

TKI-54-59
R. 291

MONTANA SILVER LEAD COMPANY

FLOTATION OF NICKEL COPPER ORE FROM DUMP "CuNi" AREA NEAR ZEEHAN

Sample

A drum containing 570 lbs. of ore was received from the company.

The ore was stated to be from a dump and this was evident on examination of the sample which showed evidence of appreciable surface oxidation.

The sulphide minerals in the ore are predominantly pyrrhotite, pentlandite and chalcopyrite. Practically all the sulphides are massive and there is considerable evidence of fine intergrowth. This is shown in contact prints accompanying this report. In addition it is known that pyrrhotite and pentlandite can give solid solutions at high temperatures. Under slow cooling conditions pyrrhotite can retain up to 1.88 per cent of nickel in solid solution at normal temperatures and remain homogeneous. References to this phenomenon are given in "Textures of the Ore Minerals" (p. 108) by Dr. A. B. Edwards (1954) who quotes W. H. Newhouse, "The equilibrium diagram of pyrrhotite and pentlandite and their relations in natural occurrences." Econ. Geol. 22, 288-299 (1927), D. L. Scholtz, "The Magnetic Nickeliferous Ore Deposits of East Griqualand and Pondoland", Trans. Geol. Soc. South Africa, 39, 81-210 (1936) and others.

The gangue is fine-grained with the appearance of a mudstone and is frequently barren of any sulphides, but sometimes veined with coarse sulphides.

Partial Analysis of Sample.

	Per cent		Per cent
Nickel	5.6	Pb, Bi, As, Sb, Zn	Nil
Copper	3.7	Cobalt	0.07
Iron	35.2	CaO	0.20
Sulphide Sulphur	24.45	MgO	1.63
SO ₂	0.7	Al ₂ O ₃	4.14
Elemental Sulphur	2.17	MnO	0.10
Acid Insoluble	13.1		

Silver: 6.8 pennyweights per ton. Gold: 0.4 pennyweights per ton.

Platinum: Possible trace.

After crushing and wet ball mill grinding 0.0001 per cent of copper was found to be in solution. The free sulphur and low sulphate radicle are probably caused by oxidation and leaching in the dump.

Investigation

Research was desired on the concentration of the valuable minerals by flotation. Assuming that the nickel copper and sulphide sulphur exist entirely as pyrrhotite, pentlandite and chalcopyrite the sample would contain the following:—

	Per cent
Chalcopyrite	10.72
Pentlandite	25.45
Pyrrhotite	31.67
Total	67.84

Research.

There is ample evidence to indicate that attempts at selective flotation of the pentlandite and pyrrhotite would result in poor selectivity due to the reasons shown under the heading of "Sample" and the first objective in this research was to determine the recovery and grade obtainable by collective flotation of all the sulphides. As a secondary objective, experiments were undertaken to investigate selective flotation designed to concentrate the pentlandite and chalcopyrite and reject the pyrrhotite.

Summary

1. As shown elsewhere the sample contains nearly 70 per cent of sulphides. The sulphide minerals are mainly pyrrhotite, pentlandite and chalcopyrite. Contact prints of polished sections of ore from several places in the "CuNi" area have been made and are shown as an appendix. These prints are actual size and show the nature of the intimate association of the pentlandite with the other sulphides. The sections which are magnetic due to the presence of pyrrhotite (fourth, fifth and sixth) also indicate a high proportion of nickel due to solution of the pentlandite in the pyrrhotite. The pink colour indicates the presence of nickel either as the pentlandite or as solid solution in the pyrrhotite, and has been obtained by chromographic contact printing of polished specimens. The specific reagent to react with the nickel ions is a solution of di-methyl gloxime with rochelle salt to suppress the reaction of iron in the minerals. Dr. David Williams and Dr. F. M. Nakhla have published a comprehensive article on chromographic contact print method of examining metallic minerals in Bulletin No. 533 of the Institute of Mining and Metallurgy. Original work is quoted as originating from Swiss workers Gutzeit, Hiller and others.

