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CRAIGMONT MINES LIMITED

SUMMARY

IRON FLOTATION TESTS

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LS/kb

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SUMMARY

(1). No satisfactory method has, as yet, been devised to make a saleable iron concentrate grade by flotation.

(2). The copper in the mill tailings are concentrated to a degree in the iron flotation product. This copper will occur penalties in the event of a satisfactory iron grade being made unless it can be removed.

INTRODUCTION

Since April 1964, over 100 investigations have been carried out on flotation of iron concentrates from mill tailings. Because the accepted practice for oxide flotation is to deslime before treatment, all investigations have been carried out on backfill sands. The experiments have been carried out mainly on tailings assaying approximately 12% total iron which is close to the average grade of mill feed over the past six months. The calculated ore reserves are in the order of 20% iron but tests were carried out on the mill tailings in preference to a simulated ore to try to include actual conditions brought in by the copper extraction. It is intended to conduct a short series of tests on selected ore running close to the reserve grade using the best flotation methods obtained from this series.

In the event of an acceptable grade of iron being obtained there will still be a problem of removing the copper from the iron concentrate. Assays were not made on all investigations but ones that were carried out indicate a copper value of 0.04% or higher.

Experiments were carried out under the following headings:

(1). Flotation using various fatty acids.

(2). Flotation under natural mill tailing conditions.

(3). Flotation with pH control.

(4). Flotation of hematite after magnetic separation.

(5). Flotation after conditioning with soluble sodium salts.

(6). Flotation and depressing of (a) Gangue (b) Iron.

(7). Effect of substituting reagents in copper circuit.

Results:

From Table 1 and Graph I it is seen that the iron content of the size fractions is at a maximum in the +400 mesh to-100, +150 mesh range, (37-105 microns) and falling away rapidly outside these values, indicating that the mineral grain is liberated at this grind and should be amenable to flotation. Table 2 and Graph II however, show that little selective flotation takes place throughout the complete size range so that, for samples assaying as low as 12% iron, no amount of cleaning will make a saleable concentrate.

RESULTS

(1). Comparative tests with various Fatty Acids.

Comparison with various fatty acids show that Actinol FA2, a fatty acid containing 51% Oleic, 45% Linoleic and 1% Rosin Acids is on a par with Parmak 4 in giving the best results; while Actinol FA1 with 46% Oleic, 41% Linoleic and 4% Resin Acids give the poorest. Oleic Acid on its own was not as good as Actinal FA2 indicating that the variation in Oleic Acid alone was not the significant factor. None of the reagents showed any great degree of selectivity, the best ratio of concentration being below 3 to 1, the majority being in the order of 2 to 1. (Table 3).

(2). Flotation under natural flotation conditions.

Flotation of mill tailings direct from cyclone underflow using mill circuit water did not give any satisfactory results. Ratio of concentration was approximately 2:1 and recoveries were between 60 and 70% total Fe regardless of the amount of collector used.

(3). Flotation with pH Control.

(a) Alkaline Pulp.

pH was adjusted to various values between 8 and 11 with Caustic Soda then floated with Sodium Oleate. Recoveries were poor with the ratio of concentration being of the order of 2.5:1, the magnetite tending to be depressed. (Table 4)

(b) Acid Pulp.

pH was adjusted to values between 4.0 and 2.5 with sulphuric acid. One series of tests were carried out on sized particles ranging from minus 100, plus 150 mesh to all minus 200 mesh using a mixture of Cyanamid Reagent 801 and fuel oil. Another series of tests were carried out on the natural backfill with Actinol FA1, adding sulphuric acid to the various stages of flotation. A third series were carried out using CO_2 gas as outlined in US patent, 2,980,253, "Flotation of Iron Ores Containing Calcium & Magnesium" by Mortenson and Magne.

High acid consumption took place in all of these tests. At the end of each float the pH was back to neutral or basic. No satisfactory results were obtained. (Table 5).

(4). Flotation of hematite after magnetic separation.

Samples were passed over a magnetic separator at varying densities. The magnetics were combined, ground for 3 minutes then passed through the separator again. The magnetic tails were floated separately, their float products being reground before being refloated.

Varying the densities did not affect the recoveries in the magnetic separation. Poor flotation is thought to have been due to the type of ore as can be seen by the low grade of both magnetites and cleaner concentrates which were both ground to practically all minus 200 mesh. Poor recovery in the cleaner circuit is attributed to overgrinding.

