CANADA

DEPARTMENT OF MINES AND TECHNICAL SURVEYS

OTTAWA

MINES BRANCH INVESTIGATION REPORT IR 65-32 c.1

CONCENTRATION OF SILVER FROM A SLAG FROM COBALT REFINERY LIMITED, COBALT, ONTARIO

by

T.F. BERRY

MINERAL PROCESSING DIVISION

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COPY NO. 15

MARCH 31, 1965

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SUMMARY OF RESULTS

The sample of slag assayed 86.2 oz Ag per ton. The silver values in the slag were contained in pellets, believed to be a cobalt-arsenic speiss, which ranged in size from coarse blebs of 1/4 inch down to minute inclusions of 1 micron or less.

The investigation showed that although 82% of the silver could be recovered by a combination of jigging and flotation in a combined concentrate assaying over 360 oz Ag per ton, the final tailing contained 11.5 oz Ag per ton which was too high grade to be discarded.

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* Technical Officer, Mineral Processing Division, Mines Branch, Department of Mines and Technical Surveys, Ottawa, Canada.

INTRODUCTION

Most of the silver concentrates, both gravity and flotation, produced by the mines in the Cobalt area of Ontario are shipped to the Cobalt Refinery Limited for refining. In the electric smelting process used at the refinery, a slag is produced containing about 100 oz Ag/ton and between 2.5% and 3% cobalt. At the present time this slag is sold to the Noranda smelter. The shipping and treatment charges plus penalties for contained cobalt and arsenic result in a cost to Cobalt Refinery Limited equivalent to about 17 oz Ag/ton of slag.

As a result of a discussion between representatives of the Mineral Processing Division and Mr. J.N. Cram, Vice President and General Manager of Cobalt Refinery Limited, an investigation was initiated to attempt to concentrate the silver-bearing material in the slag, using conventional ore dressing methods, to produce a disposable tailing containing between 3 and 4 oz Ag/ton and about 0.5% cobalt.

Shipment

A 260 lb shipment of lump slag was received at the Mines Branch on April 22, 1964.

Sampling and Analysis

The slag resembled a black crushed rock and on preliminary examination contained numerous, fairly coarse pellets of a grey metallic material.

Representative pieces of slag and several of the metallic pellets were submitted to the mineralogy laboratory for analysis.

The remaining slag was crushed to -10 m and a head sample was obtained by riffling.

TABLE 1

Chemical Analysis* of Head Sample

Silver (Ag)	86.67 oz/ton
Cobalt (Co)	1.47 per cent
Sulphur (total S)	0.30 per cent
Iron (total Fe)	24.16 per cent
Iron (soluble Fe)	23.09 per cent

* Internal Report MS-AC-64-521

MINERALOGICAL EXAMINATION*

The results of a mineralogical examination have been published and only the summary of results of that report will be included here, with several of the photomicrographs of polished sections which illustrate the complexity of processing this material.

Summary of Results

Examination of a slag from the Cobalt Refinery Limited shows that it consists of a fine grained black material and contains a number of metallic pellets that range from about 1 micron to several millimeters in diameter. The black material is composed of melilite, magnetite and pyroxene, and the metallic pellets are composed of a niccolite-type compound, native silver, chalcocite, safflorite, bornite, sphalerite and galena. These pellets contain Ag 15.94%, Co 13.38%, Ni 7.30%, Fe 6.20%, As 36.77%, Sb 1.45%, Cu 6.72%, Zn 2.77%, Pb 1.07% and S 6.49%.

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* Investigation Report IR 64-8- by W. Petruk, September 3, 1964

