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MINES BRANCH INVESTIGATION REPORT

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BENEFICIATION OF CELESTITE FROM CAPE BRETON, NOVA SCOTIA (PROJECT MP-IM-7002)

by

F.H. HARTMAN and R.A. WYMAN

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F.H. Hartman* and R.A. Wyman**

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SUMMARY

A simple one-reagent flotation system has been developed and applied to the beneficiation of celestite ore from the property of Kaiser Celestite Mining Limited, Loch Lomond, N.S. It was found necessary to grind flotation feed to 96.5% minus 325 mesh in order to liberate silica. With 3.8 lb/ton Igepon T-33, added stepwise, a celestite product was floated that, after four cleanings, upgraded to 97.5% $SrSO_4$ (67.6% recovery), 0.31% SiO_2, 0.19% Fe_2O_3.

Igepon T-33 belongs to a class patented by Canadian Patents and Developments Limited from previous work done at the Mines Branch. It is biodegradable.

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INTRODUCTION

Kaiser Celestite Mining Limited, Sydney, Nova Scotia, mine and beneficiate celestite ore at Loch Lomond, Cape Breton Island. The mill product will be processed at Point Edward, thirty-five miles away, by Kaiser Strontium Products Limited. Their process, when in operation, will produce strontium carbonate, strontium nitrate, with sodium sulfate as a by-product.

In the late stages of development of this integrated project, the Mines Branch was asked to try a flotation system, based on a new barite-celestite collector. This collector was found, developed as a system, and patented from work on "Floatability of Non-Metallic Minerals"(1). It came to the attention of Kaiser personnel from an article describing the overall research project published in Mineral Processing, February, 1970.

Though considerable work had been carried out in the U.S.A. beneficiating the celestite ore, difficulties were being experienced in lowering the silica content of the final concentrate.

Because early starting of the strontium complex depended on the successful operation of the beneficiation plant, time did not allow an elaborate investigation program. Preliminary results, however, were encouraging and a simple, one-reagent fine-grind process was developed. This was piloted at Nova Scotia Technical College under the auspices of the Atlantic Industrial Research Institute by Professor Michael A.K. Grice.

The collector reagent, Igepon T-33, is biodegradable. Under certain conditions, it can be removed from coated mineral particles by what appears to be a specific type of bacteria.

DESCRIPTION OF SAMPLE

A 50-lb head sample was received on April 20, 1970. This was part of a 40-ton lot of ore representing mineable materia It was shipped from Hazen Research, Denver, Colorado, and was labelled "PRO 555, HRI 2714, 50# Split". The sample was reduced to minus 28-mesh (Table 1).

TABLE 1

Screen Analysis of Minus 28-Mesh Head Sample

MPD 70/37

Screen Fraction Mesh (Tyler)	Weight %
-28 +35	4.8
-35 +48	21.8
-48 +65	12.4
-65 +100	10.9
-100 +150	8.4
-150 +200	7.7
-200 +325	10.8
-325	23.2
Total	100.0

X-ray analyses of the mineral constituents, identified in the head sample and screen fractions thereof, are given in Table 2, which list the elements in order of abundance. The brown and grey particles from the plus 28-mesh fraction were analyzed separately. The minus 100-mesh fraction represents the head sample.

TABLE 2

Mineralogical Distribution*: Head Sample

MPD 70/37

(X-ray data: A - abundant to E - trace)

Mineral	Screen fractions "as rec'd"			-100 mesh
	+28 mesh		-28 mesh	
	"Grey"	"Brown"		
Celestite	A	D	A	A
Quartz	C	A	B	B
Calcite	D	B	C	C
Muscovite	E	C	E	D
Chlorite	E	C	E	D
Dolomite	?	-	E(?)	E(?)
Pyroxene	-	E(?)	E(?)	E(?)
Plagioclase	-	E(?)	-	-
Hematite	-	E	E	E

* Ore Mineralogy Section - MP-MIN-1374 G-701

ANALYSIS

To find the most accurate method for determining strontium, considerable work was done with chemical, atomic absorption, and X-ray fluorescence analyses. The latter was reliable, fast, and accurate and was used throughout the report unless otherwise indicated*. Results were compared with heavy liquid separations of the concentrates, the heavy portions were checked with X-ray diffraction patterns. Samples were

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* X-ray fluorescence analyses were reported under Mineral Sciences Division Internal Reports MS-AC-70: -482, -502, -653, -655, -660, -683, -690, -789.

given to S. Dean Shopher, Kaiser Minerals, for independent analysis in Oakland, California.

Analyses were performed by Bondar-Clegg and Company Ltd., Ottawa, for SiO_2, Fe_2O_3, Ca, Ba, soluble sulfates, and strontium.

X-ray diffraction analyses were used to determine the distribution and approximate concentration of minerals in the ore and in specific fractions.

Heavy-liquid separations were made with methylene iodide, at specific gravity 3.33, if a concentration of the strontium and barite minerals, or mineral complex, were desired.

For information on the relative distribution of calcite, loss on ignition (LOI) was determined at 1000°C.

EXPERIMENTAL WORK

The ore contained a fraction that could be removed by magnetic means. In a preliminary test, after the minus 28-mesh head sample had been passed once through the Jones wet magnetic mineral separator (2), 13.2% of the material came out with the magnetics. The separator was equipped with high-intensity plates and set at 25 amperes.

The investigation was carried out to obtain meaningful results quickly. The first approach was to remove a low-celestite magnetic fraction from the ground ore and then to float, with the collector Igepon T-33, from a pulp dispersed with sodium silicate and containing a moderator, citric acid. The latter had been used to depress fluorite in a barite-fluorite ore with which a good deal of experience had been gained in the use of T-33. The preliminary concentrate was upgraded by cleaning. Quebracho was then tried,

in place of citric acid, to depress calcite. Additional apllications of reagents were made at different stages of the overall float. Results were encouraging.

It was found that a coarse primary grind, to float the celestite, and a fine secondary grind, to free the minerals and upgrade the celestite concentrate, gave good results. In practice, two-stage grinding would be economical.

After the conditions of grind for flotation and liberation had been established, unnecessary steps and reagents were eliminated. A simple, one-reagent, T-33 system was found that gave good recoveries of a high-celestite/barite concentrate; quartz, calcite, and the iron-bearing minerals were rejected. This system required stage additions of T-33 to alleviate the mechanical problem of handling and transporting a voluminous froth product.

Work was started on a series of locked tests to determine the effect of circulating middling particles. Pilot plant work at Halifax made it redundant, however, and it was discontinued.

Data on the grinds is given in Table 3. Results of significant flotation experiments are shown in Table 4; other results are included in Appendix A.

Conditioning time for each single reagent, or group of reagents, was 2 minutes; in practice this should be much less. Voluminous froth products were partly filtered before returning them to the cell for cleaning. Filtrate was reused in the system as indicated; otherwise Ottawa city water was added (Appendix F). Time of float was fast, e.g., good results were obtained after 5 or 6 minutes in the rougher and 5, 2½, 2, and 2

minutes in each of the four cleaners (Test 17). In plant operation, T-33 is best added to give as fast a float as each individual cell with handle and a further amount is added to the next cell until the celestite is almost all removed.

TABLE 3

Size Distribution Versus Grind

Head Sample (Minus 28-Mesh)

Screen Tests 2, 3, 4 and 5

Test No.	4	3	2	5
Time of Grind min	15	30	45	Primary: 15 Secondary: 15
Screen Fraction Mesh (Tyler)	Weight %			
+48	tr	tr	tr	
-48 +65	0.2	tr	tr	
-65 +100	0.8	0.1	0.1	
-100 +150	3.3	0.8	0.2	tr
-150 +200	5.0	1.4	0.6	0.5
-200 +325	16.7	7.8	3.8	3.0
-325	74.0*	89.9*	95.3*	96.5
Total	100.0	100.0	100.0	100.0

* See Bondar-Clegg Report A - 122-70 (Appendix D) for chemical analysis.

