail	41	.6		0.49	1.27							1.1	2.6		
Scav conc	14	.2	1	1.00								3.5	5.8		
Rougher tail	67	.7		0.07	0.17							4.0	8.9		
Feed (calcd)	100	.0		1.19	1.29						10	0.0	100.0		
REMARKS: *Flotation ta	<u> </u> iling	g 84.0%	% minu	s 200	mesh.	(1) Frc	 m Inte	ernal R	leport	 MS-AC-	 -70-8	79.		

9

DATE: Sept. 8, 1970 TEST NO. 15 SAMPLE: Zenmac Mines Limited - Nicopor Sample OBJECT OF TEST: Repeat of Test 4 using CaO instead of Na₂CO₃ CHARGE: 2000-g TESTED BY: W.A.W. Reagents, Ib per ton % Time Unit OPERATION pН used min Solids AF71 Ca0 **Z-**6 7x14 RM 60 67 Grind* 7.9 0.05 Condition 10 45 8.0 3.5 30 7.9 0.05 0.04 Float No. 1 Float No. 2 1.5 0.05 0.02 Float No. 3 3.0 0.02 0.10 ANALYSIS % (1) DISTRIBUTION % WT PRODUCT % Cu Cu Ni Ni Concentrate No. 1 4.96 5.08 86.6 72.2 18.5 3.7 Concentrate No. 2 6.4 0.61 1.80 8.8 3.8 Concentrate No. 3 5.6 0.72 1.56 6.7 Rougher tail 69.5 0.09 0.23 5.9 12.3 Feed (calcd) 100.0 100.0 100.0 1.06 1.30 REMARKS: *Flotation tailing 84.0% minus 200 mesh. (1) From Internal Report MS-AC-70-875.

TEST NO. 16 SAMP	LE: 2	Zenmac	Metal	Mines	s Limite	ed - Ni	copor	Sample	2				E: Sept		970
OBJECT OF TEST: Repo	eat of	Test	12										RGE: 20		
Кере												L	TED BY	: WAW	
	Time	%		υ	nit	1			Rea	igents,	lb per	ton			
OPERATION	min	Solids	pН	u	sed	Ca0	Z-6	A238	DF250	H ₂ SO ₄	CuS04				
Grind ⁽¹⁾	60	67		7 x 3	L4 RM	10.0	0.10	0.05							
Aerate	30		12.1	Aerat	or										
Condition	20	35	12.1	2000-	-g cell	8.0			0.05						
Cu float	2.0	25	12						<u> </u>		······································				
Ni condition	5	25	8.1							7.0					
Ni float	5						0.15								
Scav float	2						0.10	0.05			1.50				
Cu clean	1			250-8	g cell	<u> </u>	<u></u>		ļ						
Cu reclean	0.5			<u> </u>									_		
Ni clean	1				<u>g cell</u>							ļ		<u> </u>	ļ
Ni reclean	1				g cell										ļ
Ni re-reclean	0.75			250-8	g cell									L	<u> </u>
PRODUCT	w w	г	<u> </u>		ANAL	YSIS	% (2)				DI	STRIE	BUTION	%	
FRODUCT	%)		Cu		Ni						<u>u</u>		Ni	
Cu reclean conc	2	.2		28.30		1.61						.4		2.4	
Cu re c lean tail	0.	.8		L4.55		2.22).5		1.3	
Cu clean tail	43	.6		L7.10		1.87						.3		0.8	
Cu ro conc (calcd)	3.	.6		23.39		1.78					76	5.2		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						.5		9.5	
Ni clean tail	11	.5		0.62		4.57					1	5.4		36.7	
Ni ro conc (calcd)	25	.5		0.79		4.53						3.2		80.5	
Cu-Ni ro conc (calcd)	29	.1		3.58		4.19						4.4		85.0	
Seav conc	4	.2		0.22		0.87).8		2.5	
Rougher tail	66	.7		0.08		0.27		1				4.8	1	12.5	
Combined Scav & ro tail	70	.9		0.09		0.30						5.6		15.0	
Feed	100	.0		1.11		1.44					100	0.0]]	100.0	
REMARKS: (1) Flotatio	on toi	ling Q	40	ar con	t minue	200 me	esh.								
(1) Flocation (2) From Int	ternal	Renor	t MS-	AC-70:	885	200 m									
(2) From 111	cernar	repor													