(5). Flotation after conditioning with soluble salts.

From the experience gained it was thought that the calcium ion from the lime used in copper flotation may have been interfering with the selectivity of the iron flotation. Experiments using soluble sodium salts in which the sodium ion would replace the calcium ion in the solution were carried out.

The rougher concentrate recovery improved from 75-83% when sodium chloride was added at the rate of 8 lb/ton and the pulp conditioned at 65% solids by weight. (Graphs III & IV). The best result was obtained using a mixture of 4 lb/ton potassium chloride and 4 lb/ton sodium sulphate when a rougher concentrate showed a recovery of over 87%. (Table 7).

Over forty investigations were made using variations in pulp temperature, pH and depressants but the best results obtainable gave only ratios of concentration of approximately 3:1 and reduced the percentage iron recovered to figures in the low fifties.

(6). Flotation and depressant of (a) Gangue (b) Iron.

The depressants used were (1) NaOH (2) H_2SO_4 (3) Cyanamid reagents 610, 620 and 633, and combination of these. Best results were obtained by depressing the silicates with sulphuric acid in stages in the cleaner and recleaner circuits where the recovery was in the mid-seventy percent range with grades of 32-34% Fe. (Table 8).

(7) Effect of substituting reagents in the Copper Flotation.

To test the validity of the calcium ion being the interfering agent in the iron flotation, work has commenced on the substitution of Na_2CO_3 for lime in experimental laboratory tests. It is too early to predict accurate results but preliminary investigations are not encouraging.

Table 1.
Mill Feed.

Sieve Sizing Tylor Mesh	Size Microns	Weight Grams	% Fe	Weight Fe
+100	149	515.6	8.30	42.77
+150	105	79.6	20.05	15.96
+200	74	80.3	25.64	20.59
+270	53	10.5	25.81	2.71
+400	37	19.4	22.70	4.40
-400	-	45.5	18.75	8.53
Head	-	705.9	12.64	94.96

Table 2.

	FLOAT PRODUCT				FLOAT TAILINGS		
Sieve Sizing Tylor Mesh	Size Microns	Weight Grams	% Fe	Weight Fe	Weight Grams	% Fe	Weight Fe.
+100	149	132.6	20.7	27.45	383.0	4.0	15.32
+150	105	50.1	29.2	14.63	29.5	4.5	1.33
+200	74	60.2	32.1	19.32	20.1	6.3	1.27
+270	53	7.7	33.0	2.54	2.8	5.9	0.17
+400	37	11.7	33.3	3.90	7.7	6.5	0.50
-400	-	35.7	21.5	7.68	9.8	8.7	0.85
Head	-	353.0	21.2	75.52	452.9	4.29	19.44

Table 3.

500 gram samples conditioned for 3 minutes with 2 grams NaCl, then for 1 minute with 1 ml. fatty acid and floated for 4½ minutes.

Reagents used: Aerofloat 756: Parmak 4: Actinol FA1: Actinol FA2: Oleic Acid.

Results.

Reagent	Sample	Weight	% Fe	Wt. Fe.	% Dist. Fe
765	Flot.	199.0	24.4	48.56	79.14
	Tails	297.7	4.3	12.80	
Parmak 4	Flot.	258.8	20.1	52.02	86.92
	Tails	237.3	3.3	7.83	
FA1	Flot.	133.9	32.6	43.65	69.69
	Tails	365.2	5.2	18.99	
FA2	Flot.	246.5	20.8	51.44	86.88
	Tails	250.3	3.1	7.76	
Oleic	Flot.	231.2	22.0	50.86	84.33
Acid	Tails	270.0	3.5	9.45	

Table 4.

2130 gram conditioned for minutes with 1 gram NaDH then conditioned for 1 minute with 1 gram Sodium Oleate, then floated for 6 minutes. Float product refloated for 3 minutes.

pH before NaOH addition 8.5
pH after NaOH addition 11.4
pH after Flotation 10.7

Temperature of pulp at beginning of float 74°F.
Conditioning density 60% solids by weight.
Flotation density 50% solids by weight.
Additional water added during flotation - 440 ml.

