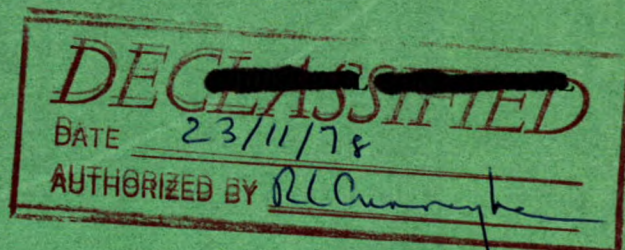


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DEPARTMENT OF MINES AND TECHNICAL SURVEYS

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MINES BRANCH INVESTIGATION REPORT IR 62-59

**BENEFICIATION OF BARYLITE
FROM SEAL LAKE, LABRADOR
(PROJECT MP-IM-6102)**

by

K. M. BROWN

MINERAL PROCESSING DIVISION

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BENEFICIATION OF BARYLITE FROM SEAL LAKE, LABRADOR
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SUMMARY OF RESULTS

The sample contains approximately 0.5% BeO and 1.0% Nb₂O₅. The valuable constituents include two beryllium minerals, berylite and eudidymite, and two niobium minerals, pyrochlore and an unidentified iron-niobium silicate. The characteristics of these minerals are such that complete separation by mineral dressing techniques is unlikely. Nevertheless, magnetic separation concentrated 75% of the niobium in the magnetic fraction and 80% of the beryllium in the non-magnetic fraction. Heavy liquid separation of the non-magnetics recovered some 2/3 of the beryllium content at a grade of 3.4% BeO. Grades of up to 6.8% BeO were obtained.

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INTRODUCTION

The Rio Tinto Mining Company of Canada Limited submitted a 232 lb sample considered to represent a beryllium deposit located at latitude 54 deg 15 min north and 62 deg 21 min west, about 100 miles northwest of Goose Bay, Labrador. The location was further described as the Seal Lake area.

The company reported a great deal of trenching and stripping over a distance of 3000 ft to open mineralized material estimated to contain over 10,000 ton per vertical ft, assaying 0.45% BeO, before diamond drilling.

The company requested that the Mines Branch investigate ways and means of producing a concentrate from this material which would preferably have a BeO content of 8% or more. Information was supplied on tests conducted by Lakefield Research, and by Dr. D.H. Gorman of the University of Toronto. A review of these tests indicated that most of the beryllium was concentrated with the non-magnetics of sp gr greater than 3.29. Dr. Gorman reported a concentrate containing 8.45% BeO with a recovery of 42%.

MINERALOGY

Three reports (1,2,3) have been issued by Dr. E.H. Nickel of the Mineral Sciences Division of the Mines Branch covering his work to date on samples from the Seal Lake deposit. This is indicated to be a complex that contains beryllium and niobium minerals in a generally gneissic syenite. The beryllium minerals are white and may be distinguished from albite and other white minerals present only by optical or staining techniques. The overall BeO content of the sample is approximately 0.5%. The niobium minerals are associated in part with the light-coloured (feldspar) and in part with the dark-coloured (amphibole and pyroxene), constituents of the rock. The Nb₂O₅ content of the sample is approximately 1.0%.

Two beryllium minerals have been identified so far, barylite and eudidymite. The barylite content varies to some extent throughout the deposit but appears to compose about 2% of the sample. Eudidymite was detected in 13 of 19 samples examined, indicating that this mineral is not uniformly distributed throughout the deposit. The eudidymite appears to compose about 1% of the deposit, or roughly half as much as barylite.

At least two niobium minerals are also known to be present, pyrochlore and a micaceous iron-niobium silicate which does not correspond to any known species. The pyrochlore is yellow and is chiefly associated with the lighter-coloured gangue minerals. The micaceous silicate is brown, similar to biotite in appearance, and is chiefly associated with the darker gangue minerals.

The iron-niobium silicate is rather magnetic whereas the pyrochlore, barylite and eudidymite are not. The latter three are fairly hard, 5 to 6, but show some contrast in sp gr, pyrochlore being 4.3, barylite 4.0 and eudidymite only 2.55.

ANALYSIS

During the early part of the investigation, BeO determinations by beryllometer procedures were performed by Rio Tinto Mining Company of Canada Limited, and also by Dr. H.P. Dibbs of the Mineral Sciences Division of the Mines Branch.

More recently a chemical analysis, developed by G.A. Kent of the Mineral Processing Division of the Mines Branch, has been employed.

