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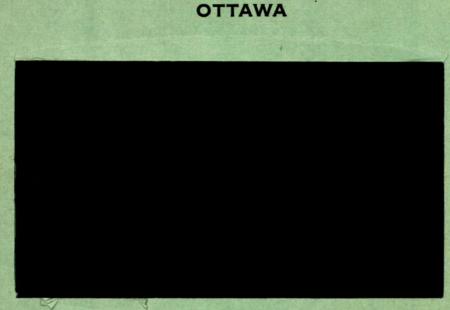
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CANADA

DEPARTMENT OF ENERGY, MINES AND RESOURCES



Mines Branch

CANADA

DEPARTMENT OF ENERGY, MINES AND RESOURCES

OTTAWA

MINES BRANCH INVESTIGATION REPORT

IR 71-20

MARCH 1971

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

Ъy

F.H. HARTMAN and R.A. WYMAN

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

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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% SrSO₄ (67.6% recovery), 0.31% SiO₂, 0.19% Fe₂O₃.

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.

* Research Scientist, and ** Head, Industrial Minerals Milling Section, Mineral Processing Division, Mines Branch, Department of Energy, Mines and Resources, Ottawa, Canada.

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INTRODUCTION

Kaiser Celestite Mining Limited, Sydney, Nova Scotia, mine and beneficiate celestite ore at Loch Lomond, Gape 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 baritecelestite 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.

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DESCRIPTION OF SAMPLE

A 50-1b 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

Screen Fraction Mesh (Tyler)	Weight %
$\begin{array}{r} -28 +35 \\ -35 +48 \\ -48 +65 \\ -65 +100 \\ -100 +150 \\ -150 +200 \\ -200 +325 \\ -325 \end{array}$	4.8 21.8 12.4 10.9 8.4 7.7 10.8 23.2
Total	100.0

MPD 70/37

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 dat	a: A'-	abundant	to	Ε		trace))
------------	--------	----------	----	---	--	--------	---

		fractions	· · · · · · · · · · · · · · · · · · ·	-100
Mineral	"Grey"	+28 mesh "Brown"	-28 mesh	mesh
Celestite	A `	D	A	A
Quartz	C	A	В	В _.
Calcite	D	В	С	С
Muscovite	Е	С	Е	D
Chlorite	Е	С	E.	D
Dolomite	?	-	E(?)	E(?)
Pyroxene	-	E(?)	E(?)	E(?)
Plagioclase	-	E(?)	-	-
Hematite	-	Е	Е	Е

* 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

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 SiO₂, Fe₂O₃, 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,

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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 highcelestite/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, $2\frac{1}{2}$, 2, and 2

- 5 -

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)

/	· · · · · · · · · · · · · · · · · · ·	I	·····	
Test No.	4	3	2	5
Time of Grind min	15	30	45	Primary: 15
				Secondary: 15
Screen Fraction		Unin	6± 9/	· .
Mesh (Tyler)		Weig	iic / ₆ .	
+48	tr	tr	tr	
-				
48 +65	0.2	tr	tr	
<pre>-65 +100</pre>	0.8	0.1	0.1	
			· ·	
-1 00 + 150	3.3	0.8	0.2	tr
	•			
-1 50 + 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

Screen Tests 2, 3, 4 and 5

* 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	<u></u>					
Primary grind min	1				45						
% -325 m					95.3						
Magnetic separation					Jonés						
Plates					<u>High-in</u>	tensity					
Атро					2.5					·····	
Runs	<u> </u>				2						
Cleanings			<u> </u>		1						
Flotation							·				<u> </u>
Sodium Silicate (1b/ton)					0.5						
Citric acid (lb/ton)					-						
Quebracho (1b/ton)		Rougher	0.5;	Cleaner	2: 0.						
Igepon T-33 (1b/ton)		Rougher	<u>8 x C</u>	.4 = 3.		ner l:	3 x 0.4	4 = 1.2	; Clean	er 2.: C).4
Pulp (% solids)				. <u> </u>	20						
pH					6						
Secondary grind min					-						
<u>% −325 m</u>								and the second state			
RESULTS	Wt)4%*	CaCO ₃ %			2%*		.S04%*	Fe203%	r*
Products	%	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 l 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)	1										

* 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.

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TABLE 4 (cont'd)

Test No.	- · · ·			4								
Primary grind min				30								
% −325 m				89.9								
Magnetic separation				Jone	mes							
Plates				High	-intensi	ty						
កំណែរិទ				25								
Runs				2								
Cleanings				1								
Flotation							•					
Sodium Silicate (1b/to	n)			0.5	····	····						
Citric acid (1b/ton)								. <u></u>				
Quebracho (1b/ton)		Rough			ner 2 :						·	
Igepon T-33 (1b/ton)		Rough	er: 8 :		3.2; C1	eaner 1	<u>:3 x 0.</u>	4 = 1.2	<u>2, Clear</u>	<u>er 2;</u>	0.4	
Pulp (% solids)				20								
pH				6								
Secondary grind min				-								
% −325 m												
RESULTS	Wt	SrS		CaCO ₃ %	(LOI)*	SiO			03%	С	a%	
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 l 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		

* CaCO₃ calculated from LOI determination in this and subsequent trials. ** Ba - 0.9.

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TABLE 4 (Cont'd)

Test No.						5					
Primary grind min				÷		15		-			
% -325 m					74	.0					
Magnetic separation					Jo	nes					
Plates	ļ				High-	intensi	ty				
Amne						25					
Runs						2					
Cleanings						1					
Flotation											
Sodium Silicate (1b/to	m)				0	.5					
Citric acid (lb/ton)						-					
Quebracho (1b/ton)		Rot	ugher:	0.5			2: 0.25				
Igepon T-33 (lb/ton)		Rot	ugher 8	x 0.4 =	= <u>3.2;</u> C		1: 3 x	0.4 = 1	<u>.2;</u> Cle	aner 2:	0.4
Pulp (% solids)					2	-					
pH						6					
Secondary grind min							- <u></u>				
<u>% −325 m</u>	1										
RESULTS	Wt	SrSC	04%	CaCO ₃ ?	(LOI)	Si0	2%	Fe ₂	03%	Ca%	Ba%
Products	%	Anal	Distn	Anal		Anal	Distn	Anal	Distn	Anal	Anal
Magnetics	8.0	3.44	0.5	27.60	16.6						<u> </u>
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						<u> </u>
Cl 2 Tails	· 6.6	26.80	3.1	30.80	15.3						
Cl l Tails	8.1	6.95	1.0	23.80	14.5						<u> </u>
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	

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TABLE 4 (Cont'd)

·		15 74.0 None' - - - - -		2 x 0.4	= 0.8				
		74.0 None ' - - - - - - -	 	2 x 0.4	= 0.8				
· · · · · · · · · · · · · · · · · · ·		None ' - - - - - - -		2 x 0.4	= 0.8				
	ouchor: 7 y			2 x 0.4	= 0.8				
	ouchor: 7 y	-		2 x 0.4	= 0.8				
	ouchor: 7 y			2 x 0.4	= 0.8		·		
	ouchor: 7 y			2 x 0.4	= 0.8				
	ouchors 7 y			2 x 0.4	= 0.8		·		
	ouchors 7 y		iner 1: 2	2 x 0.4	= 0.8				
	ouchort 7 v	-	ner 1: 2	2 x 0.4	= 0.8				
	ouchor, 7 x	-	iner 1: 2	2 x 0.4	= 0.8				
	ouchors 7 x	(- 2 - 0 - 01 - 0 - 01 - 0 - 01 - 0 - 01 - 0 - 0	iner 1: 2	2 x 0.4	= 0.8				
7 x 0.4	Rougher: $7 \ge 0.4 = 2.8$; Cleaner 1: $2 \ge 0.4 = 0.8$								
		20							
		6							
			ter roughe	er)					
		96.5							
SrS0 ₄ % CaC0 ₃ %(LOI) Si0 ₂ % Fe ₂ 0 ₃ %		03%	Ca%	Ba%					
Distn / A	Anal Distn	Anal Distn	Anal I	Distn	Anal	Distn			
64.0	97.50 64.0	4.10 12.0	0.71	1.1	0.92	11.0	1.54	0.82	
9.8 1	86.40 9.8	12.00 6.0	3.94	1.0	0.64	1.3			
12.9 18	73.50 12.9	18.50 14.4	9.63	3.9	2.19	3.8			
	63.50 6.1	18.60 7.9	16.80	3.8	2.98	9.5			
			42.10 1	12.4	4.78	11.0			
6.1 18	27.50 3.5	21.20 11.8				63.4			
6.1 18 3.5 21		21.20 11.8 18.60 47.9		77.8	5.98	0.0.4			
6.1 18 3.5 21		[77.8	5.98			<u> </u>	
6.1 18 3.5 21 3.7 18		[•		100.0			
	·····			3.7 18.60 47.9 57.60	3.7 18.60 47.9 57.60 77.8				