Results	Weight Grams	% Wt Mag.	% Fe Mag.	% Fe	Total Fe	Mag. Fe	Non Mag. Fe	Dist. % Non Mag.	Dist. % Mag.	Dist. Total Fe
Cleaner Flot.	381	8.2	63.4	38.6	147.07	19.81	127.26	41.97	9.99	29.32
Cleaner Tail.	282	19.0	66.2	37.8	106.60	35.50	71.10	23.45	17.90	21.25
Final Tail.	1467	16.7	58.4	16.9	247.92	143.07	104.85	34.58	72.11	49.43
	2130	15.48	60.15	23.55	501.59	198.38	303.21	100.00	100.00	100.00

Calculated Head Assay % Fe 23.55
Hematite % Fe 14.24
Magnetite 9.31

Table 5.

(i) Acid Flotation on sized particles.
Reagents used: Cyanamid R801 and Fuel Oil, 10% H_2SO_4 solution.

(a) 500 grams - 200 mesh.
40 ml. 10% H_2SO_4.
pH 2.5 commencement of test.
pH 6.4 at end of test.
Conditioned 10 minutes with 4 ml R801 and 4 ml. Fuel Oil.
Further 2 ml. of each added after 3 minutes flotation.
Floated for 10 minutes.
Concentrates refloated for 2 minutes.

(b) 500 grams -150 +200 mesh
Reagents: 40 ml. 10% H_2SO_4
4 ml. R801/Fuel Oil mixture ratio 801/F:0::2:1

Conditioned for 15 minutes, floated for 5 minutes.
Cleaned for 3 minutes.

pH before Test 4.5 After Test 6.7

Results.

Test No.	Sample	Weight Grams	% Fe	Wt. Fe	% Fe Dist.
-200#	Cl.Flot.	261.3	50.6	132.2	61.5
	Cl. Tls.	139.3	40.9	57.0	26.5
	F. Tls.	97.8	26.4	25.8	12.0
	Head	498.4	43.14	215.0	100.0
-150#	Cl. Flot.	34.4	27.2	9.4	8.0
+200#	Cl. Tls.	62.4	29.5	18.4	15.5
	F. Tls.	399.7	22.7	90.7	76.5
	Head	496.5	23.9	118.5	100.0

Remarks:

Insufficient reagent added to float - 150, +200# sample.

750 grams conditioned at 50% solids with varying amounts of CO_2, gas, NaCl and Fatty Acid.

(a) 41 grams CO_2 pH start 6.0 6 minutes conditioning time.
3 grams NaCl conditioning time 3 minutes.
k.5 ml. Actinol FA2 conditioning time 1 minutes.

(b) 46 grams CO_2 pH start 6.2 10 minutes conditioning time.
3 grams NaCl, conditioning time 3 minutes.
0.75 ml. Actinol FA2, conditioning time 1 minute.

(c) 48 grams CO_2 pH start 6.2- end 8.4.
NaCl - Nil.
0.75 ml. Actinol FA2 conditioning time 3 minutes.

(d) 81 grams CO_2 pH start 5.8 - end 6.7
NaCl - Nil.
0.5 ml. Actinol FA2, conditioning time 5 minutes.

Results.

Sample No.	Wt.	% Fe	Wt. Fe	% Dist.
(a) Float	192.2	30.2	58.04	63.11
Tails	556.0	6.1	33.92	
(b) Float	123.5	28.5	35.20	38.53
Tails	624.0	9.0	56.16	
(c) Float	92.6	35.1	32.50	36.16
Tails	652.0	8.8	57.38	
(d) Float	62.8	31.6	19.84	22.76
Tails	680.0	9.9	67.32	

Table 6.

4 x 2000 gram samples passed over magnetic separator. Concentrator combined, ground and cleaned, tailings kept separate. Cleaner tails split four ways and added to rougher magnetic tailings. Rougher tails floated separately, concentrates combined reground and refloated.

Grinding: Magnetic Concentrate 3 minutes with 6 rods.
Flotation Concentrate 4 minutes with 12 rods.

Flotation: Reagent mixed ratio 2:1::R801:Fuel Oil.

Sample (a) Conditioned for 10 minutes at 50% solids with 10 ml. reagent plus 3 ml. Fuel Oil; 25 ml. 10% H_2SO_4
pH flotation 2.0.
Flotation time - 10 minutes.

Sample (b) Conditioned 10 minutes 50% solids
20 ml. H_2SO_4 12 ml. reagent mix.
pH 3.7
Flotation time 5 minutes.

