Flotation Test of Grum Ore

for Kerr Addison Mines Limited

by Dowa Mining Co., Ltd.

October, 1976

Report on beneficiation of Grum ore

This report is based on the result of fundamental investigation and metallurgical test on Grum ore which were continued at Kosaka laboratory, Dowa Mining Co., Ltd. for about 2 months.

1. Summary of mineralogical investigation on the beneficiation

Informations obtained in mineralogical investigation may be summarized as follows:

The determinations of the component minerals were done by microscoping, X-ray analysis and chemical analyzing. The copper mineral is mostly chalcopyrite and occupies minor quantity of the ore. The lead mineral is galena. The zinc mineral is sphalerite. The iron sulfide minerals are pyrite, arsenopyrite and pyrrhotite. The principal gangue minerals consist of quartz and biotite. These sulfide minerals occupy approximtely 45 percent of the ore. These component sulfide minerals are finely disseminated and interlocked with each other. In particular, some parts of the sulfide minerals disseminated in the gangue minerals are finer than 10 microns.

2. Summary of preliminary examination of flotation

As preliminary examination of separation, floatability tests were run for the purpose to familiarize investigators with the ore, and obtain some suggestions contributing the process research. The flotation samples, after crushed, were made up by mixing and divided. Table 1 shows the complete analysis result of the flotation sample.

At the flotability tests, each 500 grams sample, crushed under 37 mesh, was ground to 37 micron (81%). The sample, after being transferred to the flotation machine bowl, was diluted to 25 percent solid. Conditioning was done in the bowl with air valve closed.

The test results are tabulated in Fig. 1, 2, 3, 4, 5, 6, 7. The floatability test results show the effects of collectors, pH value of the pulp and some depressants of sphalerite and pyrite. Lime, sodium cyanide, zinc sulfate and soda ash were used as depressants. The collectors were ethyl xanthate, amyl xanthate, aerofloat #208 and KL #2044 (developed for Black ore flotation by Dowa). Of the tests, the results of No. 7, 8, 10, 11 and 12 indicate that lead recovery and the selectivity are exceeded. The flotation conditioning of test No. 7 was that after grinding the pulp was conditioned by lime, and then floated by using amyl xanthate and ethylene glycol frother. Through the floatability tests, it is found that the flotation behavior of each mineral is natural and then lime is effective depressant for sphalerite and pyrite.

3. Summary of the selective flotation test

3.1 Lead flotation

The flowsheet and the results of the lead flotation are given in Fig. 8, OA 500 grams ore sample was ground to 37 micron minus 81 percent. In the rougher flotation, the sample was diluted to 25 percent solid, and then was floated by using amylxanthate and Dow #250 frother, while lime was used as the depressants of sphalerite and pyrite. The lead rougher concentrate was reground and conditioned by sodium cyanide, and was floated by using minor amount of amylxanthate and frother. Lead concentrate was produced through four stages of cleaning circuits. Biotite was rejected as froth at the first stage of the lead rougher circuit, but was depressed in the lead cleaners. The test results show that lead recoveries are 83.4 - 66.0 percent and lead assay are 65.91 - 62.75 percent.

The test flowsheet showed in Fig. 10 was arranged from the special process which was developed for recovering lead from Black ore without cyanides by Dowa. The lead rougher concentrate was first recovered as froth using lime in the normal manner with a very small quantity of amyl xanthate. Some pyrite and sphalerite remained in the lead rougher concentrate were next floated after conditioning by using sulfurous acid and keeping the pulp warm. For many years this method has been employed for Black ore flotation.

3.2 Zinc flotation

The lead rougher tailing and the cleaner tailings were fed into the zinc flotation section. At zinc rougher flotation, the pulp was conditioned to activate sphalerite by using copper sulphate, being controlled at pH 11 by using lime as pyrite depressant. The zinc rougher concentrate was reground and repeated cleanings 4 times. The metallurgical result and the flowsheet are given in Fig. 9. Zinc recovery is 65.3 percent. Unfortunately, however, some zinc minerals are difficult to float, as they are none-sulphide minerals. The chemical form analysis result of the zinc minerals is shown in Table 2, and photomicrographs suggest that the liberation of the sphalerite is very difficult. (Please refer to Photo.)

4. Cycle test of selective flotation

The cycle tests were carried out to be informed the effect of circulating materials. The flowsheet is presented in Fig. 11. Tailings of each cleaner circuit were fed to the rougher section of next stage, mixed and treated. These cycle tests consisted of 14 series, and the material balance sheet was made up from the results of No. 10, 11, 12, 13 and 14 tests. Two concentrates were produced, while lead recovery was 71.5 percent, zinc recovery was 76.0 percent. The water used for the test was fresh water for the first stage, but the recycled water was used again for next stages continued. Table 4 shows the particle size distributions of flotation feed, lead concentrate, zinc concentrate and final tailing. The final tailing consists of zinc rougher tailing and zinc first cleaner tailing. Complete analyses results of the lead concentrate and the zinc concentrate are presented in Table 3.

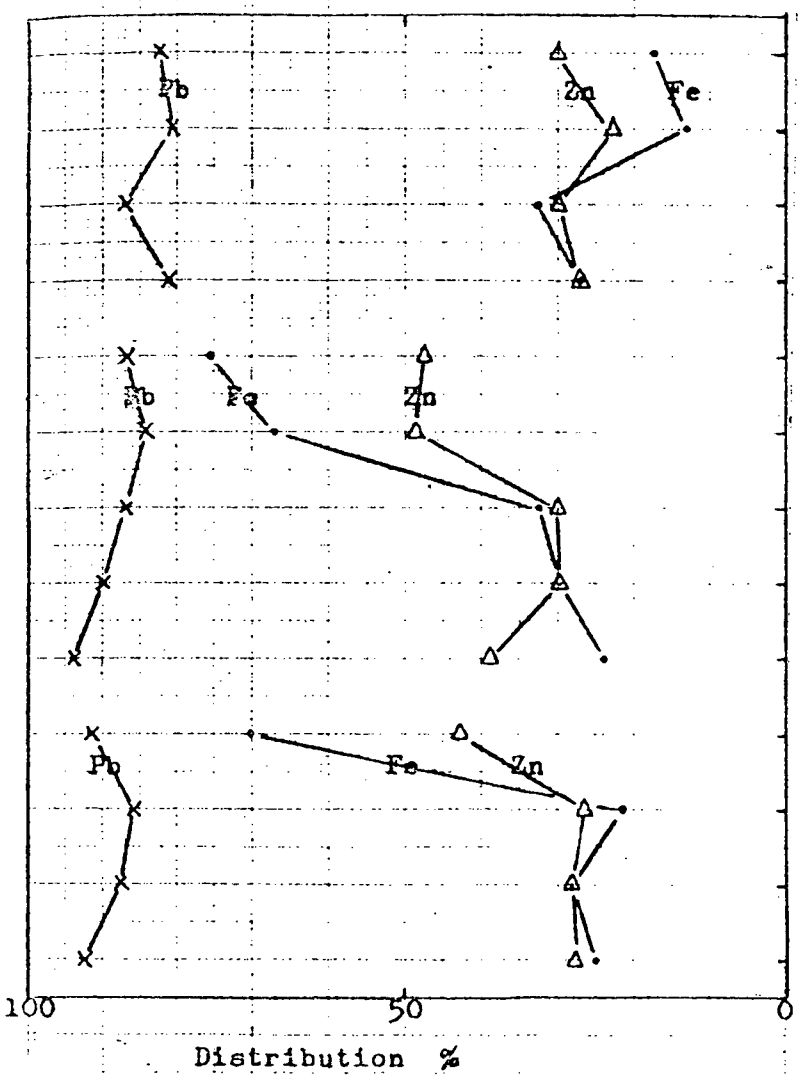
5. Comments

Through the tests, we recognized the flotation characteristic of Grum ore, which is lead and zinc ore containing poorly copper and highly iron sulfides. Separation difficulty of Grum ore is due to highly contained iron sulfides and finely disseminated mineralization. The lead and zinc sulfides are substantially liberated at a 400 mesh grind, but copper is found as being associated with sulfide minerals, and at this size many mixed grains are seen. Galena, sphalerite and copper minerals are finely grained, but iron sulfide is much more fairly and coarser disseminated.