A field test kit for the detection of Be, developed by the U.S. Bureau of Mines, was used for guidance.

The Nb₂O₅ determinations were made by R.W. Buckmaster of the Mineral Sciences Division of the Mines Branch, using a wet spectrophotometric procedure.

TEST WORK

The sample was crushed to -10 mesh. A portion of this, several pounds in weight, was riffled out and further reduced by stage crushing to -20 mesh. A small amount of persistent oversize was composed of blocky, gray-black pieces and white pieces, in about equal proportions.

Some of the -20 mesh was screened on the Tyler series and the fractions analysed for BeO as shown in Table 1.

TABLE 1

Screen Fractions of Feed

Product	Weight		BeO %	Distribution	
	%	Cum %		%	Cum %
-20 + 28m	5.62		0.46	5.60	
-28 + 35m	13.40	19.02	0.47	13.57	18.17
-35 + 48m	9.80	28.82	0.37	7.82	25.99
-48 + 65m	11.42	40.24	0.34	7.86	33.85
-65 + 100m	13.20	53.44	0.56	15.85	49.70
-100 + 150m	14.68	68.12	0.37	11.66	61.36
-150 + 200m	2.66	70.78	0.34	1.95	63.31
-200m	29.22	100.00	0.57	35.69	100.00
Feed (calc)	100.00		0.47	100.00	

The -65 + 100 mesh fraction from Table 1 was superpanned with results as shown in Table 2.

TABLE 2

Superpanning of -65 + 100 mesh

Fraction	Wt %	BeO %	Dist %
Heavy	11.5	0.87	18.0
Light	88.5	0.52	82.0
Feed (calc)	100.0	0.56	100.0

Some -200 mesh was screened from the feed and treated in a Roller Air Classifier with results as shown in Table 3.

TABLE 3

Roller Air Classifier Products

Product	Wt %	Assay %		Dist %	
		BeO	Nb ₂ O ₅	BeO	Nb ₂ O ₅
1) O'flow from 9 in. pipe, 8 psi	30.2	0.59	1.04	29.0	39.0
2) " " 4½ in. " , 8 "	52.0	0.60	0.77	51.0	50.0
3) " " 2½ in. " , 3½ "	13.7	0.67	0.50	15.0	8.0
Remainder	4.1	0.80	0.59	5.0	3.0
Feed (calc)	100.0	0.62	0.81	100.0	100.0

Four small portions were riffled from the -20 mesh feed. One was reduced to -325 mesh, another to -200 mesh, and a third to -100 mesh. The four samples were in turn passed through the Jones Wet Magnetic Mineral Separator, at 25 amp power input. In each case the magnetics were cleaned twice, and the final middling was combined with the original non-magnetics. Results are shown in Table 4.

TABLE 4

Magnetic Separation of Screen Fractions

Fraction	Product	Wt %	Assay %		Dist %	
			BeO	Nb ₂ O ₅	BeO	Nb ₂ O ₅
-20 m	Mag	43.0	0.58		43.7	
	Non-mag	57.0	0.56		56.3	
	Feed (calc)	100.0	0.57		100.0	
-100m	Mag	33.6	0.39		30.1	
	Non-mag	66.4	0.46		69.9	
	Feed (calc)	100.0	0.43		100.0	
-200m	Mag	28.6	0.31	3.34	17.9	74.7
	Non-mag	71.4	0.57	0.45	82.1	25.3
	Feed (calc)	100.0	0.49	1.28	100.0	100.0
-325m	Mag	29.2	0.39		20.6	
	Non-mag	70.8	0.62		79.4	
	Feed (calc)	100.0	0.55		100.0	

Fractionation by magnetic separator was also tried on the -20 mesh feed. Results are recorded in Table 5.

TABLE 5

Magnetic Separation of -20 mesh Feed

Product	Wt %	BeO %	Dist %
Mag - 5 amp	32.2	0.39	24.6
" - 10 "	13.5	0.86	22.9
" - 25 "	4.4	0.73	6.3
Non-mag	49.9	0.47	46.2
Feed (calc)	100.0	0.51	100.0

A trial was also made of tabling magnetic separator products. The Jones Magnetic Separator was set at 25 amp and the magnetic and non-magnetic products were passed separately over a Wilfley table. Results are recorded in Table 6.

