Industrial Confidential

CANADA

DEPARTMENT OF ENERGY, MINES AND RESOURCES

OTTAWA

MINES BRANCH INVESTIGATION REPORT

IR 69-9 February, 1969

RECOVERY OF IRON, NICKEL AND LOW-IRON ASBESTOS FIBRE FROM TAILING SAMPLES OF CAREY-CANADIAN MINES LIMITED, EAST BROUGHTON STATION, QUEBEC

by

G.W. Riley

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.

~~Industrial Confidential~~

RECOVERY OF IRON, NICKEL AND LOW-IRON ASBESTOS FIBRE FROM TAILING SAMPLES OF CAREY-CANADIAN MINES LIMITED, EAST BROUGHTON STATION, QUEBEC

by

G.W. Riley*

Mineral Processing Division

- - -

SUMMARY OF RESULTS

From a sample of total-plant tailing assaying 5.0% sol Fe and 0.25% Ni a cleaner magnetic concentrate was obtained assaying 60.2% sol Fe and 0.93% Ni with recovery of 71.8% of the soluble iron and 23% of the nickel. Gravity concentration of the rougher non-magnetics followed by superpanning of the gravity concentrate produced a concentrate assaying 24.6% Ni with a recovery of 14.2% of the nickel. From the gravity concentration stage a fibre product was obtained containing 1.6% sol Fe and 0.13% Ni.

In a similar test on the composite sample from the pilot-plant shipment, which assayed 5.57% sol Fe, 0.29% Ni and 0.30% Cr, but using an extra grinding and magnetic cleaning stage, a concentrate assaying 61.6% sol Fe, 0.91% Ni, and 1.29% Cr was obtained with the recovery of 71.0% of the soluble iron, 24.3% of the nickel and 21.8% of the chrome. One stage of gravity concentration of the rougher non-magnetics produced a concentrate assaying 5.25% Ni with a recovery of 10.5% of the nickel. A fibre product amounting to about 28% by weight of the feed and assaying 1.4% sol Fe and 0.17% Ni was also obtained from the gravity separation stage.

---

*Senior Scientific Officer, Mineral Processing Division, Mines Branch, Department of Energy, Mines and Resources, Ottawa, Canada.

INTRODUCTION

In June, 1966, Dr. R.J. Merrill, Vice-President and General Manager, Carey-Canadian Mines Limited, East Broughton Station, Quebec, requested the Mines Branch to investigate methods of recovering magnetite from an iron-rich fraction of the company's asbestos-plant rejects. A laboratory investigation showed that the magnetite, which was found to contain about 1% nickel, could be successfully recovered from an iron-rich fraction of the plant rejects. The company then asked the Mines Branch to test a sample of total-plant tailings for the recovery of the nickel-bearing magnetite and also nickel sulphide that was reported to be present in the tailings. Laboratory tests on the sample of plant tailings were successful in recovering the nickel-bearing magnetite and nickel sulphides. In addition, a fibre product was also recovered.

The company then requested the Mines Branch to do a pilot-plant investigation on a more representative sample of plant tailings to confirm the laboratory results and to provide sufficient magnetite concentrate for preliminary smelting tests to produce ferronickel.

This report covers the laboratory testing of the original sample of the total-plant tailing and of a representative sample of the pilot-plant shipment that can be regarded as a standard for comparison with the pilot-plant tests.

Shipments

A 200-lb sample of the total plant tailings designated T-15260 was received on November 10, 1966. A 20-ton shipment designated Exp. 8-C was received on September 1, 1967. This shipment consisted of 25 lots of the minus-10-mesh fraction of the total-plant tailing taken on different days when the plant was treating different sections of the orebody.

The samples were submitted by Dr. R.J. Merrill, Vice-President and General Manager, Carey-Canadian Mines Limited, East Broughton Station, Quebec.

DETAILS OF INVESTIGATION

Total-Tailing Sample

A head sample was riffled from the 200-lb sample and a size-assay test made. Size fractions were ground to minus 65 mesh and separated into magnetic and non-magnetic fractions by the Davis tube. The results of the size-assay tests and the Davis-tube tests are shown in Table 1 and Table 2.

