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O T T A W A   April 14th, 1942.

R E P O R T

of the

ORE DRESSING AND METALLURGICAL LABORATORIES.

Investigation No. 1202. c.1

Sink-and-Float Tests on Samples of
Magnesite Ore from Canadian Refractories
Limited, at Kilmar, Quebec.

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(Copy No. 19.)

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BUREAU OF MINES
DIVISION OF METALLIC MINERALS

ORE DRESSING AND
METALLURGICAL LABORATORIES

CANADA
DEPARTMENT
OF
MINES AND RESOURCES
MINES AND GEOLOGY BRANCH

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Magnesite Ore from Canadian Refractories
Limited, at Kilmar, Quebec.

Shipment:

Two parcels of ore, each weighing approximately 8 tons, were received on February 28th, 1942. The shipment was submitted by J. W. Craig, Manager of Development and Research, Canadian Refractories Limited, Canada Cement Building, Phillips Square, Montreal, Quebec.

Location of Property:

The shipment came from the company's property at Kilmar, about 40 or 50 miles west of Montreal, Quebec.

Character of the Samples:

The shipment contained two samples, one being low-grade cull rock from a surface dump, while the other was siliceous rock taken from a low-grade section of the mine. Both samples contained magnesite, dolomite and serpentine. In the mine sample magnesite predominates with dolomite and serpentine next in order of abundance, while in the sample of cull rock dolomite is the most abundant mineral, followed in order by magnesite and serpentine.

Sampling and Assaying:

The samples received were broken down to minus 1½ inches, sampled, assayed, and reported as follows:

		CaO, per cent	Insoluble, per cent	R_2O_3, per cent
Siliceous ore	-	12.18	6.42	1.58
Cull rock	-	14.01	7.94	1.49

Experimental Tests:

Small-scale sink-and-float tests were conducted on a sample of cull rock from the Kilmar property of Canadian Refractories Limited in 1941. The results of these tests are contained in Report of Investigation No. 1081, prepared in September, 1941.

These preliminary tests having shown some prospect of success it was decided to try large-scale tests on a sample of cull rock as well as on a sample of siliceous ore from the mine.

These tests have demonstrated that the lime and

(Experimental Tests, cont'd) -

insoluble can be reduced to required amounts in samples of rock that carry them in excessive quantities, thus saving for use a part of the rock that would otherwise be wasted.

The object of the process is to reject a high lime, high silica fraction of the ore at a coarse size, by making a density separation in a bath of substantially stable galena-water suspension wherein the heavier magnesite minerals sink to the bottom while the dolomite and serpentine float.

Material finer than 8 mesh can never be treated by this process under any circumstance and for any given ore the lower size limit may be even coarser. Preliminary tests indicated 3 mesh as the lower size limit for this ore while the upper size limit was set at 1.5 inches without any indication that the maximum size had yet been reached.

The medium used in the small-scale tests was the same as that used in the plant tests and its density can be controlled to an accuracy of 0.01.

The tests will be described in detail as follows. The small-scale tests on both samples will constitute Part I of this report while the plant tests will constitute Part II.

PART I.

The samples received were crushed to minus 1.5 inch and sampled in a sampling plant. The samples were screened on $1\frac{1}{2}$, $1\frac{1}{4}$, 1.0, $\frac{3}{4}$ and $\frac{1}{4}$ inch screens. The various fractions were then quartered and a head sample made up for assay. Density separations were made on another set of quarters excluding

(Part I, cont'd) -

the minus ¼ inch material, this lower size limit having already been determined in the original testing. This procedure was followed on both samples.

A series of density separations was made on each sample, starting at 2.775. The material heavier than 2.775 was retreated at 2.80, yielding an intermediate fraction and a sink which was again retreated until a maximum separating density of 2.85 had been reached.

The results of the size-density analyses are laid down in the following tables:

(Size-Density Analysis for
Magnesite Ore follows on next page)

MAGNESITE ORE

SIZE-DENSITY ANALYSIS FOR MAGNESITE ORE.