Galena responds to conventional lead flotation by using cyanides, although reagent consumption is somewhat higher than required in similar lead and zinc flotation and particle size for separation is finer. Relatively, repeating the cleaning flotation is required to achieve high lead recovery. In actual operation lead recovery of more 80 percent may be expected on our experience. Lead content of the concentrate will be approximately 65 percent.

Through the tests, zinc concentrate of high grade was not gained. The dirtiness of zinc concentrate is caused due to fine grinding and coagulation of particles, we suppose.

Fig. 1 Flotability test results



Test No.	Reagents & consumption
No. 1	KL#2044 50 g/t pH 8.8
No. 2	AF#208 50 g/t pH 8.8
No. 3	AX 50 g/t pH 8.7
No. 4	EX 50g/t pH 8.5
No. 5	AX 50 g/t pH 5.0(H_2SO_4)
No. 6	AX 50 g/t pH 7.2(H_2SO_4)
No. 3	AX 50 g/t pH 8.7
No. 7	AX 50 g/t pH10.5(Lime)
No. 8	AX 50 g/t pH11.5(Lime)
No. 9	AX 50 g/t pH 7.6 NaCN 100 g/t
No.10	AX 50 g/t pH 8.9 NaCN 200 g/t
No.11	AX 50 g/t pH 8.5 NaCN 200 g/t $ZnSO_4$ 200 g/t
No.12	AX 50 g/t pH 8.5 NaCN 200 g/t $ZnSO_4$ 200 g/t Na_2CO_3 500 g/t

Symbols;

AX : Sodium amyl xanthate

AF#208 : Aerofloat#208

KL#2044 : Sodium dialkyl dithiophosphate produced by Dowa

EX : Sodium ethyl xanthate

Conditioning & flotation

Conditioning time of depressats 10 min.
Conditioning time of collector & frother 5 min.
Flotation time 15 min.

Fig. 2 Flotability test results

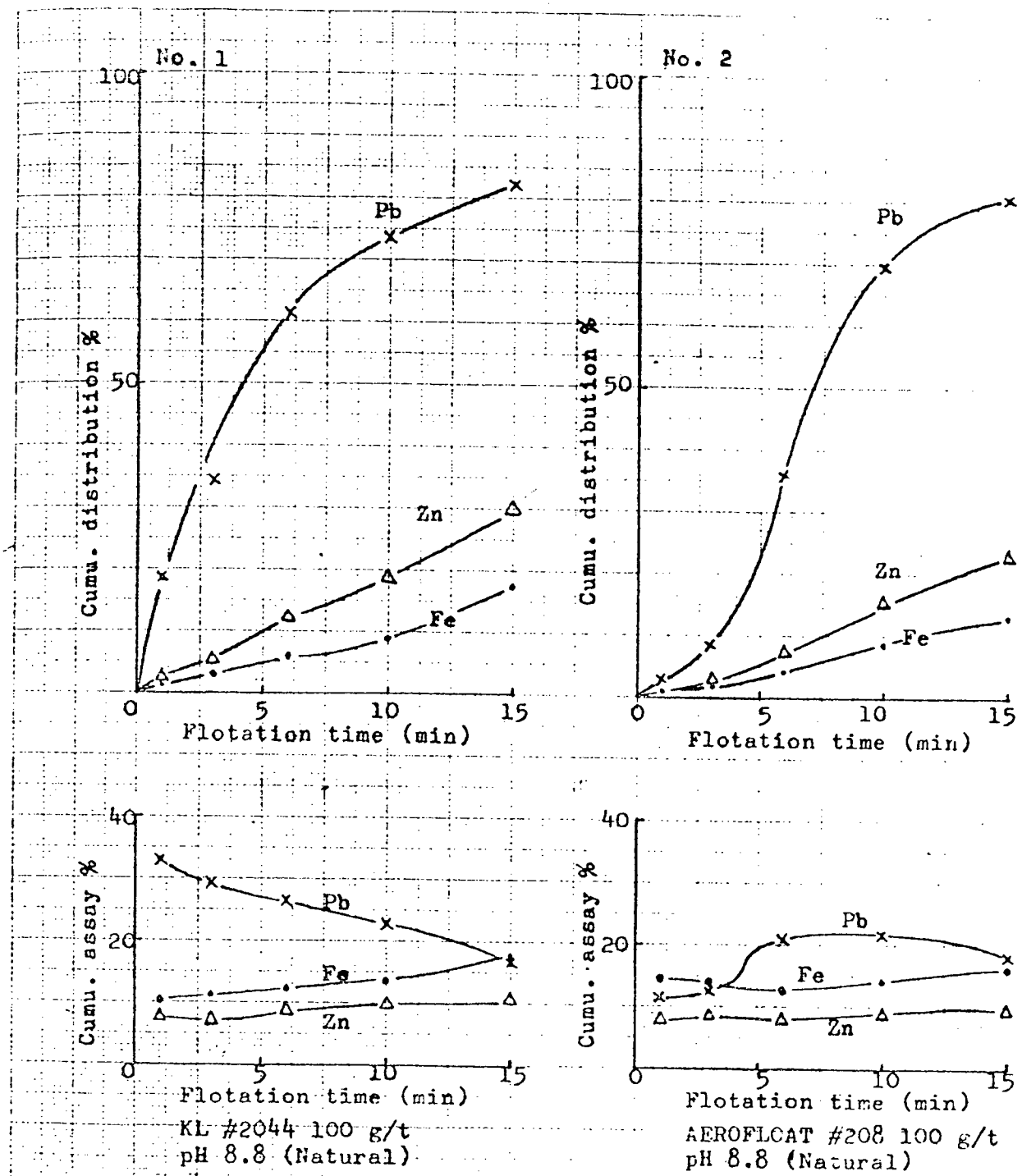
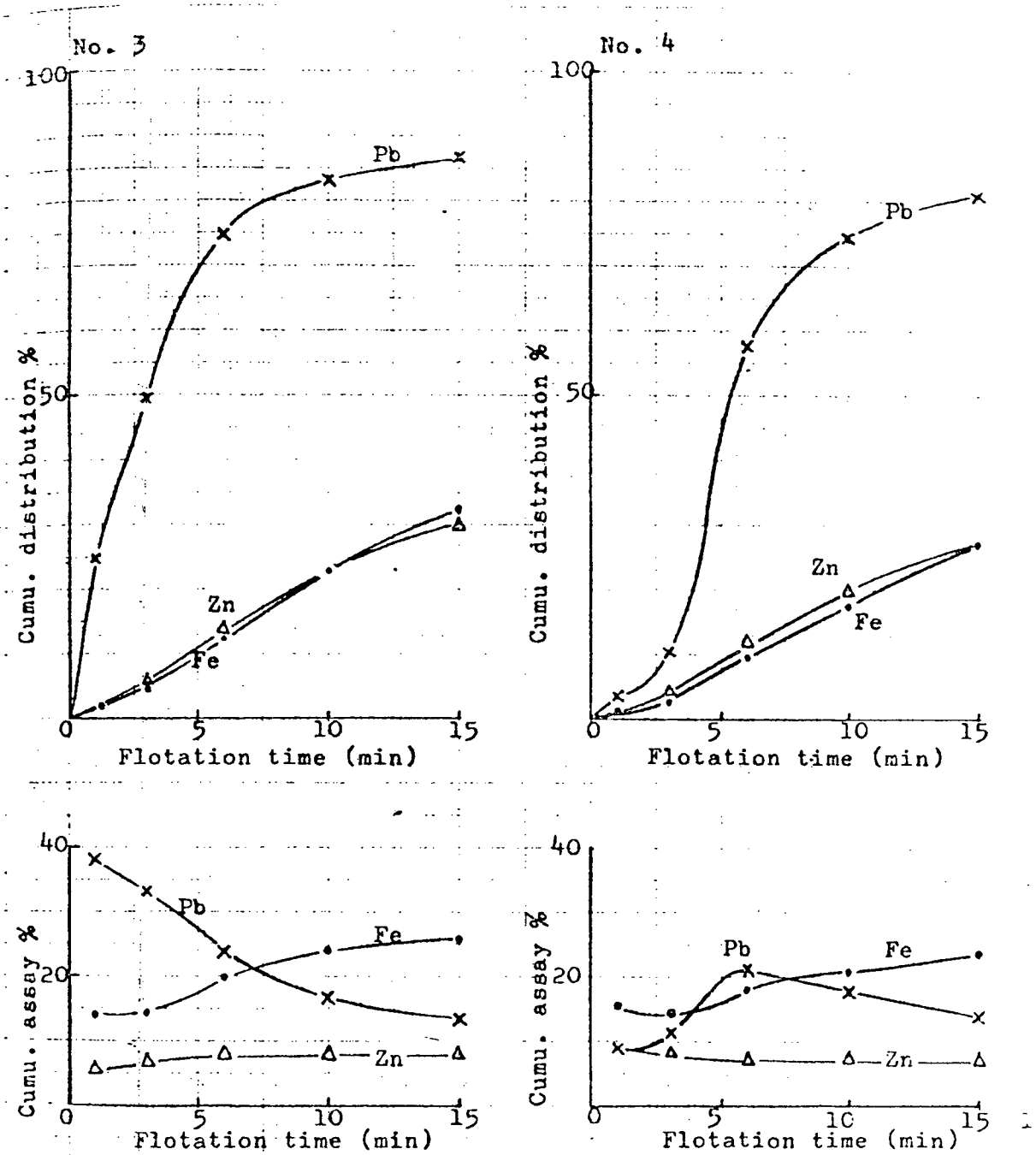