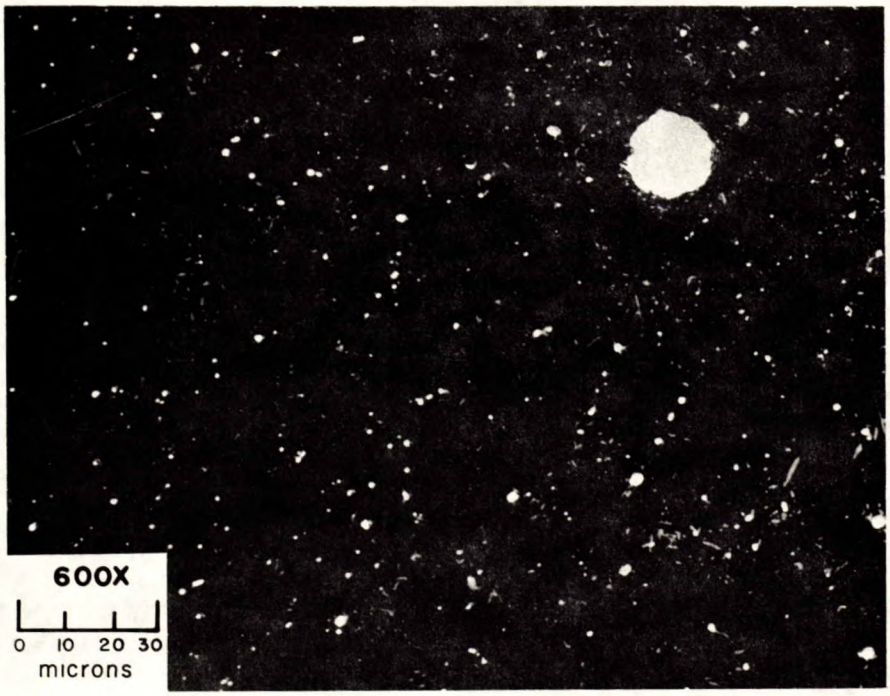

Figure 1. Photomicrograph of a polished section showing minute metallic pellets (white dots) in slag (black). One large pellet about 15 microns in diameter is shown. The grey dots represent magnetite.

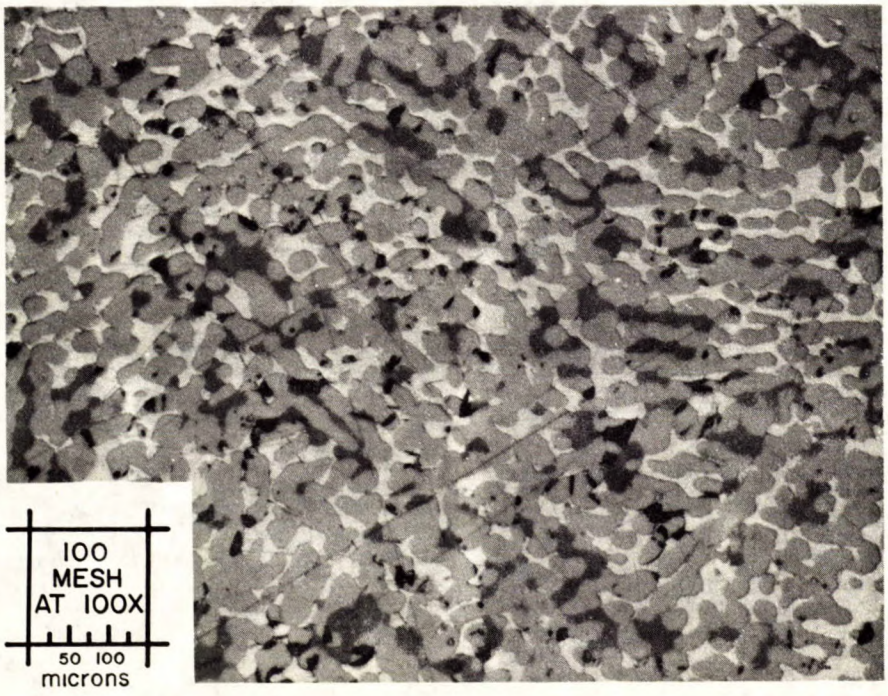

Figure 2. Photomicrograph of a polished section of a large metallic pellet. It shows the niccolite-type compound (light grey), native silver (white), and chalcocite (dark grey).