Size Fractions	$-\frac{3}{4}"+\frac{1}{4}"$		$-1.0"+\frac{3}{4}"$		$-1\frac{1}{4}"+1.0"$		$-1\frac{1}{2}"+1\frac{1}{4}"$		Total	
	- Weight Proportions -									
DENSITY FRACTIONS	% Size fraction	% S.F. feed	% Size fraction	% S.F. feed	% Size fraction	% S.F. feed	% Size fraction	% S.F. feed	% Size fraction	% S.F. feed
Float @ 2.775	31.36	14.93	18.59	4.93	14.68	2.79	17.43	1.21	23.86	23.85
Float @ 2.80; sink @ 2.775	8.86	4.22	10.57	2.80	9.08	1.72	6.09	0.42	9.16	9.16
Float @ 2.825; sink @ 2.80	7.64	3.64	8.10	2.15	6.29	1.19	7.58	0.52	7.50	7.50
Float @ 2.85; sink @ 2.825	12.01	5.72	15.40	4.08	14.49	2.75	13.52	0.93	13.48	13.48
Sink @ 2.85	40.13	19.11	47.34	12.54	55.46	10.52	55.38	3.83	46.00	46.01
TOTAL -	100.00	47.62	100.00	26.50	100.00	18.97	100.00	6.91	100.00	100.00

	Assays, per cent			Assays, per cent			Assays, per cent			Assays, per cent			Assays, per cent		
	CaO	Insol.	R_2O_3	CaO	Insol.	R_2O_3	CaO	Insol.	R_2O_3	CaO	Insol.	R_2O_3	CaO	Insol.	R_2O_3
Float @ 2.775	10.41	21.90	-	12.48	21.26	-	13.64	17.60	-	14.35	14.66	-	13.79	16.40	-
Float @ 2.80; sink @ 2.775	19.02	6.60	0.80	18.52	12.44	1.60	18.92	6.70	1.14	14.83	5.64	1.10	16.97	7.29	1.28
Float @ 2.825; sink @ 2.80	13.70	18.10	2.46	18.65	9.00	1.88	17.64	6.56	1.42	14.45	5.64	1.22	15.99	7.24	1.46
Float @ 2.85; sink @ 2.825	15.68	4.72	1.00	16.19	3.56	0.96	16.27	3.76	1.14	12.48	2.82	0.88	14.61	3.39	0.98
Sink @ 2.825	9.45	1.69	0.82	10.88	1.92	0.78	9.90	1.92	0.74	9.86	1.78	0.80	10.07	1.84	0.78

(Part I, cont'd) -

It will be noted that the table shows no indication that the upper size-limit has been reached. In fact, the coarser sizes show a higher recovery in the sink than do the finer sizes with a product of equally high grade.

The following table has been prepared by reducing the size-density analysis to simpler form and including the minus 3 mesh fines in the proper proportion. The various density fractions listed in this table are the average of all the size-fractions listed in the size-density table for the corresponding separating densities. The table shows the net result of each successive separation at a higher density.

Density Analysis on Ore.

Product	Weight, per cent	Assays, per cent			Distribution, per cent	
		CaO	Insol.	R_2O_3	CaO	Insol.
Float @ 2.775	19.04	13.79	16.40	-	20.63	47.08
Float @ 2.80; sink @ 2.775	7.32	16.97	7.29	1.28	9.76	8.05
Float @ 2.825; sink @ 2.80	5.95	15.99	7.24	1.46	7.48	6.49
Float @ 2.85; sink @ 2.825	10.76	14.61	3.39	0.98	12.36	5.49
Sink @ 2.85	36.73	10.07	1.84	0.78	29.08	10.18
Sink-and-Float feed	79.80	12.64	6.43	-	79.31	77.29
Fines -3 mesh	20.20	13.03	7.46	1.74	20.69	22.71
Ore sample (cal.)	100.00	12.72	6.63	-	100.00	100.00

Assuming that the minus 3 mesh fines are to be rejected as waste along with the float, recoveries in the sink products that would be obtained by separating at each of the above densities, and the corresponding assays, are as follows:

(Continued on next page)

(Part I, cont'd) -

Separating density	Weight per cent of sink	Assays of sink (cal.), per cent		
		CaO	Insol.	R_2O_3
2.775	60.76	12.28	3.30	0.94
2.80	53.44	11.64	2.75	0.90
2.825	47.49	11.10	2.19	0.83
2.85	36.73	10.07	1.84	0.78

When minus 3 mesh fines are combined with the sink as final product, recoveries are as follows:

Separating density	Weight per cent of sink	Assays of sink (cal.), per cent		
		CaO	Insol.	R_2O_3
2.775	80.96	12.47	4.34	1.14
2.80	73.64	12.02	4.05	1.13
2.825	67.69	11.67	3.76	1.10
2.85	56.93	11.12	3.83	1.12

(SIZE-DENSITY ANALYSIS FOR MAGNESITE

CULL ROCK FOLLOWS ON NEXT PAGE).