Fig. 3 Flotability test results



Amyl xanthate 50 g/t
pH 8.7 (Natural)

Ethyl Xanthate 50 g/t
pH 8.5 (Natural)

Fig. 4 Flotability test results

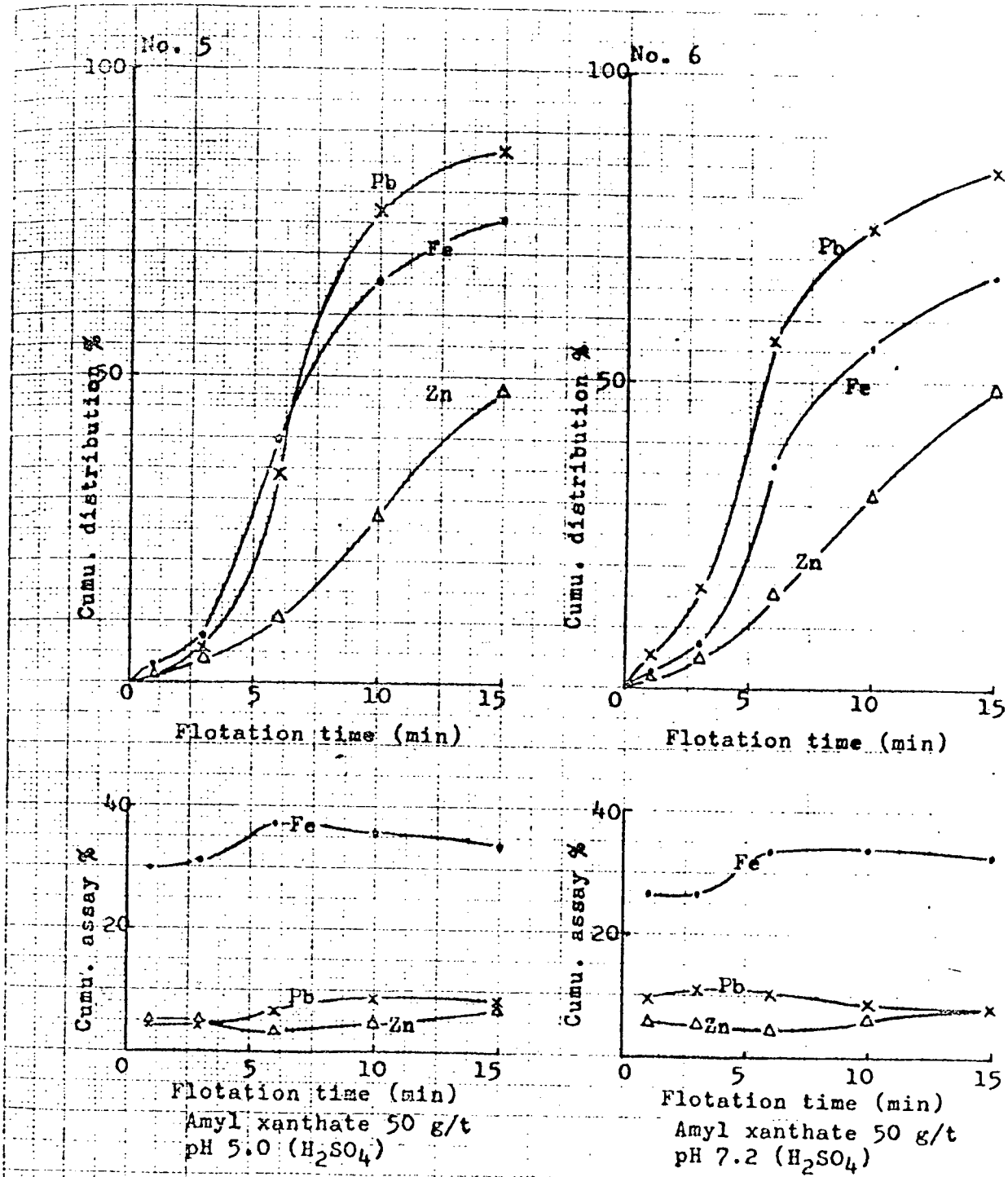


Fig. 5 Flotability test results

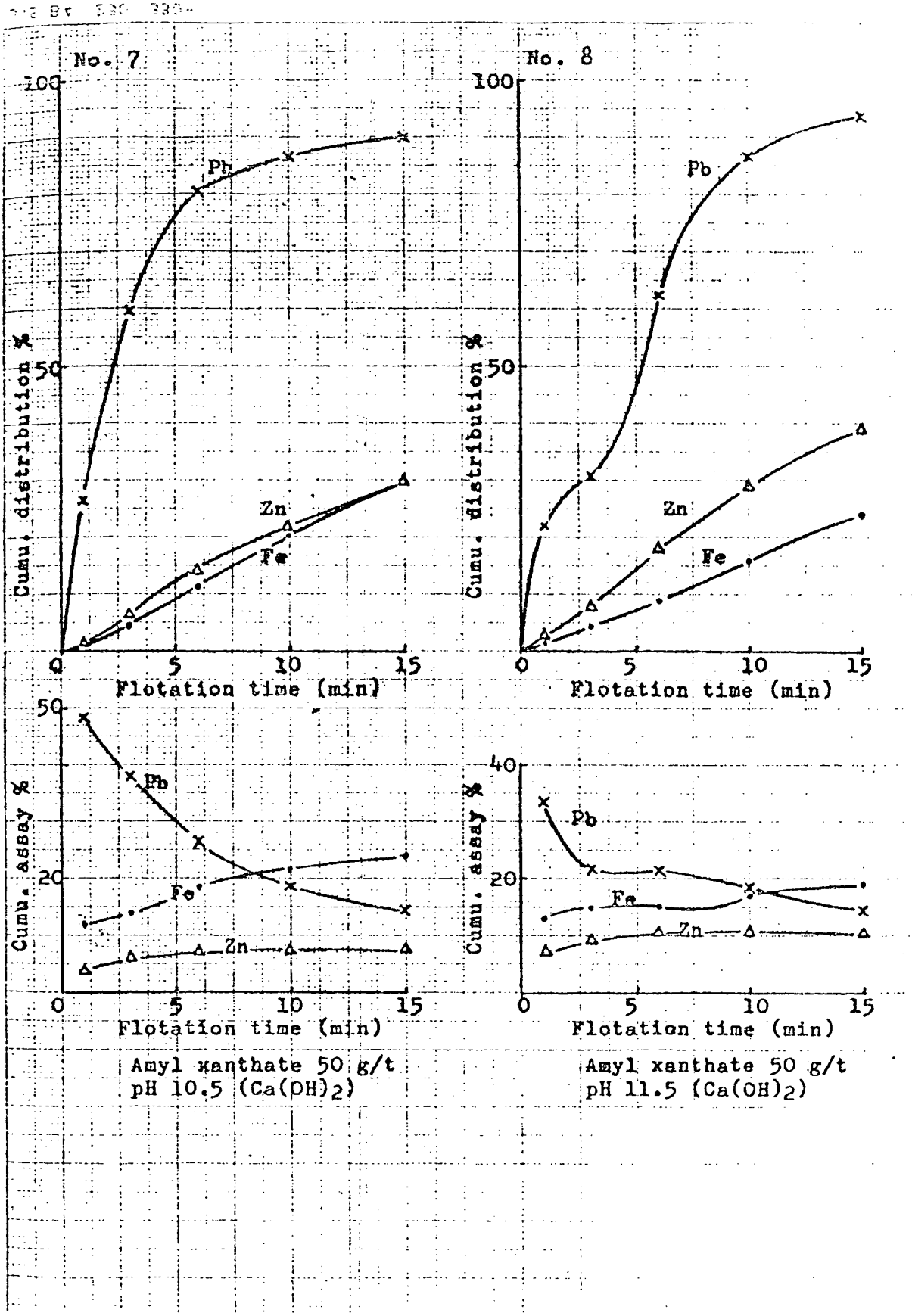


Fig. 6 Flotability test results

