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"THE BEHAVIOUR OF SOME REAGENTS IN NON-SULFIDE FLOTATION"

A Thesis Presented as Partial
Requirement for the Degree

of

Master of Applied Science

in the Dept of Metallurgy.

by

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April, 1940.

Accepted as a Master's Thesis by the Department of Mining and Metallurgy

October 19, 1945.

Head of Department

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ACKNOWLEDGEMENT

The writer wishes to express his thanks to all those who have assisted in any way in doing this work.

The work was carried on under the supervision of Mr. G. A Gillies, Professor of Ore Dressing, at the University of British Columbia, and to him the author expresses sincerest appreciation for help and advice.

The assistance of Mr. A. G. C. Lyle, who worked as the author's colleague during the earlier part of this work, cannot be overestimated. Many of the ideas worked out in this thesis are his, and of his unfailing energy and capacity for work too much cannot be said.

To Mr. F. A. Forward, Assistant Professor of Metallurgy, University of British Columbia, many thanks are due for help and advice in assaying.

FORWORD

The research which is described in this report was begun as an effort to carry on the work of Elfstrom and Dayton in the field of Non-Sulfide Flotation, carried on during the previous University term.

During the course of their research they made numerous tests, using various reagents, to investigate the separation by flotation of silica, barite, and calcite. For the sake of simplicity in preliminary investigation, they used a synthetic ore, composed of crushed barite and limestone, and pure silica sand.

An examination of their report showed that they had made an excellent survey of the usefulness of various reagents in the flotation of the above minerals. However, as they covered a great deal of ground in the course of their work, they did not make a very full investigation of the action of any of the reagents they used.

For example, in floating off a concentrate, they very often added so much reagent that the flotation of too large a bulk of concentrate prevented their obtaining a good recovery, as expressed by the Three-Mineral Index (i.e. the sum of the recovery of the desired mineral in the concentrate, and the losses of the undesired minerals to the tails). At other times the product obtained was too small to give a good recovery.

In such cases, it was seen that good recoveries might be obtained, using the same reagents, but in different amounts.

With this object in view, the author and his colleague began to check over the tests giving promise of best results.

The method used to check these results, i.e.--the removal of a number of concentrates, and the drawing of graphs, showed some very intriguing possibilities, and throughout this work more attention is paid to the method of investigation, and to its possible value as a research tool, than to the making of good separations.

CONCLUSIONS

1. By taking off a number of concentrates from a single test, smooth graphs may be plotted, showing

(a) Recovery vs. weight of concentrate.

(b) Weight of product vs. amount of reagent used.

2. With some combinations of reagents the graphs (a) above are pairs of intersecting straight lines, or, in other words, the recovery is in direct ratio to the weight of concentrate removed up to a certain point, where there is a sharp break in the curve, and the recovery varies from that point as a new direct ratio of the weight of concentrate removed.

3. The "recovery vs. weight of concentrate" curve may break either up or down, or may continue as a straight line, depending on the mineral for which the recovery is being plotted, and on the reagents used.

4. The break-points in the recovery graphs for silica, barite, and limestone may occur at very nearly the same weight of product, in which case a graph showing the Three Mineral Index for any one of the minerals will also show a sharp break-point, usually a maximum.

If the recovery graphs, when produced, pass through zero recovery at zero weight of concentrate, and through 100% recovery at full weight of product, then the Three Mineral Index graph will pass through 200 at zero concentrate, and 100 at the point where the full charge has been (theoretically) floated.

5. For combinations of reagents which give these broken lines, the maximum Three Mineral Index obtainable by varying

one reagent (frother-collector in these tests) may be found from a graph, and for this graph it may be necessary to take off only two concentrates, one on either side of the maximum index.

6. The maximum obtainable Index may always be found from the results of a single test, provided care is taken to float sufficient product to plot recoveries on both sides of the maximum.

7. When a test is run using a reagent A as a frother-collector, and reagents B and C as depressor and activator, a curve may be obtained showing directly the recoveries obtainable by floating different quantities of concentrate (by varying the amount of A).

A test may then be run using different amounts of B or C, or with addition of a new reagent D, and a single concentrate taken off. If the Three Mineral Index from this test lies above the Three Mineral Index curve from the first test, it is indicative that a higher maximum Index may be obtained with this alteration in B or C, or the addition of D, than was obtainable with the original combination of B and C.

8. A given quantity of a frothing-collection reagent brings up a larger amount of product when added all at once and a single concentrate removed, than when added in several fractions, and a concentrate removed after each addition.

9. Sodium metaphosphate is not a completely satisfactory depressor for limestone, in the presence of silica and barite, using Emulsol X-1 to float barite. Probably sodium hexa-metaphosphate will be found to be more satisfactory.

10. Grinding in an iron mill does not appear to inhibit the action of the reagents used in barite flotation.

RECOMMENDATIONS FOR FUTURE INVESTIGATION

1. More work should be done in investigation of the usefulness of the "recovery vs. weight of product" curves. Work along this line could be combined with continued research into the use of various cationic reagents in non-sulfide flotation.

The author recommends that other reagents than those used be tried, to see if the curves obtained using Lissolamine A and Emulsol X-1 can also be obtained using other reagents.

2. If possible, a commercial ore, of as simple a composition as can be obtained, should be used instead of a synthetic ore.

3. The application of the graphs used in this research to sulfide flotation should be looked into. In separation of one sulfide from an ore containing other sulfides and gangue, it is possible that the gangue minerals might be considered as a single component in plotting recoveries.

4. Regulation of the air inlet of the Fagergren cell might result in better selectivity in some tests. In the work done the air inlet was kept full open during all tests, for the sake of uniformity.

5. Regulation of PH is suggested as a possible means of obtaining a better limestone-barite separation.

REAGENTS

Lissolamine "A" (cetyl trimethyl ammonium bromide--manufactured by C. I. L.). This substance has good frothing properties, and excellent collecting properties for activated silica. It is fairly soluble in water, and was added as a water solution to the flotation cell.

Copper Sulfate--This reagent was used as an activator for silica. Experience has shown that silica will not float unless activated by a base-metal salt.

Emulsol X-1--a sulphated higher alcohol (composition not given), manufactured by The Emulsol Corporation of Chicage, Ill. This reagent was used as a collector for barite. It's chief draw-back is a definite tendency to float limestone. It needs no frother.

Sodium Metaphosphate--used as a depressor for limestone. This reagent did not seem very satisfactory. Three Mineral Index curves obtained from tests where this reagent was used were fitted in same cases by tests made by Elftom & Dayton, in which they used no depressor.

Sodium Hexa-Metaphosphate--used as a depressor for limestone. This reagent was not very fully investigated, but seems to show possibilities of being a better reagent than the metaphosphate.

Sulfonated Cod Oil--(from Cave & Co., Vancouver, B. C.). This reagent was used as a collector for barite. It seems to have some collecting action for both barite and limestone, with a marked tendency to prefer the barite in the presence of sodium metaphosphate.

PREPARATION OF THE ORE

(a) Materials.

To carry on work done by Elftom & Dayton, a synthetic ore was used. This ore was a mixture of silica sand, crushed white marble, and crushed barite. Assays on the limestone and barite were as follows:

Limestone		Barite	
$CaCO_3$	96.4%	$BaSO_4$	90.2%
$BaSO_4$	0.6	$CaCO_3$	0.6
SiO_2	3.0	SiO_2	8.1
	100.0%		98.9%

The silica sand was assumed to be free of calcite and barite, but may have contained small amounts of other silicates.

(b) Crushing.

The marble and barite were crushed in a small laboratory jaw crusher, then reduced by rolls. They were mechanically screened after each reduction until all was minus ten mesh.

The crushed limestone and barite and the silica sand were mixed in the approximate proportions of 30:30:40 respectively.

The following assays were obtained from the mixture:

$CaCO_3$	31.2%
$BaSO_4$	29.3
SiO_2	38.6
	99.1%

(c) Grinding.

For the most part, the ore was ground in a small porcelain pebble mill, inside dimensions approximately 6" long x 7½" diameter, with a charge of pebbles weighing 1425 grams.

The charge in all cases was 500 grams of ore and 500 grams of water. The grind was for 30 minutes, at 70 r.p.m. An automatic stop clock was used to time the grinding.

Two tests were ground in an iron rod mill, inside dimensions 11" x 10" diameter, with thirteen 1" rods. The grind was for 15 minutes at 44 R. P. M.

Complete screening tests were not made. A one hundred gram sample of a 30-minute pebble mill grind showed the following:

Screen Size	% Weight	Assay %		
		$BaSO_4$	SiO_2	$CaCO_3$
-200	62.9	38.9	26.5	35.1
-150,+200	23.6	18.4	51.6	29.0
+150	13.5	6.9	63.0	24.6

A sample of a rod mill grind--20 minutes at 44 R. P. M., with 13 rods, showed the following:

Screen Size	% Weight
-200	69.3
-150,+200	21.5
+150	9.2

This grind was too fine to run comparative tests with pebble mill grinds, so the tests were made on a 15-minute grind, which was assumed roughly comparable to the 30-minute pebble mill grind.

GENERAL PROCEDURE IN TESTS

1. Grinding.

The grinding process was as described in the preceding section. In some cases reagents were added to the mill (copper sulfate and sodium metaphosphate). The usual charge consisted only of 500 grams of ore and 500 grams of water. The full charge of pebbles was used at all times in the pebble mill.

When the automatic stop clock stopped the motor, the mill was unclamped from the frame, and removed to a sink. The cover was removed, and adhering pulp washed into a pan, using a fine stream of water. The pebbles were next removed from the mill (by hand) and placed on a heavy wire screen over the same pan, where the pulp was carefully washed from them. The mill was now tipped up over the pan, and the remainder of the pulp washed into the pan.

2. Floating.

(a) The Cell

The flotation cell used was a Laboratory Fagergren Flotation Machine, with a molded pyrex glass flotation chamber. The capacity was just sufficient for a 500 gram charge at 4:1 dilution.

This machine has the advantages of very simple and convenient operation and easy cleaning, but gives less opportunity of selective draining of the froth than does a Ruth flotation machine. It is also more difficult to skim.

TESTS

Test No 72 (Repeat of Test No. 8)

To pebble mill--

Ore.....500 gms.

Water.....500 gms.

$CuSO_4$.....0.50# 1ton

Grind--30 min. @ 70 R. P. M.

To cell--

Water--sufficient to give dilution 4:1

#1 Conc.

Lissolamine A 0.16# 1 ton

Conditioned 1 min.

Skimmed 3 1/3 min.

Froth--large bubbles, not plentiful.

#2 Conc.

Lissolamine A 0.16# 1 ton.

Conditioned 1 min.

Skimmed 3 1/3 min.

Froth--Smaller bubbles, fairly plentiful.

#3 Conc.

Lissolamine A 0.16# 1 ton.

Conditioned 1 min.

Skimmed 3 1/3 min.

Froth--Very fine bubbles, so plentiful that very little skimming was necessary.

Ph Conc. #1 #2 #3 = 12.0

Tails = 12.2

Wt. of Conc. #1 + #2 + #3 = 253.3 gms.

Tails = 245.2 gms.

498.5

Test	%	ASSAY %			RECOVERY %			3 Min. INDEX
72	Wt.	$BaSO_4$	$CaCO_3$	SiO_2	$BaSO_4$	$CaCO_3$	SiO_2	
Feed	100.0	27.9	29.4	42.7	100.0	100.0	100.0	
C	49.2	10.7	13.0	72.0	18.8	22.5	88.5	247.2
T	50.8	44.7	46.2	9.1	81.2	77.5	11.5	

Purpose of Test--to repeat Test #8, which gave the best 3-mineral index for Silica flotation in work done by Elfstrom & Dayton.

Summary of Test.

It was evident from the results of Test #8 that the Lissolamine A was not added all at once, but data as to how it was added was not given.

A preliminary test was run adding the full amount of Lissolamine A at the beginning. The concentrate obtained was too small to give any possibility of a good recovery, so the products were not assayed.

A test was then run adding 0.16# 1 ton Lissol. (1/3 the amount used in test #8) at a time. The first addition was not enough to give much of a concentrate. The second addition brought up a fair concentrate, which was added to the first. The final addition brought up a very heavy froth--fine bubbles --rising in the machine and overflowing the lip without skimming. This was added to the first two.

It appeared that the first addition was almost entirely

adsorbed, leaving little or none to form a froth. The second addition also left little Lissolamine to froth. On the 3rd addition enough Lissolamine appears to have accumulated in the cell to give a good froth.

The assays of the combined concentrates, and of the tails, showed an 88.5% SiO_2 recovery, and a grade of 72.0% in the concentrate (from a heads of 40% SiO_2). There was 22.5% of the $CaCO_3$ and 18.8% of the $BaSO_4$ in the conc. The 3-mineral index was 247.2--lower than for test #8.

Test No. 73

To Pebble Mill--

Ore.....500 gms.

Water.....500 gms.

$CuSO_4$.. ....0.50# / ton.

Grind--30 min. @ 70 R. P. M.

To cell--

Water sufficient to give dilution 4:1

#1 Conc.

Lissolamine A 0.24# /ton

Conditioned 3 min.

Froth poor so no skimming attempted.

Lissolamine A--0.12# / ton

Conditioned 3 min.

Skimmed 3 min.

Froth--fairly plentiful, bubbles coarse.

#2 Conc.

Lissolamine A 0.12# / ton

Conditioned 3 min.

Skimmed 3 min.

Froth--very plentiful, bubbles fine.

#3 Conc.

Lissolamine A 0.16# / ton

Conditioned 3 min.

Skimmed 2 min.

Froth--very plentiful, bubbles very fine and well mineralized for ½ min.

#4 Conc.

Lissolamine A--0.16# / ton.

Conditioned 3 min.

Skimmed 2 min.

Froth--very plentiful, bubbles very fine but poorly mineralized.

#5 Conc.

Lissolamine A--0.16# /ton.

Conditioned 3 min.

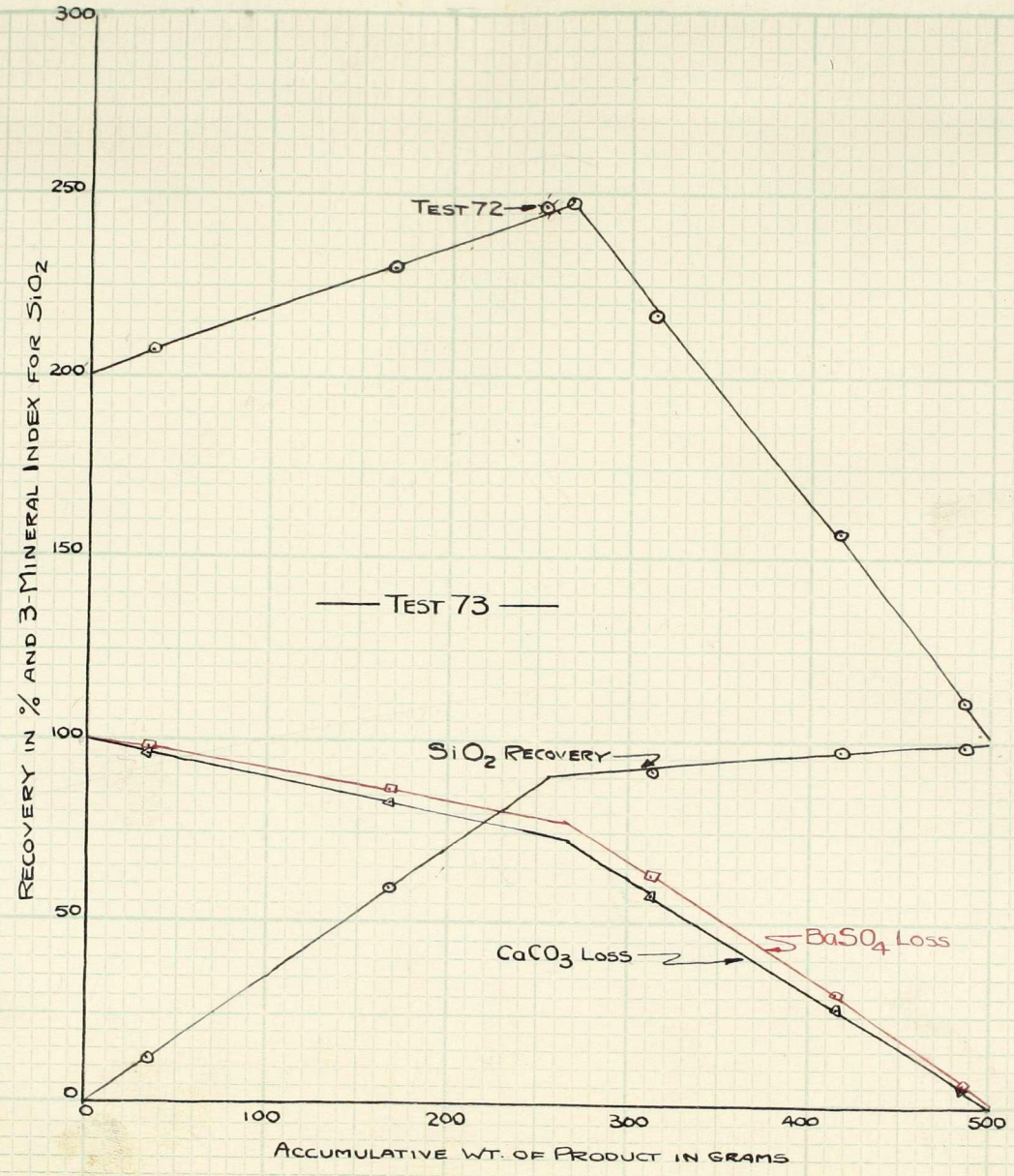
Skimmed 2 min.

Froth--very plentiful, bubbles very fine but poorly mineralized.