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

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TABLE 4 (Cont'd)

Test No.					14						
Primary grind min					15						,
% -325 m				7	4.0						
Magnetic separation					footnot	e					
Plates				High	intens	ity					
Amps					25						
Runs					2					-	
Cleanings											
Flotation											
Sodium Silicate (1b/ton))				~						
Citric acid (1b/ton)					-						
Quebracho (1b/ton)					-						
*Igepon T-33 (lb/ton)		Rougher	3 x 0.	6 + 1 x		<u>2.6;</u> C1	eaner 1	: 2 x 0	.4 = <u>0</u> .	<u>8</u>	
Pulp (% solids)					20						
рН					6						
Secondary grind min						ter rou	gher)				
% -325 m		96.5									
RESULTS	Wt	SrSC)4%	CaCO ₃ %	(LOI)	SiO	2%	Fe	03%	Ca%	Ba%
Products	%	Anal	Distn	Anal	Distn	Anal	Distn	Anal		Anal	Anal
**Celestite Conc : Mags	0.5	-	·	-				3.21	0.5		
**Celestite Conc : Non-mags	37.2	97.40		5.14	<u> </u>	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 [.]	ļ	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
		<u> </u>				<u> </u>		Į •			<u> </u>
Feed (calcd)	100.0					<u> </u>		3.69	100.0		
Feed (assay)	<u> </u>	57.20		12.50		24.50	<u> </u>	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.

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TABLE 4 (Cont'd)

Test No.				1:	5						
Primary grind min				1.	5		<u>.</u>			*****	
% −325 m				74.()						
Magnetic separation				None	3						
Plates				-							
۵٫۳۳۶				-							
Runs				-							
Cleanings											
Flotation											
Sodium Silicate (1b/ton)											
Citric acid (1b/ton)					<u> </u>						
Quebracho (1b/ton)					aner 4:						
*Igepon T-33 (lb/ton)		Rougher	: 3 x (2.6; (leaner	<u>1: 2 ></u>	c 0.4 =	0.8	
Pulp (% solids)	•			2(<u> </u>			·	
рН					· · · · · · · · · · · · · · · · · · ·	·					}
Secondary grind min					<u>(after</u>	roughe	er)				i
% -325 m				96.5)				<u></u>		
RESULTS	Wt	SrSC	14%	CaCO ₃ %	(LOI)	Si0	2%	Fe ₂	03%	Ca%	
Products	%	Anal	Distn	Anal	Distn	Anal	Distn	Anal	Distn	Anal	Distn
** Gelestite 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
							<u> </u>				
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

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Test No.					16						
Primary grind min					15						
% −325 m			······	·······	74.0					······	
· Magnetic separation					Norie	· · · · · ·					
Plates					-						
^mp <i>e</i>					-						
Runs					-						
Cleanings					-						
Flotation							•				
Sodium Silicate (lb/ton)		·									
Citric acid (lb/ton)				,	-						
Quebracho (lb/ton)			<u>.,</u>		Cleane		•08			<u>,</u>	
*Igepon T-33 (lb/ton)		Rougher	: 3 x 0.	6 + 1 x		<u>2.6;</u> Cl	eaner 1	: 2 x	0.4 = 0	<u>.8</u> .	
Pulp (% solids)					20						
рН					6						
Secondary grind min			<u> </u>		<u>15 (a</u>	fter ro	ugher)				
<u>% -325 m</u>			half. James Literature		96.5						
RESULTS	Wt	SrSC) ₄ %	CaC0 ₃ %	(LOI)	SiO	2%	Fez	03%	Ca%	
Products	%	Anal	Distn	Anal	Distn	Anal	Distn	Anal	Distn	Anal	Distr
** Celestite Copc	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 l 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	

TABLE 4 (Cont'd)

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

** Ba - 1.00 ***Ba - NIL

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TABLE 4 (Cont'd)

TEST No.	<u> </u>		······································		17						
Primary grind min					15						
% −325 m					74.0						
Magnetic separation					None						
Plates					-						
Ampo											
Runs								•			
Cleanings											
Flotation					-						
Sodium Silicate (1b/ton	.)										
Citric acid (lb/ton)										<u> </u>	
Quebracho (lb/ton)											
Igepon T-33 (lb/ton)		Rougher	<u>: 3 x C</u>).6 + 1	x 0.8	= 2.6;	<u>Cleaner</u>	1: 3	x 0.4 =	1.2	
Pulp (% solids)					20						
рН					6				<u> </u>		
Secondary grind min					15 (after r	ougher)				
% −325 m			Staf - Survey Classes		96.5						
RESULTS	Wt	SrSC	•	CaCO ₃ %			2%		03%	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
" C1 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		
" C1 2 Tails	9.9	64.80	11.5	19.10	14.2	17.14	6.9	2.07	6.9		•
" Cl l 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	

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		<u></u>		00110 07	-						
Test No.			<u> </u>	18 & 19	O Combin	ed Lock	ed Test				
CONDITIONS		Cl 2, Cl Test 19	3, C1 4	+ Tails	Test 18	filter	ed, com	bined &	added	after r	egrind
Primary grind min					15						
% −325 m					74.0						
Magnetic separation					None						
Plates					-						
Amos					-						
Runs					-			•			
Cleanings					-						
Flotation					-						
Sodium Silicate (1b/ton)									<u></u>		
<u>Citric acid (lb/ton)</u> Quebracho (lb/ton)				<u>.</u>							
Igepon T-33 (1b/ton)		Rougher:	2 0	6 4 7 7		2 6. 01	00000 1	. 3	0 / - 1	<u>ົ</u>	
Pulp (% solids)	•	Kougner:	<u> </u>		20	2.0; 01	eaner 1	<u> </u>	0.4 - 1	• 2	
DH		<u> </u>			<u></u> 6						
Secondary grind min				<u> </u>		fter ro	11oher)				
% -325 m					96.5				<u> </u>		
	Wt	SrSC	a 9/	CaCO3%	·e : (2%	Fe,0,	0/	Ca	7/	Ba%
<u>RESULTS</u> Products	wc %	Anal	Distn	(LOT) Anal	Anal	Distn		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	11	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 l 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.
11-11 11 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		100.0	-	26.21	100.0	3.10	100.0	2.48	100.0	-
Feed (assay)		57.20		12.50	24.50	1	3.65		2.81		

TABLE 4 (Cont'd)

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TABLE 4 (Cont'd)

Test No.				<u> </u>	20) & 21 (Combined	Locked	i Test		
CONDITIONS		C12, C13	, C14, 7	lails Te	est 20 f	iltered	, combin	ned and	l added	after r	egrind
Primary grind min						15				Test 21	
% -325 m						74.0			<u> </u>		
Magnetic separation	*** 2	1	<u> </u>		•	None					
Plates						-					
Amps						-					
Runs						-		•			
Cleanings						-					
Flotation						~	•				
Sodium Silicate (lb/ton)	·					-					
Citric acid (lb/ton)						-		····			
Quebracho (1b/ton)		Rougher	(20)5	~~∩~3~ =	<u></u>			- 	 ^ 8		
IgeDon T-33 (lb/ton)		Rougher Rougher	(21):-4	x-0.3-=	<u>1.2.Cl</u>	eaner 1 eaner 1	$\frac{(20): 4}{(21):3}$	<u>x 0.2</u>	- 0.6	<u> </u>	
Pulp (% solids)		ļ				20					
pH		ļ			· · · · · · · · · · · ·	6					
Secondary grind min		l				15 (after ro	ougher)			
% −325 m		<u> </u>				96.5		and a state of the state of the			
RESULTS	Wt	SrSC)4%	CaCO ₃ %	(LOI)	SiO	2%	Fe ₂	03%	Ca	%
Products	%	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	11		11		0.06	0.5	11	
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	11		11		0.88	0.8	11	
" C1 3 Tails '"	3.8	75.70	5.2	11		11		1.83	2.2	11	
" Cl 2 Tails "	6.3	64.20	7.4	11		11		2.39	4.9	11	
" Cl 1 Tails Test 20	3.7	20.90	1.4	11		11		6.38	7.6	11	
" Cl l Tails Test 21	4.4	23.80	. 1.9	11		11		5.79	8.2	11	
- Rougher Tails Test 20	17.2	8.35	2.6	11	<u> </u>	11	<u>.</u>	6.79	37.6	11	
" Test 21	19.1	12.15	4.2	11		TT		6.20	38.0	11	
Rougher Tails Combined	36.3	10.35	6.8	!1	ļ			6.42	75.6	11	
Feed (calcd)	100.0	54.97	100.0	-		-			100.0		
Feed (assay)	ł	57.20		12.50		24.50		3.65		2.81	

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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 SrSO4 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 SrSO4 and shown as "O" 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 SrSO4 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 SiO₂ 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.