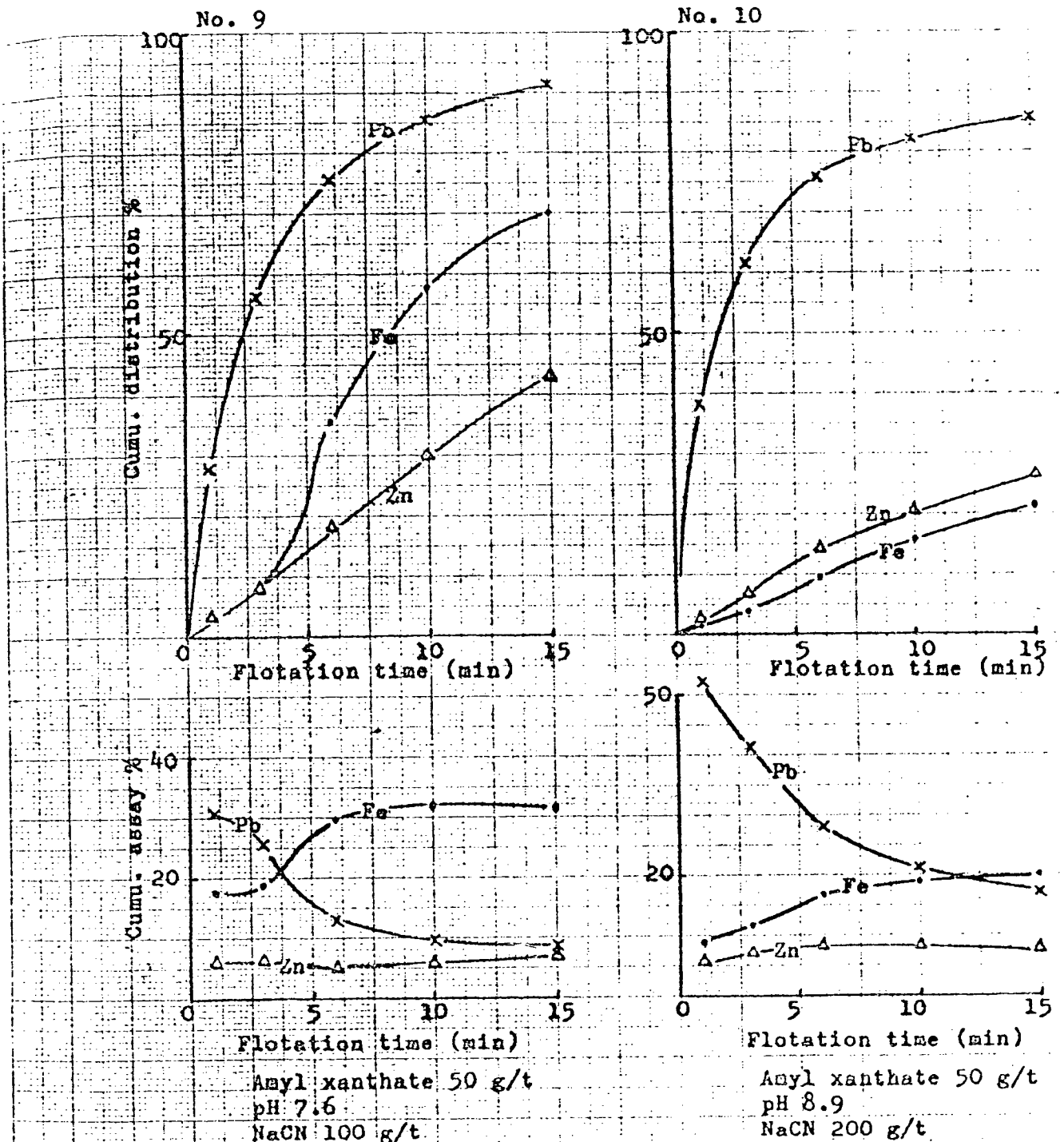


Fig. 7 Flotability test results

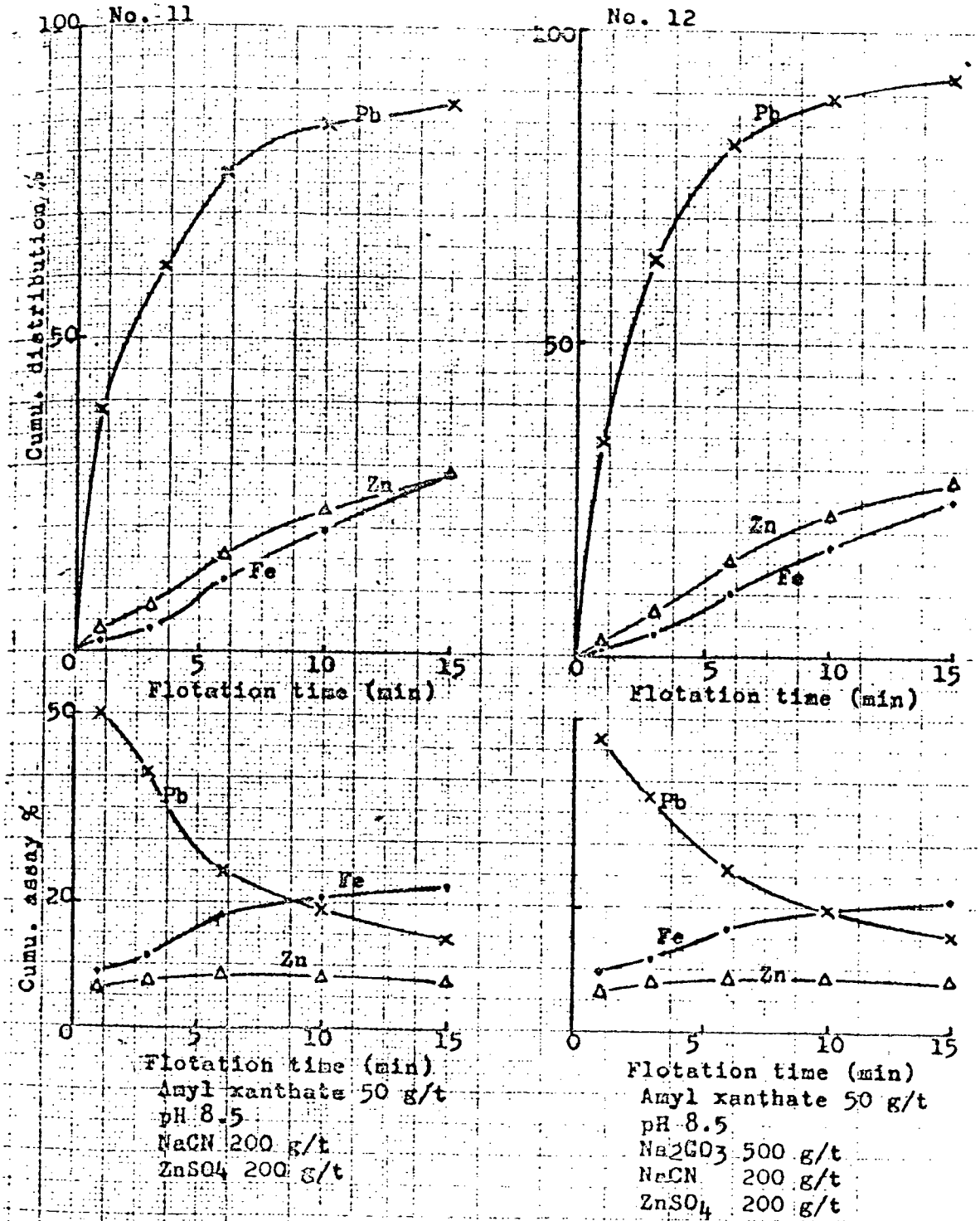
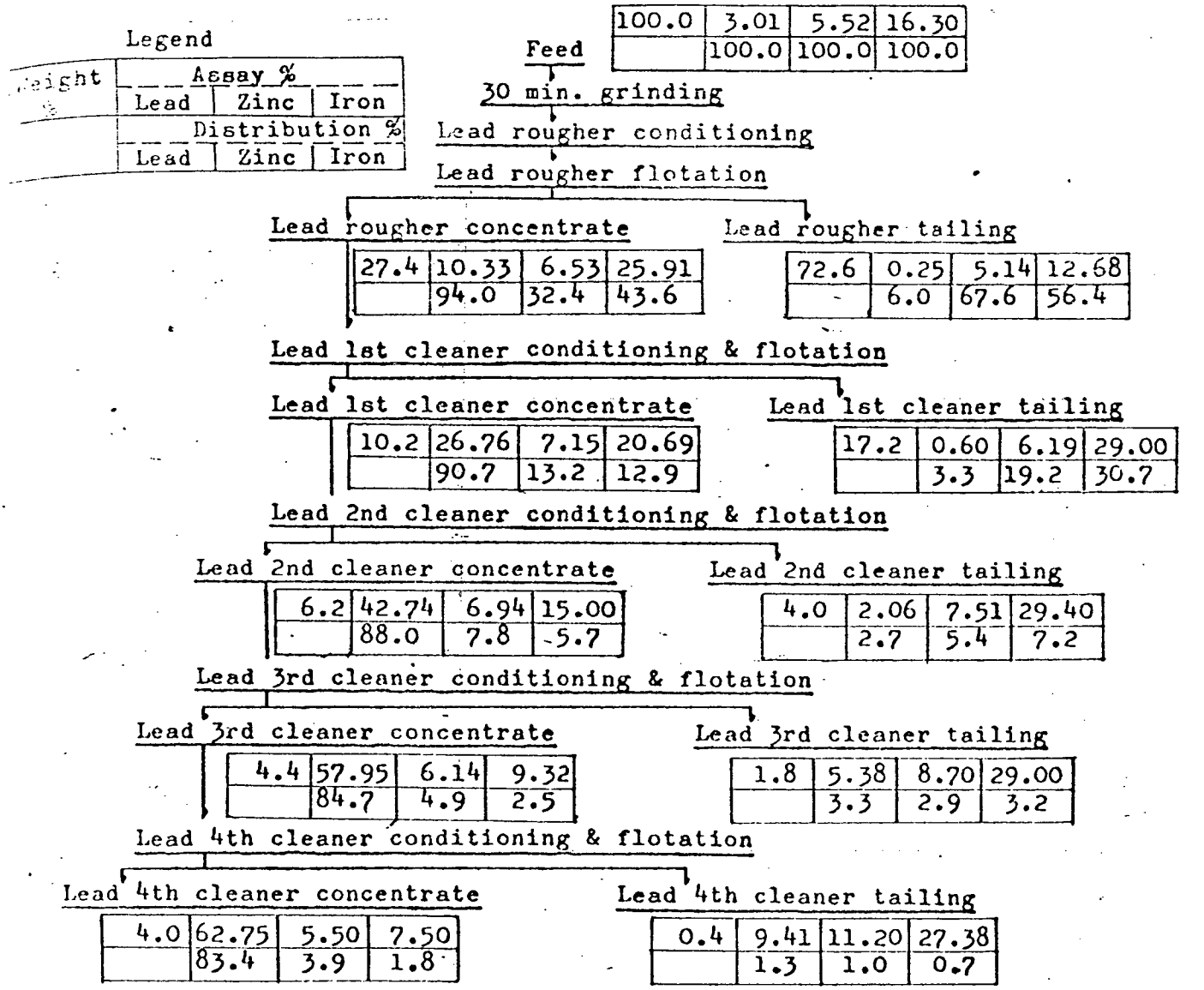