Conc--PH = 12.3
Tails--PH = 10.9

	Wt. (gms)	Wt. (%)	Liss.A # /ton	Assay % $BaSO_4$	Assay % $CaCO_3$	Assay % SiO_2	(Weight x Assay) Recovery Wt. $BaSO_4$	(Weight x Assay) Recovery Wt. $CaCO_3$	(Weight x Assay) Recovery Wt. SiO_2	Recovery (%) $BaSO_4$	Recovery (%) $CaCO_3$	Recovery (%) SiO_2
Conc. #1	34.0	6.8	0.36	8.2	10.9	69.7	2.8	3.7	23.7	2.0	2.8	11.7
" #2	135.4	26.9	0.12	11.2	12.6	70.0	15.2	17.1	94.8	10.8	12.8	46.7
" #3	141.5	28.0	0.16	24.5	21.3	49.2	34.7	30.1	69.6	24.6	22.6	34.2
" #4	105.0	20.8	0.16	46.5	39.9	9.6	48.9	41.0	10.1	34.7	30.8	5.0
" #5	69.4	13.7	0.16	44.6	48.2	4.6	30.9	33.4	3.2	21.9	25.1	1.6
Tails	19.1	3.8		43.9	40.4	8.3	8.4	7.7	1.6	6.0	5.9	0.8

Product	Accum. Wt. (gms)	Accum. % Wt.	Accumulative Recovery (%) $BaSO_4$	Accumulative Recovery (%) $CaCO_3$	Accumulative Recovery (%) SiO_2	Grade of Accum. Product Grade (%) $BaSO_4$	Grade of Accum. Product Grade (%) $CaCO_3$	Grade of Accum. Product Grade (%) SiO_2	3 Min. Index
Conc. #1	34.0	6.8	2.0	2.8	11.7	8.2	10.9	69.7	206.8
#2	169.4	33.7	12.8	15.6	58.4	10.7	12.3	69.9	230.0
#3	310.9	61.7	37.4	38.2	92.6	17.0	16.4	60.5	217.2
#4	415.9	82.5	72.1	69.0	97.6	24.4	21.9	47.8	156.7
#5	485.3	96.2	94.0	94.1	99.2	27.3	25.9	41.4	111.3
Tails	504.4	100.0	100.0	100.0	100.0	28.0	26.4	40.3	100.0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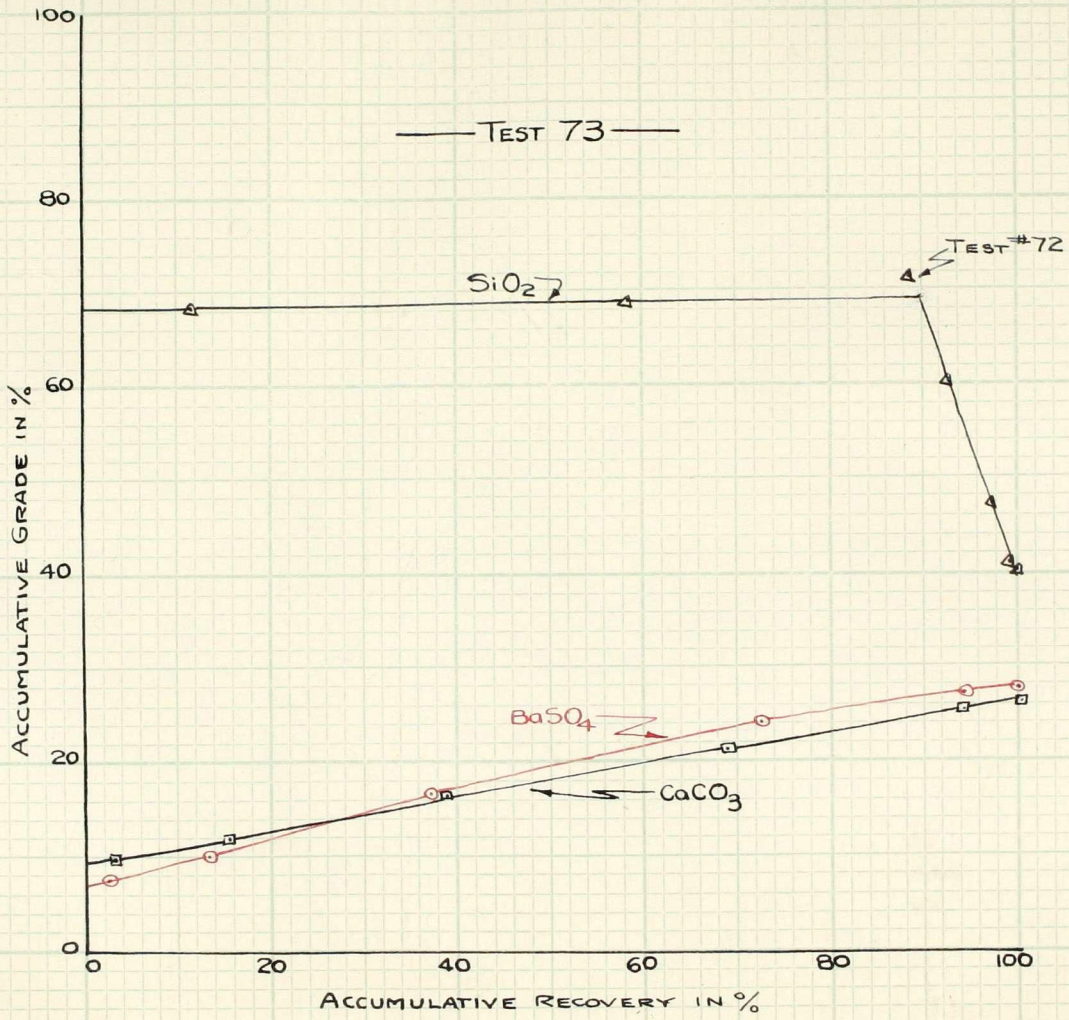
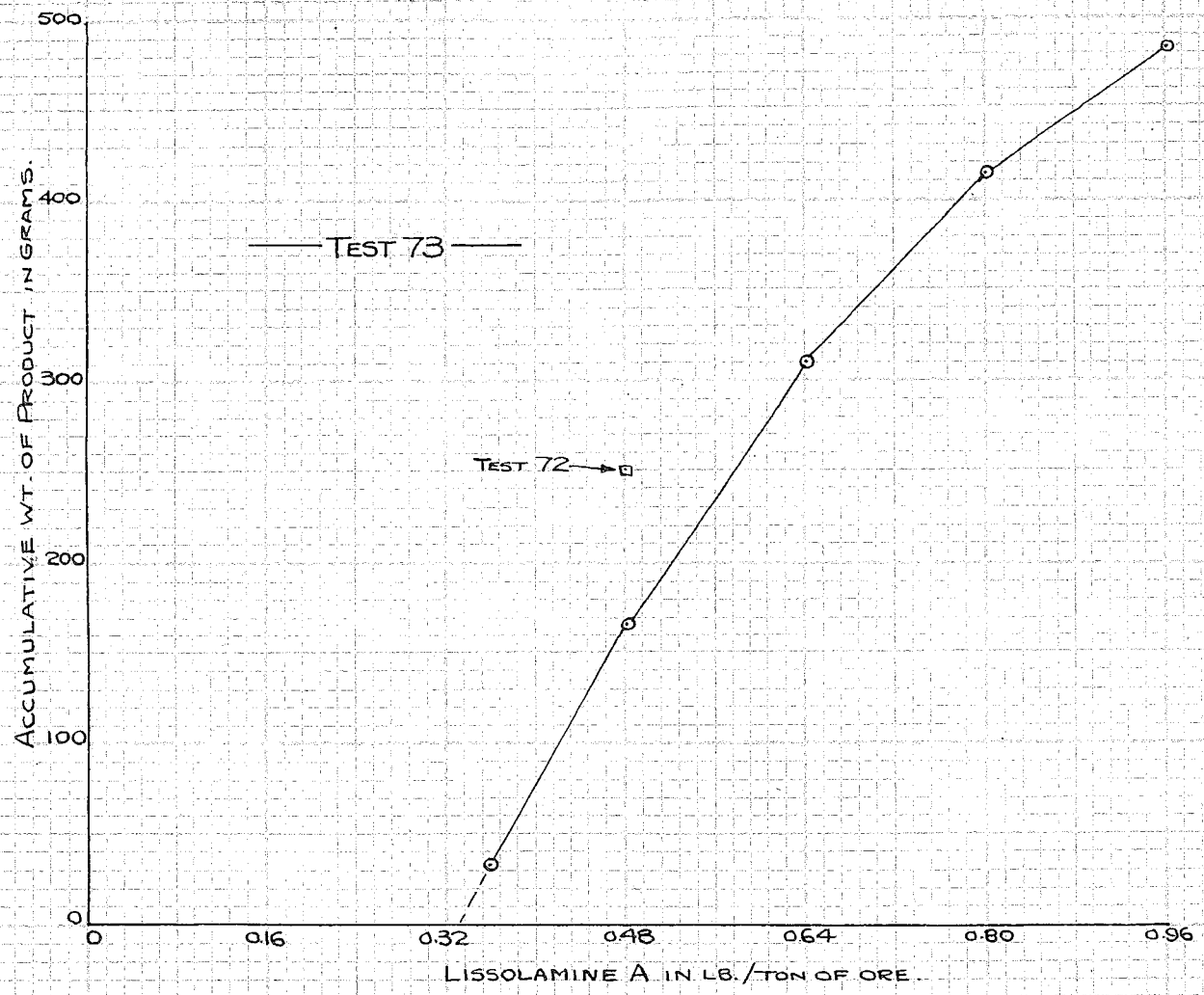
250
200
150
100
50
0
0
100
200
300
400
500
RECOVERY IN % AND 3-MINERAL INDEX FOR SiO_2
ACCUMULATIVE WT. OF PRODUCT IN GRAMS
TEST 72
TEST 73
SiO_2 RECOVERY
$BaSO_4$ LOSS
$CaCO_3$ LOSS


TEST 73
TEST #72
SiO_2
$BaSO_4$
$CaCO_3$
ACCUMULATIVE GRADE IN %
ACCUMULATIVE RECOVERY IN %
0
20
40
60
80
100


TEST 73
TEST 72
ACCUMULATIVE WT. OF PRODUCT IN GRAMS.
500
400
300
200
100
0
0
0.16
0.32
0.48
0.64
0.80
0.96
LISSOLAMINE A IN LB./TON OF ORE.

Purpose of Test

From the result of #72 it was seen that a large number of tests would have to be run to find the best possible index to be obtained using Lissolamine A as a SiO_2 collector. Therefore it was sought to devise a method by which the desired quantity of Lissolamine might be closely estimated from the results of a single test.

Summary of Test

With the above object in view, a test was run using small additions of Lissolamine at intervals, conditioning after each addition. (i.e.--equilibrium established between Liss. in sol. and Liss. reacting with interval surfaces.)

From test #72 it was seen that adding less than 0.32# /ton of Liss. would give very little recovery, but to make sure of obtaining a good series of results 0.24# /ton was added for the first concentrate, and was conditioned for 3 min. The Froth formed when the air-valve was opened was very weak and small in amount, and no skimming was attempted.

A second addition of 0.12# /ton Liss. was made, and the froth this time was fairly plentiful, with coarse bubbles. A concentrate was taken off.

For the 2nd concentrate another 0.12# /ton was added, and a very fine froth formed, rising in the cell and overflowing the lip.

Three further additions of 0.16# /ton Lissol. were made, and a concentrate taken off after each addition. Toward the end the froth, while very plentiful, was very poorly mineral-

ized.

The five concentrates and the tails were assayed.

From the results the following graphs were plotted:--

1. Grade vs. recovery for three products.
2. Lissolamine added vs. weight of product.
3. Weight of concentrate vs. 3- Min. Index.

In "1" the $CaCO_3$ and $BaSO_4$ grades increased as the recovery went up for the whole range of the tests--up to 100% recovery--in a smooth curve, nearly a straight line in both cases. The SiO_2 curve was a straight line up to about 89% recovery, but there showed a sudden break, the grade decreasing rapidly with recovery, again in approx. a straight line.

In "2" a smooth curve was obtained, showing a tendency to level off at the top--due probably to the decreasing weight of solids in the pulp.

No. 3 indicated a sharp maximum 3-mineral index, rising in a straight line to the max., and falling in a straight line again. From this graph it looked as though it might be possible to predict the best test with a given reagent by making only two concentrates and a tailing--as two points on the graph are already given by the initial index of 200 and the final index of 100.

Test No. 74

To Pebble Mill.

Ore.....500 gms.

Water.....500 gms.

Grind--30 min. @ 70 R. P. M.

To Cell.

Water to give dilution 4:1

Sod. Metaphosphate--1.0# /ton.

Conditioned 3 min.

Froth--very poor so no skimming attempted.

#1 Conc.

Emulsol(X-1) - 1 drop. (1 drop = 0.033 gm.)

Conditioned 3 min.

Skimmed ½ min.

Froth--poorly mineralized, no skimming attempted.

Emulsol X-1-1 drop.

Conditioned 3 min.

Skimmed ½ min.

Froth--fairly well mineralized.

#2 Conc.

Emulsol X-1-1 drop.

Conditioned 3 min.

Skimmed ½ min.

#3 Conc.

Emulsol X-1-2 drops.

Water--500 c. c. Conditioned 3 min. Skimmed ½ min.

#4 Conc.

Emulsol X-1-3 drops.

Water--500 c.c.

Conditioned 3 min.

Skimmed ½ min.

#5 Conc.

Emulsol X-1-3 drops.

Water--500 c. c.

Conditioned 3 min.

Skimmed ½ min.

#6 Conc.

Emulsol X-1 -3 drops.

Water--500 c.c.

Conditioned 3 min.

Skimmed ½ min.

#7 Conc.

Emulsol X-1-3 drops.

Water--500 c. c.

Conditioned 3 min.

Skimmed ½ min.

Test No. 74 (Con'd)

PH = 11.0

Prod.	Wt. (gms)	Emulsol X-1 (drops)*
Conc. #1	77.1	2
#2	58.0	1
#3	74.2	2
#4	46.9	3
#5	24.9	3
#6	4.5	3
#7	11.4	3
Tails	196.6	

* 1 drop = 0.033 gm Emulsol X-1

Product	Accum. Wt. (gms)	Drops of Emulsol X-1 (accumulative)
Conc. #1	77.1	2
#2	135.1	3
#3	209.3	5
#4	256.2	8
#5	281.1	11
#6	285.6	14
#7	297.0	17
Tails	493.6	

Purpose and Summary.

Test #71 (Elfstrom & Dayton) showed a good result using Emulsol X-1 as a barite collector, and Sodium Metaphosphate as a limestone depressor. It was run at 40°, but there was no evidence that the high temperature was responsible for the good result. It was decided to run a test using the reagents Emulsol X-1 and $NaPO_3$.

Test #74 was run to find just about where the best concentrate should lie from a curve of "Wt. of product vs. drops of

reagent". A smooth curve was obtained, and it was seen that between 3 and 4 drops should give the best result (about 150 gm) (1 dr. Em.--X-1 = 0.132# Ton.).

Test No. 75

To Pebble Mill

Ore.....500 gms.

Water..... 500 gms.

Grind--30 min. @ 70 R. P. M.

To Cell

Water to give dilution 4:1

Sod. Metaphosphate 1.0# /ton.

#1 Conc.

Emulsol X-1 -3 drops. (1drop = 0.033 gm.)

Conditioned 3 min.

Skimmed 1 min.

#2 Conc.

Emulsol X-1 -3 drops

Conditioned 3 min.

Skimmed 1 min.

#3 Conc.

Emulsol X-1 -3 drops

Water--500 grams.

Conditioned 3 min.

Skimmed 1 min.

#4 Conc.

Emulsol X-1 -3 drops

Water--800 grams.

Conditioned 3 min.

Skimmed 1 min.

#5 Conc.

Emulsol X-1 -3 drops.

Sodium metaphosphate 1.0# /ton

Water--800 grams.

Conditioned 3 min.

Skimmed 1 min.

PH--8.55

Product	Wt. (gms)	Emulsol X-1 (drops)*
Conc#1	163.2	3
#2	86.0	3
#3	42.0	3
#4	9.0	3
#5	3.3	3
Tails	193.6	

* 1 drop = 0.033 gm. Emulsol X-1

Product	Accum. Wt. (gms)	Drops of Emulsol X-1 (accumulative)
Conc. #1	163.2	3
#2	249.2	6
#3	291.2	9
#4	300.2	12
#5	303.5	15
Tails	497.1	

Purpose and Summary of Test

To check the collecting properties of $NaPO_3$ a test was run with a second addition of this reagent after 12 drops of Em-X-1 had been added. The curve obtained showed no irregularity at the point where the $NaPO_3$ was added, so it was assumed that the amount of this reagent in the pulp had little or no effect on the shape of the product-reagent graph, (provided it be present in sufficient amount to depress the ls.)

Test No. 76

To Pebble Mill.

Ore.....500 gms.

Water.....500 gms.

Grind--30 min. @ 70 R. P. M.

To Cell.

Water to give 4:1 dilution.

Sod. Metaphosphate--1.0# /ton.

#1 Conc.

Emulsol X-1 2 drops. (1 drop = 0.033 gm.)

Conditioned 3 min.

Skimmed 1 min.

Froth--plentiful, bubbles fine and well mineralized.

#2 Conc.

Emulsol X-1--1 drop.

Water--500 grams.

Conditioned 3 min.

Skimmed 1 min.

Froth--fairly plentiful, bubbles fine and fairly well mineralized.

#3 Conc.

Emulsol X-1--1 drop.

Water--500 grams.

Conditioned 3 min.

Skimmed 1 min.

Froth--plentiful, bubbles very fine but poorly mineralized.

#4 Conc.

Emulsol X-1--3 drops.

Water--500 grams.

Conditioned 3 min.

Skimmed 1 min.

Froth--plentiful, bubbles very fine and well mineralized.

#5 Conc.

Emulsol X-1--3 drops.

Conditioned 3 min.

Skimmed 1 min.

Froth--plentiful, bubbles fine but not well mineralized.

#6 Conc.

Emulsol X-1--6 drops.

Conditioned 3 min.

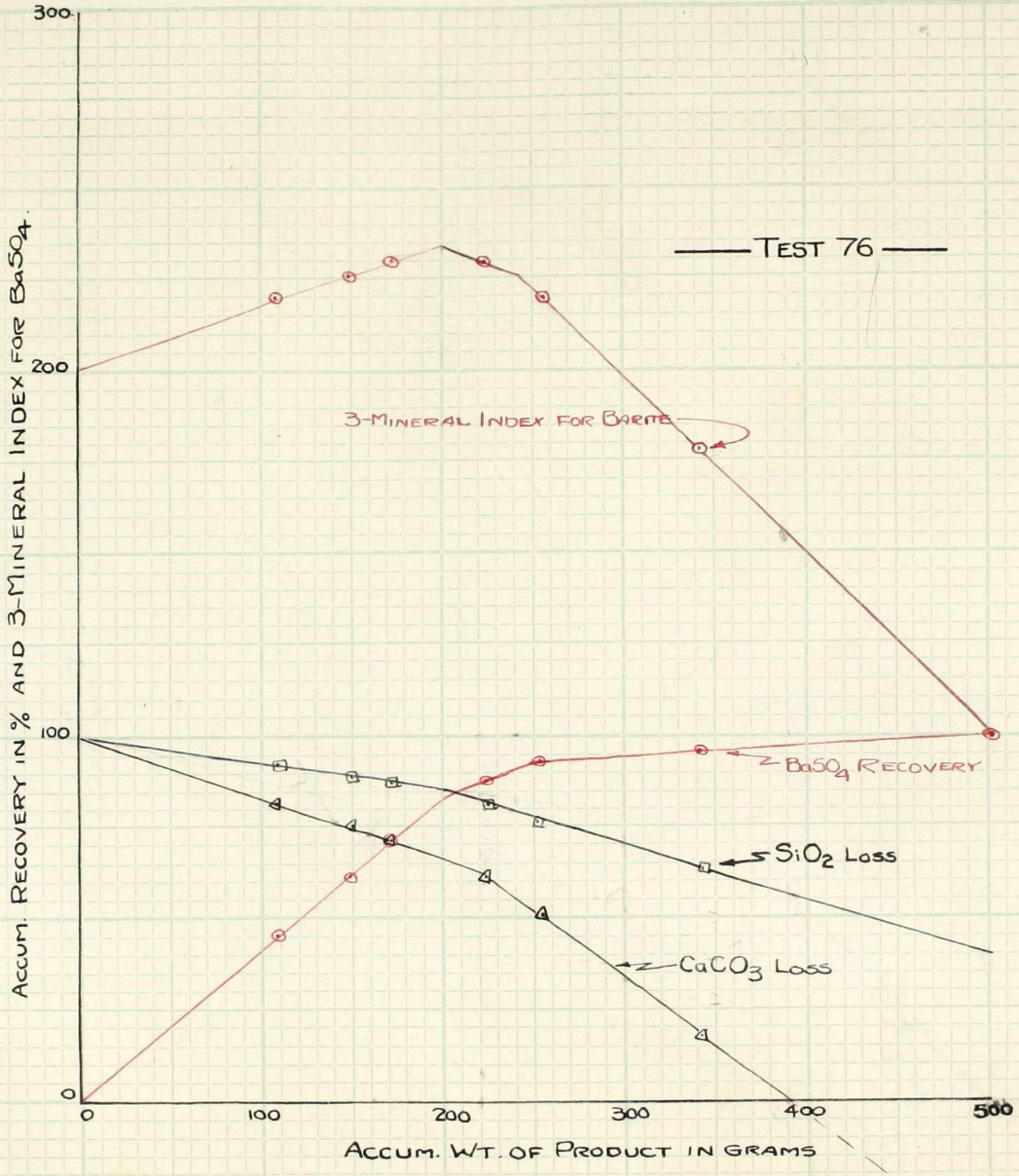
Skimmed 1 min.

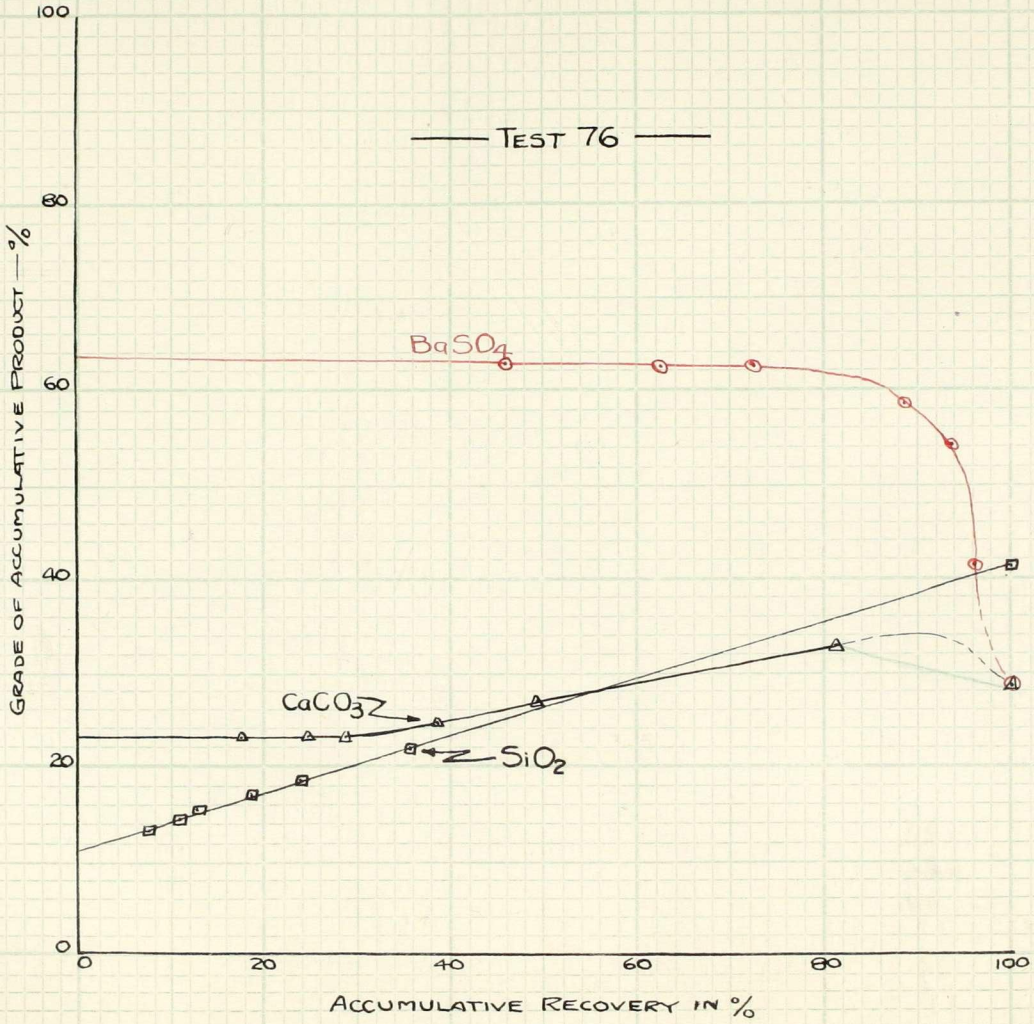
Froth--plentiful, bubbles fine and fairly well mineralized.