SIZE-DENSITY ANALYSIS FOR MAGNESITE CULL ROCK.

SIZE-DENSITY ANALYSIS FOR MAGNESITE CULL ROCK.

Size Fractions	$-\frac{3}{4}"+\frac{1}{4}"$		$-1.0"+\frac{3}{4}"$		$-1\frac{1}{4}"+1.0"$		$-1\frac{1}{2}"+1\frac{1}{4}"$		Total	
	- Weight Proportions -									
DENSITY FRACTIONS	% Size fraction	% S.F. feed	% Size fraction	% S.F. feed	% Size fraction	% S.F. feed	% Size fraction	% S.F. feed	% Size fraction	% S.F. feed
Float @ 2.775	42.71	21.32	32.26	7.34	33.01	7.31	31.57	1.64	37.61	37.60
Float @ 2.80; sink @ 2.775	11.91	5.95	8.05	1.83	4.54	1.01	2.01	0.10	8.89	8.89
Float @ 2.825; sink @ 2.80	12.82	6.40	11.85	2.70	11.32	2.51	4.77	0.25	11.86	11.85
Float @ 2.85; sink @ 2.825	10.66	5.32	12.16	2.77	10.57	2.34	16.47	0.85	11.28	11.29
Sink @ 2.85	21.90	10.93	35.68	8.11	40.56	8.98	45.18	2.34	30.36	30.37
TOTAL -	100.00	49.92	100.00	22.75	100.00	22.15	100.00	5.18	100.00	100.00

Size Fractions	$-\frac{3}{4}"+\frac{1}{4}"$ Assays, per cent			$-1.0"+\frac{3}{4}"$ Assays, per cent			$-1\frac{1}{4}"+1.0"$ Assays, per cent			$-1\frac{1}{2}"+1\frac{1}{4}"$ Assays, per cent			Total Assays, per cent		
DENSITY FRACTIONS	CaO	Insol.	R2O3	CaO	Insol.	R2O3	CaO	Insol.	R2O3	CaO	Insol.	R2O3	CaO	Insol.	R2O3
Float @ 2.775	14.51	14.66	-	13.85	16.92	-	13.85	16.16	-	14.56	13.86	-	14.25	15.36	-
Float @ 2.80; sink @ 2.775	17.14	4.54	0.98	18.90	6.96	1.44	16.48	10.94	2.56	17.38	7.54	2.34	17.44	5.81	1.27
Float @ 2.825; sink @ 2.80	15.87	3.76	1.10	15.47	4.26	1.44	22.34	6.70	1.24	19.79	4.74	1.80	17.22	4.52	1.22
Float @ 2.85; sink @ 2.825	14.36	2.72	0.78	18.52	4.00	1.02	15.48	4.74	0.96	20.80	3.44	1.08	16.12	3.52	0.90
Sink @ 2.85	9.60	2.02	0.84	10.86	2.52	0.76	11.17	2.18	0.72	9.64	2.42	0.64	10.40	2.23	0.77

(Part I, cont'd) -

Here, again, there is no indication that the upper size limit has been reached and the coarser sizes give a higher recovery in the sink than the finer sizes while the grade of product is equally good.

Density Analysis on Cull Rock.