TABLE 6

Magnetic Separation and Tabling

Fraction	Product	Wt %	BeO %	Dist %
Mag	Table conc	27.5	0.65	39.0
	" tails	22.5	0.45	22.2
Non-mag	" conc	18.0	0.49	19.2
	" tails	32.0	0.28	19.6
Feed (calc)		100.0	0.46	100.0

A further portion of -20 mesh feed was passed through the Jones Separator at 25 amp and the fractions were split by a rising current of water. Results are recorded in Table 7.

TABLE 7

Magnetic Separation and Hindered Settling

Fraction	Product	Wt %	BeO %	Dist %
Mag	Sand	23.1	0.73	34.8
	Overflow	28.4	0.45	26.2
Non-mag	Sand	11.2	0.53	12.0
	Overflow	37.3	0.35	27.0
Feed (calc)		100.0	0.48	100.0

Another portion of the -20 mesh feed was magnetically separated at 25 amp and the non-magnetic product was centrifuged in tetrabromoethane (TBE), which has a sp gr of 2.964. The results of this test are recorded in Table 8.

TABLE 8

Magnetic and Heavy Liquid Separation

Fraction	Product	Wt %	BeO %	Dist %
Mag		43.3	0.58	43.8
Non-mag	Float	53.6	0.21	19.4
"	Sink	3.1	6.81	36.8
Feed (calc)		100.0	0.57	100.0

Further trial was made of this procedure by grinding some of the feed to -100 mesh, separating in the Jones equipment at 25 amp, and centrifuging the fractions in TBE. Results are recorded in Table 9.

TABLE 9

Magnetic and Heavy Liquid Separation at -100 mesh

Fraction	Product	Wt %	BeO %	Dist %
Mag	Float	1.7	0.21	0.8
	Sink	31.9	0.40	29.1
Non-mag	Float	55.0	0.10	12.4
	Sink	11.4	2.20	57.7
Feed (calc)		100.0	0.44	100.0

A more elaborate batch test of this procedure included grinding of the feed to -200 mesh, magnetic separation at 25 amp, cleaning the magnetics twice at the same setting, and combining the middlings with the original non-magnetics. These fractions were then centrifuged in TBE. Results are recorded in Table 10.

TABLE 10

Magnetic and Heavy Liquid Separation at -200 mesh

Fraction	Product	Wt %	Assay %		Dist %	
			BeO	Nb ₂ O ₅	BeO	Nb ₂ O ₅
Mag	Float	0.5	0.17	0.36	0.2	0.2
	Sink	28.1	0.31	3.40	17.8	74.0
Non-mag	Float	64.0	0.24	0.36	30.8	18.0
	Sink	7.4	3.38	1.25	51.2	7.8
Feed (calc)		100.0	0.49	1.28	100.0	100.0

The magnetic-heavy liquid method was extended to a trial of continuous centrifuging. Feed was prepared by step reduction to -100 mesh. This was separated in the Jones equipment at 25 amp. The non-magnetics were then cleaned once, and the magnetics were cleaned twice using the same setting. The cleaner fractions, i.e. the magnetics from non-magnetics cleaning and the non-magnetics from the magnetics cleaning, were combined to form a middling. The magnetic, middling, and non-magnetic fractions were then in turn dispersed in TBE and passed through a Sharples Centrifugal Classifier running at 36,000 rpm. The Sharples separation was not sufficiently precise and a final separation was secured by clinical centrifuge. The various products were washed with carbon tetrachloride, dried, weighed, and analysed. The results obtained are shown in Table 11.

TABLE 11

Magnetic and Continuous Heavy Liquid Separation

Fraction	Product	Wt %	BeO %	Dist %
Mag	Float	1.6	0.21	0.7
	Sink	31.9	0.40	29.0
Midd	Float	4.1	0.33	3.0
	Sink	3.7	1.22	10.2
Non-mag	Float	50.9	0.08	9.1
	Sink	7.8	2.68	48.0
Feed (calc)		100.0	0.44	100.0

Typical of the flotation trials made are the following tests. Some -100 mesh feed was passed through the Jones Magnetic Separator at 25 amp. The magnetics were cleaned once and the middling was combined with the non-magnetic fraction. The magnetics were further ground to -200 mesh. Magnetics and non-magnetics were separately subjected to froth flotation using anionic reagents. Results are recorded in Table 12.