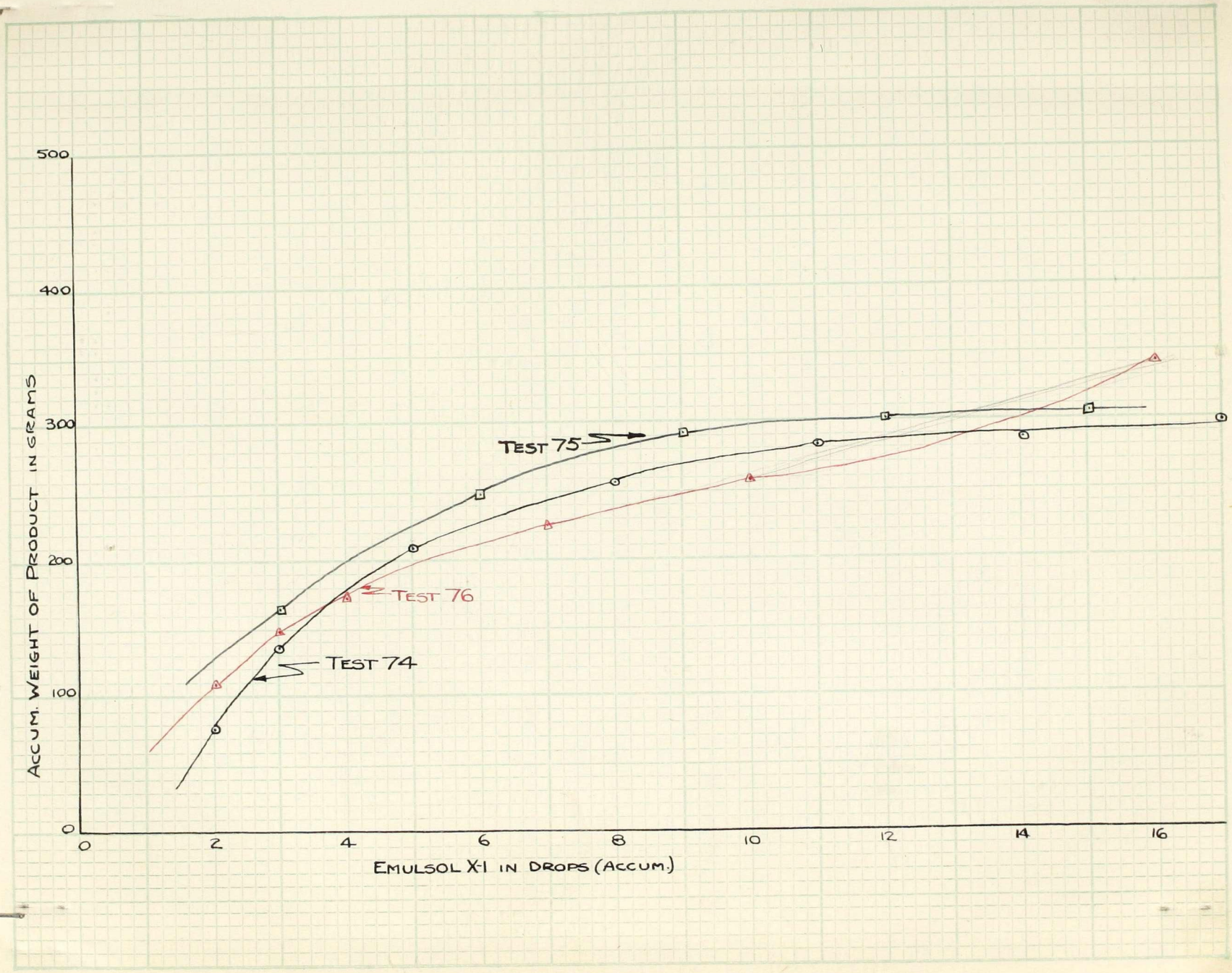
PH--8.6

	Wt. (gms)	Wt. (%)	Assay (%)			Assay x Weight			Recovery (%)		
			$BaSO_4$	$CaCO_3$	SiO_2	$BaSO_4$	$CaCO_3$	SiO_2	$BaSO_4$	$CaCO_3$	SiO_2
Conc. #1	107.8	21.5	62.7	23.0	13.5	67.5	24.8	14.5	45.6	17.7	7.1
#2	40.2	8.0	61.3	23.9	16.7	24.6	9.6	6.7	16.7	6.8	3.3
#3	23.3	4.7	63.4	22.8	17.4	14.8	5.3	4.1	10.0	3.8	2.0
#4	51.8	10.4	45.3	28.5	23.9	23.4	14.7	12.4	15.8	10.5	6.0
#5	33.7	6.7	24.2	44.0	29.5	8.2	14.8	10.0	5.6	10.5	4.9
#6	83.5	16.6	3.7	53.5	31.2	3.1	44.7	26.0	2.1	31.9	12.5
Tails	160.6	32.1	0.38	16.6	82.0	6.1	26.6	132.0	4.2	18.8	64.2

Product	Accum. Wt. (gms)	Accum. Wt. (%)	Accumulative Recovery (%)			Grade of Accum. Product (%)			3 Min. Index
			$BaSO_4$	$CaCO_3$	SiO_2	$BaSO_4$	$CaCO_3$	SiO_2	
Conc. #1	107.8	21.5	45.6	17.7	7.1	62.7	23.0	13.5	220.8
#2	148.0	29.5	62.3	24.5	10.4	62.1	23.2	14.3	227.4
#3	171.3	34.2	72.3	28.3	12.4	62.4	23.2	14.8	231.6
#4	223.1	44.6	88.1	38.8	18.4	58.5	24.4	16.9	230.9
#5	256.8	51.3	93.7	49.3	23.3	54.0	26.9	18.6	221.1
#6	340.3	67.9	95.8	81.2	35.8	41.3	33.2	21.8	178.8
Tails	500.9	100.0	100.0	100.0	100.0	28.5	28.1	41.0	100.0


TEST 76
3-MINERAL INDEX FOR BARITE
$BaSO_4$ RECOVERY
SiO_2 LOSS
$CaCO_3$ LOSS
ACCUM. RECOVERY IN % AND 3-MINERAL INDEX FOR $BaSO_4$.
ACCUM. WT. OF PRODUCT IN GRAMS
300
200
100
0
0
100
200
300
400
500


TEST 76
BaSO4
CaCO3
SiO2
GRADE OF ACCUMULATIVE PRODUCT — %
ACCUMULATIVE RECOVERY IN %
0
20
40
60
80
100


500
400
300
200
100
0
ACCUM. WEIGHT OF PRODUCT IN GRAMS
0
2
4
6
8
10
12
14
16
EMULSOL X-1 IN DROPS (ACCUM.)
TEST 75
TEST 76
TEST 74

Purpose

To see if curves similar to those obtained for Lissolamine A might be drawn for Emulsol X-1.

Summary

From the results of test #75 it was seen that the best index could not be obtained with less than 2 drops of Em. X-1, so this amount was added first, with 1#/ton of $NaPO_3$. Two further additions of 1 drop were made, two of 3 drops, and one of 6 drops. The last addition was made in an attempt to check the shape of the product-reagent curve at the upper end, as a tendency to rise after flattening was noticed from test #74. It was realized later that this addition should have been carried farther. The graph showed the rise all right, but another reason might have caused it. It was noticed previously that a single large addition of reagent seems to bring up a larger bulk of product than two smaller ones giving the same total reagent.

Graphs

Graphs were drawn as for test 73. Plotting the accumulative recovery against the calculated grade of combined products showed the sharp break in the $BaSO_4$ curve that was shown in test #73 for silica. A corresponding point was indicated for limestone, while the silica curve continued as a straight line throughout the range of the tests.

Interpretation of the above seems rather difficult at present. It seems to represent some difference in the action of the reagents used on silica on the one hand, and on lime-

stone and barite on the other. The grade of silica increases as a linear function of the product taken up. The grades of limestone and barite increase up to a point (where the recovery = approx. 94% for each of these minerals) and then suddenly fall off.

The graph of recovery vs. weight of conc. showed some interesting possibilities:--

The Three-Mineral Index curve plotted two straight lines, passing through 200 and 100 as before, and intersecting to give a max. index of 240 for these reagents under these conditions, but the graph showing the losses of limestone and silica to the tails did not pass through the 100 point, although they plotted straight lines as before, with the break in the curve at the product giving the maximum Three-Min. Index, as in test 73.

The $CaCO_3$ loss graph crosses the line of zero recovery at 380 g. of product--and may be interpreted as meaning that if a product were made containing 380 g., it would contain all the limestone.

The silica loss graph did not cross the line of zero recovery at all. It cut the 500 gm. product line at 40%--seeming to indicate that all the silica could not be floated with these reagents.

It was noticed that Lissolamine A brought up nearly the whole at the charge during the test (#73)--whereas Emulsol X-1 began to bring up very little toward the end of the test (#76) --and yet left a large tailing. This difference is well ill-

ustrated by the irregularities of the graphs for Emulsol X-1.

When the limestone curve is produced to cross the 500g. product line, it cuts at -40%-- which accounts for the balance bringing the Three-Mineral Index curve to the 100% mark as before. This may be accidental, and very possibly the index curve does not always go through 100.

Test No. 77

To Pebble Mill.

Ore.....500 gms.

Water.....500 gms.

Grind--30 min. @ 70 R. P. M.

To Cell.

Water to give 4:1 dilution.

Sodium Metaphosphate 1.0# /ton.

#1 Conc.

Emulsol X-1 5 drops (1 drop = 0.033 gms.)

Conditioned 3 min.

Skimmed 1 min.

Froth--very plentiful, bubbles fine and well mineralized.

Wt. of Conc #1 = 236.7

Tails = 261.7

Test 77	Wt. %	Assay %			Recovery %			3 Min. Index
		$BaSO_4$	$CaCO_3$	SiO_2	$BaSO_4$	$CaCO_3$	SiO_2	
Feed	100.0	27.9	29.4	42.7	100.0	100.0	100.0	
C	47.5	53.7	26.4	17.0	89.5	42.7	19.0	227.8
T	52.5	5.7	32.1	65.6	10.5	57.3	81.0	

This test was run to compare the effect of adding a large single amount of reagent with that of adding the same total reagent in smaller quantities. We had some indication previously (tests 72 compared to test 73, and the rise in the product-reagent curve for test 76) that a larger product would be obtained by the single addition, and we wished to find if this was truly the case, and also if the product obtained by the large addition would satisfy the product-recovery graph obtained by the smaller additions.

A point near the max. 3-mineral index was chosen, and 5 drops of reagent added, as indicated by the product-reagent graph, to give the desired product. The product was larger than that obtained by the small additions--236.7 gm. against 210 gm. shown by the graph.

Test No. 78.

To Pebble Mill.

Ore.....= 500 gms.

Water.....= 500 gms.

Sodium Metaphosphate = 1.0# /ton.

Grind--30 min. @ 70 R. P. M.

To Cell.

Water to give 4:1 dilution.

#1 Conc.

Emulsol X-1--1 drop (1drop = 0.033 gm.)

Conditioned 3 min.

Skimmed 1 min.

#2 Conc.

Emulsol X-1--1 drop.

Water--700 grams.

Conditioned 3 min.

Skimmed 1 min.

#3 Conc.

Emulsol X-1--1 drop.

Water--600 grams.

Conditioned 3 min.

Skimmed 1 min.

#4 Conc.

Emulsol X-1--1 drop.

Water--200 grams.

Conditioned 3 min. Skimmed 1 min.

#5 Conc.

Emulsol X-1--1 drop.

Water--300 grams.

Conditioned 3 min.

Skimmed 1 min.

#6 Conc.

Emulsol X-1--1 drop

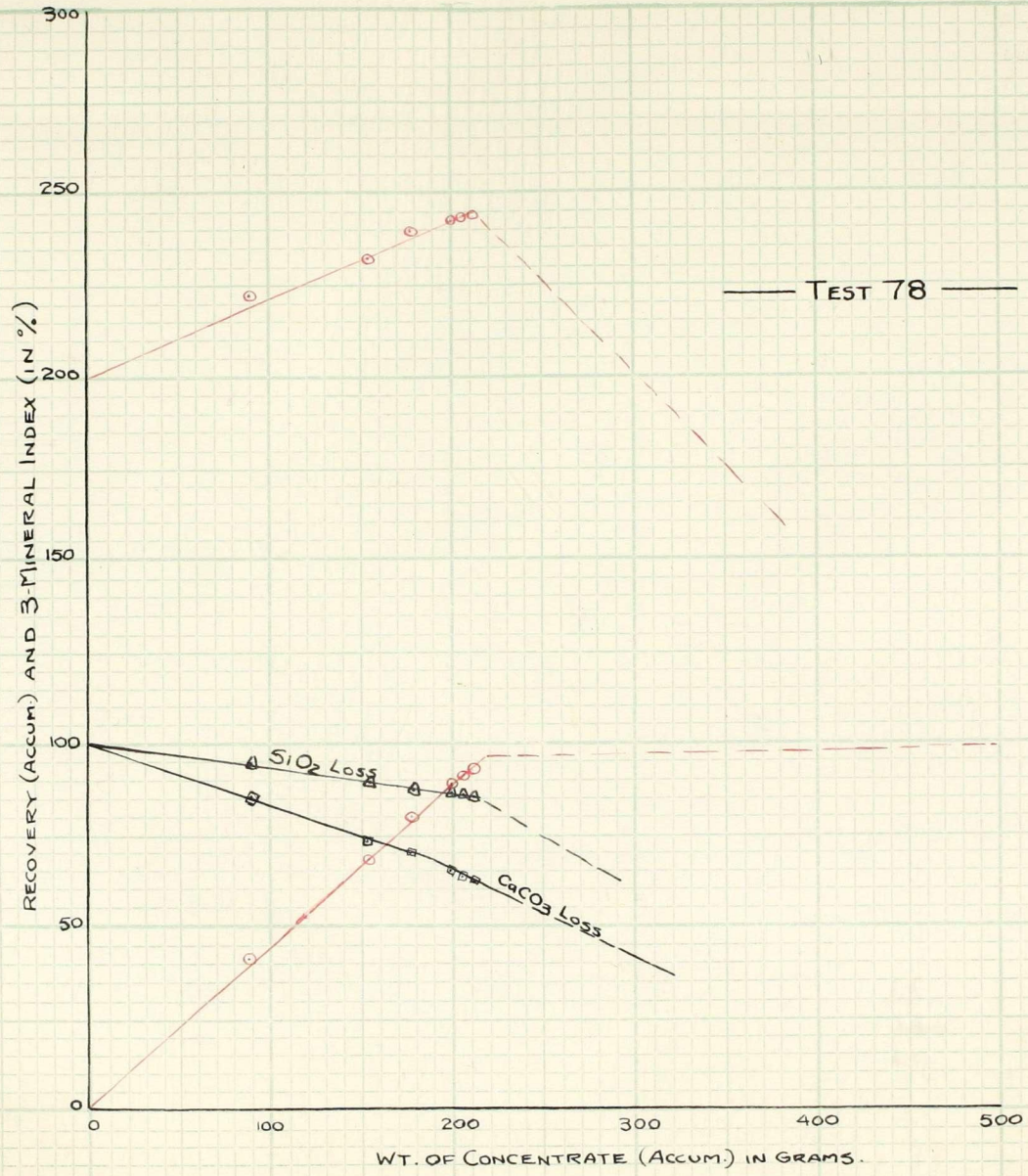
Water--200 grams.

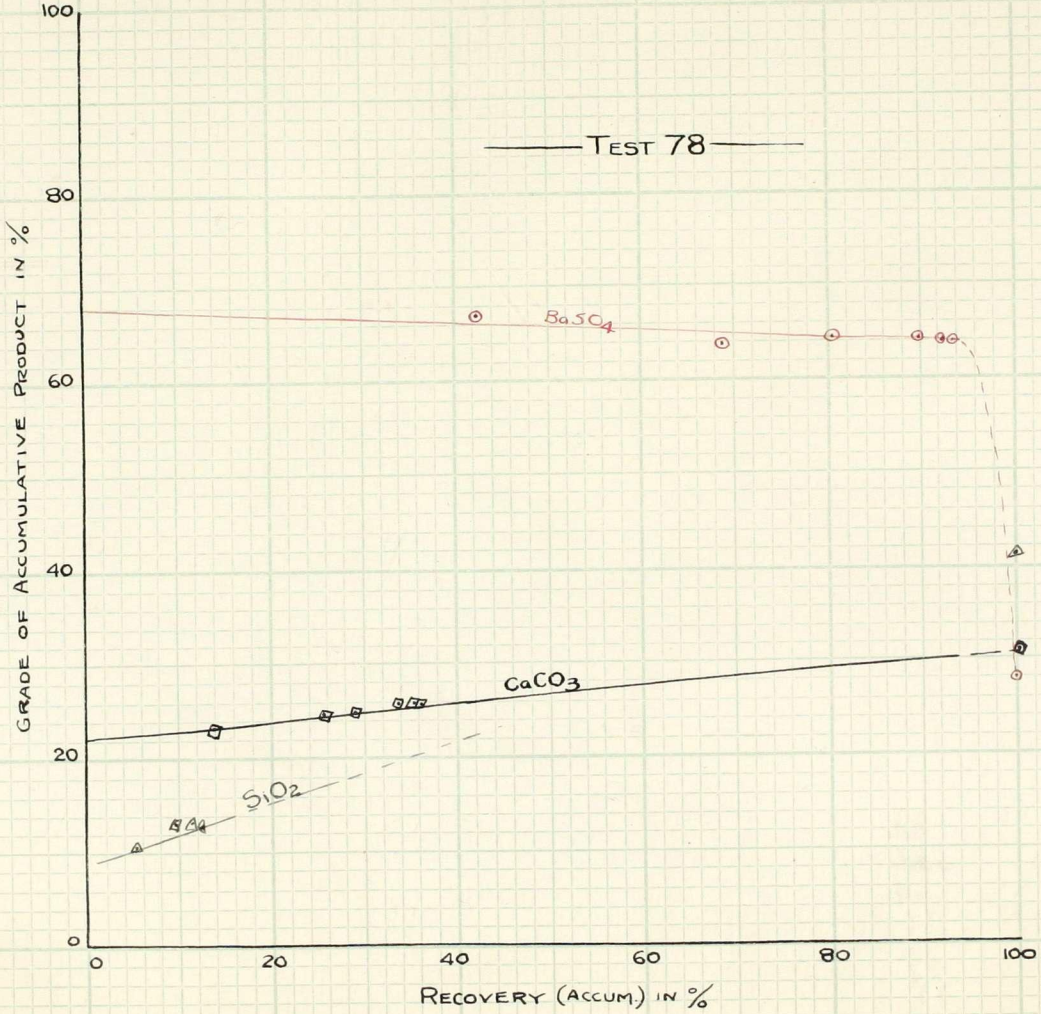
Conditioned 3 min.