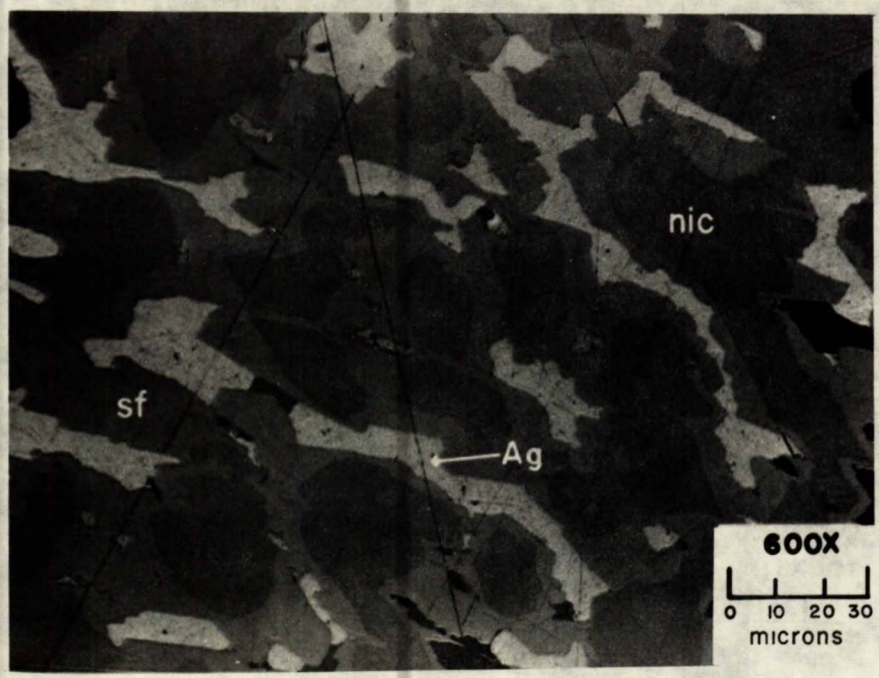

Figure 3. Photomicrograph of a polished section of a large metallic pellet. It shows the niccolite-type compound (nic), safflorite (sf), and native silver (Ag).

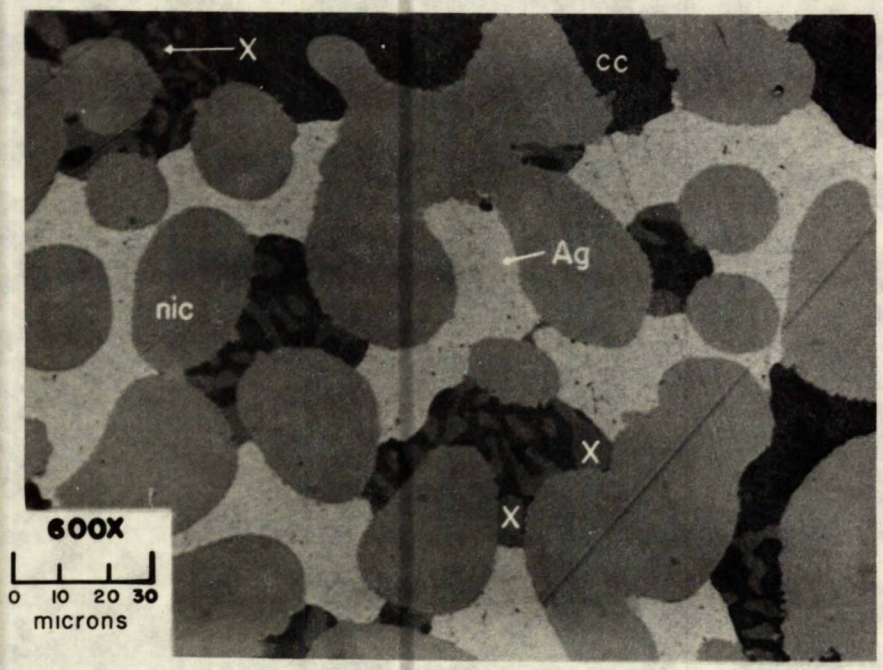

Figure 4. Photomicrograph of a polished section of a metallic pellet. It shows the niccolite-type compound (nic), native silver (Ag), chalcocite (cc) and a grey material (x) that is considered to be ZnS.

DETAILS OF INVESTIGATION

Tests 1-7

Seven tests were done involving a combination of jigging, tabling and flotation. During the flotation phase, finer and finer grinds were used in an attempt to liberate the silver-bearing material. Of primary importance was the overall recovery of the silver and cobalt rather than the grade of the different concentrates. With the flotation feed ground increasingly finer, flotation was done using 1.0 lb copper sulphate/ton, 0.15 to 0.30 lb amyl xanthate/ton, and from 0.06 to 0.10 lb pine oil/ton. In Tests 4 and 5 flotation was carried out at 40% solids and in all other tests at 25% solids.

The results of these tests may be seen in Table 2.