TABLE 4

Flotation Tests 3, 4, 5, 11, 14, 15, 16, 17, 18 and 19, 20 and 21

Test No.	3
Primary grind min	45
% -325 m	95.3
Magnetic separation	Jones
Plates	High-intensity
Amps	25
Runs	2
Cleanings	1
Flotation	
Sodium Silicate (lb/ton)	0.5
Citric acid (lb/ton)	-
Quebracho (lb/ton)	Rougher: 0.5; Cleaner 2: 0.25
Igepon T-33 (lb/ton)	Rougher: 8 x 0.4 = 3.2; Cleaner 1: 3 x 0.4 = 1.2; Cleaner 2: 0.4
Pulp (% solids)	20
pH	6
Secondary grind min	-
% -325 m	-

RESULTS Products	Wt %	$SrSO_4$%*		$CaCO_3$%*		SiO_2%*		$BaSO_4$%*		Fe_2O_3%**	
		Anal	Distn	Anal	Distn	Anal	Distn	Anal	Distn		
Magnetics	5.0	4.75	0.4	7.27	3.5	34.95	7.4	0.26	0.9		
Celestite Conc	41.2	96.10	73.2	3.19	12.6	1.26	2.2	2.32	66.6	0.30	
" Cl 3 Tails	8.6	63.80	10.2	15.60	12.7	9.80	3.6	1.86	11.2		
" Cl 2 Tails	15.7	43.70	12.7	19.50	29.2	21.30	14.2	1.17	12.9		
" Cl 1 Tails	14.1	9.20	2.4	10.91	14.7	52.46	31.4	0.37	3.6		
Rougher Tails	15.4	3.93	1.1	18.66	27.3	63.57	41.2	0.44	4.8		
Feed (calcd)	100.0	53.98	100.0	10.49	100.0	23.56	100.0	1.43	100.0		
Feed (assay)											

* See Appendix B for analysis by Kaiser - Inter-Office Memorandum D.L. Stein to G.A. Tyler, June 29, 1970. These results used above.

** Bondar-Clegg, Report A - 122-70.

TABLE 4 (cont'd)

Test No.	4
Primary grind min	30
% -325 m	89.9
Magnetic separation	Jones
Plates	High-intensity
Amps	25
Runs	2
Cleanings	1
Flotation	
Sodium Silicate (lb/ton)	0.5
Citric acid (lb/ton)	-
Quebracho (lb/ton)	Rougher: 0.5; Cleaner 2 : 0.25
Igepon T-33 (lb/ton)	Rougher: 8 x 0.4 = 3.2; Cleaner 1:3 x 0.4 = 1.2, Cleaner 2: 0.4
Pulp (% solids)	20
pH	6
Secondary grind min	-
% -325 m	-

RESULTS	Wt	$SrSO_4$%		$CaCO_3$%(LOI)*		SiO_2%		Fe_2O_3%		Ca%	
Products	%	Anal	Distn	Anal	Distn	Anal	Distn	Anal	Distn	Anal	Distn
Magnetics	7.4	2.70	0.4	28.30	15.5	37.2	11.9	17.00	35.2	5.99	13.4
** Celestite Conc	43.0	98.70	76.1	2.59	8.2	1.20	2.2	0.29	3.5	0.65	8.9
" Cl 3 Tails	7.9	70.20	10.0	20.65	12.1	9.90	3.3	2.37	5.3	5.85	19.6
" Cl 2 Tails	13.3	45.30	10.9	26.90	26.4	21.40	12.2	3.65	13.6	7.74	31.9
" Cl 1 Tails	9.7	7.80	1.3	23.75	16.9	52.90	21.9	6.26	17.0	4.70	14.4
Rougher Tails	18.7	3.80	1.3	15.20	20.9	61.00	48.5	4.85	25.4	2.83	16.8
Feed (calcd)	100.0	55.77	100.0	13.56	100.0	23.43	100.0	3.57	100.0	3.15	100.0
Feed (assay)		57.20		12.50		24.50		3.65		2.81	

* $CaCO_3$ calculated from LOI determination in this and subsequent trials.
** Ba - 0.9.

TABLE 4 (Cont'd)

Test No.	5
Primary grind min	15
% -325 m	74.0
Magnetic separation	Jones
Plates	High-intensity
Amps	25
Runs	2
Cleanings	1
Flotation	
Sodium Silicate (lb/ton)	0.5
Citric acid (lb/ton)	-
Quebracho (lb/ton)	Rougher: 0.5 Cleaner 2: 0.25
Igepon T-33 (lb/ton)	Rougher 8 x 0.4 = 3.2; Cleaner 1: 3 x 0.4 = 1.2; Cleaner 2: 0.4
Pulp (% solids)	20
pH	6
Secondary grind min	-
% -325 m	-

RESULTS	Wt	$SrSO_4$%		$CaCO_3$%(LOI)		SiO_2%		Fe_2O_3%		Ca%	Ba%
Products	%	Anal	Distn	Anal	Distn	Anal	Distn	Anal	Distn	Anal	Anal
Magnetics	8.0	3.44	0.5	27.60	16.6						
Celestite Conc	52.5	96.00	90.4	4.10	16.2	2.28	-	0.33		1.28	1.0
" Cl 3 Tails	4.1	49.50	3.6	29.40	9.1						
Cl 2 Tails	6.6	26.80	3.1	30.80	15.3						
Cl 1 Tails	8.1	6.95	1.0	23.80	14.5						
Rougher Tails	20.7	4.10	1.4	18.20	28.3						
Feed (calcd)	100.0	55.94	100.0	13.29	100.0						
Feed (assay)		57.20		12.50		24.50		3.65		2.81	

TABLE 4 (Cont'd)

Test No.	11
Primary grind min	15
% -325 m	74.0
Magnetic separation	None
Plates	-
Amps	-
Runs	-
Cleanings	-
Flotation	
Sodium Silicate (lb/ton)	-
Citric acid (lb/ton)	-
Quebracho (lb/ton)	-
*Igepon T-33 (lb/ton)	Rougher: 7 x 0.4 = 2.8; Cleaner 1: 2 x 0.4 = 0.8
Pulp (% solids)	20
pH	6
Secondary grind min	15 (after rougher)
% -325 m	96.5

RESULTS	Wt	$SrSO_4$%		$CaCO_3$%(LOI)		SiO_2%		Fe_2O_3%		Ca%	Ba%
Products	%	Anal	Distn	Anal	Distn	Anal	Distn	Anal	Distn		
Celestite Con.	37.6	97.50	64.0	4.10	12.0	0.71	1.1	0.92	11.0	1.54	0.82
" Cl 4 Tails	6.5	86.40	9.8	12.00	6.0	3.94	1.0	0.64	1.3		
" Cl 3 Tails	10.0	73.50	12.9	18.50	14.4	9.63	3.9	2.19	3.8		
" Cl 2 Tails	5.5	63.50	6.1	18.60	7.9	16.80	3.8	2.98	9.5		
" Cl 1 Tails	7.2	27.50	3.5	21.20	11.8	42.10	12.4	4.78	11.0		
Rougher Tails	33.2	6.31	3.7	18.60	47.9	57.60	77.8	5.98	63.4		
Feed (calcd)	100.0	57.14	100.0	12.86	100.0	24.48	100.0	3.14	100.0		
Feed (assay)		57.20		12.50		24.50		3.65		2.81	

* Filtrate used in secondary grind and all but cleaner 4.

TABLE 4 (Cont'd)

Test No.	14
Primary grind min	15
% -325 m	74.0
Magnetic separation	See footnote
Plates	High intensity
Amps	25
Runs	2
Cleanings	
Flotation	
Sodium Silicate (lb/ton)	-
Citric acid (lb/ton)	-
Quebracho (lb/ton)	-
*Igepon T-33 (lb/ton)	Rougher: 3 x 0.6 + 1 x 0.8 - 2.6; Cleaner 1: 2 x 0.4 = 0.8
Pulp (% solids)	20
pH	6
Secondary grind min	15 (after rougher)
% -325 m	96.5

RESULTS Products	Wt %	$SrSO_4$%		$CaCO_3$%(LOI)		SiO_2%		Fe_2O_3%		Ca%	Ba%
		Anal	Distn	Anal	Distn	Anal	Distn	Anal	Distn	Anal	Anal
**Celestite Conc : Mags	0.5	-		-		-		3.21	0.5	-	-
**Celestite Conc : Non-mags	37.2	97.40		5.14		1.01		0.32	3.2	1.83	1.06
" Cl 4 Tails	5.9	80.30		15.30		11.67		1.90	3.1	3.75	0.65
" Cl 3 Tails	4.8	65.20		17.75		18.11		3.17	4.1	3.60	0.47
" Cl 2 Tails	9.1	66.50		16.90		18.78		3.41	8.4	3.23	0.47
" Cl 1 Tails	7.0	31.50		19.40		39.11		5.86	11.1	2.05	0.03
Rougher Tails	35.5	6.44		19.15		53.98		7.25	69.6	2.95	NIL
Feed (calcd)	100.0	-		-		-		3.69	100.0	-	-
Feed (assay)		57.20		12.50		24.50		3.65		2.81	

*Filtrate used in secondary grind and all but Cleaner 4.