$ \begin{array}{c c c c c c c c c c c c c c c c c c c $	TEST NO. 17 SAMP	LE:	Zenmac	Metal	Mines Limit	ed - Ni	copor	Sample		<u> </u>		DATE		t. 29,	1970
OPERATION Time min % Solids pH Unit used Reagents, lb per ton Grind(1) 60 67 7 x 14 RM 10.0 0.10 0.05	OBJECT OF TEST:						-	-				CHAR	GE:	<u>2000-g</u>	
OPERATION min Solids pH used Na2C03 Z-6 A238 CaO Z-20CH2S04 DF250 CuS04 Grind(1) 60 67 7 x 14 RM 10.0 0.10 0.05	Кереа	AC OT	iest 1	o usir	^{1g} Na ₂ CU ₃ in	piace o						TEST	ED BY	: WAW	
$ \begin{array}{ c c c c c c c c c c c c c c c c c c c$		Time	%		Unit				Rea	gents,	lb per	ton			
Aarate 30 50 Aerator Image: condition 20 45 12 2000-g cell 10.0 20.0 Image: condition Image: conditi Image: condition <thi< td=""><td></td><td></td><td>Solids</td><td>рп</td><td>used</td><td>Na_2C0_3</td><td>Z-6</td><td>A238</td><td>CaO</td><td>Z-200</td><td>H₂SO4</td><td>DF250</td><td>CuS0</td><td>ц</td><td></td></thi<>			Solids	рп	used	Na_2C0_3	Z-6	A238	CaO	Z-200	H ₂ SO4	DF250	CuS0	ц	
Aarate 30 50 Aerator Image: condition 20 45 12 2000-g cell 10.0 20.0 Image: condition Image: conditi Image: condition <thi< td=""><td>Grind⁽¹⁾</td><td>60</td><td>67</td><td></td><td>7 x 14 RM</td><td>10:0</td><td>0.10</td><td>0.05</td><td></td><td></td><td></td><td></td><td></td><td></td><td>·</td></thi<>	Grind ⁽¹⁾	60	67		7 x 14 RM	10:0	0.10	0.05							·
Cu float 2 25 0 0 02 0 0 02 0 <th0< th=""> 0 0 <th0< td=""><td></td><td>30</td><td>50</td><td></td><td>Aerator</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></th0<></th0<>		30	50		Aerator										
$\begin{array}{c c c c c c c c c c c c c c c c c c c $	Condition _	20	45	12	2000-g cell	10.0			20.0						
Ni float 4 25 0.15 0.05 0.03 0.03 0.03 Scavenger float 2 0.10 0.05 0.03 1.50 0.03 <td>Cu float</td> <td>2</td> <td>25</td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td>0.02:</td> <td></td> <td></td> <td></td> <td></td> <td></td>	Cu float	2	25							0.02:					
Scavenger float 2 0.10 0.05 0.03 1.50 Copper conc clean 1 250-g cell -	Condition	5	25	8.3							7.0				
Scavenger float 2 $$ 0.10 0.05 0.03 1.50 Copper conc clean 1 250-g cell $$	Ni float	4	25				_0,15	0.05							1
$\begin{array}{c c c c c c c c c c c c c c c c c c c $		2					0.10	0.05				0.03	1.5	0	<u> </u>
Ni clean No. 1 1.0 500-g cel1 Image: constraint of the second secon		1			250-g ce11			. <u>.</u>		<u>, , , , , , , , , , , , , , , , , , , </u>					
$\begin{array}{c c c c c c c c c c c c c c c c c c c $		0.5													
Ni clean No. 3 0.75 $250-g cell$ Distribution % 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 6.66 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 tail 16.5 0.48 2.98 7.5 37.5 No. 1&2 Ni clean tail 1.65 0.46 2.82 10.1 49.2 Ni rougher conc (calcd) 29.9 3.33 3.70 94.5 84.4 Ni rougher conc (calcd) 29.9 3.33 3.70 94.5 1.0 Bulk Cu-Ni conc (calcd) 29.9 3.33 3.70 4.5 13.1 Scav conc 1.8 0.60 1.83 0.07 0.25 4.5 <t< td=""><td>Ni clean No. 1</td><td>1.0</td><td></td><td></td><td>500-g cell</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></t<>	Ni clean No. 1	1.0			500-g cell										