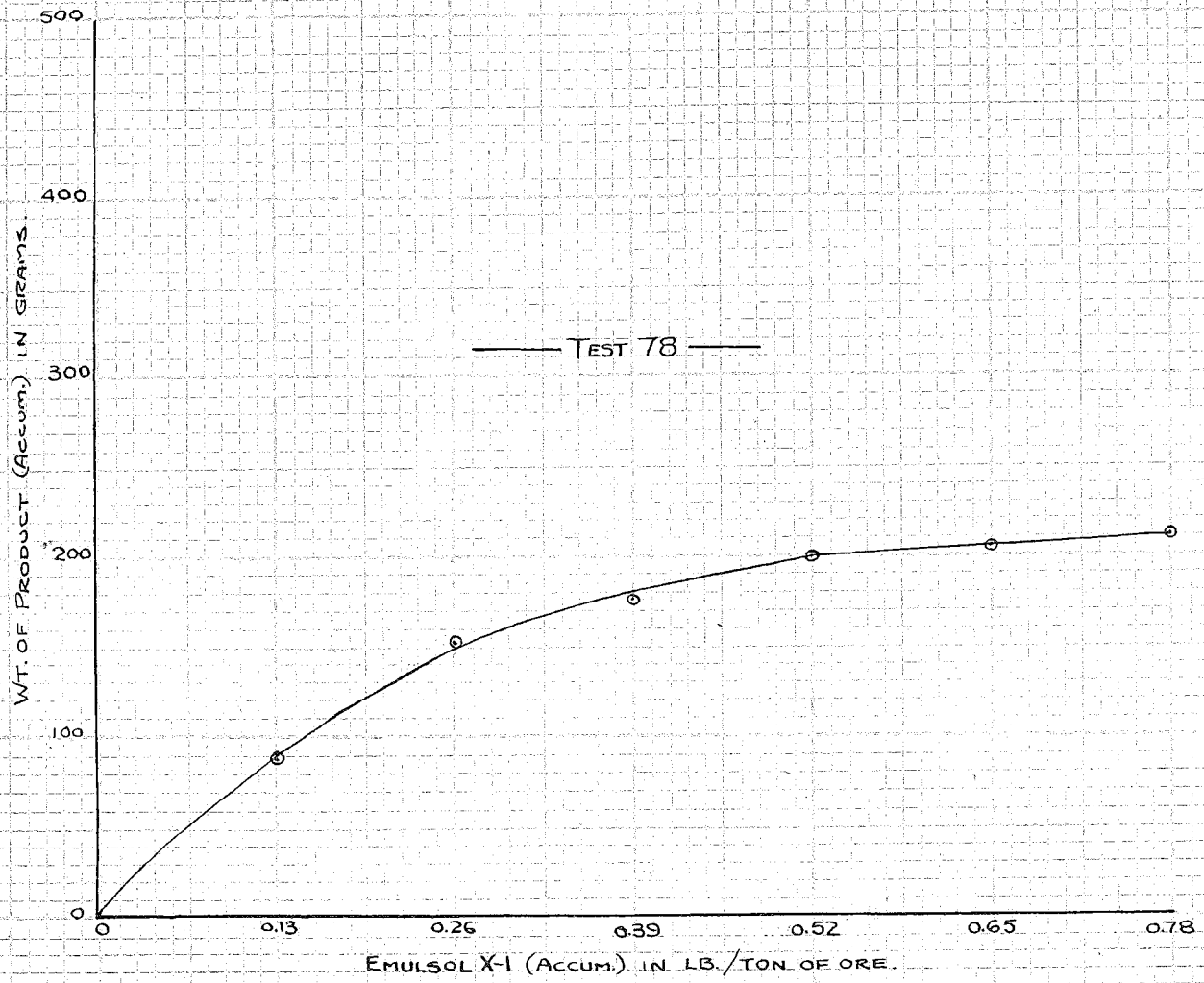
Skimmed 1 min.

	Wt. (gms)	Wt. (%)	Assay (%)			Assay x Weight			Recovery (%)		
			$BaSO_4$	$CaCO_3$	SiO_2	$BaSO_4$	$CaCO_3$	SiO_2	$BaSO_4$	$CaCO_3$	SiO_2
Conc. #1	90.0	18.0	66.5	22.9	10.9	59.8	20.6	9.8	42.5	13.7	4.7
#2	64.2	12.8	58.2	27.1	16.2	37.3	17.4	10.4	26.4	11.5	4.9
#3	24.6	4.9	68.3	23.4	12.4	16.8	5.8	3.1	11.9	3.8	1.5
#4	21.8	4.4	58.2	31.4	9.1	12.7	6.9	2.0	9.0	4.6	1.0
#5	6.9	1.4	54.0	32.9	12.9	3.7	2.3	0.9	2.6	1.5	0.4
#6	3.6	0.7	51.5	31.6	21.3	1.9	1.1	0.8	1.4	0.7	0.4
Tails	289.9	57.6	3.02	33.4	62.4	8.8	96.5	181.0	6.2	64.2	87.1

Product	Accum. Wt. (gms)	Accum. Wt. (%)	Accumulative Recovery (%)			Grade of Accum. Product (%)			3 Min. Index
			$BaSO_4$	$CaCO_3$	SiO_2	$BaSO_4$	$CaCO_3$	SiO_2	
Conc. #1	90.0	18.0	42.5	13.7	4.7	66.5	22.9	10.9	224.1
#2	154.2	30.8	68.9	25.2	9.6	63.0	24.6	13.1	234.1
#3	178.8	35.7	80.8	29.0	11.1	63.6	24.5	13.1	240.7
#4	200.6	40.1	89.8	33.6	12.1	63.3	25.3	12.7	244.1
#5	207.5	41.5	92.4	35.1	12.5	62.8	25.6	12.6	244.8
#6	211.1	42.2	93.8	35.8	12.9	62.7	25.6	12.8	245.1
Tails	501.0	100.0	100.0	100.0	100.0	28.2	30.1	41.6	100.0


TEST 78
RECOVERY (ACCUM.) AND 3-MINERAL INDEX (IN %)
300
250
200
150
100
50
0
SiO_2 LOSS
$CaCO_3$ LOSS
0
100
200
300
400
500
WT. OF CONCENTRATE (ACCUM.) IN GRAMS.


TEST 78
GRADE OF ACCUMULATIVE PRODUCT IN %
RECOVERY (ACCUM.) IN %
BaSO4
CaCO3
SiO2
0
20
40
60
80
100


TEST 78
WT. OF PRODUCT (ACCUM.) IN GRAMS.
500
400
300
200
100
0
0
0.13
0.26
0.39
0.52
0.65
0.78
EMULSOL X-1 (ACCUM.) IN LB./TON OF ORE.

Tests 69 and 70 (Elfstrom & Dayton), using the reagent we used (Emulsol X-1) without any $NaPO_3$ were found to fit our 3-mineral index curve almost exactly (although they were run at temperatures of 40° and 60° resp.). Also, several roughly comparable tests using Na_3PO_3 in the mill, or conditioning it several minutes before adding Em. X-1 gave a better index than our max. They plotted a rough curve indicating a max. index of about 270.

Consideration of these data led us to believe that quite possibly our ls. depressant was prevented from reacting fully with the ls. by adding Em. X-1 simultaneously or soon after it.

Test #78 was run to find out if our surmise was correct, and to see if a better index could be obtained by pre-conditioning the charge with $NaPO_3$. To this effect the Na_3Po_3 (1# /ton) was added to the pebble mill. Products were taken off with additions of 1 drop. of Em. X-1 per product--6 concentrates and a tailing being removed.

The results of this test showed a max. index of about 245, with 3 points very close to the apex. This index was far below what was expected from the longer conditioning of the $NaPO_3$. It was reasoned that perhaps the $NaPO_3$ coating on the surface of the ls. (or mono-molec. film--adsorption layer--or whatever..) was formed, but was worn off by continued grinding. Or perhaps for some other reason the $NaPO_3$ deteriorated before the actual flotation.

To check this line of reasoning reference was made to

tests by Elfstrom & Dayton:--

#60--0.5# ton of $NaPO_3$ was added to the mill--together with Na_3SiO_3. The weight of product taken off in this test gives, from our graph showing the relation between product and index for T. 78, almost precisely the index they obtained.

#69 and #70--No $NaPO_3$ was used in these tests--yet the results fit the curve we obtained by adding $NaPO_3$ to the mill.

The above constitutes fairly strong evidence that the $NaPO_3$ added to the mill was almost equivalent to adding none at all.

Test # 79

To Pebble Mill

Ore.....500 g.

Water..... 500 g.

Grind--full charge of pebbles--70 R. P. M.--30 m.

To Cell

Water to bring pulp dil. to 4:1.

$NaPO_3$--1# /ton.

Condition 10 min.

Conc. #1.

Emulsol X-1--2 drops. (1 dr. = 0.033 g.)

Condition 3 min.

Skim 2 min.

PH conc. = 8.55

Froth as usual--fine and copious, becoming coarser.

Conc. #2.

Emulsol X-1--2 drops.

Water 900 grams.

Conditioned 3 min.

Skimmed 2 min.

PH conc. = 8.50

Conc. #3.

Water 800 g.

Emulsol X-1--2 min.

Conditioned 3 min.

Skimmed 2 min.

Conc. #4.

Water 300 g.

Emulsol X-1--2 drops.

Conditioned 3 min.

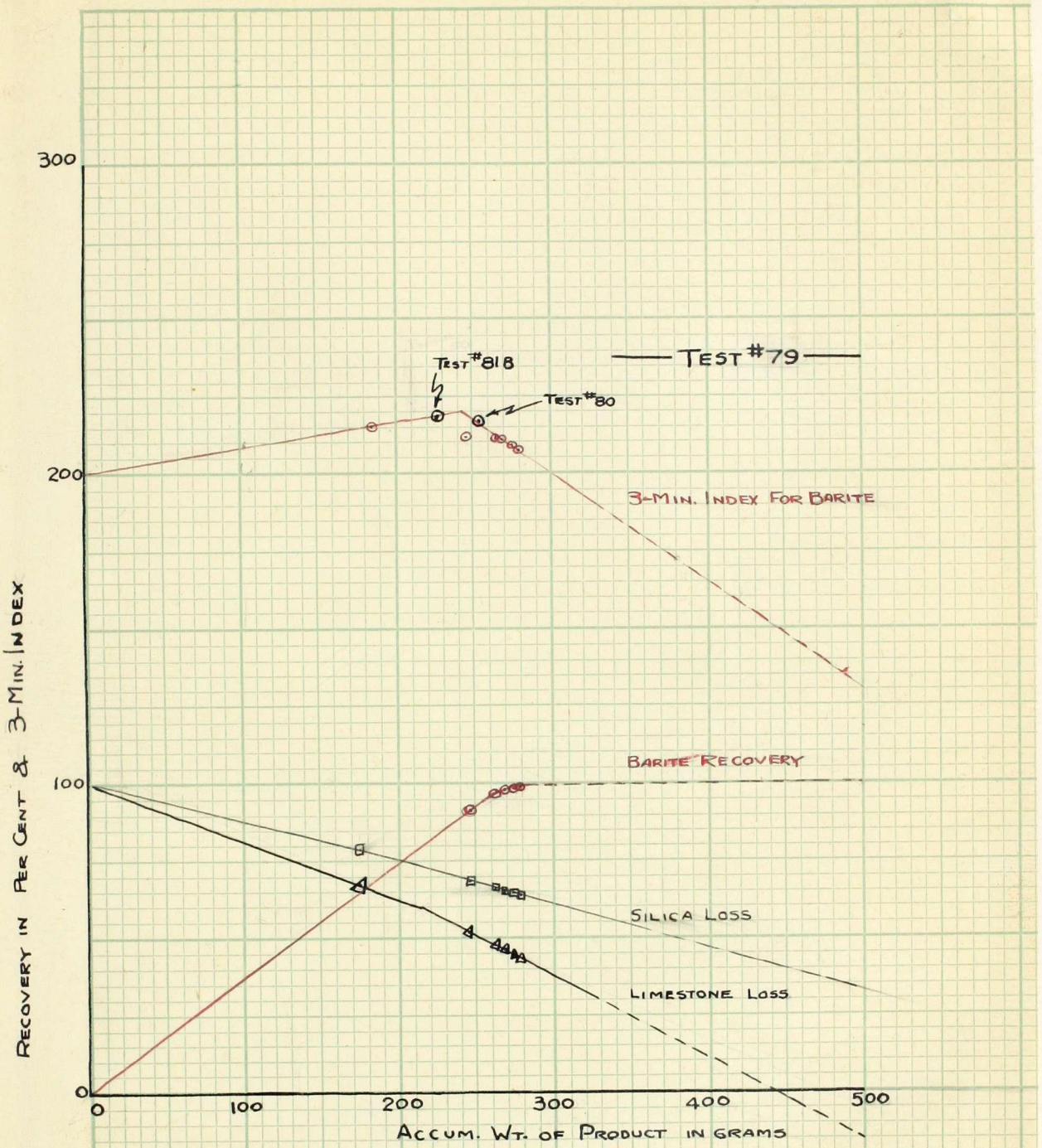
Skimmed 2 min.

Conc. #5. and Conc # 6--as for conc. #4, except that only 200 g. water was added for each.

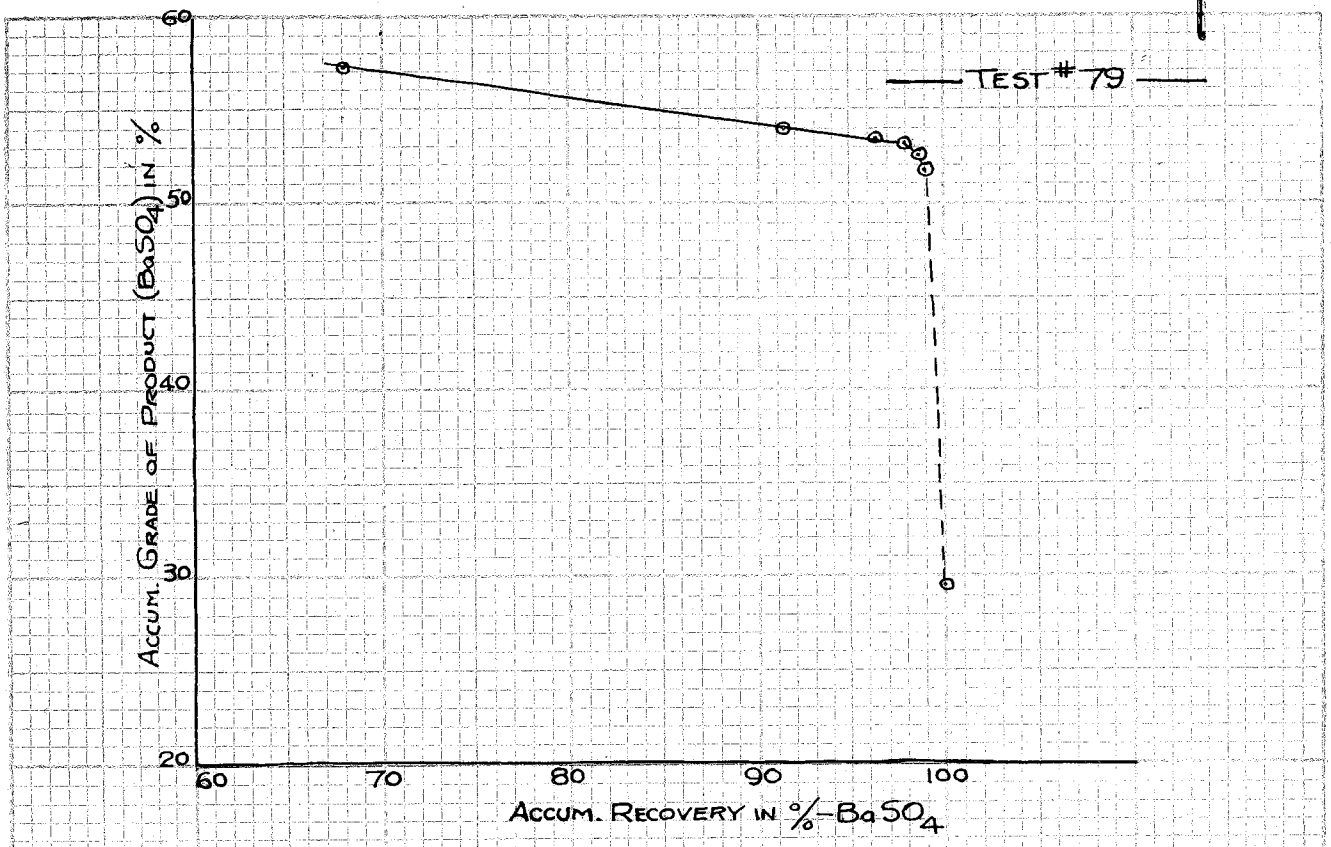
Tails--pH = 8.05

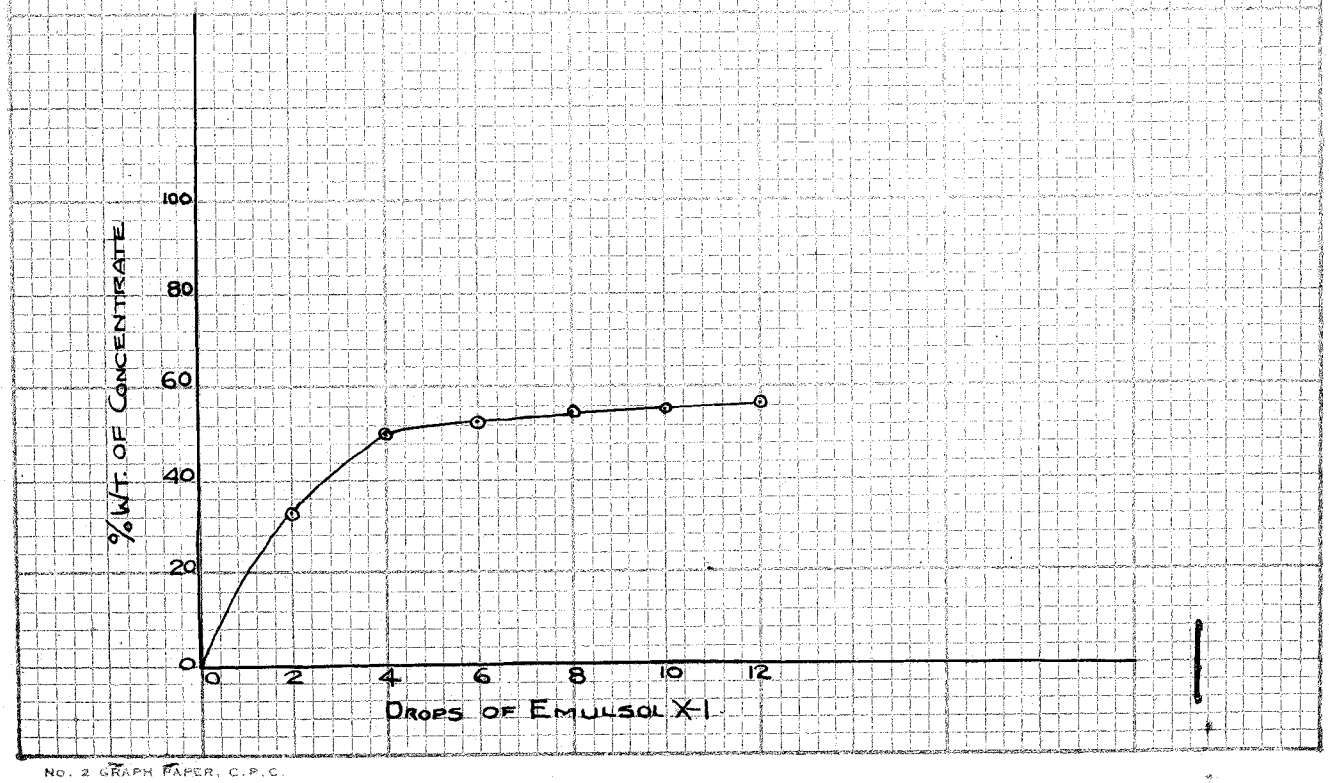
Product	Weight	% Wt.	Assay (%)			% Wt. x Assay			Recovery %		
			$BaSO_4$	$CaCO_3$	SiO_2	$BaSO_4$	$CaCO_3$	SiO_2	$BaSO_4$	$CaCO_3$	SiO_2
Conc. #1	174.3	35.3	57.2	27.7	22.0	20.2	9.7	7.7	68.0	32.1	20.9
#2	72.9	14.8	46.6	33.0	26.6	6.9	4.9	3.9	23.2	16.1	10.6
#3	16.3	3.3	43.6	34.2	21.0	1.5	1.1	0.7	5.0	3.6	1.9
#4	6.2	1.3	42.0	39.4	24.8	0.5	0.5	0.3	1.7	1.6	0.8
#5	6.0	1.2	23.4	50.2	26.8	0.2	0.5	0.3	0.7	1.6	0.8
#6	3.4	0.7	16.9	55.4	23.9	0.1	0.4	0.2	0.3	1.3	0.5
Tails	214.5	43.5	0.7	30.4	54.9	0.3	13.2	23.8	1.1	43.7	64.6
	493.6	100.0				29.7	30.3	36.9	100.0	100.0	100.0

Product	Accum. Wt.	Accum. % Wt.	Accumulative Recovery			Accum. Loss		3-Min. Index (Barite)	Accum. Grade of Prod. $BaSO_4$
			$BaSO_4$	$CaCO_3$	SiO_2	$CaCO_3$	SiO_2		
Conc. #1	174.3	35.3	68.0	32.0	21.0	68.0	79.0	215.0	57.2
#2	247.2	50.1	91.3	48.2	31.4	51.8	68.6	211.7	54.0
#3	263.5	53.4	96.4	51.8	33.4	48.2	66.6	211.2	53.6
#4	269.7	54.7	98.0	53.4	34.2	46.6	65.8	210.4	53.2
#5	275.7	55.9	98.7	55.1	35.0	44.9	65.0	208.6	52.5
#6	279.1	56.6	99.0	56.4	35.5	43.6	64.5	207.1	51.8
Tails	493.6	100.0	100.0	100.0	100.0	0.0	0.0	100.0	29.7



No. 2 GRAPH PAPER, C.P.C.