Fig. 8 Flow sheet and result of the lead flotation used sodium cyanide



Conditioning & flotation	Reagent consumption (gram/ton)
Lead rougher conditioning	Lime 1000
Lead rougher flotation	Amyl xanthate 100, Dow#250 25, 10 min.-flotation time
Lead 1st cleaner conditioning & flotation	Sodium cyanide 300, 10 min.-regringing. Amyl xanthate 5, 10 min.-flotation.
Lead 2nd cleaner conditioning & flotation	Sodium cyanide 150. 7 min.-flotation time.
Lead 3rd cleaner conditioning & flotation	Sodium cyanide 100, Dow#250 6. 7 min.-flotation time.
Lead 4th cleaner conditioning & flotation	8 min.-flotation time.

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~~Fig. 9~~ Flow sheets and results of the lead and zinc flotations

100.0	2.98	5.13	16.47
	100.0	100.0	100.0

Feed

30 min. grinding

Lead rougher conditioning

Lead rougher flotation

Lead rougher concentrate

Lead rougher tailing ※

Lead 1st - 3rd cleaner conditioning & flotation

Lead 3rd cleaner concentrate

Lead 1st - 3rd cleaner tailings

4.6	49.13	8.04	10.87
	75.3	7.2	3.0

Lead 4th cleaner conditioning & flotation

Lead 4th cleaner concentrate

3.0	65.91	5.93	5.23
	66.0	3.5	1.0

Lead 4th cleaner tailing

1.6	17.71	12.12	21.34
	9.3	3.7	2.0

Lead rougher flotation and cleaners are carried out in the same way as showing in Fig. 5.