TABLE 12

Froth Flotation of Magnetic Separator Products

Fraction	Product	Weight % of		BeO %	Distribution % of	
		Fraction	Feed		Fraction	Feed
Mag	Conc 1	4.2	1.5	0.28	3.0	1.3
	" 2	8.8	3.2	0.38	8.2	3.5
	Tails	87.0	31.7	0.41	88.8	37.4
		100.0			100.0	
Non-mag	Conc 1	6.1	3.9	0.57	6.3	3.7
	" 2	5.7	3.6	0.56	5.8	3.3
	Tails	88.2	56.1	0.55	87.9	50.8
Feed (calc)		100.0	100.0	0.50	100.0	100.0

About 1000g of -200 mesh feed were classified by teetering in the $4\frac{1}{2}$ in. tube of the Roller Classifier at a pressure of $8\frac{1}{2}$ psi. The heavy fraction was pulped and floated in warm water with oleic acid. Results are recorded in Table 13.

TABLE 13

Froth Flotation of Roller Classifier Products

Product	Wt %	Assay %		Distribution %	
		BeO	Nb ₂ O ₅	BeO	Nb ₂ O ₅
Classifier dust	79.7	0.54	0.93	78.0	82.1
Flotation conc	3.9	0.54	1.12	4.0	4.9
" tails	16.4	0.61	0.72	18.0	13.0
Feed (calc)	100.0	0.55	0.90	100.0	100.0

One further approach was tried. Some Jones Separator non-magnetics were wetted with FeSO_4 . Ferrous iron was precipitated with ammonia, and reduced by adding charcoal and heating to 800 deg C. The treated material was again passed through the magnetic separator. No concentration was obtained by this method.

DISCUSSION

The main purpose of the investigation was concentration of the beryllium. The complex association of beryllium and niobium minerals, however, made it inevitable that some knowledge of the niobium content should be gained as well.

The various means tried did not prove adequate to isolate the valuable minerals, or to produce satisfactory concentrations of either beryllium or niobium. This may be explained, at least in part, by the nature of the minerals themselves. Magnetic separation will concentrate most of the micaeous iron-niobium silicate, but the pyrochlore largely remains with the non-magnetics. Gravity separation of the non-magnetics will concentrate much of the heavy berylite but leaves the lighter eudidymite in the tails. The possibility of other beryllium and niobium minerals being present must also be considered.

The most successful overall approach was magnetic separation followed by heavy liquid separation of the non-magnetics. On -20 mesh feed, Table 3, a concentrate containing 6.4% BeO was obtained after centrifuging several times in heavy liquid. Complete wetting and separation was found difficult with this material, especially since the heavy fraction is of small size in comparison with the light fraction. It is noteworthy that in the test recorded in Table 8 the magnetics contained 43.8% of the BeO, while in that recorded in Table 10, on much finer feed, the magnetics contained only 18.0% of the BeO. On this finer feed, however, the recovery of BeO in heavy liquid sink was 51.2% as opposed to 36.8% on the -20 mesh. On the other hand, the grade dropped to 3.38% BeO on the finer feed from 6.8% BeO on the coarser. The trial with continuous centrifuging was not as successful in general as the batch work, although, as seen in Table 11, 48.0% of the BeO was recovered at a grade of 2.68%. There is no doubt that this technique could be improved with practice.

Table 1 indicates that there is some tendency for the beryllium minerals to be reduced to -200 mesh more rapidly than the other minerals present. Berylite and eudidymite are supposed to be of the same hardness as feldspar but they may be much more friable. The -65 + 100 mesh fraction in Table 1 appears to be at variance with the other fractions. This fraction was used in superpanning, Table 2, and the BeO content calculated from the superpanner fractions. The superpanner light fraction appears to have about double the BeO content which might be expected, i.e. if this product were 0.25% BeO rather than 0.52% then the calculated value for -65 + 100 mesh would be 0.32% BeO and much more in line with other fractions in Table 1.

Table 4 demonstrates a tendency for more material to collect in the non-magnetic fractions at finer particle sizes, and these fractions also contain a larger part of the BeO. At the same time niobium tends to become more concentrated in the magnetic fractions with finer grinding apparently due to a sharper separation of the micaceous iron-niobium silicates from the non-magnetics.

Flotation was not thoroughly investigated although trials were made with several reagents. No selectivity was demonstrated in any of these trials. Flotation would at best be a complicated process with such a complex of minerals.

CONCLUSIONS

It has been shown that at least four valuable minerals form a small part of a complex mineral combination, and that these minerals have conflicting characteristics for mineral dressing purposes. It would be expected, therefore, that beneficiation by mineral dressing techniques could at best effect only partial separation and concentration of the valuable constituents. The test work has born this out. There are indications that magnetic separation and heavy liquid separation could be applied to concentrate a large part of the valuable minerals into a reduced bulk as a preliminary to other forms of processing.

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