Sample (c) Conditioned 10 minutes 50% solids.
20 ml. H_2SO_4 15 ml. reagent mix.
pH 2.8
Flotation time 8 minutes.

Sample (d) Conditioned 3 minutes 50% solids.
12 ml. reagent mix, 20 ml H_2SO_4
pH 2.0
Flotation time 8 minutes.

Results.

	Wt.	% Fe
Magnetic concentrate	267.0	42.4

Sizing Tylor Mesh	Wt. Grams	Assay % Cu	Assay % Fe	Wt. Fe
+150	19.7	0.08	16.0	3.15
+200	15.4	0.04	28.1	4.33
-200	64.9	0.03	54.2	35.20
Head (Calc.)	100.0	0.04	42.68	42.68

Rougher Flotation

Sample	Wt.	% Fe	Wt. Fe	% Dist.	% Cu.	Wt. Mag. %
(a) Float	151.6	45.1	68.37	31.4		
Tail.	1694.0	8.8	149.07			6.5
(b) Float	197.9	37.5	74.1	29.0		
Tail	1576	8.4	132.38			7.5
(c) Float	236.1	40.0	74.44	38.2	0.045	
Tail	1615	7.4	119.51			7.5
(d) Float	257.4	38.5	99.10	42.5	0.032	
Tail	1598	8.4	134.23			6.5

Rougher concentrates were weighed, separately, 50 grams of each sent for sizing and a smaller sample set aside for assay. The remainder were combined for cleaner float test. 626 grams of rougher concentrates were ground for 5 minutes using 10 rods at 70% solids, diluted to approximately 30% solids and floated for 3 minutes.

Results	Wt.	% Fe	Wt. Fe
Cl Flot	181.5	28.6	51.91
Cl Tls.	440.3	45.5	200.34

Sizing	Cl Flot.	Cl. Tls.
+100		
+150		
+200	1.2	5.4
-200	98.8	94.6

Table 7.

500 grams backfill scrubbed for 3 minutes with 1 gram Na_2SO_4 and 1 gram KCl then filtered. Cake repulped and conditioned for 5 minutes with Actinol FA2 and floated.

Rougher float product conditioned for 3 minutes with 2 ml. 10% solution H_2SO_4. Cleaner float conditioned for 3 minutes with 5 ml., 10% H_2SO_4 and 0.25 grams Cyanamid Reagent 610 then refloated.

Results	Wt. Grams	% Fe	Wt. Fe Grams	Fe % Dist.
F. Tls.	268.7	2.8	7.52	12.41
Cl Tls.	67.8	6.9	4.68	7.72
ReCl. Tls	75.1	20.2	15.17	25.04
ReCl. Flot.	85.4	38.9	33.22	54.83
Heads	497.0	12.19	60.59	100.00

Table 8.

Alkaline Depressant.

750 grams backfill conditioned with varying amounts of NaOH and floated with 1.5 ml. Fatty Acid. Float product treated with varying amounts of Cyanamid depressant in 600 series, as follows.

(1). 1 gram NaOH in rougher circuit. 1 gram 633 conditioned for 5 minutes in cleaner circuit.

(2). As for (1) but using only 0.5 gram NaOH.

(3) As for (1) but using only 0.25 gram NaOH.

(4) As for (1) but adding additional 0.25 grams NaOH in rougher float.

