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FLOTATION TECHNIQUES FOR PRODUCING HIGH-RECOVERY BULK Zn-Pb-Cu-Ag CONCENTRATE FROM A NEW BRUNSWICK MASSIVE SULPHIDE ORE

A.I. STEMEROWICZ AND G.W. LEIGH

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by

A.I. Stemerowicz* and G.W. Leigh**

ABSTRACT

New Brunswick has the largest ore reserves of lead, zinc and silver in Canada but has been unable to fully utilize them because of difficulty in concentrating the massive, very fine-grained sulphides. So far, the mines have not been able to produce marketable grades of copper, lead and zinc concentrates by selective flotation without compromising recovery which is currently only 70-80% for zinc, 50-60% for lead and 40-60% for copper.

In 1975, CANMET initiated a research program aimed at increasing recovery. The scheme believed to offer the greatest potential was to produce a bulk concentrate containing all the valuable minerals and then treating this hydrometallurgically to recover the metals. An important inducement to carrying out this research was that bulk flotation could be applied to the large reserves of lower-grade, finer-grained ores in the province which had not been exploited because they were not amenable to conventional concentration and extraction methods.

One of the ores was subjected to a comprehensive investigation to develop a flotation technique for producing a bulk concentrate having a target grade of 30% zinc with optimum recovery of zinc, lead, copper and silver. The best results were achieved by floating separate lead and zinc concentrates and then combining them to produce the desired grade of bulk concentrate. On feed assaying 8.73% zinc, 3.95% lead, 0.24% copper and 87.8 g/t silver, a bulk concentrate was produced grading 30.0% zinc, 10.75% lead, 0.68% copper and 246.9 g/t silver with recoveries of 95.3, 86.6, 76.7 and 84.6% respectively. Bulk or collective flotation of the valuable minerals into a single concentrate was not as effective. For a similar concentrate grade, recoveries were lower by 2 to 4%.

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It was established that a grind of 77.5% minus 25 µm was adequate to assure optimum recovery. At this grind most of the tailing losses were sustained in the minus 4.7-µm slime fraction which can only be partially recovered by flotation. Further improvement will therefore depend on the development of a concentration method for slimed sulphides.

TECHNIQUES DE FLOTTATION POUR LA PRODUCTION D'UN CONCENTRE EN VRAC Zn-Pb-Cu-Ag A HAUT RENDEMENT PROVENANT D'UN MINERAI DE SULFURE MASSIF DU NOUVEAU-BRUNSWICK

par

A.I. Stemerowicz* et G.W. Leigh**

RESUME

Le Nouveau-Brunswick a, en son sous-sol, les réserves les plus abondantes de plomb, de zinc et d'argent au Canada. Il n'a par contre pas été capable d'en tirer profit pleinement à cause de la difficulté rencontrée lors de l'enrichissement des sulfures massifs à grains très fins. Jusqu'à ce jour, les mines ont été incapables de produire des concentrés de cuivre, plomb et zinc de qualité commerciale par la flottation sélective sans sacrifier le taux de récupération qui n'est que de 70-80% pour le zinc, 50-60% pour le plomb et 40-60% pour le cuivre.

En 1975, le CANMET a mis sur pied un programme de recherche visant à hausser la récupération. Le projet ayant le plus de mérite semble être la production d'un concentré en vrac contenant tous les minéraux de valeur pour ensuite le traiter hydrométallurgiquement pour récupérer les métaux. Un important mobile à la réalisation de cette recherche est que la flottation en vrac peut être appliquée à d'immenses réserves de minerai à basse teneur et à grains plus fins dans la province qui n'ont pas été exploitées car elles ne peuvent se prêter aux méthodes classiques d'enrichissement et d'extraction.

Un de ces minerais a fait l'objet d'une étude approfondie afin de mettre au point une technique de flottation pour la production d'un concentré en vrac ayant une teneur anticipée de 30% de zinc et une récupération optimale de zinc, de plomb, de cuivre et d'argent. Les meilleurs résultats ont été obtenus en employant une flottation sélective et en combinant les concentrés de plomb et de cuivre pour ainsi produire la teneur désirée de concentré en vrac. Sur un échantillon à 8.73% zinc, 3.95% plomb, 0.24% cuivre et 87.8 g/t argent, on a obtenu un concentré en vrac de 30.0% zinc, 10.75% plomb, 0.68% cuivre et 246.9 g/t argent et des récupérations

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de 95.3, 86.6, 76.7 et 84.6% respectivement. La flottation en vrac ou collective des minéraux précieux en un seul concentré sans flottation sélective préalable n'a pas connu un aussi grand succès; sur un échantillon de concentré semblable, les récupérations étaient plus basses de 2 à 4%.