The last two prints are massive sulphides containing three to four per cent of nickel. The major area reacting to nickel shows the substantial solution of pentlandite in pyrrhotite.

2. Bulk flotation of the sulphides resulted in a concentrate amounting to 75 per cent with assay values of nickel 7.33 per cent, copper 5 per cent, iron 20.5 per cent and acid insoluble 3.6 per cent.

The recovery of the nickel and copper amounted to 97.6 per cent and 99 per cent respectively (Tests 2 and 3). Reagents used for bulk flotation were copper sulphate, amyl or pentasol amyl xanthate with cresylic acid as a frother, and sodium silicate as a dispersant.

3. Selective flotation tests were undertaken under varying conditions substantially to depress pyrrhotite and a better degree of selectivity will be noted with copper than nickel. No special attempts were made to produce a high-grade copper concentrate low in nickel. The highest copper value is shown in Test 8 with a copper content of 9.3 per cent, representing a recovery of 47.3 per cent.

However, increase in grade of concentrates was not of a higher order, whereas nickel plus copper content of bulk flotation tests amounted to 12 per cent, the grade did not exceed 15 per cent in any individual selective flotation concentrate.

No responsibility is accepted for the results shown in this report except in so far as they apply to the samples tested. Screen sizes shown refer to British Standard Screens, and I.S. fractions 1 to 7 refer to Haultain Infrasizer fractions.

RESEARCH

Test 2—Bulk Cleaner Flotation with Amyl Xanthate

Stage ball mill grind through 60 mesh screen at a natural pH value of 4.2.

Flotation Conditions

Reagents	Lbs. tons/minutes	
	Rougher	Cleaner
Copper Sulphate	1/5	0.25/5
Sodium Silicate .....	.....	1/5
Amyl Xanthate	1/5	0.2
Cresylic Acid	0.34	0.1
Flotation time	/11	/10
pH value	/4.3	/4.3

Results

Product	Per cent			Per cent Distribution	
	Wght.	Ni	Cu	Ni	Cu
Cleaner concs.	75.4	7.31	5.0	97.6	98.8
Cleaner tailing	2.9	1.55	0.5	0.8	0.4
Rougher tailing	21.7	0.41	0.15	1.6	0.8
Composite	100.0	5.6	3.8	100.0	100.0

Cleaner concs.—Fe 20.5 per cent; Acid Insol., 3 per cent.

Rougher tailing—S 0.9 per cent.

Test 3—Bulk Cleaner Flotation with Potassium Pentasol, Amyl Xanthate

Flotation conditions similar to Test 2 with the exception of the promoter.

pH value of rougher and cleaner floats of 4.7 and 5.3.

Results

Product	Wght.	Per cent		Per cent Distribution	
		Ni	Cu	Ni	Cu
Cleaner concs.	75.0	7.33	5.0	97.6	99.0
Cleaner tailing	4.1	1.62	0.45	1.2	0.5
Rougher tailing	20.9	0.33	0.10	1.2	0.5
Composite	100.0	5.6	3.8	100.0	100.0

Cleaner concs.—Fe 20.5 per cent; Acid Insol, 3.6 per cent.

Rougher tailings—S 0.8 per cent.

Test 4

Selective flotation of nickel and copper minerals. Grinding similar to Test 2 lime to flotation cell 11.3 lbs./ton. Sodium Cyanide flotation cell 1 lb./ ton.

Flotation Conditions

Reagents	lbs. ton/minutes Concentrate			
	1	2	3	4
Sodium Ethyl Xanthate ..	0.1/2	.....	.....	.....
Potassium Amyl Xanthate ..	.....	0.2/2	0.2/2	0.5/2
Cresylic Acid	0.06	0.06	0.06	0.06
Flotation time	/5	/5	/5	/5
ph value	9.0	.....	.....	8.2

Results

Product	Wght.	Per cent		Per cent Distribution	
		Ni	Cu	Ni	Cu
Conc. 1	14.3	5.02	8.7	12.2	31.5
Conc. 2	27.4	9.46	5.94	44.0	41.1
Conc. 3	14.2	6.90	3.91	16.6	14.0
Conc. 4	17.4	6.22	1.88	18.4	8.3
Rougher tailing	26.7	1.93	0.76	8.8	5.1
Composite	100.0	5.9	4.0	100.0	100.0

Test 5

Selective flotation similar to Test 4, but using Sodium Ethyl Xanthate only as promoter.