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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 SiO₂ 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).

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There was a significant increase in the recovery of SrSO₄ 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 SiO₂ 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% SrSO₄ with a recovery of 67.6%; SiO₂ was 0.31% (0.5% distn) and Fe₂O₃ = 0.19% (2.5 distn). Losses in the rougher tails were 3.7% of the SrSO₄; SiO₂ content was 55.87% (76.4% distn), Fe₂O₃ = 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.

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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-SiO₂ 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.

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CONCLUSIONS

1. A celestite concentrate, $(97.5\% \text{ SrSO}_4, 0.31\% \text{ SiO}_2, 0.19\%$ Fe₂O₃), 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%.

 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 SrSO4 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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Professor Michael A.K. Grice, Nova Scotia Technical College, Halifax, closely co-operated on converting bench-scale testing to pilot-plant operation.

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APPENDIX A

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

Primary grind min				•	45						
% −325 m	1			ç	5.3						
Magnetic separation					ones						
Plates	1				igh-int	ensity					
Amps					25	,					
Runs					1						
Cleanings					-						
Flotation											
Sodium Silicate (lb/ton)					0.25						
Citric acid (lb/ton)					0.25						·
Quebracho (1b/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				•		
рН					6						
Secondary grind min											
% −325 m											
RESULTS	Wt	SrSO	4% *	CaCO ₃ %	(LOI)	SiO	2%	Fe2	03%	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	<u> </u>
Rougher Tails	24.7	38.20	15.6	19.90	32.4	n.d.		n.d.		n.d.	
						1	·				<u> </u>
						1	 	 			
Feed (calcd)	100.0	60.46	100.0	15.25	100.0			1			
Feed (assay)		57.20		12.50		24.50		3.65		2.81	1

* X-ray fluorescence Sr. ** Early work Sr determinations: Probably high as standards not checked for sometime.

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· · · · · · · · · · · · · · · · · · ·											
Test No.						2					
Primary grind min	1					÷5					
% -325 m					95.						
Magnetic separation					'Jon						
Plates						h-inten	sity				
Amps						.5					<u></u>
Runs			· · ·	. <u></u>		2		•			
Cleanings											
Flotation Sodium Silicate (1b/ton)		<u> </u>			0.	5	•				
Citric acid (lb/ton)							<u></u>		· · · · · · · · · · · · · · · · · · ·		<u></u>
Quebracho (1b/ton)				<u></u>	0.						
Igepon T-33 (lb/ton)		Rougher	• 8 v (h = 3			2×0	4 = 0.8			
Pulp (% solids)		Nougher	<u> </u>			<u>10</u>	<u> </u>		•		
рН	i					6				·····	
Secondary grind min						-					
% -325 m	·					-					
RESULTS	Wt	SrS	۰. ۳	CaCO3%	(ΤΟΤ)	1 910	2%	Fee	03%	C	a%
Products	%	Anal	Distn		Distn		210 Distn	Anal	Distn	Anal	Distr
Magnetics	14.2	17.45	4.3	25.40	25.2		22000				1
Celestite Conc	45.4	97.50	76.6	4.45	14.1	1.44		0.33		1.08	
•	12.1	57.00	12.0	21.40	18.0	1.044		0.33		1.00	+
Cl 2 Tails			- <u>i</u>	<u> </u>		1					
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						
	ł										
· · · · · · · · · · · · · · · · · · ·	-	1	1	1		1		1	1		1
			1	<u> </u>	<u> </u>						
Feed (calcd)	100.0	57.62	100.0	14.36	100.0				· ·		
Feed (assay)		57.20	S.	12.50		24.50		3.65		2.81	1
			- 	,	Į			4	I	<u>. </u>	_ <u>`</u>

Test No.						6	<u>, , , , , , , , , , , , , , , , , , , </u>				
CONDITIONS		· · · · · · · · · · · · · · · · · · ·	,			· · · · ·					
Primary grind min					3	0.					
% -325 m		,,,,,,		•	89.	9			·····		
Magnetic separation			· · · · · · · · · · · · ·	·	Jon						
Plates						h-inten	sity				
Amps					2.						,,
Runs		······································				2	<u> </u>	·			
Cleanings						1					
Flotation											
Sodium Silicate (lb/ton)		Rougher:	0.5;	<u>Cleaner</u>	1: 0.	25			<u></u>		
Citric acid (lb/ton) Quebracho (lb/ton)		Rougher	0.5.	Cleaner	2: 0.	<u>-</u>	· · · · · · · · · · · ·				· · · ·
Igepon T-33 (1b/ton)		Rougher:					3 20 /	= 1 2.	Cleaner	<u>~ 2. 0</u>	.4
Pulp (% solids)		<u>kougner</u> :	<u> </u>	<u> </u>	2; 01ea 2		<u>5 x 0.4</u>	- 1.2;	oreanei	. 2: 0	· · · · · · · · · · · · · · · · · · ·
pH						<u> </u>					<u></u>
Secondary grind min						-					
% -325 m						_					
RESULTS	Wt	SrSC	D ₄ %	CaCO3%	(LOI)	SiO	2%	Fe ₂	03%	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 l Tails	8.7	7.35	1.2								
Rougher Tails	21.2	3.50	1.4								
	<u></u>					1		<u> </u>		noitere toto mino	<u> </u>
Feed (calcd)	100.0	55.66	100.0			<u> </u>				· · · · · · · · · · · · · · · · · · ·	<u> </u>
Feed (assay)		57.20		12.50		24.50	<u> </u>	3.65		2.81	<u> </u>

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Test No.					7		·			<u></u>	
CONDITIONS											
Primary grind min					30						
% -325 m			•	89	.9						
Magnetic separation					nes						
Plates					gh-inte	nsity					
Amps					25						
Runs					2						
Cleanings					1						
Flotation					1 0 0			- <u>A</u> AF			
Sodium Silicate (1b/ton	n)	Rougher	•• 0.5;	Cleaner	1: 0.2	5; Clea	ner 3:	0.25			
Citric acid (lb/ton)		D 1		01	-	5					······································
Quebracho (1b/ton)		Rougher	: 0.5; 8 x 0.4	Cleaner	<u>Closes</u>	<u> </u>	<u>v 0 / =</u>	1 2. 0	leaner	2.04	
· Igepon T-33 (lb/ton)		Rougner	0 X U.4		$\frac{Cleane}{20}$	<u>r r: </u>	x 0.4 -	<u> </u>		<u> </u>	
Pulp (% solids) pH					6						
Secondary grind min					-						
% -325 m											
						1	au 1		0 %		Ba%
RESULTS	Wt		04%	CaCO ₃ %			2%		0 ₃ % Distn	Ca% - Anal	
Products	%	Anal	Distn	Anal	Distn	Anal	Distn	Anal	Distr	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	1.00.00	12.50		24.50	<u> </u>	3.65		2.81	1