On a établi qu'un broyage de 77.5% moins 25 µm était adéquat pour assurer une récupération optimale. A cette grosseur, la plupart des pertes de stériles sont retenus dans la suspension à -7.4 µm qui ne peut être récupérée que partiellement par flottation. L'amélioration du système dépendra donc du perfectionnement d'une méthode de concentration pour les sulfures en suspension.

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INTRODUCTION

BACKGROUND

Although New Brunswick has the largest known ore reserves of zinc, lead and silver in Canada it has not been able to reach its full production potential because of difficulty in concentrating the massive sulphide ores. A substantial portion of the valuable minerals are very fine-grained and are intergrown with the predominant gangue mineral, pyrite. Unusually fine grinding is, therefore, required to ensure mineral liberation. The main problem in concentrating the ore is to selectively float the relatively small amount of valuable minerals away from the much larger amount of finely-ground pyrite. The two producing mines were making separate copper, lead and zinc concentrates by selective flotation. To satisfy smelter requirements for high-grade concentrate it had been necessary to compromise on recovery which was only 70-80% for zinc, 50-60% for lead and 40-60% for copper.

CANMET thus initiated a research program to increase recovery from these ores in 1975. Because current concentration and metal extraction methods, appeared to offer little scope for achieving this, a new scheme was proposed. This was to produce a bulk flotation concentrate which would then be treated hydrometallurgically to recover the contained metals. Because concentrate grade requirements are less stringent with bulk flotation a higher recovery can be obtained. Also, all metals are available for recovery by the subsequent extraction process, whereas with separate selectively floated concentrates the contaminating metals such as lead and copper in the zinc concentrate are considered as lost as they are not paid for by the smelter.

In opting for bulk flotation an important incentive was that it would be effective in treating the large reserves of low-grade, finer-grained ores which so far could not be exploited because they were not amenable to conventional concentration and extraction methods.

Four hydrometallurgical methods are planned for trial on the bulk concentrate - ferric-ion leach, dry chlorination, sulphuric acid-pressure leach and sulphating roast-leach. The first two methods are to be investigated by CANMET whereas the other two are to be contracted out to Sherritt Gordon Mines Limited and the New Brunswick Research and Productivity Council respectively. In all cases zinc will be recovered as high-grade electrolytic metal whereas, with a few exceptions, copper and lead will be recovered as high-grade precipitate or residue and sold to a smelter. The silver will be recovered from the lead product.

OBJECT OF INVESTIGATION

The object of this investigation was to develop a feasible batch flotation technique for producing bulk zinc-lead-copper-silver concentrates at a target grade of 30% zinc and with the highest possible recovery. The techniques could then be applied to the (50 kg/h) continuous process development unit (CPDU) to produce a quantity of bulk concentrate for the hydrometallurgical investigations.

ORE SAMPLES

The ore samples were derived from two shipments of bulk ore from one of the deposits, a 10-tonne lot received in December 1975 and a 20-tonne lot received in October 1977, known as shipment No. 1 and 2 respectively. Both consisted solely of large lumps of about 15 to 30 cm in diam and were free of fines.

SAMPLING AND ANAYLSIS

No. 1 Shipment

Ideally, to obtain a representative sample it would have been desirable to crush all the ore at the start of the investigation but this was not done because it would have subjected the ore to possible oxidation. Instead, about 300 kg of lumps exhibiting the various types of mineralization were selected as follows:

1. 100 kg of massive, coarse-grained, high-grade banded ore;
2. 100 kg of massive, high-pyrite, fine grained, low-grade ore;
3. 50 kg of chlorite schist gangue with minor sulphide mineralization;
4. 50 kg of hard, black cherty gangue containing large blebs of sulphide mineralization.

After coarse crushing, the minus 2 cm plus 1 cm material was screened out to make up a composite consisting of 40% of each of the two ore types and 10% of each of the two gangue types. The composite was crushed to minus 10 mesh and riffled into 2000-g test charges, bagged and stored in a freezer to minimize oxidation. Analysis of the composite, and of the ore types making up the composite, are given in Table 1. Included is the head sample analysis of the remainder of the lump ore (bulk ore head sample) which was crushed to minus 6 mesh in April 1977 preparatory to carrying out a 50 kg/h CPDU run to produce a quantity of bulk concentrate for hydrometallurgical investigations. This project was suspended after a few days trial because of metallurgical difficulties attributed to oxidation of the ore.