**Concentrate passed through Jones. Very little material removed - not enough to clean up.

TABLE 4 (Cont'd)

Test No.	15
Primary grind min	15
% -325 m	74.0
Magnetic separation	None
Plates	-
Amps	-
Runs	-
Cleanings	-
Flotation	
Sodium Silicate (lb/ton)	
Citric acid (lb/ton)	
Quebracho (lb/ton)	Cleaner 4: 0.25
*Igepon T-33 (lb/ton)	Rougher: 3 x 0.6 + 1 x 0.8 = 2.6; Cleaner 1: 2 x 0.4 = 0.8
Pulp (% solids)	20
pH	6
Secondary grind min	15 (after rougher)
% -325 m	96.5

RESULTS	Wt	$SrSO_4$%		$CaCO_3$%(LOI)		SiO_2%		Fe_2O_3%		Ca%	
Products	%	Anal	Distn	Anal	Distn	Anal	Distn	Anal	Distn	Anal	Distn
** Celestite Conc	24.0	98.60	41.8	4.25	7.5	0.77	0.8	0.44	2.9	1.38	13.3
*** " Cl 4 Tails	20.5	91.50	33.2	8.83	13.4	2.10	1.7	0.79	4.5	2.93	24.2
" Cl 3 Tails	5.2	74.50	6.9	17.80	6.9	15.93	3.3	2.59	3.7	4.23	8.9
" Cl 2 Tails	8.5	66.80	10.0	17.80	11.2	17.66	6.0	3.49	8.2	3.24	11.1
" Cl 1 Tails	7.7	29.80	4.1	24.85	14.1	40.43	12.5	6.22	13.3	2.47	7.7
Rougher Tails	34.1	6.60	4.0	18.65	46.9	55.51	75.7	7.17	67.4	2.53	34.8
Feed (calcd)	100.0	56.64	100.0	13.53	100.0	24.96	100.0	3.62	100.0	2.48	100.0
Feed (assay)		57.20		12.50		24.50		3.65		2.81	

* Filtrate used in secondary grind and all but Cleaner 4.
** Ba - 1.06
*** Ba - 0.82

TABLE 4 (Cont'd)

Test No.	16
Primary grind min	15
% -325 m	74.0
Magnetic separation	None
Plates	-
Amps	-
Runs	-
Cleanings	-
Flotation	-
Sodium Silicate (lb/ton)	-
Citric acid (lb/ton)	-
Quebracho (lb/ton)	Cleaner 3: 0.08
*Igepon T-33 (lb/ton)	Rougher: 3 x 0.6 + 1 x 0.8 = 2.6; Cleaner 1: 2 x 0.4 = 0.8
Pulp (% solids)	20
pH	6
Secondary grind min	15 (after rougher)
% -325 m	96.5

RESULTS	Wt	$SrSO_4$%		$CaCO_3$%(LOI)		SiO_2%		Fe_2O_3%		Ca%	
Products	%	Anal	Distn	Anal	Distn	Anal	Distn	Anal	Distn	Anal	Distn
** Celestite Conc	41.6	95.10	71.2	5.55	17.9	0.84	1.5	0.40	4.6	1.65	27.9
" Cl 4 Tails	5.2	79.00	7.4	17.00	6.9	0.73	0.2	1.70	2.5	4.50	9.5
" Cl 3 Tails	5.7	67.80	6.9	20.60	9.1	7.22	1.7	2.69	4.3	5.87	13.6
" Cl 2 Tails	7.2	60.00	7.8	19.20	10.7	15.92	4.9	3.96	7.9	3.38	9.9
" Cl 1 Tails	6.8	23.92	2.9	19.10	10.0	41.27	11.8	6.69	12.6	2.19	6.1
*** Rougher Tails	33.5	6.22	3.8	17.42	45.4	56.37	79.9	7.33	68.1	2.42	33.0
Feed (calcd)	100.0	55.58	100.0	12.90	100.0	23.61	100.0		100.0	2.46	100.0
Feed (assay)		57.20		12.50		24.50		3.65		2.81	

* Filtrate used in secondary grind and all but cleaner 4.
** Ba - 1.00
***Ba - NIL

TABLE 4 (Cont'd)

TEST No.	17
Primary grind min	15
% -325 m	74.0
Magnetic separation	None
Plates	-
Amps	-
Runs	-
Cleanings	-
Flotation	-
Sodium Silicate (lb/ton)	-
Citric acid (lb/ton)	-
Quebracho (lb/ton)	-
Igepon T-33 (lb/ton)	Rougher: 3 x 0.6 + 1 x 0.8 = 2.6; Cleaner 1: 3 x 0.4 = 1.2
Pulp (% solids)	20
pH	6
Secondary grind min	15 (after rougher)
% -325 m	96.5

RESULTS	Wt	$SrSO_4$%		$CaCO_3$%(LOI)		SiO_2%		Fe_2O_3%		Ca%	Ba%
Products	%	Anal	Distn	Anal	Distn	Anal	Distn	Anal	Distn	Anal	Anal
Celestite Conc	38.9	97.50	67.6	4.16	12.2	0.31	0.5	0.19	2.5	1.48	0.74
" Cl 4 Tails	4.0	84.50	6.0	12.08	3.6	2.65	0.4	0.92	1.2	4.98	
" Cl 3 Tails	5.6	80.50	8.0	15.58	6.5	7.30	1.7	1.68	3.2		
" Cl 2 Tails	9.9	64.80	11.5	19.10	14.2	17.14	6.9	2.07	6.9		
" Cl 1 Tails	8.0	22.50	3.2	24.40	14.6	43.16	14.1	5.84	15.7		
Rougher Tails	33.6	6.05	3.7	19.30	48.9	55.87	76.4	6.25	70.5		
Feed (calcd)	100.0	55.93	100.0	13.31	100.0	24.50	100.0	2.98	100.0		
Feed (assay)		57.20		12.50		24.50		3.65		2.81	

TABLE 4 (Cont'd)

Test No.	18 & 19 Combined Locked Test
CONDITIONS	Cl 2, Cl 3, Cl 4 Tails Test 18 filtered, combined & added after regrind Test 19
Primary grind min	15
% -325 m	74.0
Magnetic separation	None
Plates	-
Amps	-
Runs	-
Cleanings	-
Flotation	-
Sodium Silicate (lb/ton)	-
Citric acid (lb/ton)	-
Quebracho (lb/ton)	-
Igepon T-33 (lb/ton)	Rougher: 3 x 0.6 + 1 x 0.8 = 2.6; Cleaner 1: 3 x 0.4 = 1.2
Pulp (% solids)	20
pH	6
Secondary grind min	15 (after rougher)
% -325 m	96.5

RESULTS	Wt	$SrSO_4$%		$CaCO_3$% (LOI)	SiO_2%		Fe_2O_3%		Ca%		Ba%
Products	%	Anal	Distn	Anal	Anal	Distn	Anal	Distn	Anal	Distn	Anal
Celestite Conc Test 18	17.7	99.60	30.8	3.48	0.59	0.4	0.03	0.2	1.05	7.5	0.66
" Test 19	17.3	99.90	30.2	3.96	1.22	0.8	0.18	1.0	1.15	8.0	0.95
Celestite Conc Combined	35.0	99.75	61.0	3.68	0.90	1.2	0.10	1.2	1.1	15.5	0.80
Celestite Cl 4 Tails Test 19	2.4	86.10	3.6	12.41	6.46	0.6	1.11	0.9	3.35	3.3	1.04
" Cl 3 Tails " "	4.3	81.50	6.1	n.d.	24.99	4.1	1.63	2.3	4.36	7.6	0.79
" Cl 2 Tails " "	8.3	66.40	9.6	"	26.30	8.3	4.03	10.8	4.05	13.6	0.57
" Cl 1 Tails Test 18	6.0	32.70	3.4	18.15	39.44	9.1	6.14	11.9	2.86	6.9	n.d.
" Cl 1 Tails " 19	8.7	44.30	6.7	19.70	35.01	11.6	3.85	10.8	2.94	10.3	0.19
Rougher Tails Test 18	17.5	15.90	4.9	18.50	48.80	32.6	5.73	32.3	2.82	19.8	n.d.
" " " 19	17.8	15.10	4.7	19.10	47.85	32.5	5.19	29.8	3.20	23.0	NIL
Rougher Tails Combined	35.3	15.50	9.6	18.80	48.40	65.1	5.42	62.1	3.00	42.8	-
Feed (calcd)	100.0	57.29	100.0	-	26.21	100.0	3.10	100.0	2.48	100.0	-
Feed (assay)		57.20		12.50	24.50		3.65		2.81		

TABLE 4 (Cont'd)

Test No.	20 & 21 Combined Locked Test
CONDITIONS	C12, C13, C14, Tails Test 20 filtered, combined and added after regrind Test 21
Primary grind min	15
% -325 m	74.0
Magnetic separation	None
Plates	-
Amps	-
Runs	-
Cleanings	-
Flotation	-
Sodium Silicate (lb/ton)	-
Citric acid (lb/ton)	-
Quebracho (lb/ton)	-
Igepon T-33 (lb/ton)	~~Rougher (20): 5 x 0.3 = 1.5 Cleaner 1(20): 4 x 0.2 = 0.8~~ ~~Rougher (21): 4 x 0.3 = 1.2 Cleaner 1 (21):3 x 0.2 = 0.6~~
Pulp (% solids)	20
pH	6
Secondary grind min	15 (after rougher)
% -325 m	96.5