Ni clean No. 3 0.75 $250-g cell$ DISTRIBUTION % PRODUCT WT $ANALYSIS % (2)$ DISTRIBUTION % WT 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) 29.9 3.33 3.70 94.5 84.4 Scav conc 1.8 0.60 1.83 0.07 0.25 4.5 13.1	Ni clean No. 2	1.0			500-g ce11										· ·
Weight of the system % 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 68.3 0.60 1.83 1.0 2.5 Rougher tail 68.3 0.07 0.25 4.5 13.1		0.75												· ·	<u> </u>
% 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 68.3 0.07 0.25 4.5 13.1		W	т		ANAL	YSIS	% (2)	• •		1	D	STRIB	UTION	1 %	
Cu clean tail 1.9 2.50 4.60 Cu clean tail 1.9 7.98 8.23 Cu rougher conc (calcd) 7.1 12.53 6.51 Ni clean conc 5.0 0.30 1.32 No. 1&2 Ni clean tail 16.5 0.48 2.98 No. 3 Ni clean tail 1.3 0.89 6.66 Ni rougher conc (calcd) 22.8 0.46 2.82 Bulk Cu-Ni conc (calcd) 29.9 3.33 3.70 Scav conc 1.8 0.60 1.83 Rougher tail 68.3 0.07 0.25	PRODUCT	%	6									Cu		Ni	•
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 84.4 35.2 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 0.25 4.5 13.1	Cu clean conc	3	.3	2	20.94	6.63	<u> </u>				6	5.5		16.7	
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 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 0.25 4.5 13.1												4.5		6.6	
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 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 0.07 0.25 4.5 13.1	Cu reclean tail					8.23					1	4.4		11.9	
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 0.07 0.25 4.5 13.1				1		6.51					8	4.4		35.2	
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 0.25 4.5 13.1															
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 0.25 10.1 10.1		11	11		• • •					.				-	
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 0.25 10.1 49.2 Rougher tail 68.3 0.07 0.25 10.1 49.2		11	11		1 1										
Bulk Cu-Ni conc (calcd) 29.9 3.33 3.70 Scav conc 1.8 0.60 1.83 Rougher tail 68.3 0.07 0.25					•		•	}							
Scav conc 1.8 0.60 1.83 1.0 2.5 Rougher tail 68.3 0.07 0.25 4.5 13.1	Ni rougher conc (calcd)	22	.8		0.46	2.82					1	0.1		49.2	
Scav conc 1.8 0.60 1.83 1.0 2.5 Rougher tail 68.3 0.07 0.25 4.5 13.1	Bulk Cu-Ni conc (colod)	20	a		3 33	3 70					a	4.5		84.4	
Rougher tail 68.3 0.07 0.25 4.5 13.1		11	11]					• ·					1	
	2 *														
Feed (calcd) 100.0 1.06 1.31 100.0 100.0	Mugnet Latt	00	• • •		0.07	0.25						··-	ł	13.1	
	Feed (calcd)	100	.0		1.06	1.31					100	0.0	1:	100.0	
						ſ									•
REMARKS: (1) Flotation tailing 84.0 per cent minus 200 mesh.			11-0	<u> </u>		200	ch	L		<u></u>	<u></u>				