Ethyl Xanthate addition to each float 0.2/2
 pH value 11.0/9.9

Product	Results			Per cent Distribution	
	Wght.	Per cent		Ni	Cu
		Ni	Cu		
Conc. 1	17.7	5.17	8.74	16.2	42.8
Conc. 2	15.7	10.42	4.62	29.0	20.0
Conc. 3	11.3	7.05	3.66	14.1	11.4
Conc. 4	9.6	6.45	1.63	11.0	4.3
Rougher tailing	45.7	3.66	1.70	29.7	21.5
Composite	100.0	5.6	3.6	100.0	100.0

Test 6

Repeat of Test 4, but using lime and cyanide in the ball mill grind in place of a grind without depressants.

Lime to ball mill	14	lbs./ton
Lime to cell	0.7	lbs./ton
Sodium Cyanide	1	lb./ton

Flotation Conditions

Reagents	lbs./ton/minutes			
	Concentrate			
	1	2	3	4
Ethyl Xanthate	0.1/2	.....	.....	.....
Amyl Xanthate .....	.....	0.2/2	0.2/2	0.5/2
Cresylic Acid	0.06	.....	0.03	0.03
Flotation time	/5	/5	/5	/5
pH value	9.0	.....	.....	8.4

Product	Results			Per cent Distribution	
	Wght.	Per cent		Ni	Cu
		Ni	Cu		
Conc. 1	22.5	7.03	8.3	27.5	48.9
Conc. 2	24.9	8.10	4.6	35.1	29.9
Conc. 3	15.3	7.31	3.0	19.5	12.0
Conc. 4	12.7	6.03	2.1	13.3	7.0
Rougher tailing	24.6	1.08	0.34	4.6	2.2
Composite	100.0	5.75	3.82	100.0	100.0

Test 7

Similar to Test 6 with additional lime and cyanide flotation at pH of 11. This resulted in no increase in selectivity with a lower recovery.

Test 8

Selective flotation similar to Test 6, but substituting sodium butyl xanthate as the promoter.

Lime to ball mill	14	lbs./ton
Cyanide to ball mill	0.9	lbs/ton
Lime to cell	1.7	lbs./ton

Flotation Conditions

Reagents	lbs./ton/minutes			
	Concentrate			
	1	2	3	4
Butyl Xanthate	0.1/2	0.2/2	0.2/2	0.5/2
Cresylic Acid	0.06	0.03	0.03	0.03
Flotation time	/5	/5	/5	/5
pH value	9.8	....	....	8.9

Results

Product	Wght.	Per cent		Per cent Distribution	
		Ni	Cu	Ni	Cu
Conc. 1	19.1	5.87	9.3	20.3	47.3
Conc. 2	19.9	9.40	4.4	33.9	23.3
Conc. 3	13.9	7.03	3.4	17.7	12.6
Conc. 4	12.2	6.59	2.9	14.6	9.4
Rougher tailing	34.9	2.14	0.8	13.5	7.4
Composite	100.0	5.52	3.76	100.0	100.0

Sizing Analysis of Flotation Feeds

B.S. Mesh	Per cent	
	Fraction	Cumulative
+ 85	18.2	18.2
+ 100	6.9	25.1
+ 150	20.3	45.4
+ 200	8.5	53.9
- 200	46.1	100.0

Bulk Flotation Concentrate

SIZING ANALYSIS TEST 2

B.S. Mesh	Per cent		
	Fraction	Wght.	Cu
+ 72	6.9	6.5	4.2
+ 85	10.0	6.3	4.2
+ 100	7.0	6.6	4.3
+ 150	18.4	6.6	4.3
+ 200	9.8	6.9	4.5
- 200	47.9	7.1	5.4