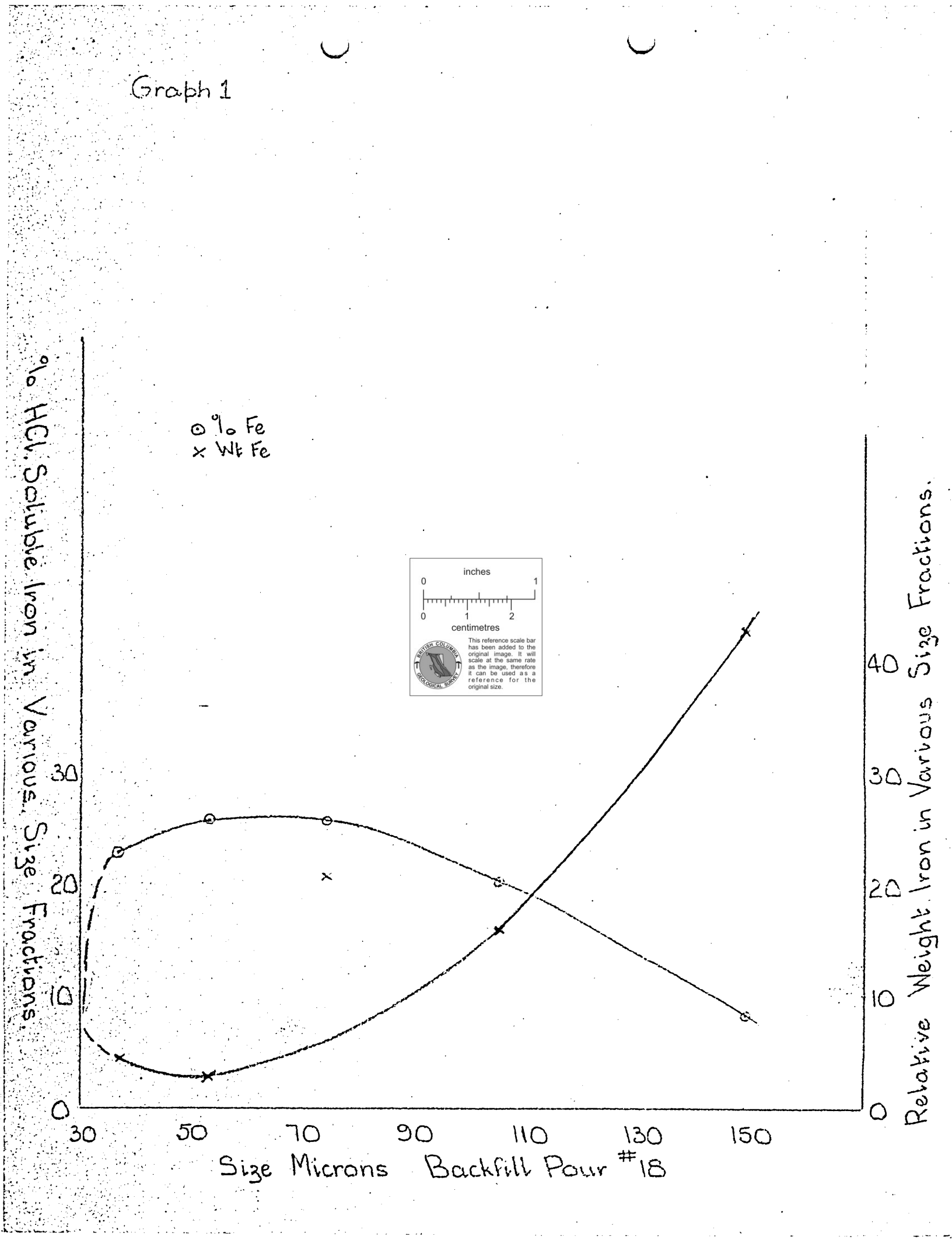
Results.

Sample No.	Wt.	% Fe	Wt. Fe.
(1) F.Tls	291.4	3.0	8.74
Cl.Flot	176.6	10.3	18.19
Cl.Tls.	281.4	22.4	63.03
(2) F.Tls.	417.9	5.8	24.24
Cl.Flot.	141.2	10.6	14.97
Cl.Tls.	189.7	26.4	50.08
(3) F. Tls.	344.5	3.5	12.06
Cl. Flot.	257.7	24.0	61.85
Cl. Tls.	148.1	10.8	15.99
(4) F. Tls.	431.2	5.1	21.99
Cl.Flot.	103.5	9.3	9.63
Cl.Tls.	216.9	28.2	61.17

500 grams backfill conditionid with 2 grams NaCl for 3 minutes then 1 ml. Fatty Acid and floated. To float product 7 ml. 10% solution H_2SO_4 added, conditioned for 3 minutes then refloated. To cleaner float 3 ml. of 10% H_2SO_4 added and floated again.