1 **4**

TEST NO. 18 SAMP	LE: 2	Cenmac	Metal	Mines Limit	ed - Ni	copor	Sample				DAT	E: Oct	. 2, 19	70
				ent reagents							СНА	RGE:	2000-g	
FIOL	ation	WILL C	LITEL	ent reagents	and co	arse s	sampre	•			TES	TED B	Y: WAW	
	Time	%		Unit	1		<u></u>	Rea	gents,	lb pe	r ton			
OPERATION		Solids	рН	used	Ca0	3501	Z-200	H ₂ SO 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	8										
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										ļ]
11 11 11 11	1.0													
11 11 11 11 4	1.0		1											
Ni conc clean No. 1	2			1000-g cell										
<u>11 11 11 2</u> 11 11 11 2	1		1	500-g cell										
	l w	T II	•	'250-ğ cell ANA	LYSIS	% (2)				C	ISTRI	BUTIO	N %	
PRODUCT	%	· .		Cu	Ni						Cu		Ni	
Cu clean conc		2.2	2	7.69	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	51	.2		8.53	3.50						17.8		5.3	
Ro cu conc (calcd)	11	.0		2.66	3.27						83.8		15.9	
Ni clean conc	-	.6		0.57	5.20						4.1	1	27.3	
No. 1 Ni clean conc	11	1		0.54	2.31						3.6		11.3	
No. 2 Ni clean conc		3.5		0.37	3.98						2.9		23.4	
No. 3 Ní clean conc	11	2.1		0.55	6.20						1.1		9.0	
Ro Ni conc (calcd)		5.3		0.49	4.06						11.7		71.0	
Ro Cu-Ni conc (calcd)	32	2.3		3.13	3.89						95.5		86.9	
Rougher tail	67	7.7		0.07	0.28						4.5		13.1	
Feed (calcd)	100	0.0		1.06	1.44					1	00.0		100.0	
REMARKS: (1) Flotatio (2) From Int			-	ent minus 20 C-70-982.) mesh.	<u> </u>	<u> </u>	1				l		

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TEST NO.n 19 SAME	LE:	Zenmac	Meta	. Mine	s Limit	ed - Ni	Lcopor	Sample				DA.	TE: Oc	t. 6, 19	970
	eat of	Test	18 wit	:h CaO	and Pr	omoters	s in Ro	d Mill	•			·	ARGE:	2000 5	
												· · · · · · · · · · · · · · · · · · ·	STED E	BY: WAW	
OPERATION	Time	%	рН		Jnit				Rea	gents,	lb per	- ton			
	min	Solids	s	ι	sed	CaO	3501	DF250	Z-200	H <u>2</u> SO4	CuS04				
Grind ⁽¹⁾	30	67	1	7 x	14 RM	10.0	0,05								
Aerate	30	50		Aera											
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			•	g cell				;						
Combined Cu conc reclear	n 1.5			250-	g cell							<u> </u>		· .	
Nickel clean No. 1				1.000	-g_cell						[
<u> </u>	1.0				g_cell_							<u> </u>			
" " 3	0.5	<u> </u>	l	250-	g cell	<u> </u>	<u> </u>				L	<u> </u>			
PRODUCT	W				ANAL	YSIS	(2)				D	ISTR	IBUTIC	N %	
	%	6		Cu%		Ni%	Au oz/7	Pt oz/1	Pd oz/	T		Cu		Ni	
Cu clean conc	2	.2		27.80		1.48	0.096	0.011	0.031		. 5	8.7		2.3	
No. 1 Cu cl tail	1	.1		L2.38	-	2.43					1	3.0		1.9	
No. 2 Gu cl tail		.3		L6.10		2.30						4.6	•	0.5	
Rougher Cu con (calcd)	3	.6		22.11		1.86					7	6.3		4.7	
		.6		1.11		7.18		! 0.020	1 0 02	-		8.1		38.1	
Ni clean conc No. 1 Ni clean tail	11	.6		0.73		2.50	0.050	0.020	0.05	'		5.3		13.2	
No. 2 Ni clean tail	11	.4		0.48		2.74				· []		3.4		14.2	
No. 3 Ni clean tail		.6		0.63		5.00		· ,				2.2		12.6	
Rougher Ni conc (calcd)	26			0.76		4.27	. •					9.0		78.1	
Cu-Ni ro conc (calcd)	29	11		3.33		3.98						5.3		82.8	
Rougher tail	70			0.07		0.35					1	4.7		17.2	
									-						
Feed (calcd)	100	.0		1.04		1.43]	l	10	0.0		100.0	
i de la constante de															
									<u> </u>	<u> </u>					
REMARKS: (1) Flotation															T
(2) From Inte	ernal R	leports	s MS-A(C-70-9	92 and	1149.									