No. 2 GRAPH PAPER, C.P.C.

This test was run to see if conditioning in the cell before adding Emulsol might enhance the action of the $NaPO_3$.

Before adding Em. X-1 the $NaPO_3$ was conditioned for 10 minutes. Two drops of Em. X-1 were added, and the mixture conditioned for a further 3 minutes. #1 conc. was taken off. The froth was very heavy, and filled two pans with fine foam, becoming coarser toward the end. Five more conc. were removed--adding two drops of Em. X-1 for each conc.

The results of this test were disappointing in regard to improvement of 3-min. index. The curves obtained indicate a a max. of about 220.

The $BaSO_4$ recovery was very good, but the curves showing loss of $CaCO_3$ and SiO_2 fall off much too rapidly to allow for a high index.

The low result here suggests that the Em. X-1, kept in a warm place, has lost its selective powers. This idea is born out by subsequent tests.

Test 80.

To Pebble Mill

Ore 500 g.

Water 500 g.

Grind--30 min.--full charge--70 R. P. M.

To Flotation Cell

Water to give 4:1 dilution.

$NaPO_3$--2#/ton.

Conditioned 10 minutes.

Conc. #1. pH = 8.3

Emulsol X-1--5 drops.

Conditioned 3 min.

Skimmed 3 min.

Tails pH = 8.3

Note--This concentrate filled two pans with froth, and these portions were separately assayed. They weighed 208.3 g. and 46.4 g.

Product	Weight	%Wt.	Assay %			% Wt. x Assay			Recovery %		
			$CaCO_3$	$BaSO_4$	SiO_2	$CaCO_3$	$BaSO_4$	SiO_2	$CaCO_3$	$BaSo_4$	SiO_2
Conc. 1a.	208.3	42.0	26.6	56.4	20.4	11.2	23.6	8.6	33.7	78.5	21.9
" 1b.	46.4	9.3	37.8	42.0	22.6	4.5	3.9	2.1	13.5	12.9	5.4
Tails	241.8	48.7	36.0	5.3	58.4	17.5	2.6	28.5	52.7	8.6	72.7
	496.5	100.0				33.2	30.1	39.2	100.0	100.0	100.0

Product	Accumulative Weight	Accumulative Recovery			3-Min. Index
		$BaSO_4$	$CaCO_3$	$BaSO_4$	$BaSO_4$
Conc. 1a	208.3	78.5	66.3	78.1	222.9
Conc. 1b	254.7	91.4	52.7	72.7	216.8
Tails	496.5	100.0	0.0	0.0	100.0

A single concentrate was taken off--using 2#/ton $NaPO_3$ --conditioned 3 minutes. The concentrate filled two pans with froth, and the pans were kept separate for assay purposes.

The assays show that the first froth to come up is higher in Barite and lower in Limestone than the last to come up. The silica was also slightly higher in the first pan-full.

The index obtained fits the curve from test #79--showing that additional amounts of $NaPO_3$ do not increase the selectivity of the Em. X-1.

This test also indicates a difference in the action of the Em. X-1 as compared to test #76 and test #77. The point it gives on the 3-Min. index vs. weight of product graph is well below the curve for test #76.

Test #81

Iron Mill.

To Mill--

Ore 500 g.

Water 500 g.

$NaPO_3$ 2#/ton.

Grind 15 min. @ 44 R. P. M. with 13 rods.

Porcelain Pebble Mill.

Ore 500 g.

Water 500 g.

$NaPO_3$ 2#/ton.

Grind 30 min. @ 70 R. P. M., with full charge.

To Cell (same for both)

Water to bring p. d. to 4:1

Emulsol X-1--4 drops.

Condition 3 minutes.

Skim 2 minutes. pH = 8.5.

Iron Mill.--Conc. 226.5 g.

Tails 267,0

Porc. Mill.--Conc. 222.8 g.

Tails 270.9 g.

A. Iron Mill

Product	Wt.	% Wt.	Assay %			% Wt. x Assay			Recovery %		
			$CaCO_3$	$BaSO_4$	SiO_2	$CaCO_3$	$BaSO_4$	SiO_2	$CaCO_3$	$BaSO_4$	SiO_2
Conc.	226.5	46.0	26.8	55.0	25.4	12.3	25.3	11.7	38.2	86.0	27.0
Tails	267.0	54.0	36.8	7.6	58.5	19.9	4.1	31.6	61.8	14.0	73.0
	493.5	100.0				32.2	29.4	43.3	100.0	100.0	100.0

3-Min. Index for $BaSO_4$ = 220.8

B. Porcelain Mill

Product	Wt.	% Wt.	Assay %			% Wt. x Assay			Recovery %		
			$CaCO_3$	$BaSO_4$	SiO_2	$CaCO_3$	$BaSO_4$	SiO_2	$CaCO_3$	$BaSO_4$	SiO_2
Conc.	227.8	45.6	27.8	56.6	17.9	12.7	25.8	8.2	38.9	87.8	22.4
Tails	270.9	53.4	37.6	6.8	53.1	20.0	3.6	28.4	61.1	12.2	77.6
	498.7	100.0				32.7	29.4	36.6	100.0	100.0	100.0

3-Min. Index for $BaSO_4$ = 226.5

Test #81 was run with the two purposes;

(1) to compare grinding in a porcelain pebble mill to grinding in an iron rod mill--(as regards selectivity of Em. X -1), and (2) to check again the apparent loss in selectivity of the Em. X-1.

2#/ton $NaPO_3$ was added in the mill, and 4 drops of Em. X-1 in the cell.

The results show little difference in the results from the different grinds--and such differences as appear may be a result of different fineness of grinding, not to any iron salts formed in the mill.

The greatest difference was shown by the SiO_2 recovery --being 27% in the conc. from the rod mill grind, and only 22.4% in the conc. from the pebble mill grind. The difference may be due to activation of SiO_2 by iron salts.

The 3-Min. index obtained was 226.5 for the pebble mill, against 220.8 for the iron rod mill. Both indices are well below the curve obtained in test #78, where 1#/ton $NaPO_3$ was added to the ball mill charge.

Test #82.

A. Pebble Mill

To Mill--

Ore 500 g.

Water 500 g.

Grind 30 min. @ 70 R. P. M.--full charge of pebbles.

To Cell--

Water to bring p. d. to 4:1.

$NaPO_3$--1#/ton.

Condition 10 min.

Conc. #1-- Sulfonated Cod Oil - 2 drops.
(1 dr. = 0.036 g.)
(pH = 8.3) (= 0.144#/T)
Condition 3 min.

Skim 3 min.

Froth as for Emulsol X-1, but not quite so plentiful, and a little tougher.

Conc. #2.-- Sulfonated Cod Oil --2 drops.

Condition 3 min.

Skim 2 min.

Froth as above.

Conc.#3.-- Sulfonated Cod Oil -- 2 drops.

Condition 3 min.

Skim 2 min.

Conc. #4.--Same as Conc #3.

Conc. #5.-- Sulfonated Cod Oil -- 5 drops.

Conditioned 3 min.--Skim 2 min.
Froth was becoming poorer--much more brittle, but still well mineralized.

Tails -- pH = 8.2.

N. B. After each concentrate was removed, water was added to bring the level of the pulp up to the original 4:1 mark.

B. Rod Mill.

Duplicate test to 82-A. Grind 13 rods --44 R. P. M for 15 min.

The froth was not so well mineralized toward the end as in the pebble mill grind.

Test #82--A

Product	Wt.	% Wt.	Assay %			% Wt. x Assay			Recovery %		
			$CaCO_3$	$BaSO_4$	SiO_2	$CaCO_3$	$BaSO_4$	SiO_2	$CaCO_3$	$BaSO_4$	SiO_2
Conc. 1	63.7	12.8	36.4	56.4	14.7	4.66	7.22	1.88	15.1	20.0	4.8
2	60.8	12.2	37.6	58.2	13.3	4.59	7.10	1.63	14.9	19.8	4.2
3	65.3	13.2	42.4	54.1	9.3	5.59	7.16	1.23	18.1	19.9	3.2
4	47.1	9.5	49.2	48.2	9.8	4.68	4.59	0.93	15.1	12.8	2.4
5	54.8	11.1	62.2	19.2	22.6	6.92	2.13	2.51	22.4	5.8	6.4
Tails	204.7	41.2	10.8	18.9	75.0	4.45	7.80	30.8	14.4	21.7	79.0
						30.89	36.00	39.0	100.0	100.0	100.0

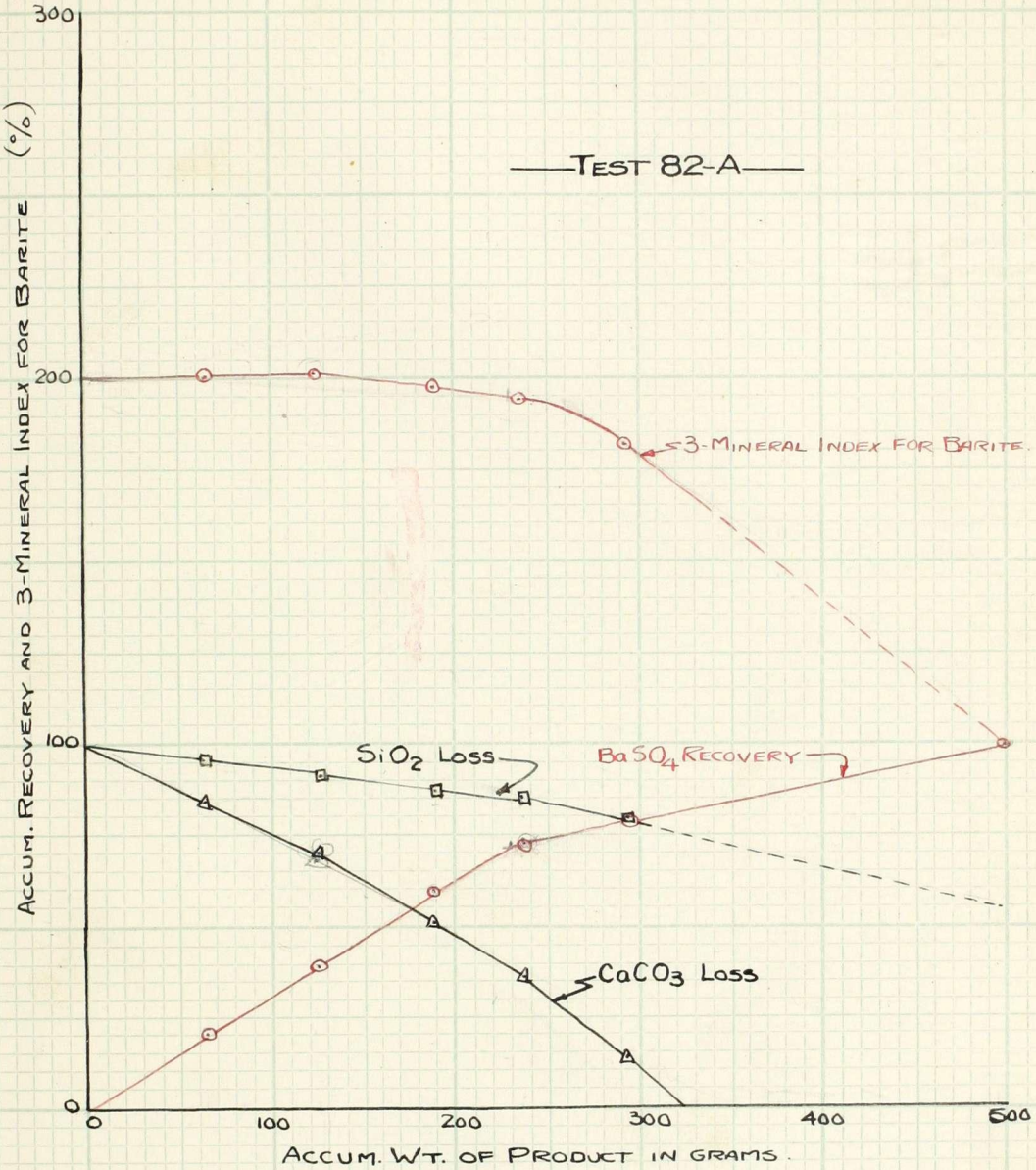
Product	Accum. Wt.	Accum. % Wt.	Accum. Recov.			Accum. Loss		3-Min. Index for $BaSO_4$	Grade of $BaSO_4$ in Accum. Product.
			$CaCO_3$	SiO_2	$BaSO_4$	$CaCO_3$	SiO_2		
Conc. 1	63.7	12.8	15.1	4.8	20.0	84.9	95.2	200.1	56.2
2	124.5	25.0	30.0	9.0	39.8	70.0	91.0	200.8	57.2
3	189.8	38.2	48.1	12.2	59.7	51.9	87.8	197.4	56.3
4	236.9	47.7	63.2	14.6	72.5	36.8	85.4	194.7	54.6
5	291.7	58.8	85.6	21.0	78.3	14.4	79.0	181.7	48.0
Tails	496.4	100.0	100.0	100.0	100.0	0.0	0.0	100.0	36.0

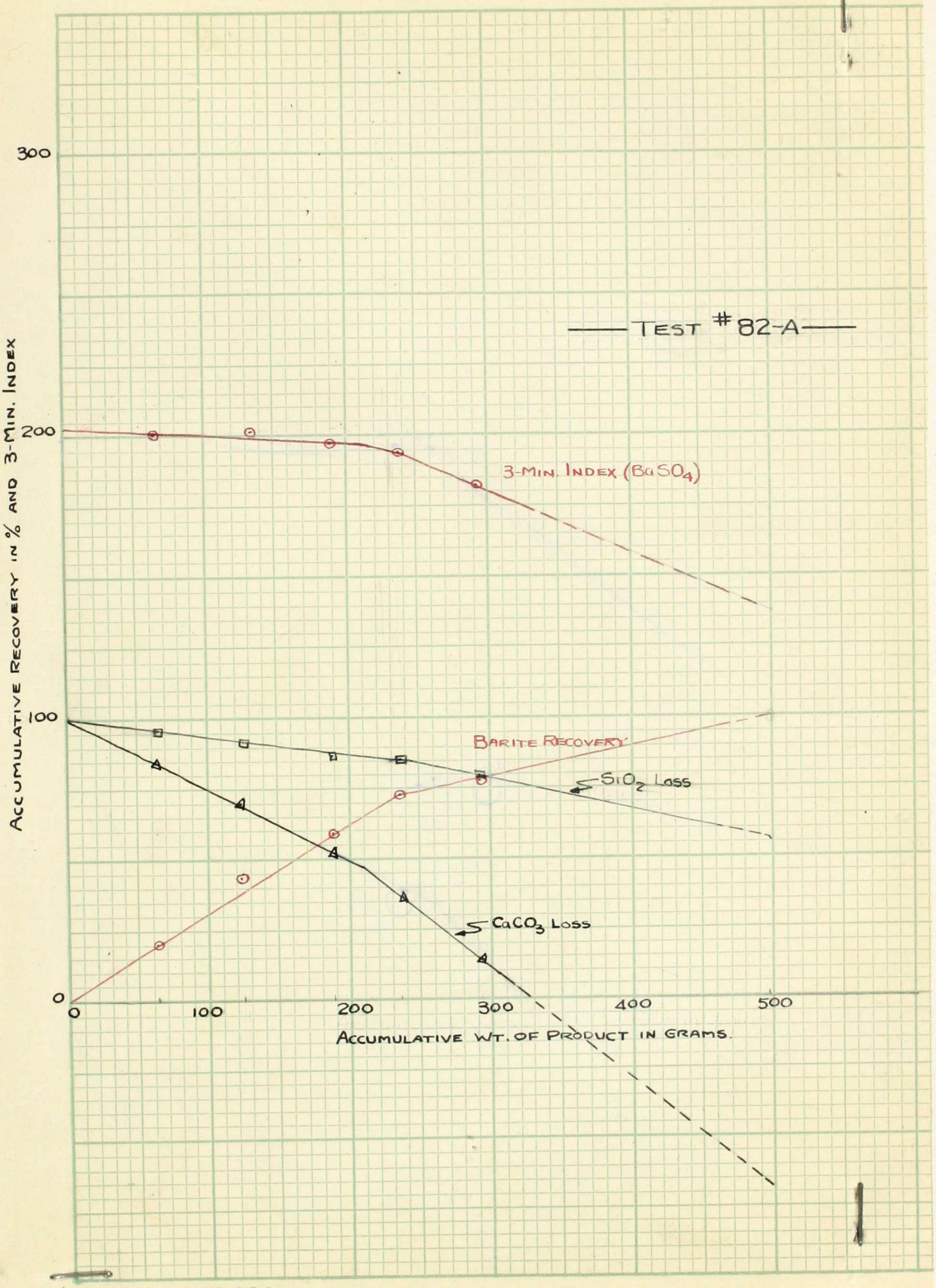
Test #82--B

Product	Wt.	% Wt.	Assay %			% Wt. x Assay			Recovery %		
			$CaCo_3$	$BaSO_4$	SiO_2	$CaCo_3$	$BaSO_4$	SiO_2	$CaCO_3$	$BaSO_4$	SiO_2
Conc. 1	52.4	10.4	28.8	67.3	6.7	3.00	7.00	0.70	9.50	23.5	1.6
2	59.1	11.8	33.8	62.8	13.2	4.00	7.40	1.56	12.60	24.8	3.6
3	51.7	10.3	38.4	56.1	12.2	3.96	5.79	1.26	12.50	19.4	2.9
4	43.1	8.6	45.6	48.5	10.5	3.93	4.17	0.90	12.40	14.0	2.1
5	96.5	19.2	56.8	22.9	25.9	10.90	4.40	4.98	34.40	14.8	11.5
Tails	199.8	39.7	14.8	2.6	85.2	5.88	1.03	33.40	18.60	3.5	78.3
	502.6	100.0				31.67	29.79	43.30	100.00	100.0	100.0

Test 82-B.--Cont'd

Product	Accum. Wt.	Accum. % Wt.	Accum. Recovery			Accum. Loss		3-Min. Index for Barite.	Grade of $BaSO_4$ in Accum. Prod.
			$CaCO_3$	SiO_2	$BaSO_4$	SiO_2	$CaCO_3$		
Conc. #1	52.4	10.4	9.5	1.6	23.5	98.4	90.5	212.4	67.3
2	111.5	22.2	22.1	5.2	48.3	94.8	77.9	221.0	64.9
3	163.2	32.5	34.6	8.1	67.7	91.9	65.4	225.0	62.2
4	206.3	41.1	47.0	10.2	81.7	89.8	53.0	224.5	59.2
5	302.8	60.3	81.4	21.7	96.5	78.3	18.6	193.4	47.8
Tails	502.6	100.0	100.0	100.0	100.0	0.0	0.0	100.0	29.8


TEST 82-A
ACCUM. RECOVERY AND 3-MINERAL INDEX FOR BARITE (%)
300
200
100
0
3-MINERAL INDEX FOR BARITE
SiO_2 LOSS
$BaSO_4$ RECOVERY
$CaCO_3$ LOSS
0
100
200
300
400
500
ACCUM. WT. OF PRODUCT IN GRAMS.