RESULTS Products	Wt %	$SrSO_4$%		$CaCO_3$%(LOI)		SiO_2%		Fe_2O_3%		Ca%	
		Anal	Distn	Anal	Distn	Anal	Distn	Anal	Distn	Anal	Distn
Celestite Conc Test 20	18.9	93.70	32.2	n.d.		n.d.		0.03	0.2	n.d.	
" Conc Test 21	23.8	94.00	40.8	"		"		0.06	0.5	"	
Celestite Conc Combined	42.7	93.90	73.0					0.05	0.7		
Celestite Cl 4 Tails Test 21	2.8	84.60	4.3	"		"		0.88	0.8	"	
" Cl 3 Tails "	3.8	75.70	5.2	"		"		1.83	2.2	"	
" Cl 2 Tails "	6.3	64.20	7.4	"		"		2.39	4.9	"	
" Cl 1 Tails Test 20	3.7	20.90	1.4	"		"		6.38	7.6	"	
" Cl 1 Tails Test 21	4.4	23.80	1.9	"		"		5.79	8.2	"	
Rougher Tails Test 20	17.2	8.35	2.6	"		"		6.79	37.6	"	
" Test 21	19.1	12.15	4.2	"		"		6.20	38.0	"	
Rougher Tails Combined	36.3	10.35	6.8	"		"		6.42	75.6	"	
Feed (calcd)	100.0	54.97	100.0	-		-		3.11	100.0	-	
Feed (assay)		57.20		12.50		24.50		3.65		2.81	

DISCUSSION

From the start of the investigation, it was recognized that an assay method for determining the amount of celestite in the ore and beneficiated products would present difficulties. Chemical analysis for strontium would be time consuming because of the presence of calcium and barium. Time did not allow for a thorough mineralogical examination. Checks and counter-checks were therefore done, viz. heavy-liquid separation of the concentrates and other products (Appendix E) and comparison of the $SrSO_4$ content by gravimetric, atomic adsorption, total soluble sulfates (Appendix D) and X-ray fluorescence. Careful determinations for total Sr, S, and Ca were made on concentrates from Tests 2, 3, and 4 (Appendix C); these were completed after the investigation was well under way.

With regard to the X-ray fluorescence analyses for Sr, overall accuracy was consistent and results were considered to be very good. Some Sr values converted to $SrSO_4$ and shown as "0" in the second decimal place are accurate only to the first decimal figure but have been rounded out. Some inaccuracy may be present in certain of the low Sr values reported because samples would have required standard additions and insufficient material was prepared. High $SrSO_4$ results may possibly be accounted for by Sr being present in other than the sulfate form. New standards were prepared and used after Test 12.

Because the presence of SiO_2 in the celestite concentrate will be detrimental to the further treatment in the Kaiser process, test work was based on keeping it minimal.

Table 4 includes Tests 3, 4, 5, 11, 14, 15, 16, 17, 18 and 19, 20 and 21; remaining tests are in Appendix A.

The ground ore contained a fraction that could be removed under strong magnetic conditions. A single-pass magnetic product, 10.3% by weight (Test 1), contained 2.7% of the $SrSO_4$; a double-pass product (Test 2), 14.2% by weight, contained 4.3% of the $SrSO_4$. A single-pass cleaning of the two-pass magnetic fractions (Tests 3 to 8) gave a product that contained 0.3 to 0.57% of the $SrSO_4$; the coarse primary grind (Tests 5 and 8) produced more material but of a low $SrSO_4$ content. The magnetic minerals apparently are not intimately associated with the celestite because a celestite concentrate, after four cleanings and being passed through the Jones separator (Test 14) contained only 0.5% of the Fe_2O_3 content. Igepon T-33, without modifiers, apparently does not float the iron-bearing minerals.

In flotation, sodium silicate was added (Tests 1 to 9) as a dispersant and to depress quartz. Except for the first test, 0.5 lb/ton was used in the rougher floats. Extra additions were made to various cleaners (Tests 6 to 9). Silica contents of the concentrates were under 1% in Tests 6, 7, and 9; Test 8 gave an unusually high SiO_2 of 1.87%. Sodium silicate was eliminated, after Test 9, with no apparent detrimental effects.

Quebracho, a calcite depressant, was added. Excess quebracho will depress more than calcite and the amount of material left behind in cleaner 4 (Test 15) suggests this effect. The effect of quebracho is pin-pointed in the Tables. It can be assumed, subject to further bench-scale testing, that the calcite content of the final concentrate may be lowered by careful application of this reagent.

The importance of fine grinding to liberating silica-bearing minerals was established early in the investigation. Three runs (Tests 3 to 5) were made under similar conditions except for time of grind (Table 3).

There was a significant increase in the recovery of $SrSO_4$ as the grind became coarser (Tests 3, 4, and 5). This suggested a 15-minute primary grind for the recovery of most of the celestite and a secondary 15-minute grind to liberate the celestite. Two-stage grinding was used after Test 7. Secondary grinding of the cleaner 1 concentrates was done twice (Tests 8 and 9); this was changed to the rougher concentrates with consistently good results. Material upgraded by flotation was 96.5% minus 325 mesh (Table 3) after regrinding.

The investigation was based on establishing the best and simplest conditions for beneficating celestite by flotation with Igepon T-33, a remarkably selective collector for certain minerals even in the fine size range. Results of Test 1 showed that a high-grade concentrate, low in SiO_2 and calcite, could be produced from a finely milled ore from which most of the iron-bearing minerals had been removed magnetically. Remaining tests were done to find optimum conditions for adding T-33 and to eliminate unnecessary treatment. Test 17 gave good results with a simple, one-reagent, stage float (Table 4). The celestite concentrate, after four cleanings, assayed 97.5% $SrSO_4$ with a recovery of 67.6%; SiO_2 was 0.31% (0.5% distn) and Fe_2O_3 = 0.19% (2.5 distn). Losses in the rougher tails were 3.7% of the $SrSO_4$; SiO_2 content was 55.87% (76.4% distn), Fe_2O_3 = 6.25% (70.5% distn).

Tests 11 to 16 were run using filtrate from the rougher float for secondary grinding and from cleaners 1 and 2 for flotation in all but cleaner 4. Two objectives were to reduce the overall amount of T-33 and to check if difficulties would develop from re-using plant water. No problems were apparent.

Tests 18-19 and Tests 20-21 were run with tap water only; two tests were combined in a locked run with middling particles from the first test being filtered and added to the second test to simulate a circulating load. Normally such a locked run would be made with 4 to 6 tests in series but pilot-plant work in Halifax provided better information at that time.

In locked Test 18-19, a 5% solution of T-33 made up and on hand for some months was used. In locked Test 20-21, a fresh 5% solution was made up and added. Long storage of the diluted reagent did not seem to be detrimental.

No attempt is made to account for discrepancies between the calcite content calculated from LOI analysis and the per cent Ca shown for some of the products. Results were judged mainly on per cent strontium and on recovery of the cleaned concentrate with particular attention to low-SiO_2 products. Critical losses were those in the rougher tails. It was thought that the handling of middlings would be solved in plant operation - nothing developed during the work in Ottawa to suggest any but mechanical difficulties would be encountered.

Copies of the analyses performed by Bondar-Clegg are included in Appendix D. Though these were carefully checked against strontium determinations by X-ray fluorescence, no clear-cut correlation was established.

CONCLUSIONS

1. A celestite concentrate, (97.5% $SrSO_4$, 0.31% SiO_2, 0.19% Fe_2O_3), can be made by fine grinding followed by flotation with the reagent, Igepon T-33 (3.8 lb/ton), for a recovery of 67.5%.

2. Modifiers such as sodium silicate and quebracho are compatible with the system but do not appear to be necessary. Quebracho can be used to depress calcite.

3. Fine grinding is necessary to completely liberate the strontium bearing minerals.

4. Losses of $SrSO_4$ in the rougher tails can be kept below 5%. Values tied-up in cleaner tails, when circulated as middlings in plant operation, will increase overall recovery.

5. The treated ore contained a magnetic fraction removable in the Jones wet magnetic mineral separator before or after flotation.

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APPENDIX A

Flotation Tests 1, 2, 6, 7, 8, 9, 10, 12, 13

Primary grind min	45
% -325 m	95.3
Magnetic separation	Jones
Plates	High-intensity
Amps	25
Runs	1
Cleanings	-
Flotation	
Sodium Silicate (lb/ton)	0.25
Citric acid (lb/ton)	0.25
Quebracho (lb/ton)	-
Igepon T-33 (lb/ton)	Conc 1: 6 x 0.4 = 2.4; Conc 2: 1 x 0.4 = 0.4
Pulp (% solids)	20
pH	6
Secondary grind min	-
% -325 m	

RESULTS	Wt	$SrSO_4$% *		$CaCO_3$%(LOI)		SiO_2%		Fe_2O_3%		Ca%	
Products	%	Anal	Distn	Anal	Distn	Anal	Distn	Anal	Distn	Anal	Distn
Magnetics	10.3	15.85 **	2.7	24.20	16.4	n.d.		n.d.		n.d.	
Celestite Conc 1 (cleaned)	15.9	101.00	26.7	2.96	3.1	1.70		0.41		0.62	
" Cl 2 Tails	9.5	79.50	12.5	11.72	7.3	n.d.		n.d.		n.d.	
" Cl 1 Tails	32.0	63.50	33.6	16.10	33.8	n.d.		n.d.		n.d.	
Celestite Conc 2 (not cleaned)	7.6	70.80	8.9	14.30	7.0	18.4		2.46		2.64	
Rougher Tails	24.7	38.20	15.6	19.90	32.4	n.d.		n.d.		n.d.	
Feed (calcd)	100.0	60.46	100.0	15.25	100.0						
Feed (assay)		57.20		12.50		24.50		3.65		2.81	

* X-ray fluorescence Sr.