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TEST NO. 20 SAMP	LE: Z	enmac	Metal	Mines Limite	d - Nio	copor a	Sample						ber 20	, 1970	
OBJECT OF TEST: Repea	at of	Test 1	2 plus	regrind of	concent	trates	before	5			CHAR	GE: 2(000-g		
	ning.											ED BY	: WAW	·	
OPERATION	Time	%	рНа	Unit	Reagents, Ib per ton										
	min	Solids		used	Na ₂ CO	Ca0	A301	DF250	H ₂ SO	A2.38	Z-6	CuSO			
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		<u> </u>		0.10		7.0	0.05	0.10	1.5			
Copper conc grind	15			Pebble Mill	<u> </u>										
Copper cleaning	1.5			250-g cell	ļ			ļ							
Copper re-cleaning	1.5	t	12.0												
Nickel conc grind	20		7 5	Pebble Mill		ļ				· · ·					
Nickel cleaning		ļ	7.5	500-g cell	ļ										
Nickel re-cleaning	1			250-g cell	<u> </u>										
Nickel re-recleaning	1	<u> </u>		<u> </u>	<u> </u>						L		<u> </u>		
PRODUCT	w w			ANAL	YSIS	% (2)	· · · · · · · · · · · · · · · · · · ·			DI	STRIB	JTION	%		
	%	<u> </u>		Cu	Ni						Cu		Ni		
Cu clean conc	1	.6		39.25	0.70					54	6		0.8		
Cu clean tail		.1	1	.3.23	2.71					12	6		2.2		
Cu reclean tail		.5		.4.27	2.16					1).5		0.8		
Rough Cu conc (calcd)		.2	2	.7.94	1.62					1	.7		3.8		
Ni clean conc	11	.4		0.77	5.18					1	5.0		28.5		
Ni clean tail	14			0.53	3.18						5.9		35.3		
Ni reclean tail	11	.2		0.90	4.45						2.5		10.6		
Ni re-reclean tail	11	.7		0.90	4.45						.3		5.7		
Rough Ni conc (calcd)	27	•2		0.66	3.95						.7		80.1		
Rough Cu-Ni conc(calcd)	30	.4		3.53	3.71					93	3.4		83.9		
Rougher tail	69	.6		0.11	0.31					6	.6		16.1		
Feed (calcd)	100	.0		1.15	1.34					100	.0	1	00.0		
REMARKS: (1) Floot To		02 0			moch										
(1) Float 12 (2) From Int				nt minus 200 C-70-1028.	mesn.										