TABLE 1

Size-Assay Test of the Total Tailing Sample

Mesh Tyler	Weight %	Analysis %		Distribution %	
		Ni	Sol Fe	Ni	Sol Fe
-4+8	0.5				
-8+10	2.0	0.17	2.0	3.76	2.18
-10+14	2.9				
-14+20	3.4	0.21	3.1	2.84	2.10
-20+28	5.7	0.30	4.7	6.84	5.32
-28+35	15.3	0.25	4.5	15.55	13.87
-35+48	16.3	0.23	4.5	15.03	14.59
-48+65	16.7	0.25	4.5	16.87	14.96
-65+100	11.4	0.24	5.1	10.92	11.63
-100+200	15.7	0.26	6.1	16.34	19.21
-200	10.1	0.29	8.0	11.85	16.14
Total	100.0	0.25	5.0	100.00	100.00

TABLE 2

Davis-tube Tests on the Tailing Fractions

Mesh Tyler	Weight %	Analysis %		Distribution %	
		Ni	Sol Fe	Ni	Sol Fe
Magnetics					
-4+14	0.03	0.73	58.1	0.09	0.35
-14+20	0.04	0.86	68.9	0.14	0.55
-20+28	0.27	0.88	56.3	0.95	3.04
-28+35	0.58	0.84	53.5	1.95	6.21
-35+48	0.51	0.84	47.1	1.72	4.80
-48+65	0.32	0.84	54.6	1.08	3.49
-65+100	0.45	0.93	56.2	1.68	5.06
-100+200	1.76	0.82	43.5	5.83	15.31
-200	1.15	0.93	57.8	4.30	13.29
Total	5.11	0.86	51.0	17.74	52.10
Non-Magnetics					
-4+14	5.37	0.17	1.7	3.67	1.83
-14+20	3.36	0.20	2.3	2.70	1.55
-20+28	5.43	0.27	2.1	5.89	2.28
-28+35	14.72	0.23	2.6	13.60	7.66
-35+48	15.79	0.21	3.1	13.31	9.79
-48+65	16.38	0.24	3.5	15.79	11.47
-65+100	10.95	0.21	3.0	9.24	6.57
-100+200	13.94	0.26	1.4	10.51	3.90
-200	8.95	0.21	1.6	7.55	2.85
Total	94.89	0.22	2.5	82.26	47.90

Test 1

A sample of the total plant tailing was treated in a Sala wet magnetic separator. The rougher magnetic concentrate was ground to 85% minus 200 mesh and repassed in the Sala magnetic separator to produce a cleaner magnetic concentrate. The rougher non-magnetic fraction was treated on a shaking table to produce a rougher-table concentrate of the heavy minerals, a sand fraction and a fibre fraction. The rougher-table concentrate was then treated by a superpanner to produce a cleaner concentrate. Results of the test are shown in Table 3.

TABLE 3

Results of Test 1

Product	Weight %	Analysis %		Distribution %	
		Ni	Sol Fe	Ni	Sol Fe
Ro mag conc	10.7	0.66	36.0	29.1	75.5
Ro non-mags	89.3	0.19	1.4	70.9	24.5
Feed (calcd)	100.0	0.24	5.1	100.0	100.0
Cl mag conc	6.1	0.93	60.2	23.4	71.8
Cl non-mags	4.6	0.30	4.1	5.7	3.7
Ro mag conc	10.7	0.66	36.0	29.1	75.5
Table ro conc	3.5	1.11	1.6	16.1	1.1
Table sands	42.4	0.18	1.3	31.5	10.8
Table fibre	43.4	0.13	1.6	23.3	12.6
Ro non-mags	89.3	0.19	1.4	70.9	24.5
Superpanner cl conc	0.14	24.60	7.4	14.2	0.2
Superpanner tail	3.36	0.13	1.4	1.9	0.9
Table ro conc	3.50	1.11	1.6	16.1	1.1

Mineralogical examination of the superpanner cleaner concentrate and the table tailing were made to identify the principal minerals in the cleaner concentrate and the presence of nickel minerals in the table sands.

Superpanner Cleaner Concentrate*

The concentrate consisted largely of chromite, which comprised about 60% of the weight. The remainder consisted of about 10% gangue minerals and 30% sulphides. The principal sulphide mineral was heazlewoodite, Ni_3S_2, but substantial amounts of millerite, NiS, and pentlandite $(FeNi)S^2$ were also present.