** Early work Sr determinations: Probably high as standards not checked for sometime.

Test No.	2
Primary grind min	45
% -325 m	95.3
Magnetic separation	Jones
Plates	High-intensity
Amps	25
Runs	2
Cleanings	-
Flotation	
Sodium Silicate (lb/ton)	0.5
Citric acid (lb/ton)	-
Quebracho (lb/ton)	0.5
Igepon T-33 (lb/ton)	Rougher: 8 x 0.4 = 3.2; Cleaner 1: 2 x 0.4 = 0.8
Pulp (% solids)	20
pH	6
Secondary grind min	-
% -325 m	-

RESULTS	Wt	$SrSO_4$%		$CaCO_3$%(LOI)		SiO_2%		Fe_2O_3%		Ca%	
Products	%	Anal	Distn	Anal	Distn	Anal	Distn	Anal	Distn	Anal	Distn
Magnetics	14.2	17.45	4.3	25.40	25.2						
Celestite Conc	45.4	97.50	76.6	4.45	14.1	1.44		0.33		1.08	
" Cl 2 Tails	12.1	57.00	12.0	21.40	18.0						
" Cl 1 Tails	14.5	19.20	5.0	25.80	26.0						
Rougher Tails	13.8	8.76	2.1	17.40	16.7						
Feed (calcd)	100.0	57.62	100.0	14.36	100.0						
Feed (assay)		57.20		12.50		24.50		3.65		2.81	

Test No.	6
CONDITIONS	
Primary grind min	30
% -325 m	89.9
Magnetic separation	Jones
Plates	High-intensity
Amps	2.5
Runs	2
Cleanings	1
Flotation	
Sodium Silicate (lb/ton)	Rougher: 0.5; Cleaner 1: 0.25
Citric acid (lb/ton)	-
Quebracho (lb/ton)	Rougher: 0.5; Cleaner 2: 0.25
Igepon T-33 (lb/ton)	Rougher: 8 x 0.4 = 3.2; Cleaner 1: 3 x 0.4 = 1.2; Cleaner 2: 0.4
Pulp (% solids)	20
pH	6
Secondary grind min	-
% -325 m	-

RESULTS	Wt	$SrSO_4$%		$CaCO_3$%(LOI)		SiO_2%		Fe_2O_3%		Ca%	Ba%
Products	%	Anal	Distn	Anal	Distn	Anal	Distn	Anal	Distn	Anal	Anal
Magnetics	4.9	3.27	0.3								
Celestite Conc	38.2	98.00	67.0	n.d.	-	0.74	-	0.23	-	0.98	0.9
" Cl 4 Tails	4.5	85.10	6.9								
" Cl 3 Tails	8.7	69.80	10.9								
" Cl 2 Tails	13.8	49.50	12.3								
" Cl 1 Tails	8.7	7.35	1.2								
Rougher Tails	21.2	3.50	1.4								
Feed (calcd)	100.0	55.66	100.0								
Feed (assay)		57.20		12.50		24.50		3.65		2.81	

Test No.	7
CONDITIONS	
Primary grind min	30
% -325 m	89.9
Magnetic separation	Jones
Plates	High-intensity
Amps	25
Runs	2
Cleanings	1
Flotation	
Sodium Silicate (lb/ton)	Rougher: 0.5; Cleaner 1: 0.25; Cleaner 3: 0.25
Citric acid (lb/ton)	-
Quebracho (lb/ton)	Rougher: 0.5; Cleaner 2: 0.25
Igepon T-33 (lb/ton)	Rougher 8 x 0.4 = 3.2; Cleaner 1: 3 x 0.4 = 1.2; Cleaner 2: 0.4
Pulp (% solids)	20
pH	6
Secondary grind min	-
% -325 m	

RESULTS	Wt	$SrSO_4$%		$CaCO_3$%(LOI)		SiO_2%		Fe_2O_3%		Ca%	Ba%
Products	%	Anal	Distn	Anal	Distn	Anal	Distn	Anal	Distn	Anal	Anal
Magnetics	6.4	2.98	0.3								
Celestite Conc	34.8	98.00	61.5	n.d.		0.87		0.19		1.19	0.5
" Cl 4 Tails	5.9	87.50	9.3								
" Cl 3 Tails	9.7	73.50	12.9								
" Cl 2 Tails	13.9	49.70	12.5								
" Cl 1 Tails	9.1	9.15	1.5								
Rougher Tails	20.2	5.45	2.0								
Feed (calcd)	100.0	55.43	100.00								
Feed (assay)		57.20		12.50		24.50		3.65		2.81	

Test No.	8
CONDITIONS	
Primary grind min	15
% -325 m	74.0
Magnetic separation	Jones
Plates	High-intensity
Amps	25
Runs	2
Cleanings	1
Flotation	
Sodium Silicate (lb/ton)	Rougher: 0.5; Cleaner 2: 0.25
Citric acid (lb/ton)	
Quebracho (lb/ton)	Rougher: 0.5; Cleaner 2: 0.25
Igepon T-33 (lb/ton)	Rougher: 8 x 0.4 = 3.2; Cleaner 1: 3 x 0.4 = 1.2; Cleaner 2: 2 x 0.4 = 0.8
Pulp (% solids)	20
pH	6
Secondary grind min	15 (after Cleaner 1)
% -325 m	96.5 (approx.)

RESULTS	Wt	$SrSO_4$%		$CaCO_3$%(LOI)		SiO_2%		Fe_2O_3%		Ca%	Ba%
Products	%	Anal	Distn	Anal	Distn	Anal	Distn	Anal	Distn	Anal	Anal
Magnetics	8.2	3.56	0.5	27.90	16.3						
Celestite Conc	41.3	96.00	70.5	5.30	15.6	1.87		0.44		2.59	0.6
" Cl 3 Tails	10.0	66.50	11.9	22.20	15.8						
" Cl 2 Tails	13.6	57.60	14.0	18.40	17.9						
" Cl 1 Tails	8.1	7.30	1.1	21.05	12.1						
Rougher Tails	18.8	5.93	2.0	16.60	22.3						
Feed (calcd)	100.0	56.10	100.0	14.02	100.0						
Feed (assay)		57.20		12.50		24.50		3.65		2.81	

Test No.	9
CONDITIONS	
Primary grind min	15
% -325 m	74.0
Magnetic separation	None
Plates	-
Amps	-
Runs	-
Cleanings	-
Flotation	-
Sodium Silicate (lb/ton)	Rougher: 0.5; Cleaner 2: 0.25
Citric acid (lb/ton)	-
Quebracho (lb/ton)	Rougher: 0.5; Cleaner 2: 0.5
Igepon T-33 (lb/ton)	Rougher: 8 x 0.4 = 3.2; Cleaner 1: 3 x 10 = 1.2 Cleaner 2: 2 x 0.4 = 0.8
Pulp (% solids)	20
pH	6
Secondary grind min	15 (after Cleaner 1)
% -325 m	96.5 (approx.)