No. 2 Shipment

This ore was used as feed to the CPDU for producing a one tonne-lot of bulk concentrate in March and April 1978. After crushing, several hundred kilograms of head sample was obtained by automatic sampler (Table 2). This material was used to complete the investigation after the supply of samples from the first shipment was exhausted.

MINERALOGY

Mineralogical studies of ore from the same deposit and from mill tailings had been

Table 1 - Head sample analysis of samples from No. 1 shipment

Sample	Analysis							
	Zn, %	Pb, %	Cu, %	Fe, %	S, %	Insol, %	g/t Ag	g/t Au
High-grade ore	14.51	7.44	0.17		34.51	12.33	128.9	0.62
Low-grade ore	5.89	1.93	0.28		41.92	10.25	51.1	0.48
Chlorite gangue	0.98	0.60	0.03		2.91	56.61		
Chert gangue	2.78	1.38	0.32		14.77	45.42		
Composite (calcd)	8.54	3.95	0.22		32.34	20.20		
Composite (assay)	8.73	3.95	0.24	27.54	32.80	17.63	87.8	0.62
Bulk ore head sample	8.64	3.21	0.38					

MSL, Chemical Laboratory.

Table 2 - Head sample analysis of No. 2 shipment

Zn, %	Pb, %	Cu, %	Fe, %	S, %	Insol, %	g/t Ag	g/t Au
9.76	3.64	0.22	29.63	38.02	11.36	85.4	0.24

MSL, Chemical Laboratory

carried out previously. Therefore, further studies were not warranted. Image analysis of the tailings indicated that a much finer primary grind than that employed by the company, ∿60% minus 38 μm (400 mesh), was required to fully liberate the sphalerite from pyrite.

OUTLINE OF INVESTIGATION

BULK CONCENTRATE PRODUCTION TECHNIQUES

The standard flotation technique for producing bulk zinc-lead-copper-silver concentrate from massive sulphide ore is to treat it as a straight zinc ore. However, to prevent excessive depression of galena, the pH must be kept at a value lower than optimum for good zinc flotation. For these ores it was found that to selectively float sphalerite from the pyrite, sufficient lime had to be added to give a pH of plus 11 in both roughers and cleaners, whereas the critical pH for galena depression is around 10. An alternative bulk flotation technique is to saturate the pulp solution with calcium ion by adding gypsum to the grind. It is generally believed that it is the calcium ion rather than high pH which depresses pyrite. In this method some lime is added for pH regulation but the pH is maintained at the lower value of 9.0 or less.

A bulk concentrate of the desired composition can also be produced by subjecting the ore to selective lead-zinc flotation and then combining the lead and zinc concentrates. A lead rougher concentrate is floated first using sodium cyanide as a pyrite depressant and soda ash as alkalinity regulator. After cleaning to the required lead concentrate grade the lead cleaner tailings are combined and added to zinc rougher flotation. The significant difference in selective flotation procedure from that employed by the mines is that no attempt is made to recover chalcopyrite in the lead concentrate as it will be recovered in the subsequent zinc flotation step. This allows conditions to be adjusted for optimum lead flotation.

SCOPE OF INVESTIGATION

A total of 46 tests employing the techniques described above were carried out on representative samples from the two ore shipments. The tests were conducted at primary grinds ranging from 57 to 81% minus 25 μm (500 mesh). The effect of a high pH of about 11.0 versus a lower pH of <10.0, in bulk rougher flotation and in the cleaning of the bulk rougher concentrate was thoroughly investigated. Two levels of copper sulphate addition to bulk flotation were tried, i.e., 1 and 1.5 kg/tonne of solids. In selective flotation the effect of regrinding lead and zinc rougher concentrates prior to cleaning was investigated.

To determine the mode of occurrence of tailing losses and the metallurgy for individual size fractions, bulk concentrates and tailings produced at various grinds were sized down to 4.7 μm and the size fractions were analyzed.