Product	Weight, per cent	Assays, per cent CaO	Insol.	R_2O_3	Distribution, per cent CaO	Insol.
Float @ 2.775	30.0	14.25	15.36	-	30.47	57.16
Float @ 2.80; sink @ 2.775	7.1	17.44	5.81	1.27	8.82	5.12
Float @ 2.825; sink @ 2.80	9.5	17.22	4.52	1.22	11.67	5.32
Float @ 2.85; sink @ 2.825	9.0	16.12	3.52	0.90	10.33	3.92
Sink @ 2.85	24.1	10.40	2.23	0.77	17.86	6.67
Sink-and-float feed	79.7	13.94	7.91	-	79.15	78.19
Fines -3 mesh	20.3	14.41	8.66	2.14	20.85	21.81
Ore sample (cal.)	100.0	14.03	8.06	-	100.00	100.00

Recoveries in sink produced at various densities, with corresponding assays, are as follows:

Separating density	Weight per cent of sink	Assays of sink (cal.), per cent CaO	Insol	R_2O_3
2.775	49.7	13.75	3.41	0.95
2.80	42.6	13.13	3.01	0.90
2.825	33.1	11.95	2.58	0.80
2.85	24.1	10.40	2.28	0.77

PART II.

The small-scale tests having indicated the possibility of beneficiating the ore by the sink-and-float process, it was decided to try large-scale tests on a tonnage basis using a semi-commercial-size unit.

Plant tests were conducted on both ore and cull rock. In each case the ore was fed to the separator at the rate of 1,200 pounds per hour, while assay samples were cut from the feed and products at regular intervals during the period of operation. The size range of the feed was minus $1\frac{1}{2}$ inches plus 3 mesh and the fact that the samples cut out were small fractions of the product being sampled, whereas considering the size of product a large fraction should have been taken, may account for discrepancies between the actual sink-and-float feed sample assays and the assays calculated from the products.

The first plant test on the ore was carried out at a separating density of 2.825 with the idea in mind of producing a sink product at or near 3.00 per cent insoluble. In this case the lime in the sink product was expected to be somewhat high but this was to be adjusted by mixing with low-lime rock. Average densities at different points in the circuit are as follows:

Feed	-	2.821
Weir	-	2.855
Boom	-	2.777

(Continued on next page)

(Part II, cont'd) -

Summaries of Results:

Separating Mine Ore at 2.825.

Product	Weight, per cent	Assays, per cent CaO	Insol.	R2O3	Distribution, per cent CaO	Insol.	R2O3
Sink-and-float feed	80.55	12.33	5.30	2.10			
Float @ 2.825	19.63	14.05	17.06	2.94	21.91	50.90	37.55
Weir product	13.86	13.85	3.50	0.90	15.25	7.37	8.11
Fines -3 mesh	19.45	13.29	7.92	2.02	20.53	23.42	25.56
Sink @ 2.825	47.06	11.32	2.56	0.94	42.31	18.31	28.78
Ore sample (cal.)	100.00	12.59	6.58	1.54	100.00	100.00	100.00
Weir and Sink Combined as Final Product.							
Weir	13.86	13.85	3.50	0.90	15.25	7.37	8.11
Sink @ 2.825	47.06	11.32	2.56	0.94	42.31	18.31	28.78
Recovery	60.92	11.90	2.77	0.93	57.56	25.68	36.89
Weir, Sink and Fines Combined as Final Product.							
Weir and sink	60.92	11.90	2.77	0.93	57.56	25.68	36.89
Fines	19.45	13.29	7.92	2.02	20.53	23.42	25.56
Recovery	80.37	12.23	4.02	1.19	78.09	49.10	62.45
Sink and Fines Combined as Final Product.							
Sink @ 2.825	47.06	11.32	2.56	0.94	42.31	18.31	28.78
Fines	19.45	13.29	7.92	2.02	20.53	23.42	25.56
Recovery	66.51	11.90	4.13	1.26	62.84	41.73	54.34

The foregoing summaries show that the sink and weir products may be combined and still keep below the limit of 3.00 per cent insoluble but all of the fines cannot be included without exceeding it by a considerable margin.

It would, however, be possible to add a part of the fines to the sink and weir products and after treatment on a table to remove some insoluble it might be possible to use a

(Part II, cont'd) -

considerable fraction of the fines.

The matter of reducing the insoluble content of the fines by treatment on tables will be examined in due course.

The next test on the ore was conducted at a separating density of 2.85, with the idea in mind of reducing the lime content in the sink to less than 10 per cent.

Average densities in the circuit were as follows:

Feed - 2.852
Weir - 2.878
Boom - 2.825

The medium was circulated at the rate of 9.25 gallons per minute.