Fig 9

Legend

	Assay %		
	Lead	Zinc	Iron
	Distribution %		
	Lead	Zinc	Iron

100.0	2.98	5.13	16.47
	100.0	100.0	100.0

Lead rougher tailing and lead 1st - 3rd cleaner tailings

10 min. regrinding

Zinc rougher conditioning & flotation

Zinc rougher concentrate

15.2	2.89	25.07	15.86
	15.3	74.3	14.6

Zinc rougher tailing

80.2	0.35	1.19	16.91
	9.4	18.5	82.3

Zinc 1st cleaner conditioning & flotation

Zinc 1st cleaner concentrate

7.8	4.36	45.13	10.38
	12.0	68.6	4.9

Zinc 1st cleaner tailing

7.4	1.41	3.95	21.75
	3.3	5.7	9.7

Zinc 2nd cleaner conditioning & flotation

Zinc 2nd cleaner concentrate

7.0	4.71	49.14	8.86
	11.0	67.1	3.8

Zinc 2nd cleaner tailing

0.8	3.12	10.54	23.36
	1.0	1.5	1.1

Zinc 3rd cleaner conditioning & flotation

Zinc 3rd cleaner concentrate

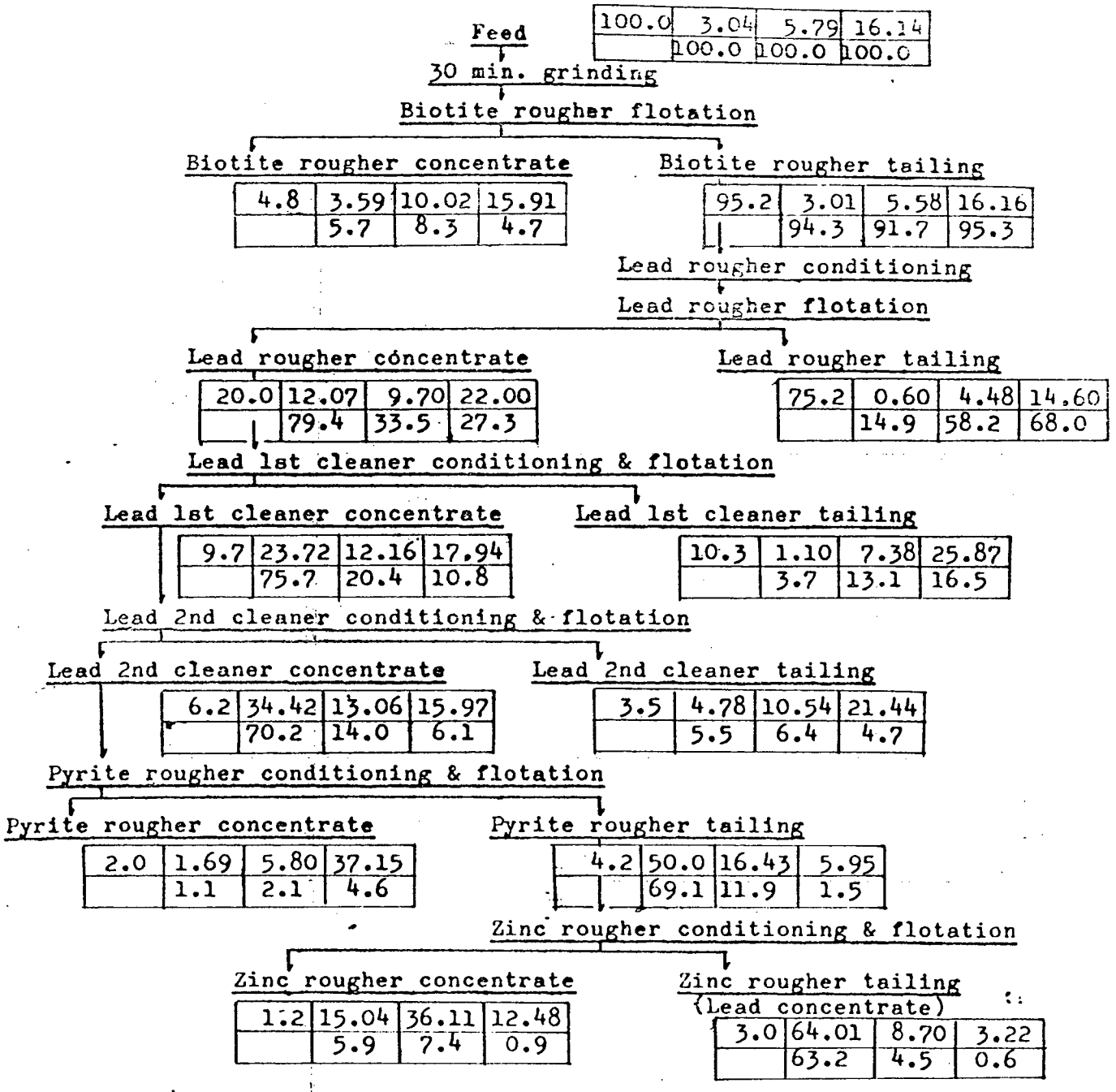
6.6	4.88	50.74	8.26
	10.7	65.3	3.3

Zinc 3rd cleaner tailing

0.4	3.12	21.61	19.53
	0.3	1.8	0.5

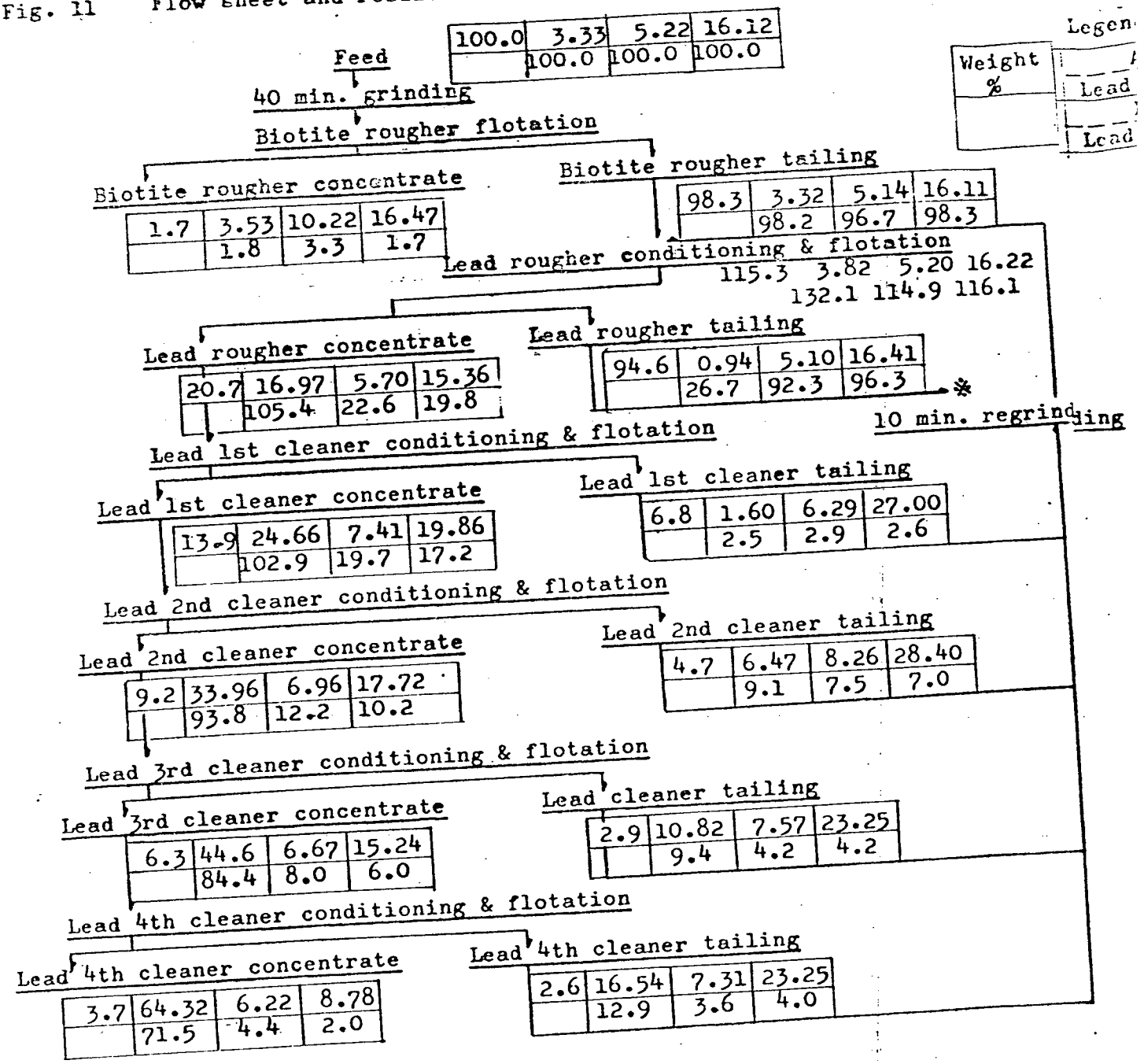
Conditioning & flotation	Reagent consumption (gram/ton)
Zinc rougher conditioning & flotation	Copper sulphate 1500, Lime 2000, pH 11. Amyl xanthate 100, Dow#250 25, 10 min.-flotation time.
Zinc 1st cleaner conditioning & flotation	Lime 500, pH 11.5, 10 min.-flotation time.
Zinc 2nd cleaner conditioning & flotation	Lime 100 pH 11.5 7 min.-flotation time.
Zinc 3rd cleaner conditioning & flotation	pH 10.5, 7 min.-flotation time.

Fig. 10 F[illegible]eet and result of the lead flotation used sodium sulfide and sulfurous acid



Conditioning & flotation	Reagent consumption (gram/ton)
Biotite rougher flotation	Natural pH 7.3, Dow#250 25.
Lead rougher conditioning	Lime 1400, pH 10.8.
Lead rougher flotation	Amyl xanthate 80, Dow#250 10, 15 min. flotation time.
Lead 1st cleaner conditioning & flotation	10 min.-regrinding, Lime 200, pH 10.5, Amyl xanthate 5, Dow#250 10, 10 min. flotation time.
Lead 2nd cleaner conditioning & flotation	Lime 100, pH 10.5, 10 min. flotation time.
Pyriye rougher conditioning & flotation	Sodium sulfide 200, Sulfurous acid 500, Pulp temperature 70°C, Dow#250 5, 10 min. flotation time.