RESULTS	Wt	$SrSO_4$%		$CaCO_3$% (LOI)		SiO_2%		Fe_2O_3%		Ca%	
Products	%	Anal	Distn	Anal	Distn	Anal	Distn	Anal	Distn	Anal	
Celestite Conc	24.6	99.90	43.6	1.59	2.8	0.33		0.31		0.46	
" Cl 4 Tails	4.4	96.00	7.5	8.10	2.6	-		-			
" Cl 3 Tails	10.9	82.70	16.1	14.10	11.1	-		-			
" Cl 2 Tails	23.2	68.50	28.2	16.65	27.6	-		-			
" Cl 1 Tails	11.5	9.15	1.8	26.50	21.8	-		-			
Rougher Tails	25.4	6.30	2.8	18.65	34.1	57.90		7.51			
Feed (calcd)	100.0	56.42	100.0	13.94	100.0						
Feed (assay)		57.20		12.50		24.50		3.65		2.81	

Test No.	10
CONDITIONS	
Primary grind min	
% -325 m	15
Magnetic separation	74.0
Plates	None
Amps	-
Runs	-
Cleanings	-
Flotation	-
Sodium Silicate (lb/ton)	-
Citric acid (lb/ton)	-
Quebracho (lb/ton)	-
Igepon T-33 (lb/ton)	Rougher: 6 x 0.4 = 2.4; Cleaner 1: 4 x 0.4 = 1.6
Pulp (% solids)	20
pH	6
Secondary grind min	15 (after rougher)
% -325 m	96.5

RESULTS	Wt	$SrSO_4$%		$CaCO_3$%(LOI)		SiO_2%		Fe_2O_3%		Ca%
Products	%	Anal	Distn	Anal	Distn	Anal	Distn	Anal	Distn	Analysis
Celestite Conc	30.0	100.0	52.6	0.34	0.8	0.30		0.24		0.80
" Cl 4 Tails	4.4	90.80	7.0	9.30	3.4	-				
" Cl 3 Tails	5.2	74.80	6.8	15.00	6.5	-				
" Cl 2 Tails	9.1	59.90	9.6	18.60	14.1	-				
" Cl 1 Tails	8.2	25.00	3.6	20.60	14.1	-				
Rougher Tails	43.1	26.90	20.4	17.10	61.1	43.1		5.89		
Feed (calcd)	100.0	56.92	100.0	12.02	100.0					
Feed (assay)		57.20		12.50		24.50		3.65		2.81

Test No.	12
CONDITIONS	
Primary grind min	15
% -325 m	74.0
Magnetic separation	None
Plates	-
Amps	-
Runs	-
Cleanings	-
Flotation	
Sodium Silicate (lb/ton)	-
Citric acid (lb/ton)	-
Quebracho (lb/ton)	-
*Igepon T-33 (lb/ton)	Rougher: 4 x 0.6 = 2.4
Pulp (% solids)	20
pH	6
Secondary grind min	15 (after rougher)
% -325 m	96.5

RESULTS	Wt	$SrSO_4$%		$CaCO_3$%(LOI)		SiO_2%		Fe_2O_3%		Ca%	
Products	%	Anal	Distn	Anal	Distn	Anal	Distn	Anal	Distn	Anal	Distn
** Celestite Conc	25.0	98.20	43.0	5.52	10.7	0.30	0.3	0.08	0.6	2.30	17.6
" Cl 4 Tails	4.2	82.90	6.1	12.90	4.2	1.40	0.2	0.96	1.3	4.00	5.2
" Cl 3 Tails	4.0	78.10	5.5	15.40	4.7	3.37	0.6	2.01	2.5	4.70	5.8
" Cl 2 Tails	7.9	71.50	9.9	12.90	8.1	12.60	4.3	2.23	5.6	3.53	8.7
" Cl 1 Tails	23.5	73.80	30.4	10.90	19.8	14.50	14.8	2.24	16.8	2.54	18.4
Rougher Tails	35.4	8.13	5.1	19.10	52.5	51.80	79.8	6.48	73.2	4.05	44.3
Feed (calcd)	100.0	57.00	100.0	12.90	100.0	23.05	100.0	3.14	100.0	3.24	100.0
Feed (assay)		57.20		12.50		24.50		3.65		2.81	

* Filtrate used in secondary grind and all but cleaner 4

** Ba - 0.66.

Test No.	13
CONDITIONS	
Primary grind min	15
% -325 m	74.0
Magnetic separation	None
Plates	-
Amps	-
Runs	-
Cleanings	-
Flotation	
Sodium Silicate (lb/ton)	-
Citric acid (lb/ton)	-
Quebracho (lb/ton)	-
*Igepon T-33 (lb/ton)	Rougher: 4 x 0.6 = 2.4; Cleaner 1: 0.4
Pulp (% solids)	20
pH	6
Secondary grind min	15 (after rougher)
% -325 m	96.5

RESULTS	Wt	$SrSO_4$%		$CaCO_3$% (LOI)		SiO_2%		Fe_2O_3%		Ca%	
Products	%	Anal	Distn	Anal	Distn	Anal	Distn	Anal	Distn	Anal	Distn
** Celestite Conc	30.2	97.60	52.3	5.16	-	0.23	0.3	0.43	3.5	2.00	19.2
" Cl 4 Tails	7.0	84.50	10.6	10.90	-	3.99	1.1	1.43	2.7	3.12	7.0
" Cl 3 Tails	4.5	76.00	6.1	n.d.	-	21.50	3.9	2.69	3.3	4.07	5.9
" Cl 2 Tails	9.4	69.70	11.7	14.0	-	26.60	10.0	2.93	7.4	3.37	10.0
" Cl 1 Tails	13.4	57.40	13.7	15.4	-	31.30	16.9	4.12	14.8	3.30	14.0
Rougher Tails	35.5	8.84	5.6	19.0	-	47.40	67.8	7.15	68.3	3.90	43.9
Feed (calcd)	100.0	56.21	100.0	-	-	24.85	100.0	3.72	100.0	3.14	100.0
Feed (assay)		57.20		12.50		24.50		3.65		2.81	

* Filtrate used in secondary grind and all but cleaner 4.
** Ba - 0.62

DN

Analyses - Test 3
Kaiser Minerals, California

TO G. A. Tyler - KC 1085
AT

DATE June 29, 1970

FROM D. L. Stein
AT CFT B-354

COPIES TO

SUBJECT Ottawa Celestite Flotation Sample Analyses

S. D. Shopher - KC 1041
M. L. Spealman - El Dorado, 4th Fl.
J. A. Thompson - El Dorado, 4th Fl.
L. J. Trew - El Dorado, 4th Fl.

R. L. Coatney - CFT B-134
L. M. Housh - CFT B-114
M. L. Van Dreser - CFT A-414

The analyses of Ottawa celestite flotation samples of June 4, 1970, (MP-IM-7002-flotation test 3) as obtained at CFT are reported herein.

Sample Description	%SrO	%BaO	%CaO	%SiO_2
Mags	2.68	0.17	3.78	34.95
Rougher Tails	2.22	0.29	9.70	63.57
Cleaner 1 Tails	5.18	0.24	5.68	52.46
Cleaner 2 Tails	24.68	0.77	10.14	21.30
Cleaner 3 Tails	36.00	1.22	8.12	9.80
Celestite Concentrate	54.20	1.52	1.66	1.26

DLS:meb

S. D. SHOPHER
JUL 1 1970

Analyses - Concentrates, Tests 2, 3 & 4

Mineral Sciences Division, Mines Branch

Test Report AC- Internal Report MS-AC- 71-105

Sample Description: Celestite as received Date: Mar. 8, 1971

From: Mr. R.A. Wyman, M.P.D.

Our Lab. No.	Product	%	%	% Tot. S	% Ca	% Sr	%	Oz/ton	Oz/ton
1157	Flot. test #2, Celestite conc.			16.61	1.00	44.90			
1158	Flot. test #3, "	"		16.55	0.76	45.52			
1159	Flot. test #4, "	"		16.18	1.46	45.08			

The sulphur determinations were made by leaching a sodium carbonate fusion in water; precipitating the sulphate from the filtrate with barium chloride and weighing the barium sulphate to calculate the sulphur.

The strontium and calcium were converted to the insoluble carbonates and weighed together. The carbonates were leached and the calcium value determined by A/A and subtracted from the total. Aluminum, magnesium, iron, silica and barium interferences were eliminated by various means during the procedure.

Approved: L.O. Kane Analyst: R. Craig

Section Head

Chief Chemist

Copies to: 1. Mr. R.A. Wyman 4. Divisional Files

2. 5. Section Files

3. 6. Divisional Reports Secretary

APPENDIX D

Certificates of Analysis

Bondar-Clegg & Company Ltd.

pages 1 - 15

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768A BELFAST ROAD (M.R. 1), OTTAWA 8, ONTARIO
PHONE: 237-3110 TELEX: 013-3548

CERTIFICATE OF ANALYSIS

TO ... Mr. R.A. Wyman
... Head, Industrial Minerals
... Milling Section, 40 Lydia St., Ottawa 1, Ontario

REPORT NO. ... A-122-70
DATE ... May. 25, 1970

I hereby certify that the following are the results of analyses made by us upon the herein described ... Ore dressing ... samples MP-IM-7002

MARKED		% Ba	% SO_4/S	% SiO_2	% Fe_2O_3	% Ca	% T/Sr *	% T/Sr **		
Head Sample (MPD 70/37)		~ 0.6	28.7	24.5	3.65	2.81	21.6	22.0		1895 Flotation Test 1
Mags			7.9				5.4	5.3		
Celestite Conc 1			49.1	1.70	0.41	0.62	42.6	40.1		
Celestite Conc 2			34.6	18.4	2.46	2.64	30.3	30.0		
#2 Cleaner Tails			37.8				32.4	33.4		1897 Flotation Test 2
#1 Cleaner Tails			31.1				25.5	26.3		
Rougher Tails			13.4					6.1		
Mags 25 amps			8.5					7.4		
Celestite Conc		~1.2	48.7	1.44	0.33	1.08	42.6	40.0	1)	
#2 Cleaner Tails			25.8				22.2	23.1		1898 Flotation Test 3
#1 Cleaner Tails			8.5					4.2		

NOTE: Rejects retained two weeks
Pulps retained three months unless otherwise arranged.