Table Sands**

Polished sections were made and examined microscopically. A few very tiny grains of metallic minerals were observed, but they were too small for positive identification. As these minerals did not appear to be abundant enough to account for the reported nickel content of the sample, it is probable that at least some of the reported nickel is chemically combined in the serpentine minerals.

Pilot-Plant Shipment

A 100-lb head sample was riffled from a 2500-lb composite obtained by taking a 100-lb bag at random from each of the twenty-five daily lots which made up the shipment. Results of a size-assay test are shown in Table 4.

TABLE 4

Size-Assay Test of the Minus-10-Mesh Tailing

Mesh Tyler	Weight %	Analysis %			Distribution %		
		Ni	Sol Fe	Cr	Ni	Sol Fe	Cr
-10+14	6.86	0.24	2.49	0.23	5.86	3.07	5.26
-14+20	6.16	0.22	2.79	0.34	4.80	3.05	7.03
-20+28	7.58	0.26	4.49	0.52	6.77	6.11	13.05
-28+35	11.52	0.27	3.95	0.42	10.93	8.18	15.96
-35+48	13.07	0.26	4.63	0.30	11.95	10.88	13.24
-48+65	14.25	0.28	5.14	0.26	13.72	13.16	12.56
-65+100	13.92	0.29	5.25	0.22	14.04	13.13	10.36
-100+200	14.42	0.33	7.85	0.26	16.49	20.32	12.35
-200	12.22	0.36	10.07	0.25	15.44	22.10	10.19
Total	100.00	0.29	5.57	0.30	100.00	100.00	100.00

*From Internal Report MS-67-66 by E.H. Nickel
**From Internal Report MS-67-12 by E.H. Nickel

Each size-fraction after being ground to minus 65 mesh was separated into magnetic and non-magnetic fractions by the Davis tube. Results are shown in Table 5.

TABLE 5

Davis-tube Tests on Tailing Fractions

Mesh Tyler	Weight %	Analysis %			Distribution %		
		Ni	Sol Fe	Cr	Ni	Sol Fe	Cr
Mags							
-10+14	0.26	0.61	41.41	1.74	0.56	1.93	1.51
-14+20	0.18	0.65	48.89	3.06	0.41	1.58	1.84
-20+28	0.39	0.72	45.87	2.65	0.98	3.22	3.45
-28+35	0.60	0.66	43.88	1.60	1.38	4.73	3.20
-35+48	0.60	0.71	45.85	0.79	1.49	4.94	1.58
-48+65	0.77	0.72	44.04	0.86	1.94	6.09	2.21
-65+100	2.04	0.63	30.20	0.88	4.49	11.06	5.99
-100+200	2.64	0.76	38.97	0.78	7.02	18.48	6.87
-200	2.15	0.93	52.93	0.67	6.99	20.44	4.81
Total	9.63	0.75	40.35	0.98	25.26	72.47	31.46
Non-Mags							
-10+14	6.60	0.23	0.96	0.17	5.30	1.14	3.75
-14+20	5.98	0.21	1.37	0.26	4.39	1.47	5.19
-20+28	7.19	0.23	2.24	0.40	5.79	2.89	9.60
-28+35	10.92	0.25	1.76	0.35	9.55	3.45	12.76
-35+48	12.47	0.24	2.65	0.28	10.46	5.94	11.66
-48+65	13.48	0.25	2.92	0.23	11.78	7.07	10.35
-65+100	11.88	0.23	0.97	0.11	9.55	2.07	4.37
-100+200	11.78	0.23	0.87	0.14	9.47	1.84	5.48
-200	10.07	0.24	0.92	0.16	8.45	1.66	5.38
Total	90.37	0.24	1.53	0.23	74.74	27.53	68.54

Test 2

A portion of the head sample was treated as follows:

1. Magnetic separation to produce a cobber magnetic concentrate which was upgraded by two stages of grinding and magnetic separation.
2. Gravity separation of the minus-20-mesh, non-magnetic fraction using a shaking table to obtain a high-grade nickel concentrate by cutting only the brass-coloured, upper portion of the heavy-mineral band on the table. The remainder of the heavy-mineral band was recirculated until the end of the test and then was collected as a middling. The gravity concentrate was upgraded by a combination of low- and high-intensity magnetic separations to remove the magnetite and chromite respectively. Results of the test are shown in Table 6.