DETAILS OF INVESTIGATION

GRINDING

Both single and two-stage grinding were employed; the former for coarse and fine grinds and the latter only for the 81%, minus 25 μm grind. Single-stage and the first stage of two-stage grinding were done in a 7 x 14 Denver laboratory rod mill at 50 rpm and 65% solids with 20 kg of rods from 13 to 38 mm in diam. The second stage was carried out in a 30-cm steel Abbé ball mill at 60 rpm using a mixed charge of 3.6 kg each of minus 2.5, plus 19 mm and minus 16, plus 13 mm ceramic pebbles. For density control it was necessary to filter the ground pulp prior to the second-stage grind but a portion of filtrate was used for repulping the second stage to 65% solids.

CONDITIONING

After a few preliminary tests is was established that aerative conditioning of the flotation feed was essential for good galena

flotation. It was therefore subsequently employed as a standard procedure for all tests and was carried out in a 18-cm diam x 122-cm aerating column.

FLOTATION

The Denver D-1 laboratory flotation cell was used throughout the investigation. The standard test charge was 2000 g which when added to the 1000-g tank of 4 L capacity and pulped with water to the skimming level at about 2.5 cm below the overflow lip gave an initial pulp density of 36% solids. The froth was skimmed with a rubber paddle and the skimming time was precisely recorded. After each 30-s skimming period the pulp volume was adjusted to the skimming level by adding water. Impeller speeds employed for the various tank sizes were as follows: 1000-g, 2100 rpm; 500-g, 1800 rpm; and 250-g, 1500 rpm.

FLOWSHEETS AND REAGENTS

The test flowsheets used for bulk and selective flotation along with reagents added and points of addition are given in Fig. 1 and 2. Various combinations of Aerofloat 242, sodium isopropyl xanthate and Z-200 were employed as collectors for both bulk and selective flotation. Generally the frothing characteristics of Aerofloat 242 and Z-200 were sufficient to produce an adequate rougher flotation froth but in some tests it was necessary to add small amounts of frother Dowfroth 250. The latter was also added to the cleaners to increase recovery by producing a finer-grained, more heavily-mineralized froth.

PARTICLE SIZE ANALYSIS

Canadian standard sieves were used for coarse particle size analysis down to 400 mesh. The minus 400-mesh material was then sized by a Warman Cyclosizer after first removing the fine slime fraction by beaker decantation. (Fig. A-1, Appendix A).

ANALYSIS OF TEST PRODUCTS

Except as noted all test products were analyzed for zinc, lead and copper using an INAX X-ray fluorescence analyzer.

TEST DATA

Test data and metallurgical balances for 21 of the most important flotation tests are given in Appendix A along with particle size analysis of the various grinds employed. Also included are size analysis - metal distribution tables for target grade bulk concentrate and corresponding tailings produced by bulk and selective flotation at various grinds. To readily identify the test ore samples, the following numbering system was adopted: Tests prefixed: A - composite ore, B - bulk ore, both No. 1 shipment; C - head sample, No. 2 shipment.

DISCUSSION AND EVALUATION OF RESULTS

EVALUATION CRITERIA

To obtain a meaningful comparison of bulk flotation results it is necessary to express concentrate grades and recoveries in terms of the valuable mineral (VM) content rather than in terms of the individual metals - zinc, lead and copper. The VM content is calculated on the assumption that the three valuable minerals, sphalerite, galena and chalcopyrite contain 60% zinc, 86.6% lead and 34.5% copper respectively.

Separation efficiency as expressed by Schultz is used as a measure of the degree to which the VM have been concentrated (1). It is calculated by subtracting the per cent recovery of the unwanted gangue minerals (GM) in the concentrate from the per cent recovery of the VM concentrated.

When necessary, for comparison purposes, to determine various grade-recovery combinations, a grade-recovery curve can be drawn and the required data taken. However, in bulk flotation, because more than one metal was involved, this method proved too cumbersome and instead recoveries for the target grade bulk concentrate were calculated by combining the final bulk cleaner concentrate with the required amount of cleaner tailings. Generally, only the first and a portion of the second stage cleaner tailings remain-