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						-					
· Test No.					8						
CONDITIONS											
Primary grind min					15				-		
% -325 m				74							
Magnetic separation				Jo	nes′						
Plates					gh-inter	nsity					
Amps					25						
Runs					2			· · · · · · · · · · · · · · · · · · ·		<u>_</u>	
Cleanings					1						
Flotation							·				
Sodium Silicate (1b/ton)	Rougher	: 0.5;	Cleaner	2: 0.2	25					
Citric acid (lb/ton)						0.5					<u> </u>
Quebracho (1b/ton)		Rougher		Cleaner			<u> </u>	1 0	01		- 0 /
Igepon T-33 (lb/ton)		Rougher	: 8 x (ner 1:	3 x 0.4	= 1.2;	Cleane	$r_{2:.2}$	<u>x</u>
Pulp (% solids)					20						
рН					6 15 (aft	om (1.00					,
Secondary grind min							ner 1)				
% −325 m				90	.5 (app:	rox.)					7
RESULTS	Wt	SrSC	04%	CaCO ₃ %	(LOI)	SiO	2%	Fe ₂	03%	Ca%	Ba%
Products	%	Anal	Distn	Anal	Distn	Anal	Distn	Anal	Distn	Anal	Anal
Magnetics	8.2	3.56	0.5	27.90	16.3						ļ
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 l Tails	8.1	7.30	1.1	21.05	12.1						<u> </u>
Rougher Tails	18.8	5.93	2.0	16.60	22.3						<u> </u>
		<u> </u>	<u> </u>			1					
			<u> </u>			\					<u> </u>
Feed (calcd)	100.0	56.10	100.0	14.02	100.0						
Feed (assay)		57.20		12.50		24.50		3.65		2.81	

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9 CONDITIONS 15 Primary grind min 15 X -325 m 74.0 Magnetic separation None Plates - Amos - Runs - Cleanings - Runs - Cleanings - Clitric acid (1b/ton) Rougher: 0.5; Cleaner 2: 0.25 Clitric acid (1b/ton) Rougher: 0.5; Cleaner 2: 0.5 Igepon T-33 (1b/ton) Rougher: 0.5; Cleaner 2: 0.5 Igepon T-33 (1b/ton) Rougher: 0.5; Cleaner 1: 3 x 10 = 1.2 Cleaner 2: 2 x 0.4 = Pulp (X solids) - Secondary grind min - X -325 m - RESULTS Wt SrSo ₄ X Caco ₂ X CaCy Cary Y - - - Y - <th colspa<="" th=""><th></th><th></th><th></th><th></th><th></th><th>······.</th><th></th><th></th><th></th><th></th><th></th><th></th></th>	<th></th> <th></th> <th></th> <th></th> <th></th> <th>······.</th> <th></th> <th></th> <th></th> <th></th> <th></th> <th></th>						······.						
$ \begin{array}{c c c c c c c c c c c c c c c c c c c $	Test No.						9						
Trian of grant man 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) Rougher: 0.5; Cleaner 2: 0.5 Jgepon T-33 (lb/ton) Rougher: 0.5; Cleaner 2: 0.5 Jgepon T-33 (lb/ton) Rougher: 0.5; Cleaner 1: 3 x 10 = 1.2 Cleaner 2: 2 x 0.4 = Pulp (X solids)	CONDITIONS												
$\chi = -325 \text{ m}$ 74.0 Magnetic separation 74.0 Magnetic separation None Plates - Amps - Runs - Cleanings - Piltetion coldim Silicate (lb/ton) Rougher: 0.5; Cleaner 2: 0.25 Citric acid (lb/ton) Rougher: 0.5; Cleaner 2: 0.5 Quebracho (lb/ton) Rougher: 0.5; Cleaner 2: 0.5 Cleaner 1: 3 x 10 = 1.2 Cleaner 2: 2 x 0.4 = Pulp (% solide) - $\chi = -325 \text{ m}$ - RESULTS Wt SrSou [%] Caco ₃ % (DI) None - Products Wt SrSou [%] Caco [%] RESULTS Wt SrSou [%] Caco [%] "It cl 4 Tails 4.4 96.00 7.5 8.10 2.6 - - - - - "It cl 1 Tails 10.9 82.70 16.1	Primary grind min					1.	5						
Magnetic separation None Plates - Amps - Runs - Runs - Claanings - Flotation - Sodium Silicate (lb/ton) Rougher: 0.5 ; Cleaner 2: 0.25 Citric acid (lb/ton) Rougher: 0.5 ; Cleaner 2: 0.5 - Pulp (% solids) - pH - Secondary grind min - $X - 325$ m 9.5 (after Cleaner 1) Wt SrSou% Ca% Celestite Con 20 Wt SrSou% Ca% Cas - Products % SrSou% Ca% Cas - - Wt SrSou% Ca% Cas - - I'' Cl 4 Tails			<i>;-</i>			74.	0	·····					
$\begin{array}{ c c c c c c c c c c c c c c c c c c c$						Non	e						
Runs - Cleanings - Flotation - Sodium Silicate (lb/ton) Rougher: 0.5; Cleaner 2: 0.25 Citric acid (lb/ton) Rougher: 0.5; Cleaner 2: 0.5 Quebracho (lb/ton) Rougher: 0.5; Cleaner 2: 0.5 Iggon T-33 (lb/ton) Rougher: 8 x 0.4 = 3.2; Cleaner 1: 3 x 10 = 1.2 Cleaner 2: 2 x 0.4 = Pulp (% solids) - pH - Secondary grind min - $\chi -325 m$ - Products χ'' Anal Distn Anal Distn Mt SrS0 ₄ % CaC0 ₃ % (LOI) Si0 ₂ % Fe ₂ O ₃ % Ca% 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 - -						-							
$\begin{array}{c c c c c c c c c c c c c c c c c c c $	Amps					-							
$\begin{array}{ c c c c c c c c c c c c c c c c c c c$	Runs					-							
Sodium Silicate (lb/ton) Rougher: 0.5; Cleaner 2: 0.25 Citric acid (lb/ton) Rougher: 0.5; Cleaner 2: 0.5 Igepon T-33 (lb/ton) Rougher: 0.5; Cleaner 2: 0.5 Pulp (% solids) 20 20 pH 6 6 Secondary grind min 05; Cleaner 1: 3x 10 = 1.2 Cleaner 2: 2x 0.4 = χ -325 m 96.5 (approx.) 6 6 RESULTS Wt SrSO ₄ % CaCO ₃ %(LOI) SiO ₂ % Fe ₂ O ₃ % Ca% 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 -						-							
						-		<u> </u>					
Quebracho (1b/ton) Rougher: 0.5; Cleaner 2: 0.5 Igepon T-33 (1b/ton) Rougher: 8 x 0.4 = 3.2; Cleaner 1: 3 x 10 = 1.2 Cleaner 2: 2 x 0.4 = Pulp (% solids) 20 pH 6 Secondary grind min 15 (after Cleaner 1) $\chi -325$ m 96.5 (approx.) RESULTS Wt SrS0 ₄ % Cac0 ₃ %(LOI) Silo ₂ % Fe ₂ 0 ₃ % Ca% Products % SrS0 ₄ % Cac0 ₃ %(LOI) Silo ₂ % Fe ₂ 0 ₃ % Ca% (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 1 Tails 23.2 68.50 28.2 16.65 27.6 - - - - '' Cl 1 Tails 11.5 9.15 1.8 26.50 21.8 - - - - '' Cl 1 Tails 10.5 2.8			Rougher:	0.5;	Cleaner	2: 0.	25						
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 = Pulp (% solids) 20 pH 6 Secondary grind min 5 (after Cleaner 1) $%$ -325 m 96.5 (approx.) RESULTS Wt SrS04% Cac03%(LOI) Si02% Fe203% Ca% Products % Anal Distn Anal <					-			<u></u>					
$\begin{array}{c c c c c c c c c c c c c c c c c c c $			Rougher:	0.5;	$\frac{\text{Uleaner}}{\sqrt{1-2}}$	<u>∠:</u> ∪.			1 2 01	00000 2	. 2 . 0	h = 0	
$\begin{array}{c c c c c c c c c c c c c c c c c c c $			Kougner:	0 X U.	4 - 3.2			x 10 -	1.2 01	eaner z	. 2 . 0		
Secondary grind min 15 (after Cleaner 1) χ -325 m 96.5 (approx.) RESULTS Nt SrS04% CaC03%(LOI) Si02% Ge_03% Ca% RESULTS Wt SrS04% CaC03%(LOI) Si02% Fe203% Ca% Celestite Conc 24.6 99.90 43.6 1.59 2.8 0.33 0.31 0.46 0.46 " Cl 4 Tails 4.4 96.00 7.5 8.10 2.6 - <td></td> <td></td> <td></td> <td>······</td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td>				······									
$ \begin{array}{c c c c c c c c c c c c c c c c c c c $								r Clean					
$\begin{array}{c c c c c c c c c c c c c c c c c c c $			<u></u>										
Products % Anal Distn Anal </td <td></td> <td>1</td> <td> </td> <td></td> <td>1</td> <td></td> <td></td> <td>فنظام شكاه والمواد المواد</td> <td>1</td> <td>- "</td> <td></td> <td></td>		1			1			فنظام شكاه والمواد المواد	1	- "			
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 - <t< td=""><td></td><td>4</td><td>1</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></t<>		4	1										
'' Cl 4 Tails 4.4 96.00 7.5 8.10 2.6 - - - 1 1 '' Cl 3 Tails 10.9 82.70 16.1 14.10 11.1 - - - 1 1 '' Cl 2 Tails 23.2 68.50 28.2 16.65 27.6 - - - 1 1 '' Cl 1 Tails 11.5 9.15 1.8 26.50 21.8 - - - 1	Products	1			<u>├</u>			Distn	t	Distn		1	
'' Cl 3 Tails 10.9 82.70 16.1 14.10 11.1 - - Image: Constraints - - Image: Constraints - - Image: Constraints - Image: Constraints - Image: Constraints - - - <	Celestite Conc	24.6	99.90	43.6	1.59	2.8	0.33		0.31	·	0.46	<u> </u>	
'' Cl 3 Tails 10.9 82.70 16.1 14.10 11.1 - - Image: Constraint of the state	" Cl 4 Tails	4.4	96.00	7.5	8.10	2.6	-					<u> </u>	
'' Cl 1 Tails 11.5 9.15 1.8 26.50 21.8 - - - Image: Constraint of the state of the sta	" Cl 3 Tails	10.9	82.70	16.1	14.10	11.1	-		-				
Rougher Tails 25.4 6.30 2.8 18.65 34.1 57.90 7.51 Image: Constraint of the second	" Cl 2 Tails	23.2	68.50	28.2	16.65	27.6	-		-				
Feed (calcd) 100.0 56.42 100.0 13.94 100.0 100.0 13.94 100.0	" Cl l 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	1	24.50		3.65		2.81		