TEST NO. 21 SAMP	PLE:	Zenmao	c Meta	l Mine	s Limit	ed - N	icopor	Sample	3					28, 19	970	
OBJECT OF TEST: Rep	eat of	E Test	20 at	coars	er grin	nd with	no re	agents	in er	ind.		[RGE: 2			
-								0				TEST	ED BY	· WAW		
ODERATION	Time	%		U	nit	Reagents, Ib per ton										
OPERATION	min	Solids	pH	u	used		Ca0	A238	A301	DF250	H_2SO_4	Z-6	CuS01			
Grind ⁽¹⁾	50	67		7 x 3	L4 RM								<u> </u>		<u> </u>	
Aerate	30	50		Aera					<u>-</u>		ļ				ļ	
Condition	20	40	11.5		-g cell	3.0	20.0	0.05	0.10	0.06						
Cu float	2	25	11.5											1		
Ni condition	5		7.0								7.0					
Ni float	8	25	7.3					0.05	0.10		ļ	0.05	1.50			
Cu conc grind	15				le Mill	· ·										
Cu clean	1.5		12.0	500-	g cell		2.0					L		[
Cu reclean & re-reclean	1.5		12.0	250-8	g cell										ļ	
Ni conc grind	25			Pebb:	<u>le Mill</u>											
Ni clean	2		7.9		g cell									· · · ·		
Ni reclean & re-reclean	1			250-	g cell											
PRODUCT	W	т			ANAL						STRIB	UTION	%			
	%	6		Cu		Ni				1	. (Cu		Ni		
Cu clean conc	1	.8		28.73		3.47					48	3.2		4.4		
Cu clean tail No. 1	7	.7		1.38		3.22					9	9.9		17.4		
Cu clean tail No. 2	0	.9		7.46		5.00						5.2		3.2		
Cu clean tail No. 3		.4		10.39	-	6.45				11		3.9		1.8		
R& Cu Conc (calcd)	10	11		6.78		3.53						3.2		26.8		
Ni clean conc		.5		3.43		8.46						1.2		20.8		
Ni clean tail No. l	14	11		0.83		3.07						L.4		31.8		
Ni clean tail No. 2	11	.6		1.38		4.85						2.0		5.5		
Ni clean tail No. 3	1)	.1		1.49		5.16						L.5		4.0		
Ro Ni conc (calcd)	20	.9		1.34		4.22	*				20	5.1		62.1		
Ro Cu-Ni conc (calcd)	31	.7		3.19		3.98	•	· ·			94	4.3		88.9		
Rougher tail	68	.3		0.09		0.23					-	5.7		11.1	•	
Feed (calcd)	100	.0		1.07		1.42					100	0.0	.]]	0.00		
						Ì								-		
REMARKS: (1) Float tai		0/ 1			- 200	maak		<u></u>								
(1) Float tab	TTUR (04.1 р	er cer		15 200 1	mesn.										

(2) From Internal Report MS-AC-70-1037.

TEST NO. 22 SAME	PLE: Z	enmac 1	1etal	Mines	Limited	1 - Nic	opor S	amp1e						v. 19,	1970	
OBJECT OF TEST: Rep	eat of	Test 4	4.									CH.	ARGE:	2000-g	_	
[<u> </u>										TES	STED B	Y: W.A.	W	
OPERATION	Time	%	рН	U	nit				Rea	gents,	lb per	ton				
OFERATION	min	Solids		us	sed	Na cO2	Z-6	CaO	AF71							
Grind	50	67		7x14	RM											
Condition (1)	10	45	7.6		g cell	8.0	0.05	2.0								
Flotation	7.5	25	7.9			ļ	0.20		0.05							
				1000		<u> </u>	ļ									
Clean	2.0			1000-	g cell											
									<u> </u>							
					<u> </u>											
				1							· · · -					
						[ii				_			
				1												
	l w	WT ANALYSIS % (2)								DI	DISTRIBUTION %					
PRODUCT		6	1	Cu	Ni						Cu Ni					
Clean bulk conc Clean bulk tail	25	.5		4.00	4.56 2.00	1						3.9 2.4	79.1 9.9			
Clean Durk Larr	'	• 3		0.55	2.00							2 • - 7				
Ro bulk conc (calcd)	32	.8		3.19	3.99						9	6.3	89.0			
Ro tail (3)	67	.2		0.06	0.24							3.7	11.0			
Feed (calcd)	100	.0		1.09	1.47						10	0.0	100.0			
	<u> </u>															
REMARKS: (1) Flotat:		<u> </u>			l	(2)	Erom T	nterna	1 1 Repor	11 + MS-	AC-70-	1157				
REMARKS: (1) Flotat: (3) Flotat	ion ce	iling 8	86.1%	-200 m	iesh.	(4)	I LOIL L		.r nepu				-			
		U														