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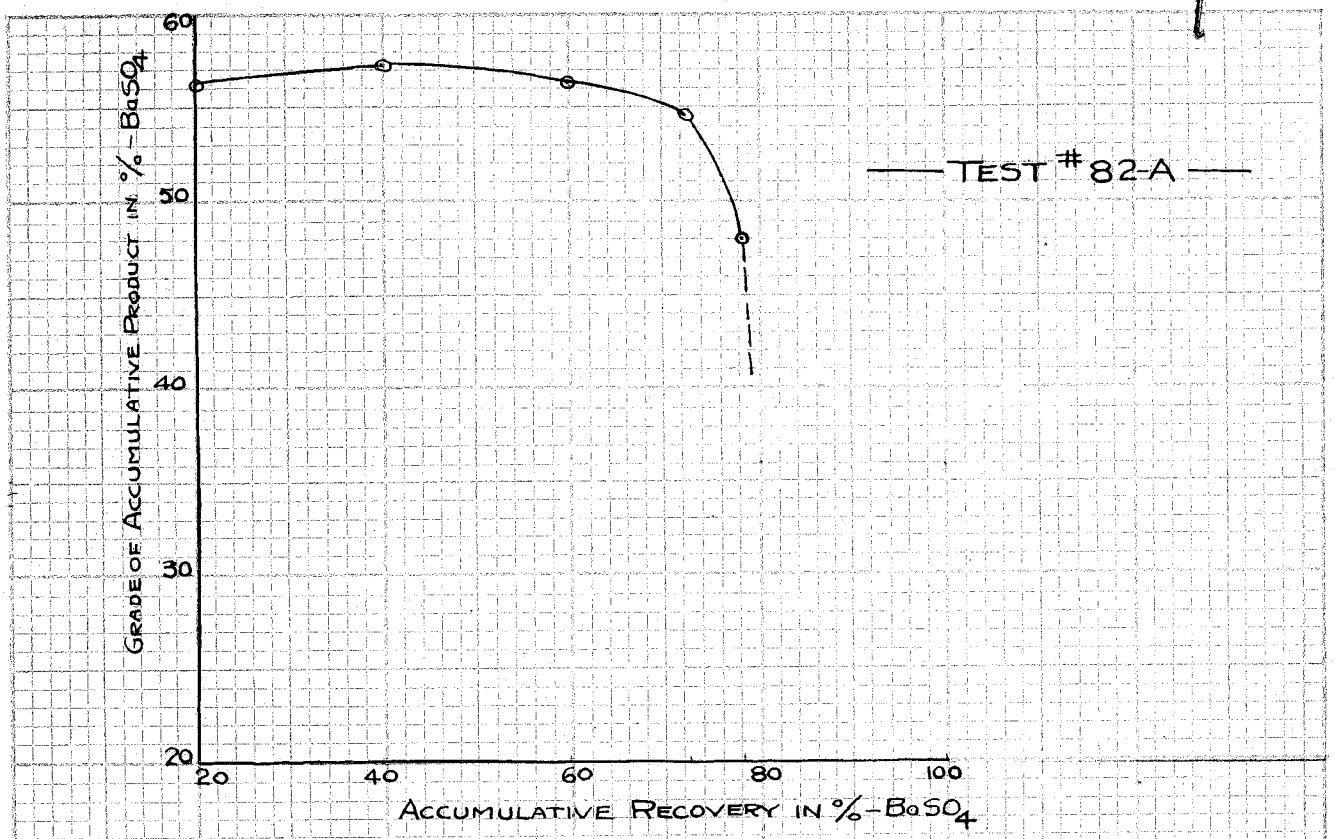

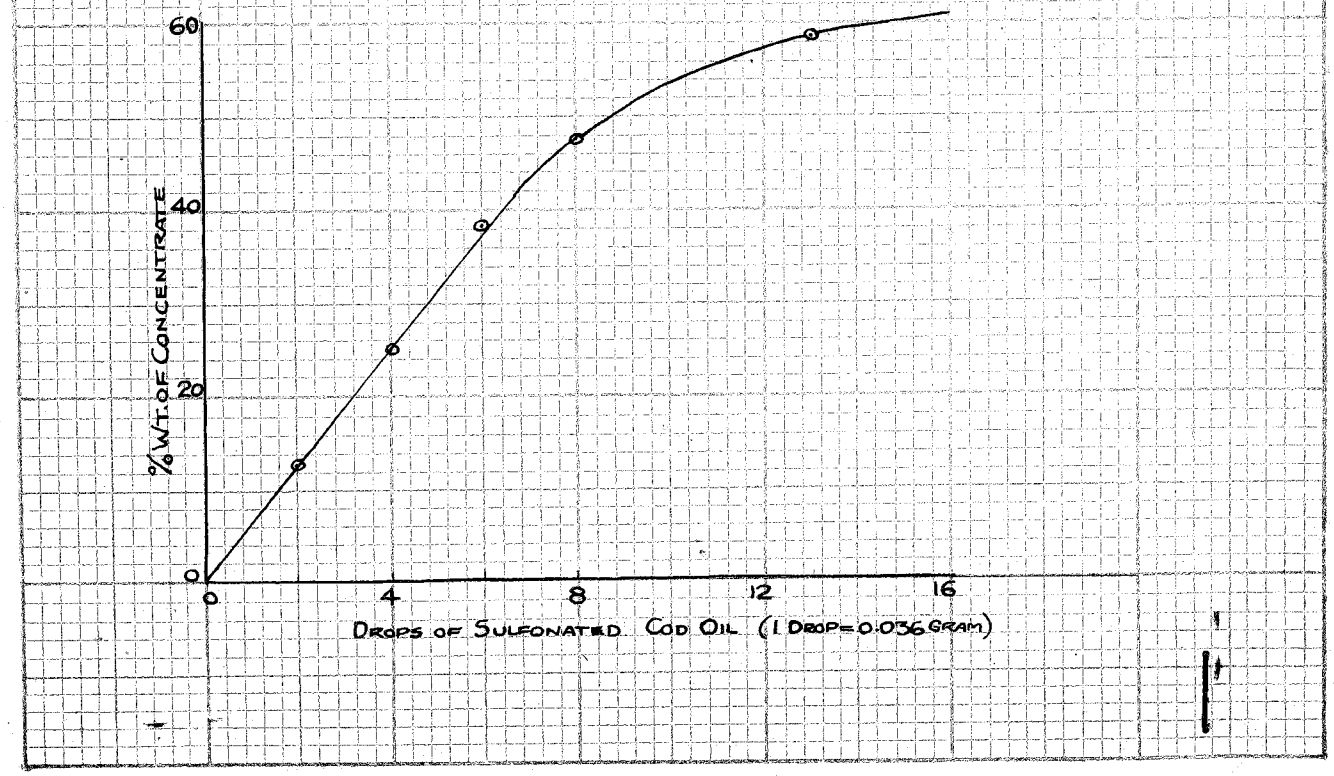

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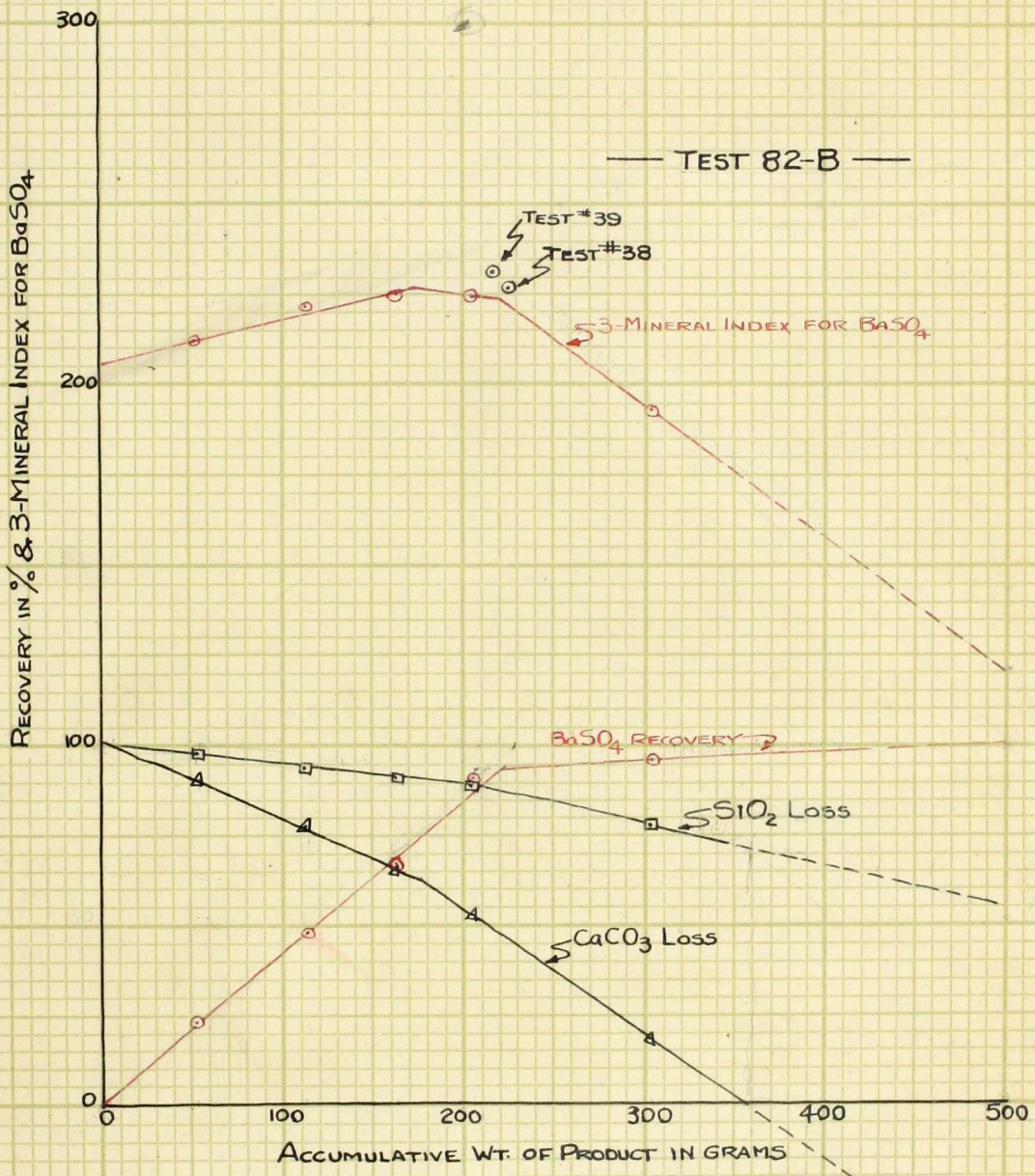
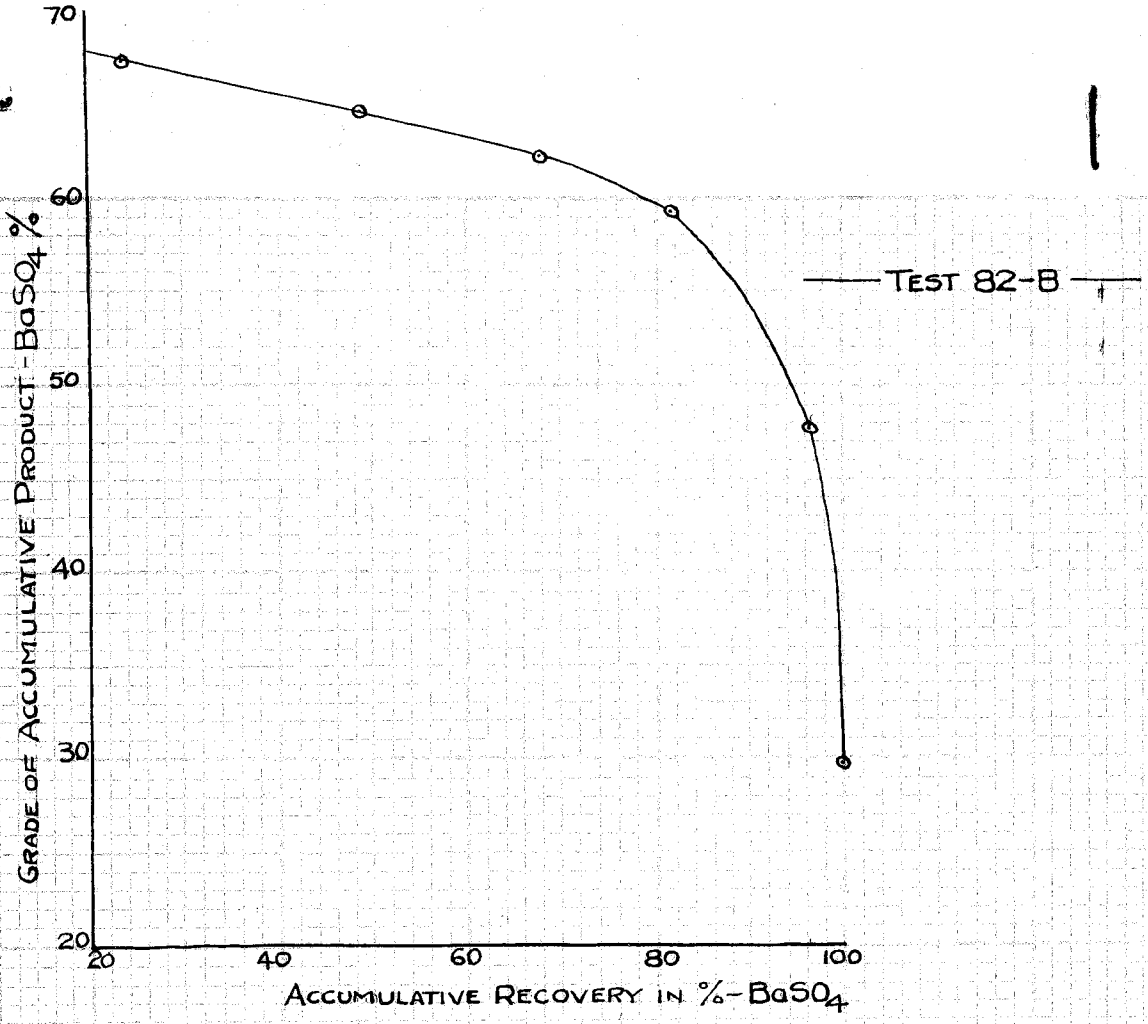
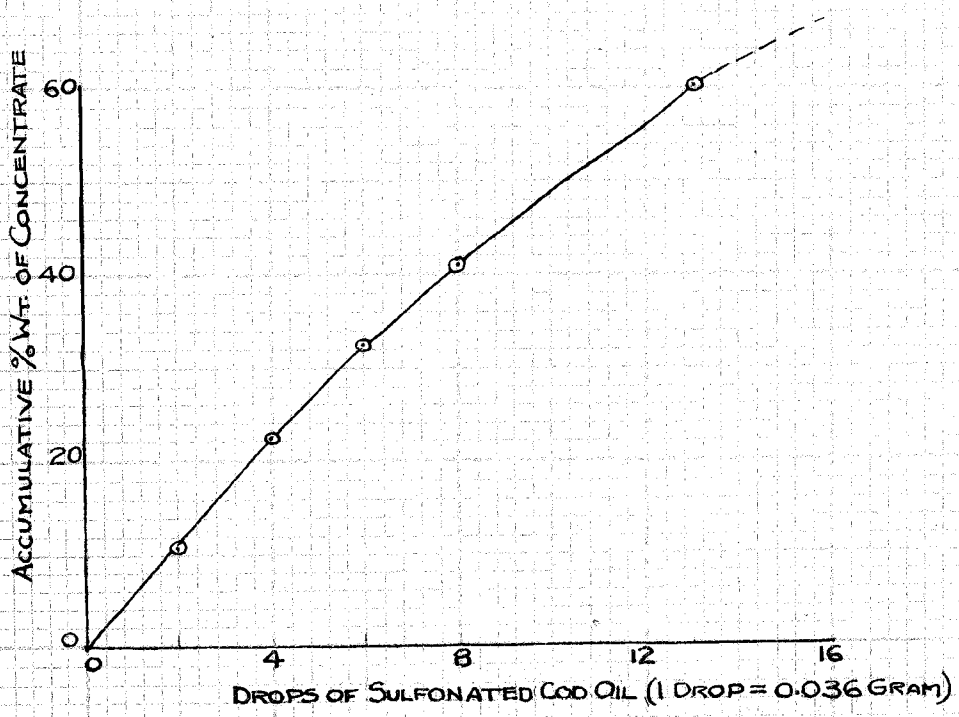


No. 246 GRAPH PAPER. THE CLARKE & STUART CO., LTD., VANCOUVER, B.C.





No. 246 GRAPH PAPER, THE CLARKE & STUART CO., LTD., VANCOUVER, B.C.

The purpose of this test was to check the work of Elfstrom & Dayton using sulfonated cod oil to float Barite, with $NaPO_3$ as a ls. depressant; and to check the comparative results obtained by grinding iron and porcelain mills.

Duplicate tests were run, using a porcelain mill for one, and an iron rod mill for the other.

The results obtained were not very good from the standpoint of floating $BaSO_4$ away from $CaCO_3$. The best 3-mineral index obtainable, as indicated by the graphs of 3-Min. Index vs. Accum. Wt. of Product, is about 227 for the rod mill grind. The pebble mill grind indicated an index of about 200.1 as a maximum.

Tests #38 and #39, (Elfstrom & Dayton) give indices above the curve we obtained here (using an iron mill). They used Na_2SiO_3 in the mill, and this may have had some additional depressing effect on SiO_2, and perhaps on $CaCO_3$.

Why such poor results were obtained with the pebble mill grind is not apparent, and a check on this test seems advisable.

The "break-points" in the SiO_2 and $CaCO_3$ curves for sulf. c. c., do not occur at the same weight of product as the corresponding point in the $BaSO_4$ curve; consequently the 3-Min. Index curve does not show a sharp maximum point, but rather a broader region of maximum 3-Min. Index. This irregularity as compared to the curves for Lissol. A will hamper somewhat the use of these curves in predicting the best obtainable index--and the right wt. of product to give this index. The same irregularity appears--tho' not to so marked a degree, in the Em. Xl curves.

Test #83

To Mill.

Ore 500 g.

Water 500 g.

Grind 30 min. @ 70 R. P. M., full charge of pebbles.

To Cell.

Water to bring p. d. to 4:1.

$NaPO_3$ --1#/ton.

Condition 10 min.

Conc. #1.

Added Emulsol X-1 --1 drop.

Condition 3 min.

Skim 2 min. Froth as in Test # 79.

Conc. #2.

Added Emulsol X-1 -- 1 drop.

Condition 3 min.

Skim 2 min.

Same for Conc. #3, #4, #5, and #6. Water was added each time, to bring level of pulp up to the original 4:1 mark.