Primary grind min 15 X -325 m 15 Magnetic separation 74.0 Plates None Amps - Amps - Runs - Cleanings - Flotation - Sodium Silicate (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) X -325 m 96.5 RUSUITS Wt SrSoux% CaC03%(IOI) Sidoga 7.0 9.30 '' Cl 4 Tails 4.4 9.1 59.90 '' Cl 2 Tails 9.1 '' Cl 1 Tails 8.2 '' Cl 1 Tails 8.2 '' Cl 1 Tails 43.1 26.90 20.4 '' Cl 1 Tails 43.1 '' Cl 1 Tails 43.1 '' Cl 1 Tails 8.2 '' Cl 1 Tails 8.2 ''					· .	<u>ہ</u> ۔ ۔			-			
$\begin{array}{ c c c c c c c c c c c c c c c c c c c$						•					÷	
Primary grind min 15 X -325 m 15 Magnetic separation 74.0 Plates None Amps - Amps - Runs - Cleanings - Flotation - Sodium Silicate (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) X -325 m 96.5 RUSUITS Wt SrSoux% CaC03%(IOI) Sidoga 7.0 9.30 '' Cl 4 Tails 4.4 9.1 59.90 '' Cl 2 Tails 9.1 '' Cl 1 Tails 8.2 '' Cl 1 Tails 8.2 '' Cl 1 Tails 43.1 26.90 20.4 '' Cl 1 Tails 43.1 '' Cl 1 Tails 43.1 '' Cl 1 Tails 8.2 '' Cl 1 Tails 8.2 ''	Test No.		·			1	.0					
$\begin{array}{c c c c c c c c c c c c c c c c c c c $	CONDITIONS								-			
$\begin{array}{c c c c c c c c c c c c c c c c c c c $	Primary grind min											
Plates None Amps - Runs - Cleanings - Flotation - Sodium Silicate (lb/ton) - Citric acid (lb/ton) - Quebrarho (lb/ton) - Igepon T-33 (lb/ton) Rougher: $6 \times 0.4 = 2.4$; Cleaner 1: $4 \times 0.4 = 1.6$ Pulp (% solids) - 20 - pH - Secondary grind min - X=325 m - 20 - Products % X Anal Distn Anal Products % X Anal Distn Anal Distn </td <td></td> <td>1</td> <td></td>		1										
Plates None Amps - Runs - Cleanings - Flotation - Sodium Silicate (lb/ton) - Citric acid (lb/ton) - Quebrarho (lb/ton) - Quebrarho (lb/ton) - Pulp (% solids) - PH - Secondary grind min - X -325 m 96.5 ZESULTS Wt Products % Anal Distn Anal Distn Anal Distn Anal Oldestive Conc 30.0 100.0 52.6 0.34 0.8 0.30 0.24 0.80 " C1 4 Tails 4.4 90.80 7.0 9.30 3.4 -						74.	0					
Runs - Cleanings - Flotation - Sodium Silicate (lb/ton) - Citric acid (lb/ton) - Quebracho (lb/ton) - Pulo (% solids) 20 PH - Secondary grind min 15 (after rougher) $% -325$ m 96.5 RESULTS Wt Products $\%$ Anal Distn Anal Distn Anal Distn Anal Celestite Conc 30.0 100.0 52.6 0.34 0.8 0.30 0.24 0.80 " Cl 4 Tails 5.2 74.80 6.8 15.00 6.5 -						Non	e					
$\begin{array}{c c c c c c c c c c c c c c c c c c c $	Amps					-						
Flotation - Sodium Silicate (1b/ton) - Citric acid (1b/ton) - Quebracho (1b/ton) - Igepon T-33 (1b/ton) Rougher: $6 \ge 0.4 = 2.4$; Cleaner 1: $4 \ge 0.4 = 1.6$ Pulp (% solids) 20 pH - Secondary grind min 15 (after rougher) $\chi = -325 m$ 96.5 RESULTS Wt SrS04 χ CaC03 χ (LOI) Si0 $_2\chi$ Fe $_20_3\chi$ Ca χ 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 -	Runs					-	, 					
Sodium Silicate (lb/ton) - Cttric acid (lb/ton) - Quebracho (lb/ton) Rougher: 6 x 0.4 = 2.4; Cleaner 1: 4 x 0.4 = 1.6 Pulp (% solids) 20 pH - Secondary grind min - χ -325 m 96.5 RESULTS Wt Products % Anal Distn Anal Distn Anal Distn Anal V 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 -										. <u></u>	<u></u>	
Citric acid (lb/ton) - Quebraho (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) χ -325 m 96.5 RESULTS Wt SrS0 $_{\mu}$ % CaC0 $_{3\%}(LOI)$ Silo $_{2\%}$ Fe20 $_{3\%}$ Calestire Conc 30.0 100.0 52.6 "C1 4 Tails 4.4 9.1 52.7 "C1 2 Tails 9.1 9.1 59.90 "C1 1 Tails 8.2 25.00 3.6 20.00 10.1 43.1 26.90 20.2 10.0 10.1 11.43.1 5.89 10.1 10.1 10.1 10.1 10.1 10.1 10.0 10.1 10.0 10.1 10.0 10.1 10.0 10.1 10.0 10.1 10.0 10.1 10.0 10.1					<u></u>							
Quebracho (lb/ton)						• ••• · · · · · · · · · · · · · · · · ·			<u></u>			
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 96.5 X -325 m 96.5 RESULTS Wt SrSO ₄ % CaC0 ₃ %(LOI) SiO ₂ % Fe ₂ O ₃ % Ca% RESULTS Wt SrSO ₄ % CaC0 ₃ %(LOI) SiO ₂ % Fe ₂ O ₃ % Ca% Image: 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 - 1 1 " Cl 2 Tails 9.1 59.90 9.6 18.60 14.1 - 1 1 Rougher Tails 43.1 26.90 20.4 17.10 61.1 43.1 5.89 1 Feed (calcd) 100.0 56.92 100.0 12.02 100.0 12.02 100.0 12.02 100.0						-	, 					
$\begin{array}{c c c c c c c c c c c c c c c c c c c $	Quebracho (1b/ton)		Densta	6 - 0	1-21	-	0 1 . <i>l</i> .	<u>~ 0 / -</u>	= 1 6			
$\begin{array}{c c c c c c c c c c c c c c c c c c c $	lgepon T-33 (lb/ton)		Rougner:	<u>, 0 x 0.</u>	4 - 2.4			X U.4 -	<u> </u>	•		
Secondary grind min 15 (after rougher) $\chi -325 \text{ m}$ 96.5 ESULTS Products $\chi' SrSo4\chi' CaCO3\chi(LOI) SiO2\chi' Fe2O3\chi' Ca% 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 - $		·	<u></u>					<u> </u>				
96.5 $\chi = 325 \text{ m}$ Wt SrSO ₄ % CaCO ₃ %(LOI) SiO ₂ % Fe ₂ O ₃ % Ca% Products % Anal Distn Anal							-	r rough	<u>عم ا</u>			
n 325 m Wt $SrSO_4\%$ $CaCO_3\%(101)$ $SiO_2\%$ $Fe_2O_3\%$ $Ca\%$ RESULTS $\%$ $Anal$ Distn Anal Distn Analysis Celestice Conc 30.0 100.0 52.6 0.34 0.8 0.30 0.24 0.80 0.24 0.80 0.24 0.80 0.24 0.80 0.24 0.10 0.24 0.10 0.10 0.10 0.10 0	Secondary grind min		·								<u></u>	
Products % Anal Distn Anal Distn <t< td=""><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td>1</td><td></td><td></td><td>and the second second</td></t<>									1			and the second second
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 -										03%		, <u> </u>
'' C1 4 Tails 4.4 90.80 7.0 9.30 3.4 -	Products	%	Anal	Distn	Anal	Distn	Anal	Distn	Anal	Distn	1	
"Cl 4 Tails 4.4 90.80 7.0 9.30 3.4 - <	Celestite Conc	30.0	100.0	52.6	0.34	0.8	0.30		0.24		0.80	
'' Cl 2 Tails 9.1 59.90 9.6 18.60 14.1 - <t< td=""><td></td><td></td><td></td><td></td><td>9.30</td><td>3.4</td><td></td><td></td><td></td><td></td><td></td><td></td></t<>					9.30	3.4						
"CllTails 8.2 25.00 3.6 20.60 14.1 - Image: Cll Tails Image: Cll Tails<	" Cl 3 Tails	5.2	74.80	6.8	15.00	6.5	_			<u> </u>		
Rougher Tails 43.1 26.90 20.4 17.10 61.1 43.1 5.89	". Cl 2 Tails	9.1	59.90	9.6	18.60	14.1	-		 			
Feed (calcd) 100.0 56.92 100.0 12.02 100.0 100.0	" Cl l Tails	8.2	25.00			<u> </u>			ļ			<u> </u>
	Rougher Tails	43.1	26.90	20.4	17.10	61.1	43.1		5.89			ļ
	·			ļ	<u> </u>	<u> </u>		· · · · ·			_ <u>_</u>	<u> </u>
					<u> </u> .	 			 	 		<u> </u>
Feed (assay) 57.20 12.50 24.50 3.65 2.81	Feed (calcd)	100.0		100.0	1	1			·			<u> </u>
	Feed (assay)		57.20	<u> </u>	12.50	<u> </u>	24.50		3.65		2.81	<u> </u>
							. •					
							r			•		