Test 3

Additional laboratory tests were made to increase nickel recovery. A lower-grade nickel, gravity concentrate with a higher recovery was produced from the non-magnetic fraction by cutting well below the heavy-mineral band on the table. The splitter on the table was also arranged to cut the remaining material on the table into sand and fibre fractions. The rougher concentrate was treated by two procedures. In one procedure, the concentrate was upgraded by two stages of tabling without any additional treatment. In the second procedure, the concentrate was ground to minus 65 mesh, to liberate any heavy minerals, prior to the upgrading stages.

In the cleaning and recleaning stages for both procedures the table was operated to produce a concentrate, which included most of the heavy-mineral band, and a tailing. A small amount of middling was cut and recirculated. At the end of the test the dark portion of the middling was included with the concentrate; the lighter-coloured portion was included with the tailing. Results of the tests are shown in Table 7.

TABLE 6

Results of Test 2

Product	Weight %	Analysis %			Distribution %		
		Ni	Sol Fe	Cr	Ni	Sol Fe	Cr
Mag Sep							
Cobber Conc	14.5	0.60	33.25	1.86	33.6	80.4	66.5
Non-mag							
+20 mesh	16.3	0.17	1.25	0.14	10.7	3.4	5.7
-20 mesh	69.2	0.21	1.41	0.16	55.7	16.2	27.8
Feed (calcd)	100.0	0.26	6.00	0.41	100.0	100.0	100.0
(assay)		0.27	5.62	0.38			
Ro mag conc	10.85	0.69	42.08	1.86	29.0	76.1	49.7
Ro non-mag	3.65	0.32	7.00	1.86	4.6	4.3	16.8
Cobber conc	14.50	0.60	33.25	1.86	33.6	80.4	66.5
Cl mag conc	6.92	0.91	61.60	1.29	24.3	71.0	21.8
Cl non-mag	3.93	0.31	7.77	2.88	4.7	5.1	27.9
Ro mag conc	10.85	0.69	42.08	1.86	29.0	76.1	49.7
Gravity Sep							
Table conc	0.16	11.17	19.01	8.60	6.9	0.5	3.4
Table midd	0.36	2.61	4.90	2.70	3.6	0.3	2.4
Table tail	68.68	0.17	1.35	0.13	45.2	15.4	22.0
-20 mesh non-mag	29.20	0.21	1.41	0.16	55.7	16.2	27.8
Comb conc & midd	0.52	5.25	11.16	4.70	10.5	0.8	5.8
LI Mag conc	0.06	2.00	48.65	10.3	0.4	0.48	1.5
LI Non-mag	0.10	16.67	1.23	7.6	6.5	0.02	1.9
Table conc	0.16	11.17	19.01	8.6	6.9	0.50	3.4
HI Mag conc	0.05	2.43	1.55	15.0	0.5	0.01	1.8
HI Non-mag	0.05	30.90	0.90	0.1	6.0	0.01	0.1
LI Non-mag	0.10	16.67	1.23	7.6	6.5	0.02	1.9

TABLE 7

Results of Test 3

Product	Weight %	Analysis %		Distribution %	
		Ni	Sol Fe	Ni	Sol Fe
Mag Separation					
Mag conc	14.7	0.58	29.75	33.0	80.0
Non-mag					
+20 mesh	17.0	0.19	1.15	12.5	3.6
-20 mesh	68.3	0.21	1.31	54.5	16.4
Feed (calcd)	100.0	0.26	5.47	100.0	100.0
(assay)		0.26	5.50		
Table ro conc	21.9	0.29	1.30	24.6	5.2
Table sands	18.3	0.16	1.20	11.4	4.0
Table fibre	28.1	0.17	1.40	18.5	7.2
-20-mesh non-mag	68.3	0.21	1.31	54.5	16.4
Procedure 1					
Table cl conc	2.9	1.23	1.90	13.8	1.0
Table tailing	19.0	0.15	1.21	10.8	4.2
Table ro conc	21.9	0.29	1.30	24.6	5.2
Table recl conc	0.62	4.73	4.70	11.3	0.5
Table tailing	2.28	0.28	1.14	2.5	0.5
Table cl conc	2.90	1.23	1.90	13.8	1.0
Procedure 2					
Table cl conc	5.5	0.66	1.62	14.1	1.6
Table tailing	16.4	0.16	1.20	10.5	3.6
Table ro conc	21.9	0.29	1.30	24.6	5.2
Table recl conc	0.74	3.87	4.85	11.0	0.7
Table tailing	4.76	0.17	1.12	3.1	0.9
Table cl conc	5.50	0.66	1.62	14.1	1.6