Results	Wt.	% Fe	Wt. Fe	% Fe Dist.
F. Tls.	236.0	3.4	8.02	12.86
Cl. Tls.	86.9	5.4	4.69	7.52
ReCl. Tls.	27.1	8.8	2.38	3.81
ReCl.Flot.	146.2	32.3	47.22	75.81
Heads	496.2	12.59	62.31	100.00

Graph 1


⊙ % Fe
× Wt Fe
% HCl Soluble Iron in Various Size Fractions.
Relative Weight Iron in Various Size Fractions.
0
10
20
30
40
30
50
70
90
110
130
150
Size Microns Backfill Pour #18
inches
0
1
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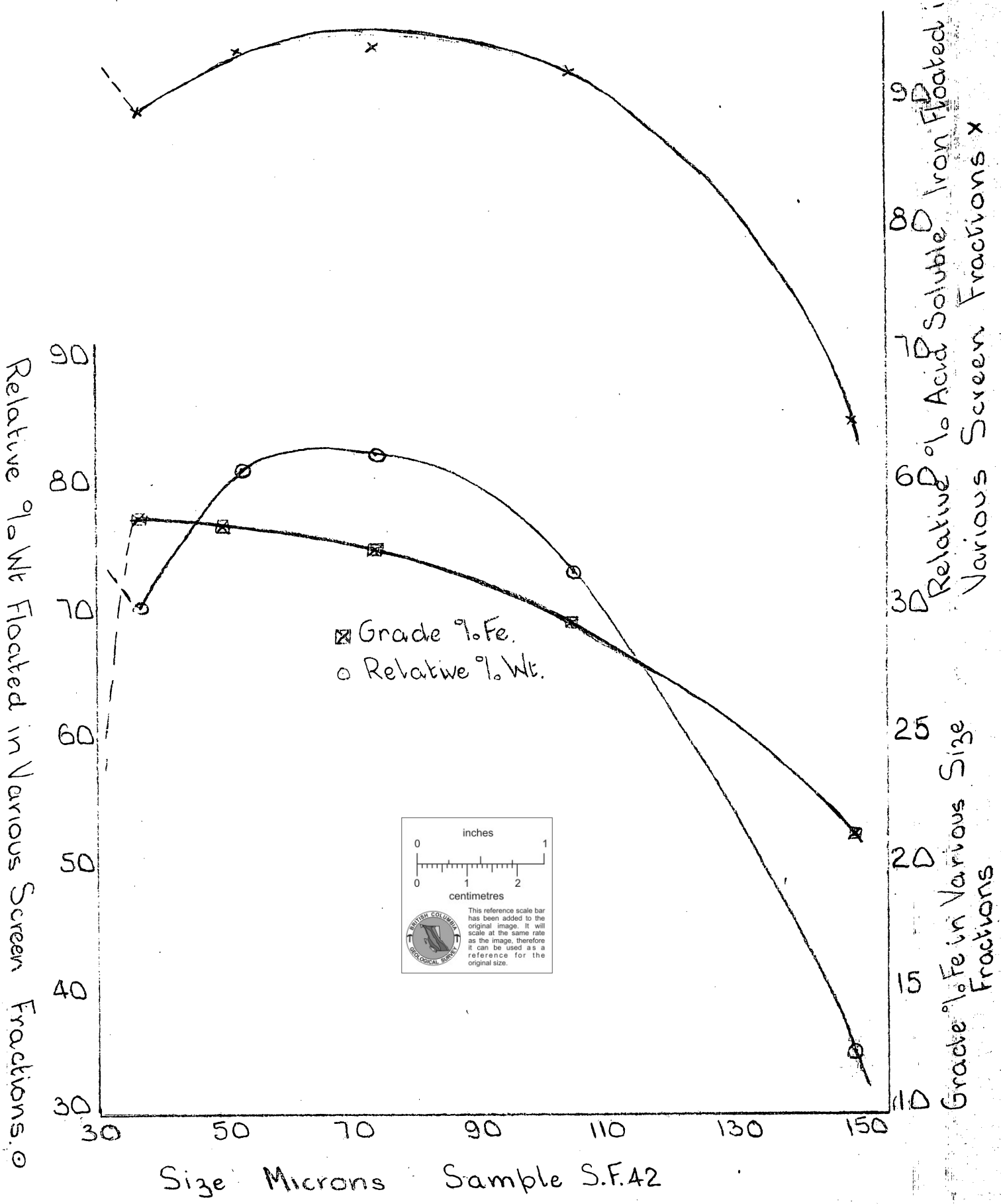
centimetres
This reference scale bar has been added to the original image. It will scale at the same rate as the image, therefore it can be used as a reference for the original size.
BRITISH COLUMBIA GEOLOGICAL SURVEY