Fig. 11 Flow sheet and result of the cycle test



	Reagent consumption (gram/ton)
Conditioning & flotation	
Biotite rougher flotation	Natural pH 7.8, Dow#250 20.
Lead rougher conditioning & flotation	Lime 1400, pH 10.8, Amyl xanthate 80, Dow#250 10, 15min. flotation time.
Lead 1st cleaner conditioning & flotation	Sodium cyanide 300, 10min. regrinding, Amyl xanthate 15, 10min. flotation time.
Lead 2nd cleaner conditioning & flotation	Sodium cyanide 150, 7min. flotation tim
Lead 3rd cleaner conditioning & flotation	Sodium cyanide 100, Dow#250 3, 7min.- flotation.
Lead 4th cleaner conditioning & flotation	Sodium cyanide 50, 8min. flotation time

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Legend

Assay %		
Lead	Zinc	Iron
Distribution %		
Lead	Zinc	Iron

※

94.6	0.94	5.10	16.42
	26.7	92.3	95.3

Lead rougher tailing

Zinc rougher conditioning & flotation

103.7	1.12	5.37	17.58
	35.0	106.6	113.1

Zinc rougher concentrate

40.7	2.23	12.73	28.70
	27.4	99.1	72.5

Zinc rougher tailing

63.0	0.40	0.62	10.40
	7.6	7.5	40.6

Zinc 1st cleaner conditioning & flotation

Zinc 1st cleaner concentrate

17.1	3.23	27.60	21.17
	16.7	90.3	22.5

Zinc 1st cleaner tailing

23.6	1.51	1.96	34.16
	10.7	8.8	50.0

Zinc 2nd cleaner conditioning & flotation

Zinc 2nd cleaner concentrate

11.6	3.77	37.93	16.47
	13.2	84.2	11.9

Zinc 2nd cleaner tailing

5.5	2.11	5.74	31.04
	3.5	6.1	10.6

Zinc 3rd cleaner conditioning & flotation

Zinc 3rd cleaner concentrate

9.5	3.62	44.00	13.89
	10.4	80.0	8.2

Zinc 3rd cleaner tailing

2.1	4.41	10.44	28.10
	2.8	4.2	3.7

Zinc 4th cleaner conditioning & flotation

Zinc 4th cleaner concentrate

8.0	3.49	49.68	11.38
	8.4	76.0	5.7

Zinc 4th cleaner tailing

1.5	4.31	13.83	27.49
	2.0	4.0	2.5

Conditioning & flotation	Reagent consumption (gram/ton)
Zinc rougher conditioning & flotation	Copper sulphate 1500, Lime 2000, pH 11, Amyl xanthate 100, Dow#250 25, 10 min.-flotation time.
Zinc 1st cleaner conditioning & flotation	15 min. regrinding, Lime 1000, pH 11.8 10 min. flotation time.
Zinc 2nd cleaner conditioning & flotation	Lime 200, pH 11.8, 8 min. flotation time.
Zinc 3rd cleaner conditioning & flotation	Lime 100, pH 11.7, 8 min. flotation time.
Zinc 4th cleaner conditioning & flotation	Lime 100, pH 11.8, 8 min. flotation time.

Table 1. Result of complete analysis of the Grum Ore

Au	0.4 gram/ton
Ag	55 gram/ton
Hg	42.5 gram/ton
Cu	0.08%
Pb	3.21%
Zn	5.22%
Fe	16.82%
S	20.16%
$BaSO_4$	tr.
SiO_2	49.48%
Na_2O	0.03%
K_2O	0.15%
CaO	0.42%
MgO	0.15%
Al_2O_3	2.28%
Cd	0.008%

Table 2 Chemical form analysis of zinc minerals remained in final tailing

Product	Form	Zinc assay %					
		$ZnSO_4$	ZnO	$ZnSiO_3$	ZnS	$ZnFe_2O_4$	Total Zn
Zinc rougher tailing & zinc 1st cleaner tailing		0.01	0.20	0.10	0.79	0.10	1.20

Ratios of zinc minerals were meassured with methode of chemical form analysis.

Table 3. Results of the analyses of the lead concentrates and the zinc concentrates

	Lead Concentrates	Zinc Concentrates
Au	3.6 gram/ton	tr.
Ag	908 gram/ton	60 gram/ton
Hg	53.7 gram/ton	486 gram/ton
Cu	0.21%	0.10%
Pb	66.16%	1.86%
Zn	7.05%	49.85%
Fe	3.82%	9.00%
S	16.97%	32.39%
Cd		0.07%
SiO_2	5.66%	5.28%
$BaSO_4$	tr.	tr.
Al_2O_3	0.69%	0.52%
As	0.29%	0.06%
Sb	0.35%	0.02%
Bi	0.005%	0.007%
Sn		0.009%
Ni		0.002%

Table 4 Size distribution of flotation feed, lead concentrate, zinc concentrate, and final tailing

Size Fraction	Flotation feed Weight %	Assay % Pb	Zn	Fe	Distribution % Pb	Zn	Fe
Mesh							
+150	1.1	0.40	5.48	39.53	0.1	1.0	2.6
150-200	1.3	0.80	2.61	14.46	0.2	0.5	1.1
200-270	2.7	1.01	1.83	10.51	0.7	0.8	1.7
270-325	5.5	0.90	2.61	10.41	1.2	2.4	3.4
325-400	5.5	1.31	3.13	14.86	1.7	2.9	4.9
Micron							
+35.5	2.0	7.22	4.69	32.15	3.5	1.5	3.9
35.5-26.6	7.3	6.11	6.00	37.10	10.8	7.4	16.3
26.6-18.6	17.6	3.51	6.00	19.31	15.0	17.9	20.5
18.6-12.1	15.6	3.21	5.74	13.14	12.1	15.2	12.3
12.1- 8.9	9.5	3.51	6.79	13.04	8.1	11.0	7.5
8.9-	31.9	6.04	7.30	13.44	46.6	39.3	25.8
Total	100.0	4.13	5.92	16.62	100.0	100.0	100.0

Size Fraction	Lead concentrate Weight %	Assay % Pb	Zn	Fe	Distribution % Pb	Zn	Fe
Micron							
+19.3	3.2	57.35	8.35	8.79	2.8	5.3	5.6
19.3-13.5	11.4	62.13	7.05	6.67	10.8	15.8	15.3
13.5- 8.8	19.8	67.67	5.74	5.36	20.5	22.5	21.3
8.8- 6.4	18.6	69.18	5.74	4.95	19.7	21.2	18.5
6.4-	47.0	64.14	5.06	4.97	46.2	35.2	39.3
Total	100.0	65.34	5.06	4.97	100.0	100.0	100.0

Size Fraction	Zinc concentrate Weight %	Assay % Pb	Zn	Fe	Distribution % Pb	Zn	Fe
Micron							
+27.8	0.9	2.51	40.72	16.58	0.6	0.7	1.6
27.8-20.9	5.0	1.51	46.19	13.85	2.4	4.5	7.6
20.9-14.5	17.5	1.51	48.55	11.52	7.9	16.6	22.1
14.5- 9.5	19.6	3.52	51.16	9.70	21.0	19.6	20.8
9.5- 7.0	17.2	3.62	53.24	8.59	18.9	17.8	16.2
7.0-	39.8	4.06	52.59	7.28	49.2	40.8	31.7
Total	100.0	3.29	51.30	9.14	100.0	100.0	100.0

Size Fraction	Final tailing Weight %	Assay % Pb	Zn	Fe	Distribution % Pb	Zn	Fe
Mesh							
+200	0.4	0.40	1.83	47.16	0.3	0.7	1.4
200-270	0.3	1.01	1.30	28.00	0.5	0.4	0.6
270-400	3.0	0.40	0.26	8.59	2.1	0.8	1.9
Micron							
+27.8	0.9	0.90	0.26	44.79	1.4	0.2	2.9
27.8-20.8	4.0	0.60	0.26	41.25	4.2	1.0	12.1
20.8-14.5	19.8	0.20	0.26	15.77	7.0	5.0	22.8
14.5- 9.5	23.1	0.30	0.26	10.21	12.1	5.9	17.3
9.5- 6.9	6.9	0.20	0.26	8.89	6.0	4.4	11.0