Test No.	12											
CONDITIONS												
Primary grind min	15											
% -325 m	ĺ		74.0									
Magnetic separation		' None										
Plates												
Amps					-							
Runs					-	•	~					
Cleanings					-							
Flotation							•					
Sodium Silicate (1b/ton)			· · · · · · · · · · · · · · · · · · ·		-							
Citric acid (1b/ton)					-				<u></u>			
Quebracho (1b/ton)		Develo	:: 4 x	0 6 - 0		·····						
*Igepon T-33 (lb/ton)		Kougner	4 X ·	0.0 - 2		20				· · · · · · · · · · · · · · · · · · ·		
Pulp (% solids)		20 6										
pH		-										
Secondary grind min % -325 m		<u>15 (after rougher)</u> 96.5										
~ 525 ili	, ,					Carlos and a second state (Second						
RESULTS Wt		SrSO		CaCO ₃ %			2%		203%		a%	
Products	%	Anal	Distn	Anal		Anal	Distn	Anal		Anal	Distn	
** Selestite 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	
	100.0	57.00	100.0	12.90	100.0	23.05		2 1/	100.0	3.24	100.0	
Feed (calcd)	100.0	57.00	100.0		100.0		L00.0				1200.0	
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.

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Test No.				13							
CONDITIONS											
Primary grind min	15										
% -325 m		,,,,,,,			74.0						
Magnetic separation					None						
Plates					-						
Amps					**						
Runs	· · · ·				-			·			
Cleanings		-									
Flotation								•			
Sodium Silicate (1b/ton)											
Citric acid (1b/ton)											
Quebracho (1b/ton)											
*Igepon T-33 (lb/ton)		Rougher	c: 4 x	0.6 = 2		aner 1:	0.4				
Pulp (% solids)					20						
рН	6										
Secondary grind min		15 (after rougher)									
% -325 m		96.5									
RESULTS	Wt	SrSC	SrS04% CaCO3%(LOI) SiO2% Fe2O3%			Ca7	Ca%				
Products	%	Anal	Distn	Anal	Distn	Anal		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
	1					 		 			
Feed (calcd)	100.0	56.21	100.0	-	-	24.85	100.0		100.0		100.0
Feed (assay)		57.20		12.50		24.50	ļ	3.65		2.81	

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

DN		APPENDIX F <u>Analyses - Te</u> <u>Kaiser Minerals, Ca</u>	<u>est 3</u>	1.	
COPIES TO	G. A. Tyler	- кс 1085	DATE FROM AT SUBJECT	June 29, 1970 D. L. Stein CFT B-354 Julian Ottawa Celestite Flotation Sample Analyses	
	S. D. Shopher M. L. Spealman J. A. Thompson L. J. Trew R. L. Coatney L. M. Housh M. L. Van Dreser	 KC 1041// El Dorado, 4th Fl. El Dorado, 4th Fl. El Dorado, 4th Fl. El Dorado, 4th Fl. CFT B-134 CFT B-114 CFT A-414 			n

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	%Sr0	\$BaO	%CaO	%SiO2
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 I (970) APPENDIX C

nalyses - Concentrates. Tests 2. 3 &

Mineral Sciences Division, Mines Branch

Test Report AC-

Internal Report MS-AC- 71-105

Date: Mar. 8, 1971 ,

Sample Description: Celestite as received

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

Jur Lab. Oz/ton Oz/tor % %. % % % % Product No. Tot. S Sr Ca 16.61 1.00 44.90 Flot. tost #2, Celestite conc. 1157 45.52 Flot. test #3, 16.55 0.76 1158 45.08 16.18 1.46 Flot. tost #4, **1**159

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.

pproved: 60 Charett	Analyst; R. Craig
Section Head Chief Chemist	
opies to: 1 Mr. R.A. Wyman	4. Divisional Files
2	5. Section Files

APPENDIX D

Certificates of Analysis

Bondar-Clegg & Company Ltd.

pages 1 - 15

BONDAR-CLEGG & COMPANY LTD.

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

CERTIFICATE OF ANALYSIS

TO Mr. R.A. Wyman

Head, Industrial Minerals

Milling Section, 40 Lydia St. Ottawa 1, Ontario

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

	%	7/0	%	%	%	%	%		
MARKED	Ba	S0₄/S	Si0,	Fe ₂ 0 ₂	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	\backslash	
Celestite Conc l		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		A A A A A A A A A A A A A A A A A A A
Rougher Tails		13.4					6.1_		
Mags 25 amps		8.5					7.4		
Celestite Conc	\sim 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		<u> </u>			4.2	Į	•

NOTE: Rejects retained two weeks 1) April 1, 1971 additions for clarification. Pulps retained three months unless otherwise arranged.