1) April 1, 1971 additions for clarification.

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Authorized Signature

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CERTIFICATE OF ANALYSIS

TO Mr. R.A. Wyman (Page 2) REPORT NO. A-122-70

DATE

I hereby certify that the following are the results of analyses made by us upon the herein described samples

MARKED		% Ba	% SO_4/S	% SiO_2	% Fe_2O_3	% Ca	% T/Sr *	% T/Sr **		
Rougher Tails			3.9					4.7		Flotation Test 2
Mags 25 Amps/cleaned			1.95					1.0		
Celestite Conc		~ 0.8	49.3	0.90	0.30	0.83	42.6	39.1		
#3 Cleaner Tails			33.4				28.8	30.0		Flotation Test 3
#2 Cleaner Tails			21.7				18.2	19.2		
#1 Cleaner Tails			4.24				2.0	2.14		
Rougher Tails			1.18				1.0	1.25		
325 mesh fraction			27.9				23.5/23.6	15.1		Screen Test 2
mesh fraction			28.5				22.6/22.6	15.7		Screen Test 3
mesh fraction			28.3				22.5/22.5	19.4		Screen Test 4

* Gravimetric Analysis.

** Atomic Absorption Analysis with standard addition.

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CERTIFICATE OF ANALYSIS

TO Mr. R.A. Wyman
Head, Industrial Minerals
Milling Section, 40 Lydia St., Ottawa 1

REPORT NO. A-139-70

DATE May 25, 1970

I hereby certify that the following are the results of analyses made by us upon the herein described flotation samples

MARKED		% SO_4/S	% SiO_2	% Fe_2O_3	% Ca	% T/Sr *	% T/Sr **	% Ba		
Mags 25 amps (cleaned)		1.96					1.32			Flotation Test 5
Rougher Tails		2.16					1.04			
Celestite Conc.		45.6	2.28	0.33	1.28	43.4	44.4	R.A.		
#1 Cl Tail		3.18				1.57	1.72			
#2 Cl Tail		12.2				8.3	8.3			
#3 Cl Tail		23.4				18.4	16.8			

NOTE: Rejects retained two weeks
Pulps retained three months unless otherwise arranged.

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Address Head

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CERTIFICATE OF ANALYSIS

TO ..... Mr. R.A. Wyman .....

..... Head, Industrial Minerals .....

..... Milling Section, 40 Lydia St., Ottawa 1

REPORT NO. . . A-139-70 .....

DATE ..... May 25, 1970 .....

I hereby certify that the following are the results of analyses made by us upon the herein described ..flotation..... samples

MARKED	% SO_4/S	% SiO_2	% Fe_2O_3	% Ca	% T/Sr *	% T/Sr **	% Ba			
Celestite Conc. Sinks	50.1				43.2					Test 3
Mags 25 amps	2.03	37.2	17.0	5.99	1.54	1.14				Test 4
Rougher Tail	2.08	61.0	4.83	2.83	1.55	1.02				
Celestite Conc.	45.2	1.20	0.29	0.65	42.7	42.8	R.A.			
#1 Cl. Tail.	3.4	52.9	6.26	4.70	2.8	2.22				
#2 Cl. Tail.	20.5	21.4	3.65	7.74	19.4	14.7				
#3 Cl. Tail.	31.7	9.9	2.37	5.85	30.0	24.5				

NOTE: Rejects retained two weeks
Pulps retained three months unless otherwise arranged.

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CERTIFICATE OF ANALYSIS

TO . Mr. .R.A.. Wyman .....

. Head, . Industrial Minerals.....

. Milling. Section,. .40 .Lydia. Street, OTTAWA 1, Ontario.

REPORT NO. . . A-140-70.....

DATE .....June 8, 1970.....

I hereby certify that the following are the results of analyses made by us upon the herein described ....celestite..... samples

MARKED	% T/Sr		% SO_4/S		% SiO_2		% Fe_2O_3	% Ba	% Ca	
35 Mags	1.6		2.24							Kaiser Celestite Flotation Test 6
36 Rougher Tails	1.2		1.97							
37 Cl 4 Tails	36.8		38.6							
38 Cl 3 Tails	27.5		29.8							
39 Cl 2 Tails	20.9		22.5							
40 Cl 1 Tails	2.3		3.6							
41 Conc.	41.7		49.6		0.74		0.23	0.9	0.98	

NOTE: Rejects retained two weeks
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CERTIFICATE OF ANALYSIS

TO ... Mr. R.A. Wyman ...
... Head, Industrial Minerals ...
... Milling Section, 40 Lydia St. OTTAWA 1, Ontario.

REPORT NO. ... A-148-70 ...
DATE ... June 8, 1970 ...

I hereby certify that the following are the results of analyses made by us upon the herein described ... Celestite ... samples

MARKED	% T/Sr		% SO_4/S		% SiO_2		% Fe_2O_3	% Ba	% Ca	
Mags	1.45		2.02							MP-IM-7002
Celestite Conc.	42.5		50.3		0.87		0.19	0.5	1.19	Flotation Test 7
Cl 4 Tails	37.0		43.6							
Cl 3 Tails	30.6		34.7							
Cl 2 Tails	21.2		23.7							
Cl 1 Tails	3.6		4.53							
Rougher Tails	2.2		2.97							
Celestite Conc.			48.2					0.9		Flotation Test 4
Cl 2 Tails	+)		20.7							"
Cl 3 Tails	+)		31.8							"
Celestite Conc.			46.6					1.0		Flotation Test 5

NOTE: Rejects retained two weeks
Pulps retained three months unless otherwise arranged.

+) Will be re-analyzed.

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... A. Dziadkiewicz ...

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CERTIFICATE OF ANALYSIS

TO Mr. R.A. Wyman

Head, Industrial Minerals

Milling Section, 40 Lydia St. OTTAWA 1, Ontario

REPORT NO. A-152-70

DATE June 8, 1970

I hereby certify that the following are the results of analyses made by us upon the herein described celestite samples

MARKED	% T/Sr		% SO4/S		% SiO_2		% Fe_2O_3	% Ba	% Ca	
49 Mags	2.0		2.51							Flotation Test 8 MP-IM-7002
50 Celestite Conc.	41.1		48.2		1.87 Telephone		0.44	0.6	2.59	
51 Cl 3 Tails	27.9		32.4							
52 Cl 2 Tails	24.2		27.8							
53 Cl 1 Tails	2.4		2.6							
54 Rougher Tails	1.5		2.2							

NOTE: Rejects retained two weeks
Pulps retained three months unless otherwise arranged.

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CERTIFICATE OF ANALYSIS

TO Mr. R.A. Wyman,
Head, Industrial Minerals,
Milling Section, 40 Lydia St., Ottawa 1, Ont.

REPORT NO. A-178-70

DATE July 6, 1970

I hereby certify that the following are the results of analyses made by us upon the herein described celestite samples

MARKED		% SiO_2	% Fe_2O_3	% Ca	% SO_4/S					MP-IM-7002
55 Celestite Conc.		0.33	0.31	0.46						Flotation test 9
56 Rougher Tails		57.9	7.51							" "
57 Celestite Conc.		0.30	0.24	0.80						Flotation test 10
58 Rougher Tails		43.1	5.89							" "
59 Celestite Conc.		0.71		1.54						Flotation Test 11
60 Cl 4 Tails		3.94								
61 Cl 3 Tails		16.8								
62 Cl 2 Tails		9.63								
63 Cl 1 Tails		42.1								
64 Rougher Tails		57.6								
65 Celestite Conc.		-0.30		2.30	47.6					Flotation Test 12

NOTE: Rejects retained two weeks
Pulps retained three months unless otherwise arranged.

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CERTIFICATE OF ANALYSIS

TO Mr. R.A. Wyman

REPORT NO. A-178-70

DATE July 10, 1970

I hereby certify that the following are the results of analyses made by us upon the herein described celestite samples

MARKED		% SO_4/S	% SiO_2	% Fe_2O_3	% Ca					
66 Cl 4 Tails		42.0	1.40		4.00					
67 Cl 3 Tails		35.0	3.37		4.70					
68 Cl 2 Tails		36.2	12.6		3.53					
69 Cl 1 Tails		34.7	14.5		2.54					
70 Rougher Tails		4.11	51.8		4.05					
71 Celestite Conc		47.6	0.23	0.43	2.00					Flotation Test 13
72 Cl 4 Tails		42.4	3.99	1.43	3.12					
73 Cl 3 Tails		35.4	21.5	2.69	4.07					
74 Cl 2 Tails		36.7	26.6	2.93	3.37					
75 Cl 1 Tails		27.2	31.3	4.12	3.30					

NOTE: Rejects retained two weeks
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CERTIFICATE OF ANALYSIS

TO Mr. R.A. Wyman

REPORT NO. A-178-70

DATE July 10, 1970

I hereby certify that the following are the results of analyses made by us upon the herein described Celestite samples

MARKED		% SO_4/S	% SiO_2	% Fe_2O_3	% Ca				
76 Rougher Tails		4.07	47.4	7.15	3.90				

NOTE: Rejects retained two weeks
Pulps retained three months unless otherwise arranged.