TABLE 2

Results of Tests 1-7

Test No.	Products	Weight %	Assays *		Distribution %		Remarks
			Ag oz/ton	Co%	Ag	Co	
1	Jig conc	2.9	795.25	5.13	26.4	9.4	Jig -10 mesh ore
	Jig bed	7.0	94.51	1.65	7.6	6.9	
	Table conc	2.5	364.50	5.25	10.4	8.2	Table jig tail ground to 40%
	Flot conc	1.8	483.82	5.30	10.0	6.0	-200 mesh. Float table
	Flot tail	85.8	46.29	1.29	45.6	69.5	tail at 40% -200 mesh
	Head (calcd)	100.0	89.22	1.59	100.0	100.0	Flotation time 4 min
2	Jig conc	4.6	537.11	8.83	27.7	11.0	Jig -10 mesh ore
	Jig bed	7.5	86.44	1.51	7.3	7.1	Table jig tail ground to 75%
	Table conc	4.0	369.74	4.42	16.6	11.0	-200 mesh. Float table
	Flot conc	11.5	209.46	3.08	27.0	22.1	tail at 75% -200 mesh
	Flot tail	72.4	26.26	1.08	21.4	48.8	
	Head (calcd)	100.0	89.08	1.60	100.0	100.0	Flotation time 8 min
3	Jig conc	4.3	582.16	4.02	27.9	11.0	Jig -10 mesh ore
	Jig bed	7.3	90.50	1.45	7.4	6.7	Float jig tail ground to
	Flot cl conc	5.6	676.42	7.50	42.3	26.6	88% -200 mesh
	Flot cl tail	5.7	65.92	1.47	4.2	5.3	one cleaner stage
	Flot tail	77.1	21.12	1.03	18.2	50.4	
	Head (calcd)	100.0	89.56	1.58	100.0	100.0	Flotation time 9 min

(cont' d)

TABLE 2

Results of Tests 1-7 (cont'd)

Test No.	Products	Weight %	Assays *		Distribution %		Remarks
			Ag oz/ton	Co%	Ag	Co	
4	Jig conc	3.9	641.72	4.30	28.1	10.6	Jig -10 mesh ore
	Jig bed	3.5	85.00	1.48	3.3	3.2	Float jig tail ground to
	Flot conc	4.5	840.14	9.26	42.4	26.2	88% -200 mesh.
	2nd cl tail	2.2	99.76	1.98	2.5	2.7	Float at 40% solids
	1st cl tail	6.2	64.00	1.43	4.4	5.6	2 cleaner stages
	flot tail	79.7	21.49	1.03	19.3	51.7	
	Head (calcd)	100.0	89.10	1.59	100.0	100.0	Flotation time 11 min
5	Jig cl conc	1.3	1160.82	5.94	17.2	4.7	Jig ore ground to 40%
	Jig cl tail	7.1	107.86	1.68	8.7	7.3	-200 mesh re-jig conc.
	Jig bed	2.1	241.26	2.53	5.8	3.2	Float jig tail reground to
	Flot conc	8.4	471.96	5.60	45.1	28.9	92% -200 mesh at 40%
	Scav conc	9.7	59.16	1.43	6.5	8.5	solids.
	Flot tail	71.4	20.52	1.08	16.7	47.4	Rougher float 5 min
	Head (calcd)	100.0	87.85	1.63	100.0	100.0	Scavenger float 7 min
6	Jig conc	3.6	635.32	4.60	26.5	10.1	Jig -10 mesh ore
	Jig bed	6.0	99.84	1.51	6.9	5.5	Float jig tail ground to
	Flot conc	12.5	354.40	4.60	51.4	35.0	94% -200 mesh
	Scav conc	11.5	29.29	1.13	3.9	7.9	
	Flot tail	66.4	14.63	1.03	11.3	41.5	Rougher float 6 min
	Head (calcd)	100.0	86.23	1.64	100.0	100.0	Scavenger float 5 min
7	Jig conc	7.1	386.42	3.30	30.2	13.2	Jig - 10 mesh ore
	Jig bed	6.6	89.66	1.60	6.5	6.0	Float jig tail ground to
	Flot conc	13.6	347.40	4.90	52.1	37.7	99% -200 mesh
	Scav conc	9.5	30.50	1.03	3.2	5.5	
	Flot tail	63.2	11.48	1.05	8.0	37.6	Rougher float 6 min
	Head (calcd)	100.0	90.75	1.77	100.0	100.0	Scavenger float 4 min

* Internal Report MS-AC-64-40

Table 3 shows the silver distribution in screen and infrasizer fractions of the flotation tailing from Test 7.