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				Mines Limite	<u>1 - Nic</u>	opor S	Sample				ATE: Nov HARGE: 20	. 20, 1970				
OBJECT OF TEST: Flotation of bulk float.											TESTED BY: W.A.W.					
OPERATION	Time	%	рН	Unit	Reagents, Ib per ton											
OFERATION	min	Solids		used	Na ₂ CO ₂	Z-6	AF71	S0,	Ca0							
Grind	50	67		7x14 RM					`							
Condition (1)	15	45 25	8.7	2000-g cell	12.0	0.05	0.015									
Float No. 1	1	25	8.7													
Float No. 2 Float No. 3	<u>1</u> 1		8.5				0.015	· · ·	1							
Float No. 4	1	{	7.5			0.10		5.0				<u> </u>				
Float No. 4	<u>L</u>		1.0.													
Combined conc					_											
No. 1 clean	2		9.4						3.0	·		ļ				
No. 2 clean	1.5		12.1	[`				3.0							
No. 3 clean	1	ļ	11.9	·					1.0							
No. 4 clean	1	<u> </u>	11.8	<u> </u>		705			1.0	·						
PRODUCT	W %				YSIS	% (2)	1			<u> </u>						
	_			Cu	Ni					Cu	++	Ni				
Clean conc	11	•7	1	.14	3.00					63.1		11.5				
No. 1 clean tail	11	•2		.33	2.55					5.1 10.4	1 1	7.2 28.0				
No. 2 clean tail No. 3 clean tail	11	.4		.00	3.65					6.6		18.7				
No. 4 clean tail	11	.1		.55	7.37				1	9.6		20.3				
							1									
Bulk conc (calcd)	29	.0	3	.58	4.40					94.8	3	85.7				
Rougher tail (3)	71	.0	0	.08	0.30	•				5.2	2	14.3				
Feed (calcd)	100	•0	1	.10	1.49					100.0		L00.0				
REMARKS: (1) Flotat: (3) Flotat:	ion ce lon ta	ll air iling	inlet 86.1%	open. -200 mesh.	(2) F	rom In	iternal	Repor	t MS-A	C-70-1157	• •					

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	MPLE:					ed - N	the second s	Samp1	e					26, 1	970
BJECT OF TEST: P:	roductio										HARGE: 2000-g TESTED BY: WAW				
												<u> </u>	TED B	/: WA	.w
OPERATION	Time	1	рН	Unit		Reagents, Ib per								1	т
	min	Solids		u	sed	Na ₂ CO	Z-6	AF71	Ca0	NaOH	S02	<u> </u>		;	
Frind	50	67		7x14		6.0	0.05	0.015							
lerate	20	45		Aerat				ļ							
Condition	15	35			g cell	ļ	0.05	0.015	15.0	6.0					
Copper float	4	25	12.0				0.05	0.015			ļ	<u> </u>			
lickel condition	5	25	8.2		<u> </u>						15.0				
lickel float	5					1	0.10	0.03			1.5.0			-	
		<u> </u>					ļ		ļ 	<u></u>					
						· .	[
<u></u>											 				+
		<u> </u> 	[I YSIS	% (1)			<u> </u>	<u>ا م</u>	STRI	JUTION	1 %	1
PRODUCT	11	6		Cu		Ni.	/0 (-)					·····		Ni	
Copper conc	3	3.1		23.90		1.00					6	9.6		2.2	
lickel conc	28	3.2		1.00		4.17					2	6.5 k		84.5	
Gu-Ni conc (calcd)	31	3		3.27		3.86					9	6.1		86.7	
lough tail (2)	68	3.7		0.06		0.27						3.9		13.3	
eed (calcd)	100	0.0		1.06		1.39					10	0.0		100.0	
REMARKS: (1) From	Interna	al Repo	rt MS	-AC-70	-1168.		(2)) Flota	ation	tailin	g 86.1	% -20	0 mesh.		

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