DISCUSSION OF RESULTS

The pilot-plant shipment assayed 5.57% sol Fe, 0.29% Ni, and 0.30% Cr compared to 5.0% Sol Fe and 0.25% Ni in the small preliminary sample. The size distributions of both samples were much the same. However, the amount of iron and nickel was higher in the finer sizes of the pilot-plant shipment than it was in the corresponding size-fractions in the preliminary sample. Davis-tube tests indicated that the weight of magnetics in the pilot-plant shipment was almost double that in the preliminary sample with most of this increase accounted for in the minus 65 mesh fractions. The soluble-iron assay of the Davis-tube magnetics from the pilot-plant shipment was somewhat lower, being 40.35% sol Fe compared to 51.00% sol Fe for the magnetics from the preliminary sample. This difference in magnetic grades and recoveries was confirmed in the laboratory single-drum magnetic cobber separations. However, the cleaner magnetic concentrates from both samples were similar in grade and recovery.

Grades of nickel concentrate produced by tabling the non-magnetics could be varied by the size of the cut taken. With the preliminary sample, an average cut was taken from the table, but, as the amount of concentrate produced was small, it was finally upgraded using the superpanner.

When the samples from the pilot-plant shipment were treated, different-width cuts of concentrate were taken. In one test, to obtain high recovery of the nickel, a wide cut was taken which was retabled to bring it up to the grade of the feed to the superpanner in the preliminary samples. However, the recovery of nickel was 13.8% compared to 16.1% from the preliminary sample. An additional stage of tabling to increase the grade comparable to that obtained with the superpanner was not successful; the grade was increased to only 4.7% Ni and the recovery of nickel was 11.3% compared to a recovery of 14.2% at a grade of 24.6% Ni from the preliminary sample. Grinding of the rougher table concentrate before any cleaning resulted in a concentrate of lower grade with lower recovery.

In another test, an attempt was made to make a high-grade concentrate by taking a narrow cut of concentrate from the table. However, the concentrate was still considerably lower than from the superpanner. An attempt to upgrade this concentrate by low-intensity and high-intensity magnetic separations resulted in a high-grade concentrate assaying 30.9% Ni with a recovery of 6.0% of the nickel compared to a concentrate assaying 24.6% Ni with a recovery of 14.2% of the Ni from the preliminary sample using a superpanner. The difference in recovery of nickel from the two samples may have been because of the upgrading of the preliminary sample by superpanning instead of by tabling as was

done for the pilot-plant sample. Other factors may include basic differences in the two samples such as the size of the nickel minerals, the degree of liberation and the mineral form in which the nickel occurred.

The nickel content of the sand portion from gravity concentration of both samples was about the same. The nickel content in the fibre product of the preliminary sample was lower at 0.13% Ni compared to 0.17% Ni from the pilot-plant sample which would indicate more entrainment of mineral particles. However, per cent weight of the fibre product from the preliminary sample was 43.4% compared to 28.1% from the pilot-plant sample so that the nickel losses to the fibre product from the preliminary sample were a little higher. The fine mineral particles entrained in the fibre were not considered recoverable by any simple low-cost method.

CONCLUSIONS

A laboratory investigation of a sample of the total plant tailing showed that a nickel-bearing magnetite concentrate, of a grade acceptable for smelting could be produced by magnetic separation. In addition a nickel concentrate and low-iron fibre could be produced by gravity separation of the cobber non-magnetic fraction.

The grade and recovery of the nickel concentrate produced in the preliminary sample could not be obtained from the sample of the pilot-plant shipment.

Some of the nickel is chemically combined with the gangue and therefore not recoverable in a high-grade concentrate. Fine mineral particles entrained in the fibres are not recoverable by any simple low-cost method.

A pilot-plant investigation is required to show the practicability of the process and to provide data for a preliminary feasibility study.

ACKNOWLEDGEMENTS

The writer wishes to acknowledge the contribution to this investigation by members of the Mineral Sciences Division, namely, E.H. Nickel for the mineralogical examinations, R. Craig, and P. Lanthier for the chemical analyses. The magnetic separation and tabling tests were performed by J. Banks, technician with the Mineral Processing Division.

/mn