Weights of Products:

Conc. #1	= 70.9 g.	Conc. #4	= 19.3 g.
Conc. #2	= 65.5 g.	Conc. #5	= 8.9 g.
Conc. #3	= 51.6 g.	Conc. #6	= 11.4 g.
	Tails	= 268.7	

Product	Wt.	% Wt.	Assay % x Wt.			Assay %			Recovery %		
			$CaCO_3$	$BaSO_4$	SiO_2	$CaCO_3$	$BaSO_4$	SiO_2	$CaCO_3$	$BaSO_4$	SiO_2
Conc. #1	70.9	14.3	4.27	8.84	1.73	29.8	61.7	12.1	13.0	30.0	3.6
2	65.5	13.2	3.28	8.38	2.54	24.8	63.4	19.2	10.0	28.4	5.3
3	51.6	10.4	2.79	5.84	2.86	26.8	56.1	27.5	8.5	19.8	6.0
4	19.3	3.9	1.13	2.03	1.07	29.0	52.6	27.5	3.5	7.1	2.2
5	8.9	1.8	0.49	1.03	0.38	27.2	57.2	20.9	1.5	3.5	0.8
6	11.4	2.3	0.66	1.24	0.69	28.8	53.9	29.9	2.0	4.2	1.5
Tails	268.7	54.1	20.15	2.06	38.40	37.2	3.8	70.9	61.5	7.0	80.6
	496.3	100.0	32.77	29.42	47.67				100.0	100.0	100.0

Product	Accum. Wt.	Accum. % Wt.	Accum. Recovery			Accum. Loss		3-Min. Index	Grade of Accum. Product.
			$CaCO_3$	SiO_2	$BaSO_4$	$CaCO_3$	SiO_2	(Barite)	($BaSO_4$)
Conc. #1	70.9	14.3	13.0	3.6	30.0	87.0	96.4	213.4	61.7
2	136.4	27.5	23.0	8.9	58.4	77.0	91.1	226.5	62.5
3	188.0	37.9	31.5	14.9	78.2	68.5	85.1	231.8	60.8
4	207.3	41.8	35.0	17.1	85.3	65.0	82.9	233.2	59.9
5	216.2	43.6	36.5	17.9	88.8	63.5	82.1	234.4	59.6
6	227.6	45.9	38.5	19.4	93.0	61.5	80.6	235.1	59.2
Tails	496.3	100.0	100.0	100.0	100.0	0.0	0.0	100.0	29.3

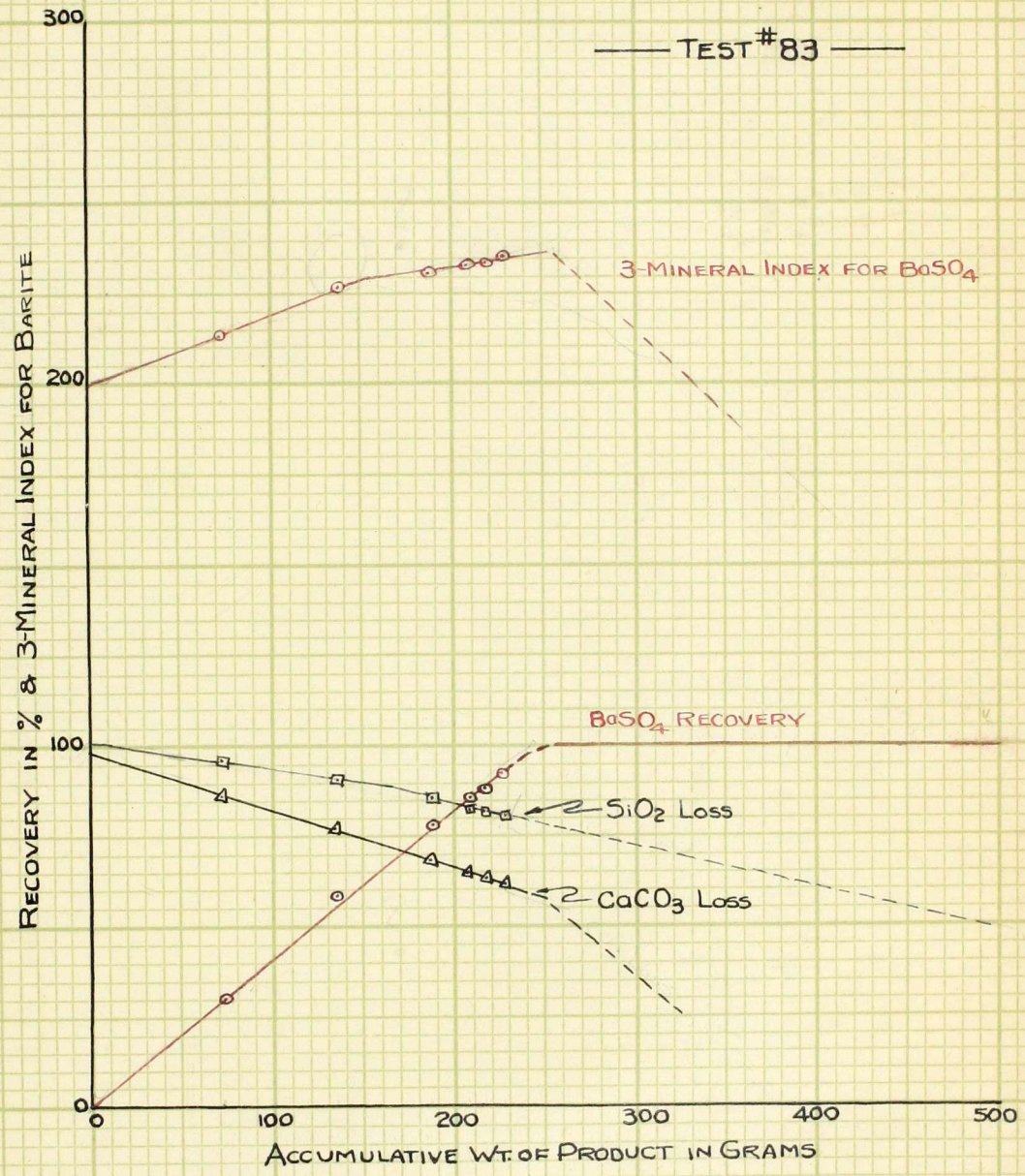
The purpose of this test was to repeat test 79, using newly -purchased Emulsol X-1, to see if the new Em. had better selective properties than the old.

In comparing the product-reagent curves of this test with those from Test #79, the following is shown:--

1. The silica loss lines for both tests are very nearly straight lines, tho' both show a slight break downwards. The curve for test 83, indicating a greater selectivity of the old Em. X-1 for silica.

2. The Ls. loss lines are both much steeper than the silica curves, with the curve for test 79 again falling off more rapidly toward the right. There was a sharper break in the curve than for SiO_2, occurring with about 45 gm. less product than the corresponding point for $BaSO_4$. The curves show that $CaCO_3$ is still by far the more difficult to keep down, and use of a better depressor is necessary if $BaSO_4$ is to be successfully floated away from $CaCO_3$.

3. The $BaSO_4$ recovery lines in both tests rise very rapidly to their maximum, which is nearly 100% recovery, with the curve for test 83 rising a little more steeply, and reaching a max. at about 250 gm. of product, as against 280 gm. for test 79.



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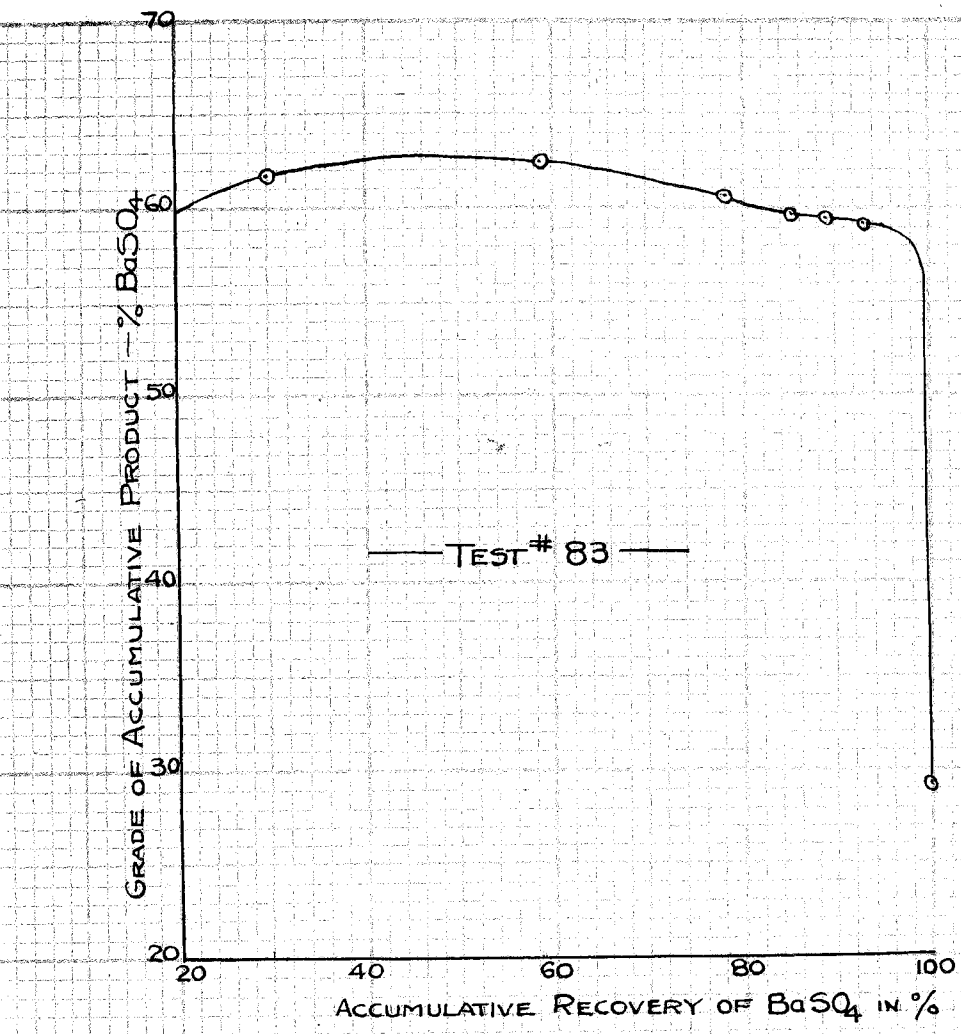
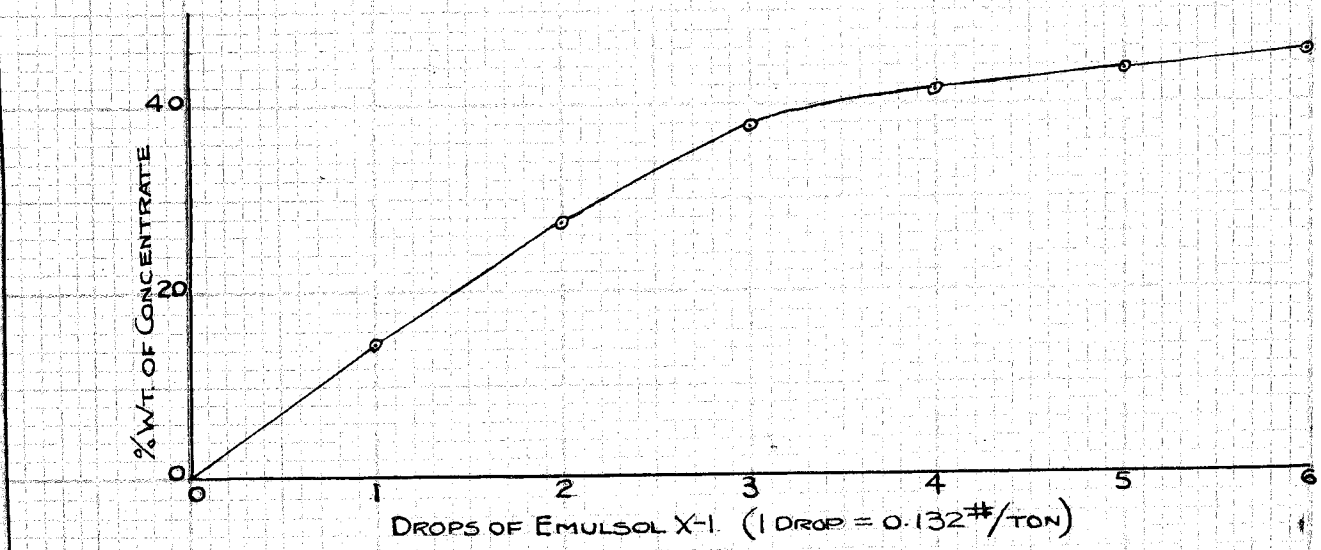




No. 246 GRAPH PAPER. THE CLARKE & STUART CO., LTD., VANCOUVER, B.C.

Test #84

To Mill

Ore 500 g.

Water 500 g.

Grind 30 min. @ 70 r. P. M. --full charge.

To Cell -- Water to bring p. d. to 4:1.

Sodium Hexametaphosphate --2#/ton.

Condition 10 min.

pH = 9.4

Conc. #1

Emulsol X-1 -- 1 drop.

Condition 3 min.

Skim 2 min.

Froth--not as much as with $NaPO_3$ depressor--and very poorly mineralized.

Conc. #2

Emulsol X-1 -- 1 drop.

Condition 3 min.

Skim 2 min.

Froth--as above.

Conc. #3

Emulsol X-1 -- 2 drops.

Condition 3 min.

Skim 2 min.

Froth somewhat tougher--and finer at first.

Conc. #4

Conc. #4

Emulsol X-1 -- 3 drops.

Condition 3 min.

Skim 2 min.

Froth more copious, tougher.

Conc. #5

Emulsol X-1 -- 3 drops.

Condition 3 min.

Skim 2 min.

Froth finer.

Conc. #6

Emulsol X-1 --3 drops.

Condition 3 min.

Skim 2 min.

Larger vol. -- finer froth.

Weights of Products.

Conc. #1	-- 4.1 g.	Conc. #4	-- 22.9
2	-- 4.4 g.	5	-- 25.6
3	--11.2 g.	6	-- 25.8

Tails -- 401.5

An assay was run on Conc. 1+2+3. There was not enough total product to be worthwhile working out recoveries.

Product	Wt.	Assay %		
		$BaSO_4$	$CaCO_3$	SiO_2
Conc. 1 2 3	19.7	27.1	53.8	15.8

<u>Purpose</u> -- To investigate $Na_6P_6O_{18}$ as a depressor for limestone.

Sodium hexametaphosphate was used by Elfstrom & Dayton in an attempt to float silica from barite and l.s. using Lissol. A. The quantity used (2#/ton) showed a general depressing action, and the recoveries were all very small.

In this test -- (#84) -- the same quantity of $Na_6P_6O_{18}$ -- 2#/ton -- was added and conditioned in the cell for 10 min. A drop of Emulsol X-1 was added, and while a fair amount of froth formed, it was poorly mineralized. Six concentrates were taken off, with increased amounts of Em. X-1, but all froths were very poorly mineralized, and the total product removed was only 94.0 gm. This was obviously too little to give a good $BaSO_4$ recovery, so complete assays were not run. An assay on $C_1+C_2+C_3$ showed $BaSO_4$ 27.1%, $CaCO_3$ 53.8%, and SiO_2 15.8%. The $CaCO_3$ seemed to be depressed less than the $BaSO_4$ or SiO_2.

Test #85

To Mill

Ore -- 500 g.

Water 500 g.

Grind -- 30 min. @ 70 R. P. M. -- full charge.

To Cell -- Water to bring p. d. to 4:1.

Sodium hexametaphosphate -- 0.5#/ton.

Conditioned 10 min. pH = 9.0

Conc. #1 --

Emulsol X-1 -- 1 drop.

Conditioned 3 min.

Froth was poor -- little of it, and poorly mineralized, so no skimming was attempted.

Added Emulsol X-1 -- 3 drops.

Conditioned 3 min.

Skim 2 min.

Froth -- one panful --well mineralized.

Conc. #2. --

Emulsol X-1 -- 4 drops.

Conditioned 3 min.

Skim 2 min.

Froth as for #1.

Conc. #3.

Emulsol X-1 -- 4 drops.

Conditioned 3 min.

Skim 2 min. Froth finer.

Conc. #4.

Emulsol X-1 -- 4 drops.

Conditioned 3 min.

Skim 2 min.

Froth not so sell mineralized -- not so plentiful, tougher.

Conc. #5.

Emulsol X-1 -- 4 drops.

Conditioned 3 min.

Skim. 2 min.

Froth as above.

Weights of Products:

Conc. #1	-- 59.9	Conc. #4	-- 38.1
2	-- 80.0	5	-- 31.9
3	-- 65.2	Tails	--221.1

Product	Wt.	% Wt.	Assay %			% Wt. x Assay			Recovery %		
			$CaCO_3$	SiO_2	$BaSO_4$	$CaCO_3$	SiO_2	$BaSO_4$	$CaCO_3$	SiO_2	$BaSO_4$
Conc. #1	59.9	12.1	18.8	7.1	75.1	2.3	0.9	9.1	7.3	2.2	30.7
2	80.0	16.1	20.6	15.0	71.9	3.3	2.4	11.6	10.6	5.9	39.2
3	65.2	13.2	32.6	23.6	46.6	4.3	3.1	6.2	13.8	7.6	21.0
4	38.1	7.7	46.8	34.1	20.1	3.6	2.6	1.5	11.5	6.4	5.1
5	31.9	6.4	46.2	46.4	6.9	2.9	3.0	0.4	9.3	7.3	1.3
Tails	221.1	44.5	33.4	65.0	1.9	14.8	28.9	0.8	47.5	70.6	2.7
	496.2					31.2	40.9	29.6	100.0	100.0	100.0

Product	Accum. Wt.	Accum. % Wt.	Accum. Recov. %			Accum. Loss		3-Min. In. For $BaSO_4$	Accum. Grade of Product.
			$CaCO_3$	SiO_2	$BaSO_4$	$CaCO_3$	SiO_2		
Conc. #1	59.9	12.1	7.3	2.2	30.7	92.7	97.8	221.2	75.1
2	139.9	28.2	17.9	8.1	69.9	82.1	91.9	243.9	73.5
3	205.1	41.4	31.7	15.7	90.9	68.3	84.2	243.5	65.1
4	243.2	49.1	43.2	22.1	96.0	56.8	77.9	230.7	57.8
5	275.1	55.5	52.5	29.4	97.3	47.5	70.6	215.4	52.0
Tails	296.2	100.0	100.0	100.0	100.0	0.0	0.0	100.0	29.6

Purpose -- To repeat #84, with less $Na_6P_6O_{18}$.

In this test only 0.5 #/ton $Na_6P_6O_{18}$ was used. The froth with addition of 1 drop Em. X-1 was small in amount and poorly mineralized, so 3 more drops were added, and the froth obtained was better mineralized and greater in amount. Five concentrates were removed, with 4 drops Em. X-1 per cencentrate. A total of 275.1 gm. of conc. was taken off.

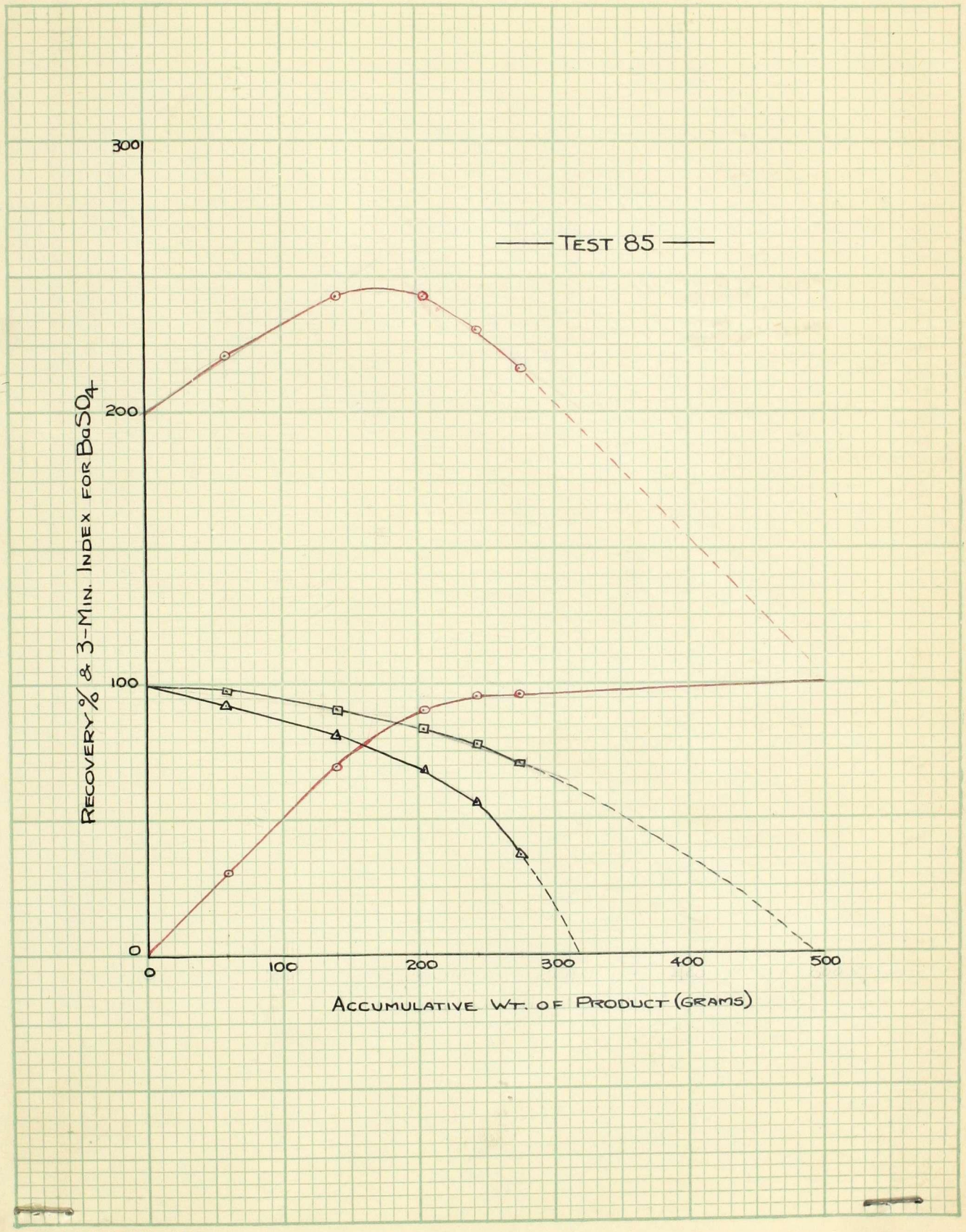
The curves obtained did not show the tendency to straight lines, as exhibited by previous tests, but were quite regular, and showed a possible maximum 3-Mineral index for $BaSO_4$ of 246. Due to the fact that the weight of Product vs. Recovery graphs for $BaSO_4$, $CaCO_3$, and SiO_2 were not straight lines with break-points, the 3-Min. Index curve showed a fairly wide range of near-maximum, instead of a sharp point, as in some previous tests.