<u>Summary of Results</u>:

Separating Mine Ore at 2.85.

Product	Weight, per cent	Assays, per cent			Distribution, per cent		
		CaO	Insol.	R_2O_3	CaO	Insol.	R_2O_3
Sink-and-float feed	79.7	11.81	6.10	1.42			
Float @ 2.85	34.5	14.05	6.40	1.90	40.24	46.31	42.50
Sink @ 2.85	33.8	9.62	1.84	1.04	27.00	13.04	22.79
Weir product	11.4	10.95	2.90	1.10	10.36	6.93	8.13
Fines -3 mesh	20.3	13.29	7.92	2.02	22.40	33.72	26.58
Ore sample (cal.)	100.0	12.04	4.77	1.54	100.00	100.00	100.00

Weir and Sink Products Combined as Final Product.

Product	Weight, per cent	CaO	Insol.	R_2O_3	CaO	Insol.	R_2O_3
Weir	11.4	10.95	2.90	1.10	10.36	6.93	8.13
Sink @ 2.85	33.8	9.62	1.84	1.04	27.00	13.04	22.79
Recovery	45.2	9.96	2.11	1.06	37.36	19.97	30.92

While the sink product is well below 10 per cent in lime the weir and sink products combined are still just below this limit, with 45 per cent of the ore in the form of a

(Part II, cont'd) -

usable product.

These two tests, along with the size-density analysis, indicate the possibilities of producing a wide range of products simply by altering the separating density. They definitely show that the ore can be beneficiated by this process.

A test was conducted on the sample of cull rock with the idea in mind of producing a sink product that would assay about 3.00 per cent insoluble. The separation was made at 2.80, the small-scale tests having indicated this to be the proper density.

Average densities in the circuit were as follows:

Feed - 2.814
Weir - 2.844
Boom - 2.779

The medium was circulated at the rate of 9.5 gallons per minute during part of this test but was reduced to 7.25 gallons per minute by reducing the head in the stabilizer tank from 12 inches to 9 inches.

Summary of Results:

Separating Cull Rock at 2.80.

Product	Weight, per cent	Assays, per cent			Distribution, per cent		
		CaO	Insol.	R_2O_3	CaO	Insol.	R_2O_3
Sink-and-float feed.	79.91	14.51	7.08	1.28			
Float @ 2.80	35.10	14.86	13.70	2.46	37.88	59.15	56.09
Weir product	8.85	15.92	3.66	0.92	10.23	3.98	5.29
Fines -3 mesh	20.09	14.30	9.66	1.42	20.86	23.87	18.53
Sink @ 2.80	35.96	11.88	2.94	0.86	31.03	13.00	20.09
Ore sample (cal.)	100.00	13.77	8.13	1.54	100.00	100.00	100.00
Weir and Sink Products Combined as Final Product.							
Weir	8.85	15.92	3.66	0.90	10.23	3.98	5.29
Sink @ 2.80	35.96	11.88	2.94	0.86	31.03	13.00	20.09
Recovery	44.81	12.68	3.08	0.87	41.26	16.98	25.38

This test shows that the cull rock can be beneficiated

(Part II, cont'd) -

by this process, from 36 to 45 per cent of the rock being obtained as a usable product.

CONCLUSIONS:

The results of the foregoing tests show that this ore can be beneficiated by the sink-and-float process. That the insoluble is more efficiently eliminated than the lime is due to the fact that the serpentine occurs in more massive form than the dolomite and also has a lower specific gravity.

The sample of mine ore can be treated at a density of 2.825 or thereabouts, yielding more than 60 per cent of the rock as a product assaying about 12.0 per cent lime and less than 3.0 per cent insoluble. Such a product can be adapted to use in this form or mixed with low-lime rock for a product calling for more exacting specifications.

By separating at a still higher density, the lime can be brought down below 10 per cent and the insoluble below 2 per cent. Under these conditions, from 35 to 45 per cent of the ore would be recovered as a useful product.

In the case of the cull rock, recoveries would be somewhat lower owing to the higher serpentine and dolomite contents. Nevertheless a product of such grade as can be adapted to use can be obtained.

This process, if used, would make possible the mining of ore bodies heretofore considered to be of no value owing to their high dolomite and serpentine contents.

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