TABLE 3

Silver Distribution in Flotation Tailing Test 7

Particle Size	Weight %	Analysis * Ag oz/ton	Distribution Ag %
+ 200 mesh	1.0)	17.61	14.0
+ 325 "	8.1)		
+ 56 microns)	9.9	22.08	19.2
+ 40 ")			
+ 28 "	19.7	14.86	25.6
+ 20 "	17.4	10.66	16.2
+ 14 "	14.2	7.48	9.3
+ 10 "	8.8	5.46	4.2
- 10 "	20.9	6.20	11.5
Total	100.0	11.41	100.0

* Internal Report MS-AC-64-641

Test 8

A 2000 g sample of the -10 mesh slag was ground in a ball mill to 89.5% -325 mesh (1 1/2 hr). The ground pulp was concentrated using a Sala drum wet magnetic separator. The non-magnetic fraction was split in half. One half was floated directly, and the other was ground to 98.2% -325 mesh (30 min) and then floated. The flotation scheme was the same as is outlined in Test 7, Table 2. The results of this test may be seen in the following tables.

TABLE 4-a

Results of Magnetic Separation and Flotation - Test 8

Operation	Product	Weight %	Assay* Ag oz / ton	Distribution % Ag
Magnetic Separation 89.5% -325 m	Magnetics	45.1	41.48	22.1
	Non-magnetics	54.9	120.32	77.9
	Head (calcd)	100.0	84.76	100.0
Flotation of non-magnetics	Ro conc	20.1	524.12	86.8
	Scav conc	5.1	175.20	7.4
	Flot tailing	74.8	9.49	5.8
	Head (calcd)	100.0	121.38	100.0
Flotation of reground non-magnetics, 98.2% -325 m	Ro conc	24.9	433.10	90.0
	Scav conc	11.1	43.00	4.0
	Flot tailing	64.0	11.32	6.0
	Head (calcd)	100.0	119.86	100.0

* Internal Report MS AC - 64-2136

TABLE 4-b

Screen Tests on Products - Test 8

Particle Size	Ground Slag Weight %	Magnetics Weight %	Non-magnetics Weight %	Reground non-magnetics Weight %
+ 200 mesh	1.1	1.8	0.6	-
+ 325 "	9.4	11.6	7.6	1.2
- 325 "	89.5	86.6	91.8	98.2
Total	100.0	100.0	100.0	100.0

TABLE 4-c

Infrasizer Tests on Flotation Tailings - Test 8

Particle Size	Tailing from non-magnetics			Tailing from reground non-magnetics		
	Weight %	Ag oz/ton*	Distn %	Weight %	Ag oz/ton *	Distn %
+ 56 microns	3.1	18.43	6.0	0.3	40.16	1.1
+ 40 "	11.7	8.74	10.8	4.7	8.75	3.7
+ 28 "	17.5	8.34	15.4	14.0	8.11	10.3
+ 20 "	15.8	8.09	13.5	16.8	8.03	12.3
+ 14 "	14.1	7.81	11.6	16.3	8.01	11.9
+ 10 "	9.8	7.42	7.7	11.8	7.93	8.5
- 10 "	28.0	11.87	35.0	36.1	15.89	52.2
Total	100.0	9.48	100.0	100.0	10.99	100.0

* Internal Report MS-AC-64-2161

CONCLUSIONS

The investigation has shown that about 30 per cent of the silver in the slag can be recovered in a fairly high grade jig concentrate. Flotation of the jig tailing will recover over 50 per cent of the remaining silver in a concentrate containing 350 oz Ag per ton. However, the final tailing from processing the slag by this method, still contains over 11 oz Ag per ton.

The results of the screen analyses of the flotation tailings indicate that it might be possible to increase the silver recovery, if the feed to flotation was ground through 20 microns. However, this is somewhat impractical and even then the tailing would still contain 6 to 7 oz Ag per ton. This silver most likely occurs in the numerous minute metallic inclusions. These inclusions, which are only one micron in size, cannot be liberated from the slag by mechanical means.

Magnetic separation was not successful because in addition to the problem of liberation, the matrix, melilite, which is the main slag constituent, is in itself non-magnetic.

TFB:lh