The loss curve for SiO_2, when produced to cut the recovery line, passes nearly through the 500 gram mark, whereas the $CaCO_3$ curve passes cuts this axis at 315 gm. -- indicating a rapid increase in $CaCO_3$ recovery with the amount of product removed.

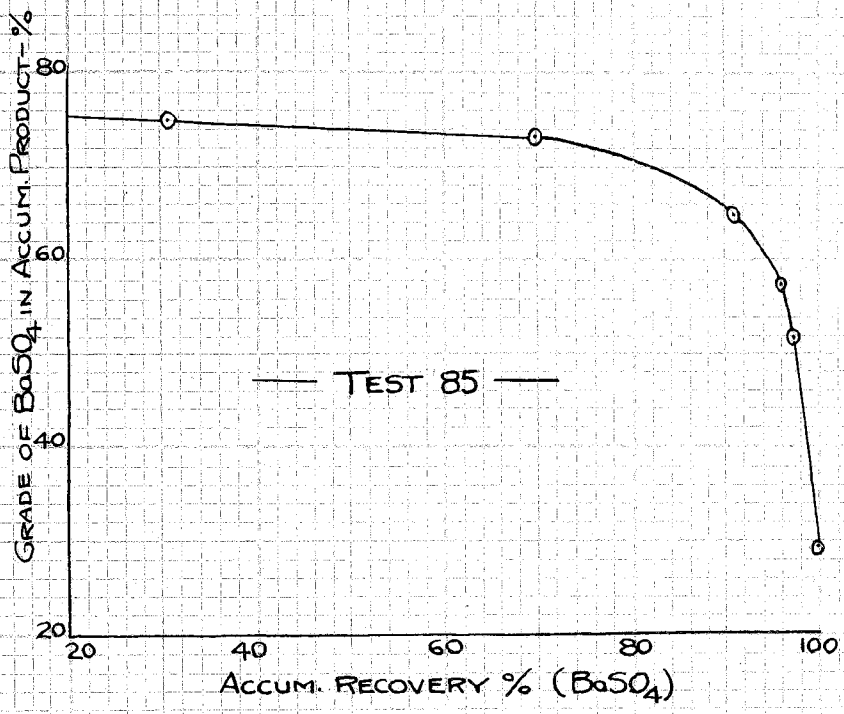
It would be interesting, from the theoretical standpoint, to keep removing products until nearly all the charge has been floated. If the curves continue as indicated, the L.s. would be entirely removed if 315 gm. of Conc. were removed, and pure SiO_2 would be left.

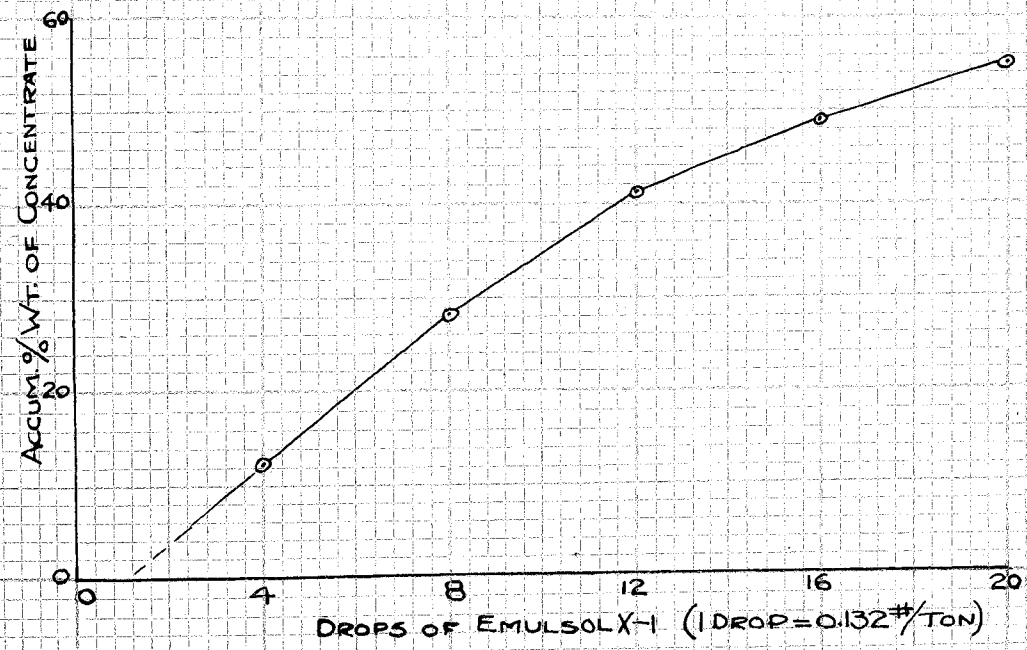
It is quite possible that a smaller quantity of sodium hexametaphosphate, and a smaller amount of Em. X-1 might give a better separation than the above, and an investigation would

be advisable. By running several tests, removing and assaying only one concentrate for each, and noting whether the 3-min. index fell above or below the curve for Test 85, a better combination of reagents might be easily obtained, and the amount of product to give the best recovery (3-Min. Index) could then be determined from a graph similar to the above.



No. 2 GRAPH PAPER, C.P.C.





No. 2 GRAPH PAPER, C.P.C.

Test & Product	Wt. of Ore (gm)	Wt. of Water (gm)	Accumulative Wt of Product (gm)	Accum. % Wt.	Grind (min.)	Condition (min)	Skim (min)	Pulp Density	pH	Reagents-lb/ton To Mill $CuSO_4$	To Mill $NaPO_3$	To Cell Lissolamine A	To Cell $NaPO_3$	To Cell Emulsol X-1	To Cell Sulfonated Cod Oil	Assay % $BaSO_4$	Assay % $CaCO_3$	Assay % SiO_2	Recovery % (Accumulative) $BaSO_4$	Recovery % (Accumulative) $CaCO_3$	Recovery % (Accumulative) SiO_2	Loss % (Accumulative) $BaSO_4$	Loss % (Accumulative) $CaCO_3$	Loss % (Accumulative) SiO_2	Index	Remarks
Head																27.9	29.4	42.7								
72	500	500			30			4:1		0.50																Silica
C			253.3	49.2		3	3 1/3		12.0			0.48				10.7	13.0	72.0	18.8	22.5	88.5	81.2	77.5		247.2	
T			498.5	50.8					12.2							44.7	46.2	9.1	100.0	100.0	100.0	0.0	0.0			
73	500	500			30			4:1		0.50																
C-1			34.0	6.8		3	3		12.3			0.36				8.2	10.9	69.7	2.0	2.8	11.7	98.0	97.2		206.8	
2			169.4	33.7		3	3					0.12				11.2	12.6	70.0	12.8	15.6	58.4	87.2	84.4		230.0	
3			310.9	61.7		3	2					0.16				24.5	21.3	49.2	37.4	38.2	92.6	62.6	61.8		217.2	
4			415.9	82.5		3	2					0.16				46.5	39.9	9.6	72.1	69.0	97.6	27.9	31.0		156.0	
5			485.3	96.2		3	2					0.16				44.6	48.2	4.6	94.0	94.1	99.2	6.0	5.9		111.3	
T			504.4	100.0					10.9							43.9	40.4	8.3	100.0	100.0	100.0	0.0	0.0		100.0	
74	500	500			30			4:1			1.0															Frothing Test
C-1						3	0.5							0.13												
			77.1			3	0.5		11.0					0.13												
2			135.1			3	0.5							0.13												
3			209.3			3	0.5							0.26												
4			256.2			3	0.5							0.39												
5			281.1			3	0.5							0.39												
6			285.6			3	0.5							0.39												
7			297.0			3	0.5							0.39												
T			495.6																							
75	500	500			30			4:1			1.0															Effect of $NaPO_3$
C-1			163.2			3	1.0		8.5					0.39												
2			249.2			3	1.0							0.39												
3			291.2			3	1.0							0.39												
4			300.2			3	1.0							0.39												
5			303.5			3	1.0						1.0	0.39												
T			497.1																							
76	500	500			30			4:1			1.0															Barite
C-1			107.8	21.5		3	1.0		8.6					0.26		62.7	23.0	13.5	45.6	17.7	7.1		82.3	92.9	220.8	
2			148.0	29.5		3	1.0							0.13		61.3	23.9	16.7	62.3	24.5	10.4		75.5	89.6	227.4	
3			171.3	34.2		3	1.0							0.13		63.4	22.8	17.4	72.3	28.3	12.4		71.7	87.6	231.6	
4			223.1	44.6		3	1.0							0.39		45.3	28.5	23.9	88.1	38.8	18.4		61.2	81.6	230.9	
5			256.8	51.3		3	1.0							0.39		24.2	44.0	29.5	93.7	49.3	23.3		50.7	76.7	221.1	
6			340.3	67.9		3	1.0							0.78		3.7	53.5	31.2	95.8	81.2	35.8		18.8	64.2	178.8	
T			500.9	100.0												0.4	16.6	82.0	100.0	100.0	100.0		0.0	0.0	100.0	
77	500	500			30			4:1					1.0													
C			236.7	47.5		3	1.0							0.65		53.7	26.4	17.0	89.5	42.7	19.0		57.3	81.0	227.8	
T			261.7	100.0												5.7	32.1	65.6	100.0	100.0	100.0		0.0	0.0		
78	500	500			30			4:1			1.0															
C-1			90.0	18.0		3	1.0							0.13		66.5	22.9	10.9	42.5	13.7	4.7		86.3	95.3	224.1	
2			154.2	30.8		3	1.0							0.13		58.2	27.1	16.2	68.9	25.2	9.6		74.8	90.4	234.1	
3			178.8	35.7		3	1.0							0.13		68.3	23.4	12.4	80.8	29.0	11.1		70.1	88.9	240.7	
4			200.6	40.1		3	1.0							0.13		58.2	31.4	9.1	89.8	33.6	12.1		66.4	87.9	244.1	
5			207.5	41.5		3	1.0							0.13		54.0	32.9	12.9	92.4	35.1	12.5		64.9	87.5	244.8	
6			211.1	42.2		3	1.0							0.13		51.5	31.6	21.3	93.8	35.8	12.9		64.2	87.1	245.1	
T			501.0	100.0												3.0	33.4	62.4	100.0	100.0	100.0		0.0	0.0	100.0	
79	500	500			30	10		4:1					1.0			29.4	31.0	38.0								
C-1			174.3	35.3		3	2		8.6					0.26		57.2	27.7	22.0	68.0	32.0	21.0		68.0	79.0	215.0	
2			247.2	50.1		3	2		8.5					0.26		46.6	33.0	26.6	91.3	48.2	31.4		51.8	68.6	211.7	
3			263.5	53.4		3	2							0.26		43.6	34.2	21.0	96.4	51.8	33.4		48.2	66.6	211.2	
4			269.7	54.7		3	2							0.26		42.0	39.4	24.8	98.0	53.4	34.2		46.6	65.8	210.4	
5			275.7	55.9		3	2							0.26		23.4	50.2	26.8	98.7	55.1	35.0		44.9	65.0	208.6	
6			279.1	56.6		3	2							0.26		16.9	55.4	23.9	99.0	56.4	35.5		43.6	64.5	207.1	
T			493.6	100.0					8.1							0.7	30.4	54.9	100.0	100.0	100.0		0.0	0.0	100.0	
80	500	500			30	10		4:1					2.0													
C-1			208.3	42.0		3	3		8.3					0.65		56.4	26.6	20.4	78.5	33.7	21.9		66.3	78.1	222.9	
2			254.7	51.3												42.0	37.8	22.6	91.4	47.3	27.3		52.7	72.7	216.8	
T			496.5	100.0					8.3							5.3	36.0	58.4	100.0	100.0	100.0		0.0	0.0	100.0	
Screen Test																										
+150																6.9	24.6	63.0								
−150 +200																18.4	29.0	51.6								
−200																38.9	35.1	26.5								

Test & Product	Wt. of Ore (gm)	Wt of Water (gm)	Accumulative Wt. of Product (gm)	Accum. % Wt.	Grind (min)	Condition (min)	Skim (min)	Pulp Density	pH	Reagents – lb/ton: To Mill: $NaPO_3$	To Mill: $Na_4P_2O_8$	To Cell: $NaPO_3$	To Cell: Emulsol X-1	To Cell: Sulfonated Cod Oil	Assay %: $BaSO_4$	Assay %: $CaCO_3$	Assay %: SiO_2	Recovery-% (Accumulative): $BaSO_4$	Recovery-% (Accumulative): $CaCO_3$	Recovery-% (Accumulative): SiO_2	Loss-% (Accumulative): $BaSO_4$	Loss-% (Accumulative): $CaCO_3$	Loss-% (Accumulative): SiO_2	Index for $BaSO_4$	Remarks
81-A	500	500			15			4:1		2															Iron Mill
C			226.5	46.0		3	3		8.5				0.52		55.0	26.8	25.4	86.0	38.2	27.0		61.8	73.0	220.8	
T			493.5	100.0											7.6	36.8	58.5	100.0	100.0	100.0		0.0	0.0		
81-B	500	500			30			4:1		2															
C			227.8	45.6		3			8.5				0.52		56.6	27.8	17.9	87.8	38.9	22.4		61.1	77.6	226.5	
T			498.7	100.0											6.8	37.6	53.1	100.0	100.0	100.0		0.0	0.0		
82-A	500	500			30	10		4:1				1.0													
C-1			63.7	12.8		3	3		8.3					0.28	56.4	36.4	14.7	20.0	15.1	4.8		84.9	95.2	200.1	
2			124.5	25.0		3	2							0.28	58.2	37.6	13.3	39.8	30.0	9.0		70.0	91.0	200.8	
3			189.8	38.2		3	2							0.28	54.1	42.4	9.3	59.7	48.1	12.2		51.9	87.8	197.4	
4			236.9	47.7		3	2							0.28	48.2	49.2	9.8	72.5	63.2	14.6		36.8	85.4	194.7	
5			291.7	58.8		3	2							0.70	19.2	62.2	22.6	78.3	85.6	21.0		14.4	79.0	181.7	
T			496.4	100.0					8.2						18.9	10.8	75.0	100.0	100.0	100.0		0.0	0.0	100.0	
82-B	500	500			15	10		4:1				1.0													
C-1			52.4	10.4		3	3		8.4					0.28	67.3	28.8	6.7	23.5	9.5	1.6		90.5	98.4	212.4	Iron Mill
2			111.5	22.2		3	2							0.28	62.8	33.8	13.2	48.3	22.1	5.2		77.9	94.8	221.0	
3			163.2	32.5		3	2							0.28	56.1	38.4	12.2	67.7	34.6	8.1		65.4	91.9	225.0	
4			206.3	41.1		3	2							0.28	48.5	45.6	10.5	81.7	47.0	10.2		53.0	89.8	224.5	
5			302.8	60.3		3	2							0.70	22.9	56.8	25.9	96.5	81.4	21.7		18.6	78.3	193.4	
T			502.6	100.0					8.2						2.6	14.8	85.2	100.0	100.0	100.0		0.0	0.0	100.0	
83	500	500			30	10		4:1				1.0													
C-1			70.9	14.3		3	2		8.5				0.13		61.7	29.8	12.1	30.0	13.0	3.6		87.0	96.4	213.4	
2			136.4	27.5		3	2						0.13		63.4	24.8	19.2	58.4	23.0	8.9		77.0	91.1	226.5	
3			188.0	37.9		3	2						0.13		56.1	26.8	27.5	78.2	31.5	14.9		68.5	85.1	231.8	
4			207.3	41.8		3	2						0.13		52.6	29.0	27.5	85.3	35.0	17.1		65.0	82.9	233.2	
5			216.2	43.6		3	2						0.13		57.2	27.2	20.9	88.8	36.5	17.9		63.5	82.1	234.4	
6			227.6	45.9		3	2						0.13		53.9	28.8	29.9	93.0	38.5	19.4		61.5	80.6	235.1	
T			496.3	100.0					8.5						3.8	37.2	70.9	100.0	100.0	100.0		0.0	0.0	100.0	
84	500	500			30	10			9.4		2.0														Sodium Hexa-Metaphosphate
C-1			4.1			3	2						0.13												
2			8.5			3	2						0.26		27.1	53.8	15.8								
3			19.7			3	2						0.39												
4			42.6			3	2						0.39												
5			68.2			3	2						0.39												
6			94.0			3	2						0.39												
T			495.5																						
85	500	500			30	10			9.0		0.5														
C-1			59.9	12.1		3	2						0.52		75.1	18.8	7.1	30.7	7.3	2.2		92.7	97.8	221.2	
2			139.9	28.2		3	2						0.52		71.9	20.6	15.0	69.9	17.9	8.1		82.1	91.9	243.9	
3			205.1	41.4		3	2						0.52		46.6	32.6	23.6	90.9	31.7	15.7		68.3	84.3	243.5	
4			243.2	49.1		3	2						0.52		20.1	46.8	34.1	96.0	43.2	22.1		56.8	77.9	230.7	
5			275.1	55.5		3	2						0.52		6.9	46.2	46.4	97.3	52.5	29.4		47.5	70.6	215.4	
T			496.2	100.0											1.9	33.4	65.0	100.0	100.0	100.0		0.0	0.0	100.0	

ASSAY PROCEDURES

The simple composition of the synthetic ore used allowed the use of special adaptations of commercial assay procedures. Such procedures were developed by Elfstrom and Dayton, and were used with minor alterations in this research.

Determination of Calcium

Weigh out 0.5 grams of ore into a 400 c.c. beaker. Add 10 c.c. HCl, cover with a watch glass until all action ceases, add 5 c.c. HNO_3 and boil until brown fumes are all off. Place beaker on a low plate, rinse off cover glass, and take assay to dryness. Bake on a high plate for ½ hour, cool, add 10 c.c. HCl and 40 c.c. water, boil till clear, filter through a 12.5 cm. rapid filter, and wash with boiling water, with hot 1:1 HCl, and then with water four times.

Make the filtrate ammonaical; then 5 c.c. in excess. Boil, filter, and wash with boiling water.

To the filtrate add HCl until acid, then one c.c. excess. Add 3 grams ammonium oxalate, bring to boil, and add ammonia drop by drop till alkaline. Allow the precipitate to settle out for ½ hour, decant the solution through the filter, wash the precipitate into the filter, and wash well (5 times at least) with boiling water. Rinse out the beaker, washing it at least eight times, to remove all the ammonium oxalate.

Wash the precipitate into the original beaker, fold the paper over the edge of the beaker, add 100 c.c. hot water

and 5 c.c. 1:1 H_2SO_4, and heat nearly to boiling. Titrate to a pink colour with $KMnO_4$, add the filter paper, and finish titration.

Determination of Barite and Quartz

Fuse 1 gram of ore with 3 grams of sodium carbonate in a platinum crucible at 950° C. until the melt is clear. Pour the fused material into the crucible cover, immerse both crucible and cover, with contents, in a 250 c.c. beaker of hot water.

Digest for 10 minutes (or longer--overnight if convenient) remove the cover and crucible, and scrub and rinse well.

When solution is complete (i.e.all lumps have disintegrated) filter through a 12.5 cm. #1 Whatman filter, and wash well with hot water.

Reserve the filtrate for determination of silica.

Wash the residue back into the original beaker and dissolve with 1:1 HCl, adding 10c.c. free HCl in excess. Boil for 10 minutes. Add 4 c.c. H_2SO_4 in 20 c.c. water to the hot barium chloride solution. Cover the beaker, place on a medium plate and allow to settle for ½ hour. Decant the solution into a filter, wash the precipitate into the beaker, and wash at least eight times with boiling water. Ignite and weigh as barium sulfate.

Determination of Silica

Acidify the filtrate reserved for silica determination, adding 20 c.c. HCl in excess. Evaporate to dryness, and bake for ½ hour on a high plate. Add 15 c.c. 1:1 HCl, 150 c.c. water, and heat to boiling. Filter, and wash the residue.

To the filtrate, add 10 c.c. HCl and again evaporate to dryness. Take up with 15 c.c. 1:1 HCl, and 150 c.c. water, heat to boiling, and filter through the same filter paper. Wash six times with boiling water.

Ignite, and weigh as SiO_2.

Note. Some silica may be contained in the barium carbonate residue, hence in the high silicas, the filtrate from the barium sulfate filtration is best further acidified, taken to dryness, dissolved in 14 c.c. 1:1 HCl and 150 c.c. water, filtered, ignited, and the resultant silica obtained added to the regular silica assay.

	Green	James	
Chem 3	150	150	
" 4b	100	100	
Zool 9	100	75	
" 24	150	150	Grad 23
		100	Met 7
		100	Met 36
Thesis	300	300	675
98	400	300	550
	1200	1275	