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CERTIFICATE OF ANALYSIS

TO Mr. R.A. Wyman, Head
Industrial Mineral Processing Section
40 Lydia Street, OTTAWA 1, Ontario

REPORT NO. A-197-70

DATE July 27, 1970

I hereby certify that the following are the results of analyses made by us upon the herein described celestite samples

MARKED		% SO_4/S	% SiO_2	% Fe_2O_3	% Ca	% Ba				
77 Celestite Conc.-Mags		37.8	--	3.21	--	--				Flotation Test 14
78 Celestite Conc.-Non Mags		48.1	1.01	0.32	1.83	1.06				"
79 Cl 4 Tails		35.6	11.67	1.90	3.75	0.65				"
80 Cl 3 Tails		32.1	18.11	3.17	3.60	0.47				"
81 Cl 2 Tails		30.7	18.78	3.41	3.23	0.47				"
82 Cl 1 Tails		14.0	39.11	5.86	2.05	0.03				"
83 Rougher Tails		3.40	53.98	7.25	2.95	NIL				"
84 Celestite Conc.		49.1	0.77	0.44	1.38	1.06				Flotation Test 15
85 Cl 4 Tails		45.6	2.10	0.79	2.93	0.82				"
86 Cl 3 Tails		35.7	15.93	2.57	4.23					"
87 Cl 2 Tails		30.9	17.66	3.49	3.24					"

NOTE: Rejects retained two weeks
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CERTIFICATE OF ANALYSIS

TO Mr. R.A. Wyman - PAGE 2 -

REPORT NO. A-197-70

DATE July 27, 1970

I hereby certify that the following are the results of analyses made by us upon the herein described .....celestite..... samples

MARKED		% SO_4/S	% SiO_2	% Fe_2O_3	% Ca	% Ba				
88 Cl 1 Tails		12.0	40.43	6.22	2.47					Flotation Test 15
89 Rougher Tails		3.07	55.51	7.17	2.53					"
90 Celestite Conc.		47.0	0.84	0.40	1.65	1.00				Flotation Test 16
91 Cl 4 Tails		36.3	0.73	1.70	4.50					"
92 Cl 3 Tails		31.6	7.22	2.69	5.87					"
93 Cl 2 Tails		25.8	15.92	3.96	3.38					"
94 Cl 1 Tails		9.50	41.27	6.69	2.19					"
95 Rougher Tails		2.61	56.37	7.33	2.42	NIL				"

NOTE: Rejects retained two weeks
Pulps retained three months unless otherwise arranged.

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CERTIFICATE OF ANALYSIS

TO Mr. R.A. Wyman, Head,
Industrial Minerals Milling Section,
40 Lydia St., OTTAWA 1, Ontario.

REPORT NO. A-217-70

DATE August 12, 1970

I hereby certify that the following are the results of analyses made by us upon the herein described celestite samples

MARKED		%	%	%	%					
		SO_4/S	SiO_2	Ca	Ba					
96 Celestite Conc.		48.4	0.31	1.48	0.74					Flotation Test 17
97 Cl 4 Tails			2.65	4.98						"
98 Cl 3 Tails			7.30	--						"
99 Cl 2 Tails			17.14	--						"
100 Cl 1 Tails			43.16	--						"
101 Rougher Tails		2.55	55.87	--						"
102 Celestite Conc.		48.6	0.59	1.05	0.66					Flotation Test 18
103 Cl 1 Tails			39.44	2.86						"
104 Rougher Tails		6.87	48.80	2.82						"
105 Celestite Conc.		48.7	1.22	1.15	0.95					Flotation Test 19
106 Cl 4 Tails		41.5	6.46	3.35	1.04					"

NOTE: Rejects retained two weeks
Pulps retained three months unless otherwise arranged.

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PHONE: 237-3110 TELEX: 013-3548

CERTIFICATE OF ANALYSIS

TO Mr. R.A. Wyman

REPORT NO. A-217-70

DATE August 12, 1970

I hereby certify that the following are the results of analyses made by us upon the herein described celestite samples

MARKED		% SO_4/S	% SiO_2	% Ca	% Ba					
107 Cl 3 Tails		37.5	24.99	4.36	0.79					Flotation Test 19
108 Cl 2 Tails		29.9	26.30	4.05	0.57					"
109 Cl 1 Tails		19.3	35.01	2.94	0.19					"
110 Rougher Tails		6.97	47.85	3.20	NIL					"

NOTE: Rejects retained two weeks
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CERTIFICATE OF ANALYSIS

TO Mr. R.A. Wyman, Head
Industrial Minerals Milling Section
40 Lydia Street, OTTAWA 1, Ontario

REPORT NO. A-222-70

DATE July 27, 1970

I hereby certify that the following are the results of analyses made by us upon the herein described celestite samples

MARKED		% Ba								
Celestite Conc.		0.82								Test 11
Celestite Conc.		0.66								Test 12
Celestite Conc.		0.62								Test 13

NOTE: Rejects retained two weeks
Pulps retained three months unless otherwise arranged.

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W. Wasteneys

15.

APPENDIX E

Heavy Liquid Separations

Methylene Iodide: S.G. 3.33

Test No	Fraction	Sinks %
1	Concentrate 1	99.06
2	Concentrate	97.89
4	Concentrate	95.15
5	Concentrate	94.35
6	Concentrate	97.70
6	Cl 4 Tails	94.42
7	Concentrate	96.96
7	Cl 4 Tails	95.38
8	Concentrate	97.26
8	Cl 3 Tails	62.58
9	Concentrate	97.32
10	Concentrate	97.61
11	Concentrate	97.48
12	Concentrate	98.15
13	Concentrate	97.63
14	Concentrate	97.67
15	Concentrate	97.66
16	Concentrate	97.27
17	Concentrate	98.07
18	Concentrate	98.14
19	Concentrate	98.20

APPENDIX F

Analysis - Ottawa Tap Water

INLAND WATERS BRANCH — WATER QUALITY DIVISION

ANALYSIS OF WATER SAMPLE (S)
(milligrams per litre)

Location	Ottawa	Ottawa
Source of Water	Ottawa River	Ottawa River
Sampling point	Tap - Lemieux Island	Tap - 45 Spencer Street
Reference		
Laboratory Number	3048	3602
Date of Sampling	2-12-66	10-3-71
Date Sample Received		
Date of Analyses	3-2-67	11-3-71
*Storage Period (days)	.63	1
Temp. at Sampling (°C)	5.0	
Temp. at Testing (°C)	18.4	21.8
Alkalinity, Phenolphthalein ($CaCO_3$)	0.0	0.0
Alkalinity, Total ($CaCO_3$)	23.4	31.4
Aluminum (Al)	0.35	
Bicarbonate (HCO_3)	28.5	38.3
Calcium (Ca)	16.8	19.4
Carbonate (CO_3)	0.0	0.0
Chloride (Cl)	3.5	1.5
Colour (Hazen Units)	5	5
Copper (Cu) (Total)	0.000	
Fluoride (F)	1.0	1.0
Hardness, Total ($CaCO_3$)	53.0	61.6
Hardness, Non Carbonate ($CaCO_3$)	29.6	30.2
Iron (Fe) Total		
Dissolved		
Magnesium (Mg)	2.7	3.2
Manganese (Mn) Total	0.00	
Dissolved	0.00	
Nitrogen, Ammonia (N)		
Nitrogen, Nitrate + Nitrite (N)	0.10	0.26
Oxygen, Consumed from $KMnO_4$		
Oxygen Demand, Chemical (COD)		
pH	7.9	7.9
Phosphate Inorganic (PO_4)		
Phosphate Ortho (PO_4)		
Phosphorus Total (PO_4)		
Potassium (K)	0.7	0.8
Residue, Filterable		
Residue, Fixed Filterable		
Residue, Nonfilterable		
Residue, Fixed Nonfilterable		
Silica (SiO_2)	4.7	5.6
Sodium (Na)	2.1	2.4
Specific Conductance (μmhos/cm at 25°)	124	144
Sulphate (SO_4)	28.0	31.1
Turbidity (Jackson Units)		0.5
Zinc (Zn) (Total)	0.004	
Sum of Constituents	74.5	85.0
% Sodium	7.5	7.7
Saturation Index at Test Temperature	-1.0	-0.8
Stability Index at Test Temperature	9.9	9.4
Sodium Absorption Ratio (SAR)	0.1	0.1
Carbon Dioxide, Calculated (CO_2)	1.0	0.8

* From date of sampling to testing