Walkens Bach

DATE May 25, 1970

geologists • geochemists • assayers • analytical chemists

		BONDAF	l-CLEGG		FAST ROAD			A 8, ONTARIO TELEX: 013-3548	<u></u>
			CERTIF	FICATE C				IELEA: 015-5548	
TOMr. R.A.	Wuman				2)	1010	DED		-122-70
				(1460	-, .				
•••••••••••••••	••••••••••••••••••••••••••••••••••••••						DAI		
I hereby certify that th			ts of analyses	made by us	upon the her	ein describ	ed		. samples
		%	%	%	%	%	%	%	
MARKED -		Ba	so ₄ /s	Si0 ₂	Fe203	Ca	* T/Sr	** T/Sr	
Rougher Tails			3.9					4.7	· Flotation Test
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	- +	Analysis	28.3			22	.5/22.5	19.4	Screen Test 4

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geologists \circ geochemists \circ assayers \circ analytical chemists

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	I I	BONDAR	-CLEGG	& COM	PANY I	.TD				
					FAST ROA), OTTAWA		RIO	
· .			CERTIF		OF ANAL	YSIS				
TOMr. R.A. Wyn	nan						REPO	DRT NO	A-139	9–70
Head, Indus	trial Mi	nerals					DAT	Ε	_May_2	5, 1970
Milling Sec I hereby certify that t					upon the he	erein describ	edflot	ation	samp	ples
MARKED		%	%	%	%	%	% **	%		
MANNED	• ,	so ₄ /s	si0 ₂	Fe_20_3	Ca	T/Sr	T/Sr	Ba		
Mags 25 amps (cleaned) Rougher Tails Celestite Conc. #1 Cl Tail #2 Cl Tail #3 Cl Tail		1.96 2.16 45.6 3.18 12.2 23.4	2.28	0.33	1.28	43.4 1.57 8.3 18.4	1.32 1.04 44.4 1.72 8.3 16.8	R.A.	•	Flotation Test 5

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

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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

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

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

0 ₄ /s	1			%	%	%			4
~4/	$\mathrm{Si0}_2$	Fe_20_3	Ca	* T/Sr	** T/Sr	Ba			
50.1				43.2				•	Test 3
2.03	37.2	17.0	5.99	1.54	1.14				Test 4
2.08	61.0	4.83	2.83	1.55	1.02				
45.2	1.20	0.29	0.65	42.7	42.8	R.A.			
3.4	52.9	6.26	4.70	2.8	2.22				
20.5	21.4	3.65	7.74	19.4	14.7				
31.7	9.9	2.37	5.85	30.0	24.5				
-									
	2.03 2.08 45.2 3.4 20.5	2.03 37.2 2.08 61.0 45.2 1.20 3.4 52.9 20.5 21.4	2.03 37.2 17.0 2.08 61.0 4.83 45.2 1.20 0.29 3.4 52.9 6.26 20.5 21.4 3.65 31.7 9.9 2.37	2.03 37.2 17.0 5.99 2.08 61.0 4.83 2.83 45.2 1.20 0.29 0.65 3.4 52.9 6.26 4.70 20.5 21.4 3.65 7.74 31.7 9.9 2.37 5.85	2.03 37.2 17.0 5.99 1.54 2.08 61.0 4.83 2.83 1.55 45.2 1.20 0.29 0.65 42.7 3.4 52.9 6.26 4.70 2.8 20.5 21.4 3.65 7.74 19.4 31.7 9.9 2.37 5.85 30.0	2.03 37.2 17.0 5.99 1.54 1.14 2.08 61.0 4.83 2.83 1.55 1.02 45.2 1.20 0.29 0.65 42.7 42.8 3.4 52.9 6.26 4.70 2.8 2.22 20.5 21.4 3.65 7.74 19.4 14.7 31.7 9.9 2.37 5.85 30.0 24.5	2.03 37.2 17.0 5.99 1.54 1.14 2.08 61.0 4.83 2.83 1.55 1.02 45.2 1.20 0.29 0.65 42.7 42.8 R.A. 3.4 52.9 6.26 4.70 2.8 2.22 20.5 21.4 3.65 7.74 19.4 14.7 31.7 9.9 2.37 5.85 30.0 24.5	2.03 37.2 17.0 5.99 1.54 1.14 2.08 61.0 4.83 2.83 1.55 1.02 45.2 1.20 0.29 0.65 42.7 42.8 R.A. 3.4 52.9 6.26 4.70 2.8 2.22 20.5 21.4 3.65 7.74 19.4 14.7 31.7 9.9 2.37 5.85 30.0 24.5	2.03 37.2 17.0 5.99 1.54 1.14 2.08 61.0 4.83 2.83 1.55 1.02 45.2 1.20 0.29 0.65 42.7 42.8 R.A. 3.4 52.9 6.26 4.70 2.8 2.22 20.5 21.4 3.65 7.74 19.4 14.7 31.7 9.9 2.37 5.85 30.0 24.5

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

BONDAR-CLEGG & COMPANY LTD.

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BONDAR-CLEGG & COME	geologists • geochemists • assayers • analytical chemists
768A BELE PHONE: 237-3	AST ROAD (M.R. 1), OTTAWA 8, ONTARIO TELEX: 013-3548
CERTIFICATE C)FANALYSIS
TO Mr. B.A. Wyman	REPORT NO
. Head, Industrial Minerals	DATEJune 8, 1970
. Milling Section, .40 Lydia Street, OTTAWA	l, Ontario.

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

MARKED	70	%	<i>¶</i> 0.	%	%	%	
MARKED	T/Sr	504/S	Si02	Fe_20_3	Ba	Ca	
35 Mags 36 Rougher Tails	1.6	2.24				•	Kaiser Celestite Flotation Test 6
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 l Tails	2.3	. 3.6					
41 Conc.	41.7	49.6	0.74	0.23	0.9	0.98	

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

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BONDAR-CLEGG & COMPANY LTD.

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

CERTIFICATE OF ANALYSIS

TO Mr. R.A. Wyman

B

 REPORT NO.
 A-148-70

 DATE
 June 8, 1970

Head, Industrial Minerals

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

MARKED	%	. %	%	%	1/0	1/2	
	T/Sr	s04/s	Si02	Fe203	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 l 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					٢٢
Cl 3 Tails	+),	31.8					11 -
Celestite Conc.		46.6			1.0		Flotation Test

NOTE: Rejects retained two weeks

Pulps retained three months un-+) Will be re-analyzed. less otherwise arranged.

BONDAR-CLEGG & COMPANY LTD.

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

MARKED	%	%	%	%	%	%	
MARKED	T/Sr	S04/S	Si02	Fe ₂ 03	Ba	Ca	
49 Mags 50 Celestite Conc. 51 Cl 3 Tails 52 Cl 2 Tails	2.0 41.1 27.9 24.2	2.51 48.2 32.4 27.8	1.87 Telepho	ne 0.44	0.6	2.50	Flotation Test 8 MP-IM-7002
53 Cl l Tails 54 Rougher Tails	2.4 1.5	2.6					
· ·							
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BONDAR-CLEGG & COMPANY LTD.

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

k. Dienstlech

DED

DATE June 8, 1970

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				FAST ROAD		OTTAWA 8, ON TELEX: 0		
		CERTIF		DFANALI	'SIS	. ·		
TO . Mr. R.A. Wyma	an,			·		REPORT NO.	A-178	-70
Head, Industr	rial Minerals,					DATE	July 6	, 1970
Milling Sect I hereby certify that	ion, 40 Lydia S the following are the resul				in described .	celestit	e	uples
MARKED	16°	%	%	%				
	si0 ₂	Fe203	Ca	s0,/s				MP-IM-7002
55 Celestite Conc.	0.33	0.31	0.46				•	Flotation test 9
56 Rougher Tails	57.9	7.51						11
57 Celestite Conc.	0.30	0.24	0.80					Flotation test 10
58 Rougher Tails	43.1	5.89						11 II
59 Celestite Conc.	0.71		1.54					Flotation Test 11
60 Cl 4 Tails	3.94							
61 Cl & Tails	16.8							
.62 Cl 2 Tails	9.63		·					
63 Cl l Tails	42.1							
64 Rougher Tails	57.6	- -						
65 Celestite Conc.	0.30	h n	2.30	47.6				Flotation Test 12

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

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	BONDA	R-CLEGG	& COMI	PANY L	TD	geolo	gists o geoc	chemists • as	ssayers o analytical chemists
			768A BELF PHONE: 237-3	AST ROA		, OTTAW.	A 8, ONT. TELEX: 013-		in di Manifesta di Anglesia
		CERTIF		FANAL	YSIS				
TO Mr. R.A. Wyma	<u>m</u>	· · · · · · · · ·		•		REPO	ORT NO	A-178-	70
		• • • • • • • •	- page	e 2 -		DAT	E Ju	ly 10,	1970
I hereby certily that t	he following are the resu	lts of analyses	made by us u	upon the her	rein <u>d</u> escribe	cel	estite	samj	ples
	%	%	. %	%					
MARKED	so _µ /s	Si02	^{Fe} 2 ⁰ 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 l 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 l Tails	27.2	31.3	4.12	3•30					

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NOTE: Rejects retained two weeks Pulps retained three months unless otherwise arranged. BONDAR-CLEGG & COMPANY LTD.