Graph II


Relative % Wt Floated in Various Screen Fractions ⊙
Relative % Acid Soluble Iron Floated in Various Screen Fractions ×
Grade % Fe in Various Size Fractions
Size Microns
Sample S.F.42
90
80
70
60
50
40
30
30
50
70
90
110
130
150
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⊠ Grade % Fe.
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This reference scale bar has been added to the original image. It will scale at the same rate as the image, therefore it can be used as a reference for the original size.
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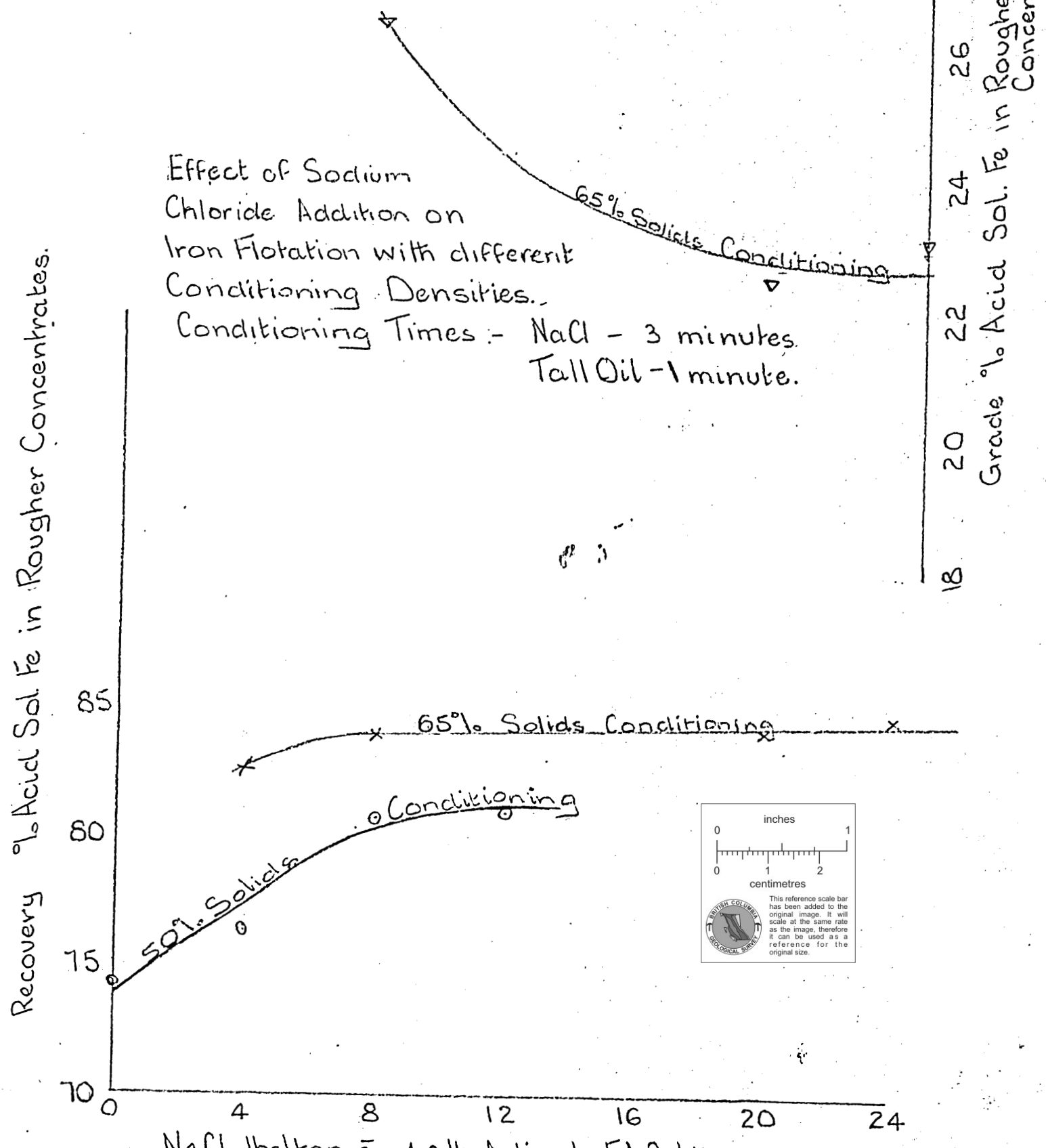
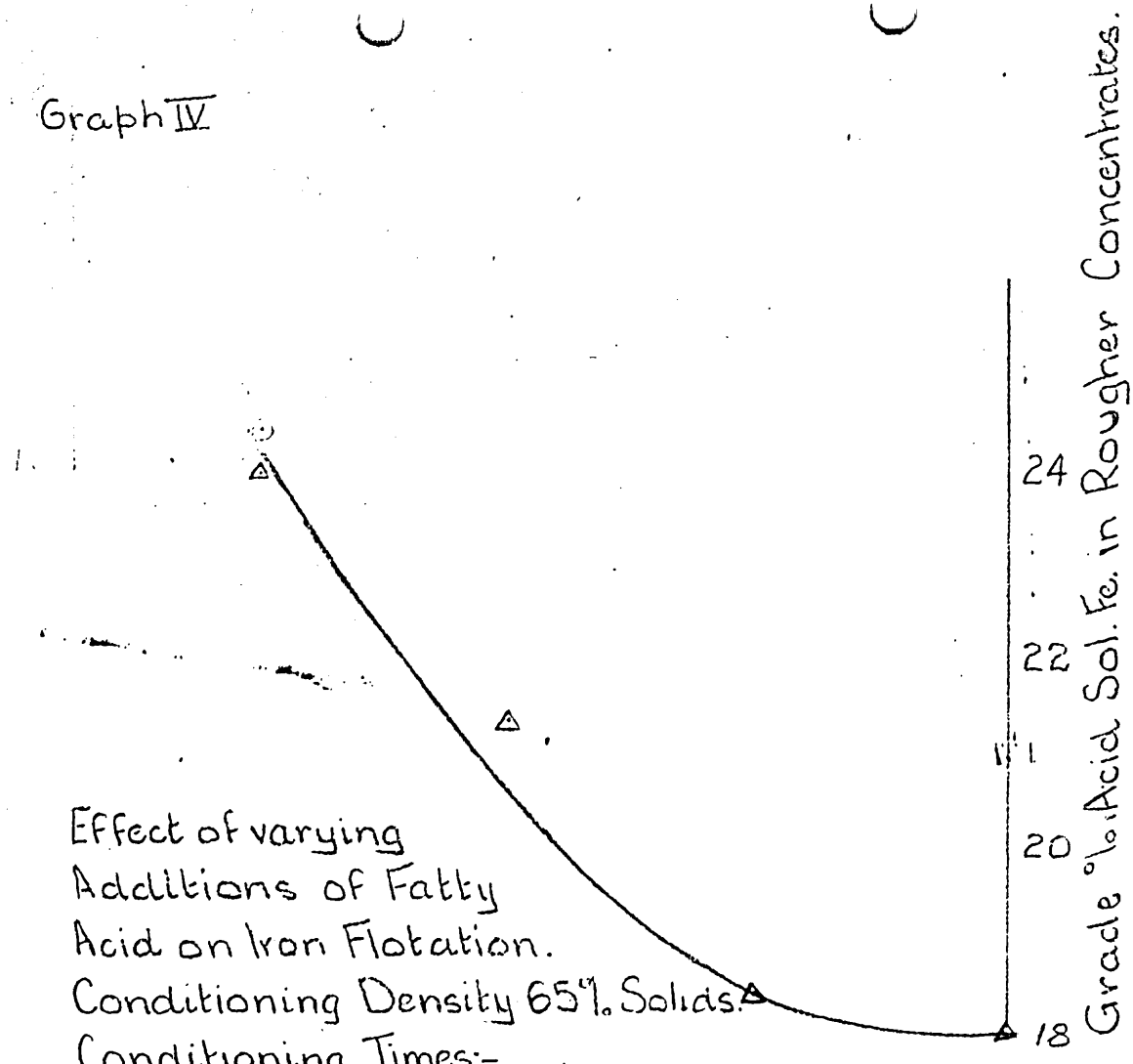
Graph III.

Effect of Sodium Chloride Addition on Iron Flotation with different Conditioning Densities.

Conditioning Times :- NaCl - 3 minutes.
Tall Oil - 1 minute.



Graph IV



Effect of varying Additions of Fatty Acid on Iron Flotation.
Conditioning Density 65% Solids.
Conditioning Times:-
NaCl. - 3 minutes
Tall Oil - 1 minute.