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				768A BELF PHONE: 237-3		8. 1), OTTAWA 8, C telex	ONTARIO :: 013-3548	
			CERTIF	FICATE C	FANALYSIS			
TO Mr. R.A. Wy	man					REPORT N	oA-178-	70
· · · · · · · · · · · · · · · · · · ·							July 10,	
				- pag	;e 3 -			
I hereby certify the	at the followir	ng are the result	s of analyses	made by us u	pon the herein des	cribed Celesti	tesamples	
MARKED		%	%	%	%			
		soj /s	Si02	Fe203	Ca	•		
Rougher Tails		4.07	47.4	7.15	3.90		•	
			,	-				
				-				
	•							

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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 Mineral Processing Section

...40 Lydia Street, OTTAWA 1, Ontario

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

MARKED	%	%	%	%	%		 	
	S04/S	Si02	Fe ₂ 0 ₃	Ca	Ba	-		
77 Celestite ConcMags	37.8		3.21				•	Flotation Test 14
78 Celestite ConcNon Mags	48.1	1.01	0.32	1.83	1.06			11
79 Cl 4 Tails	35.6	11.67	1.90	3.75	0.65			ŦŦ
80 Cl 2 Tails	32.1	18.11	3.17	3.60	0.47			Ħ
Sl Cl 2 Tails	30.7	18.78	3.41	3.23	0.47			1t
82 Cl l Tails	i4.0	39.11	5.86	2.05	0.03			TT
83 Rougher Tails	3.40	53,98	7.25	2.95	NIL			17
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			11
86 Cl 3 Tails	35.7	15.93	2.57	4.23				87
87 Cl 2 Tails	30.9	17.66	3.49	3.24				f f •

NOTE: Rejects retained two weeks Pulps retained three months unless otherwise arranged. BONDAR-CLEGG & COMPANY LTD.

K. Jienstoach 11

DATE July 27, 1970

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	BONDAR	CIECC	& COM	DANIV I	тр	-	gists 🗢 geoche	mists o assa	ayers • analytical chemists
		-CLEGG		AST ROA			A 8, ONTAR TELEX: 013-354		
		CERTIF	FICATE C	FANAL	YSIS				
TO Mr. R.A. Wyman			- PAGE	2 -		REP	DRT NO ⁴	<u>197-7</u>	<u> </u>
									7, 1970
I hereby certify that the	following are the result	ts of analyses	made by us	upon the he	rein describ	ed Ç e	lestite	sample	es
MARKED	%	%	%	%	%				
MARKED	S04/S	Si02	Fe ₂ 03	Ca	Ba				
38 Cl l Tails	12.0	40.43	6.22	2.47				•	Flotation Test 15
39 Rougher Tails	~ 3.07	55.51	7.17	2.53					17
00 Celestite Conc.	47.0	0.84	0.40	1.65	1.00				Flotation Test 16
Ol Cl 4 Tails	36.3	0.73	1.70	4.50					17
92 Cl 3 Tails	31.6	7.22	2.69	5.87					T
93 Cl 2 Tails	25.8	15.92	3.96	3.38					25
94 Cl l Tails	9,50	41.27	6.69	2.19					Ť2
95 Rougher Tails	2.61	56.37	7.33	2.42	NIL				ŵ
		,							

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

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BONDAR-CLEGG & COMPANY LTD.

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	PON		ECC	•- СОМ			-			sayers • analytical chemists
	BON.	DAR-CL			FAST ROAL	D (M.R. 1),			RIO	
		CE	ERTIF	ICATE C	DFANAL	YSIS				
TO Mr. R.A. Wym					REPO	ORT NO.	A-217-	-70		
Industrial M	ction	•,			DAT	e Augu	st 12,	1970		
40 Lydie St.	, OTTAWA 1,	Ontario	.							
I hereby certify that		••••••		made by us	upon the her	rein describe	d celes	stite	samp	oles
	70		76	%	7/0					
MARKED	Soj	/S S:	i0 ₂	Ca	Ba					
96 Celestite Conc.	Ц8.	4 0	.31	1.48	0.74				•	Flotation Test 17
97 Cl 4 Tails		2	.65	4.98						ti .
98 Cl 3 Tails		7	.30							Ħ
99 Cl 2 Tails		17	.14							Π
100 Cl 1 Tails		4	3.16							11
101 Rougher Tails	2.	55 55	.87							11
102 Celestite Conc.	48.	6 0	•59	1.05	0.66					Flotation Test 18
.103 Cl l Tails		3	9.44	2.86						п
104 Rougher Tails	6.	87 48	.80	2.82						11
105 Celestite Conc.	48.	7 1	.22	1.15	0.95					Flotation Test 19.
106 Cl 4 Tails	Ц <u>т</u> .	5.6	.46	3.35	1.04					11

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

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K. Ji ens Veach

BONDAR-CLEG	G & COMPANY LTD	geologists o geochemists o assayers o analytical chemists
	768A BELFAST ROAD (M.R. 1 PHONE: 237-3110	1), OTTAWA 8, ONTARIO TELEX: 013-3548
CERT	IFICATE OF ANALYSIS	
TO Mr. R.A. Wyman		REPORT NO. <u>A-217-70</u>
	- PAGE 2 -	DATE August 12, 1970

MARKER	Ÿ0	%	0/0	%			
MARKED	Soj/S	Si02	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		0.57			11
109 Cl l Tails	19.3	35.01	2.94	0.19			tt
110 Rougher Tails	6.97	47.85	3.20	NIL			11 .
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NOTE: Rejects retained two weeks Pulps retained three months unless otherwise arranged.

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U. Jienstoach

		768A BE PHONE: 23		1), OTTAWA 8, ONTA TELEX: 013-1	ARIO
	C	ERTIFICATE	OFANALYSIS		
TO Mr. R.A. Wyman	, Head			REPORT NO.	A-222-70
Industrial Min	erals Milling S	Section		DATE	July 27, 1970
40 Lydia Stree I hereby certify that the	following are the results of		s upon the herein descr	ribed celestite	samples
MARKED	96				
MARKED	Ba				
elestite Conc.	0.82				Test ll
elestite Conc.	0.66				Test 12
elestite Conc.	0.62				Test 13

NOTE: Rejects retained two weeks Pulps retained three months un-less otherwise arranged.

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Wienstfeech

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APPENDIX E

Heavy Liquid Separations

Methylene Iodide: S.G. 5.33

Test No	Fraction	Sinks %
1	Concentrate 1	99.06
2	Concentrate	97.89
4	Concentrate	95.15
5	Concentrate	94.35
6 6	Concentrate Cl 4 Tails	97.70 94.42
7 7	Concentrate Cl 4 Tails	96.96 95.38
8 8	Concentrate Cl 3 Tails	97.26 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)

(π.)	lligrams per litre)	
Location	Ottawa	Ottawa
Source of Water	Ottawa River	
Sampling point	Tap - Lemieux Island	Tap - 45 Spencer Street
Reference		
Laboratory Number	3048	3602
Date of Sampling Date Sample Received	2-12-66	10-3-71
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 (CaCO3)	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) Chloride (Cl)	0.0 3.5	0.0
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 (CaCO3)	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)	/.9	<u> </u>
Phosphate Ortho (PO_A)		
Phosphorus Total (PO4)		
Potassium (K)	0.7	0.8
Residue, Filterable		
Residue, Fixed Filterable		
Residue, Nonfilterable		
Residue, Fixed Nonfilterable		
Silica (SiO ₂)	4.7	5.6 2.4
Sodium (Na)		144
Specific Conductance (jumhos/cm at 25 ⁰) Sulphate (SO ₄)	28.0	31.1
Turbidity (Jackson Units)		0.5
Zinc (Zn) (Total)	0.004	
	•	
	74.5	85.0
Sum of Constituents		7.7
% Sodium Saturation Index at Test Temperature	7.5	-0.8
Stability Index at Test Temperature	9.9	9.4
Sodium Absorption Ratio (SAR)	0.1	0.1
Carbon Dioxide. Calculated (CO2)	1.0	0.8
Carpon Droxide, Carculated [602]		
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** From date of sampling to testing