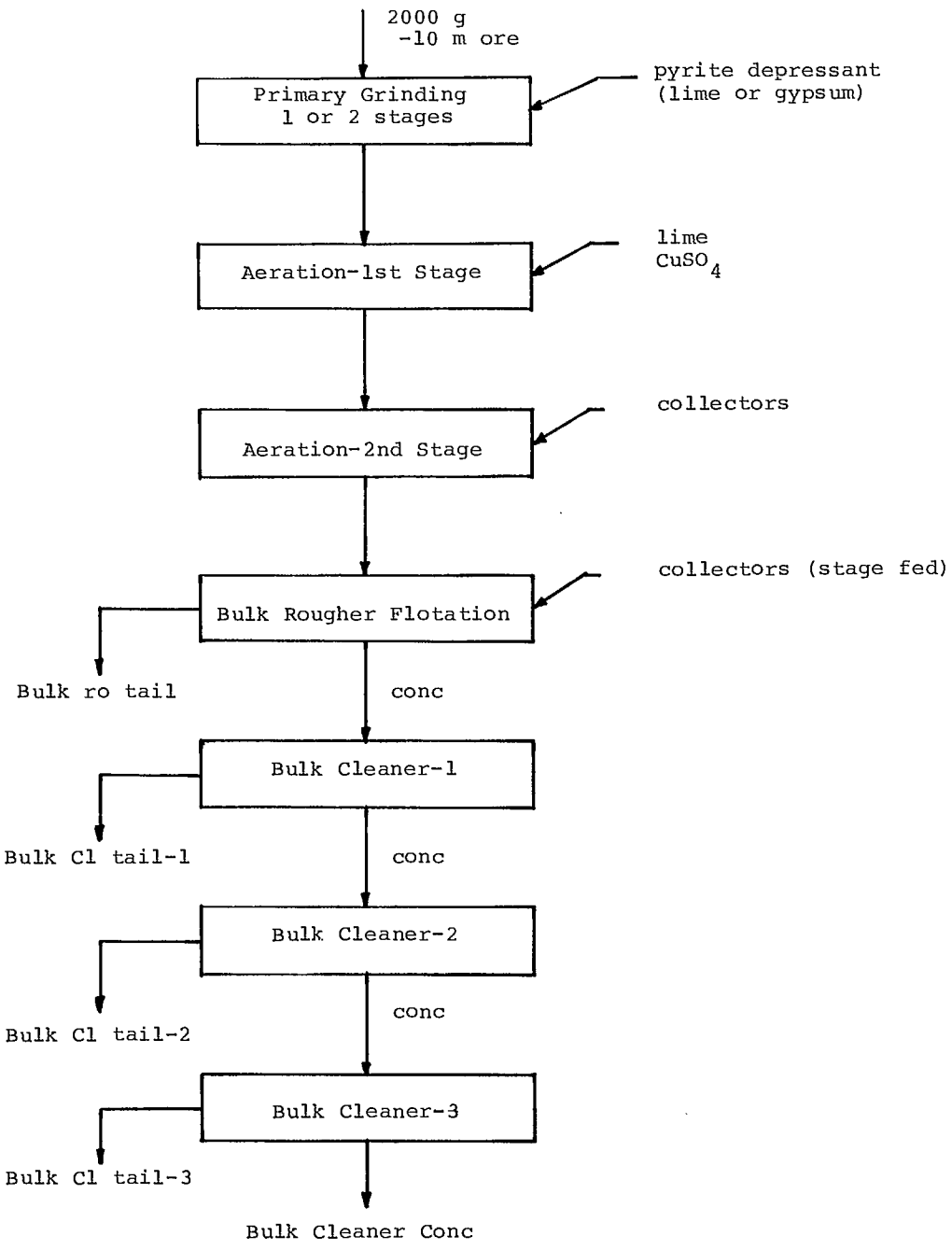

Fig. 1 - Test flowsheet for bulk flotation

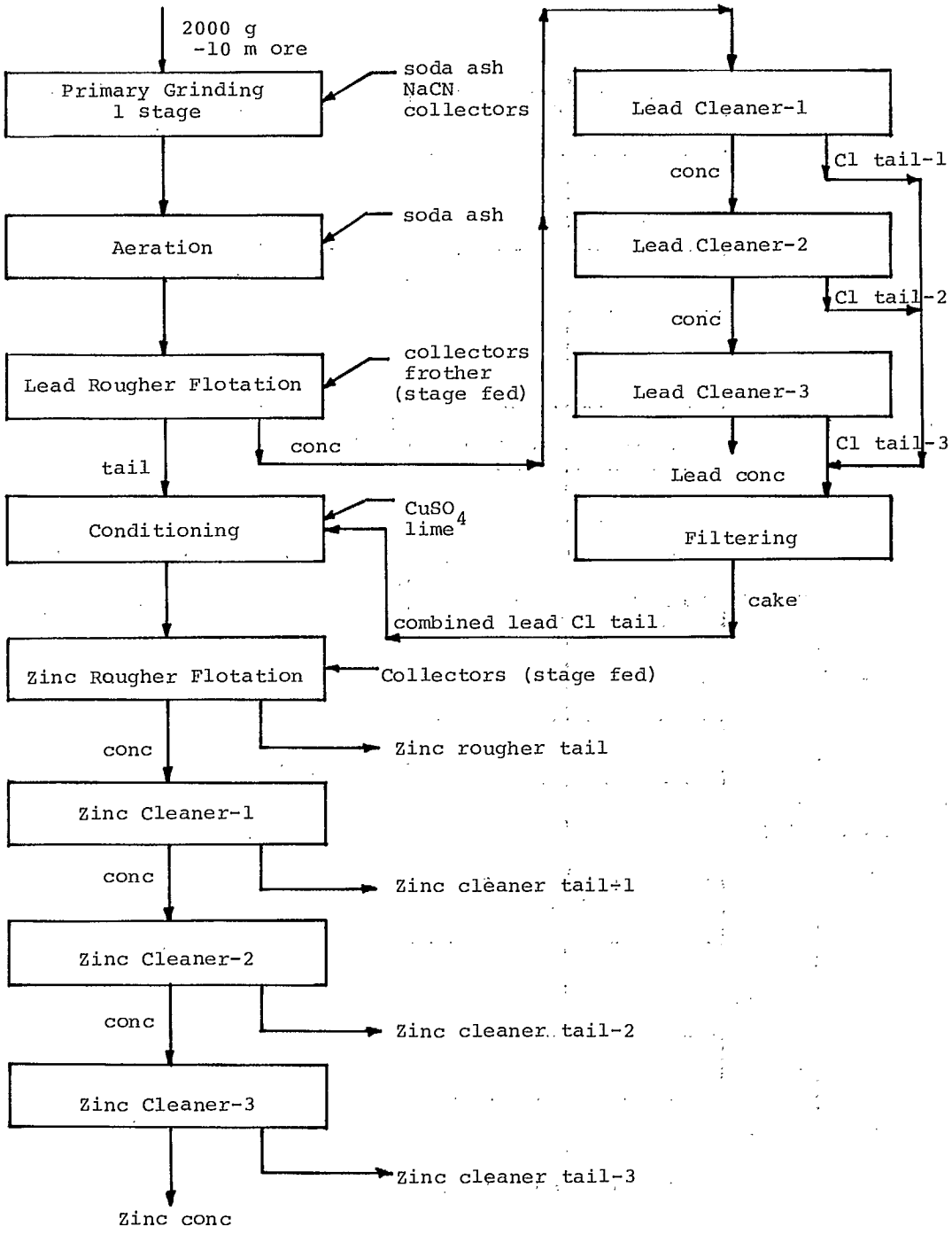

Fig. 2 - Test flowsheet for selective flotation

ed after the target grade was reached. These products were combined with the rougher tailings to give a resultant tailing corresponding to the target grade bulk concentrate. For selective flotation the same results were achieved by combining the lead and zinc concentrates with the zinc cleaner tailings.

BEST RESULTS

Table 3 compares the best results for the composite ore sample using the two bulk concentrate production methods. Recoveries and separation efficiences were calculated for the target grade of 30% zinc. Also given are various grade-recovery combinations, which represent the bulk flotation results after each cleaning stage. For selective flotation, bulk concentrate grades and recoveries were calculated by combining lead and zinc concentrates and then adding in succession the zinc cleaner tailings (tests A-21 and A-30, Appendix A).

Table 3 shows that selective flotation gives significantly higher recoveries for the target grade. The superiority of selective over bulk flotation is also confirmed by the higher separation efficiences obtained for the various grade-recovery combinations.

EFFECT OF FINENESS OF GRIND

Tables 4 and 5 compare results obtained using the two production methods at various primary grinds. Table 4 compares recoveries obtained for the target grade and Table 5 gives results for rougher flotation.

From data in Tables 4 and 5 it can be concluded that:

1. Bulk flotation at the fine grind of 77.5% minus 25 µm gave significantly improved results over those obtained at the coarse grind of 57% minus 25 µm. For the target grade the increases in VM recovery and separation efficiency were 4.3 and 3.8%, respectively (Table 4).
2. The differences in recovery and separation efficiency between coarse and fine grinds were much less when selective flotation was

Table 3 - Comparison of best bulk concentrate production results - bulk versus selective flotation

Product	Wt %	Analysis %					Distribution %					Sep eff %
		Zn	Pb	Cu	VM	GM	Zn	Pb	Cu	VM	GM	
Test A-21 - Selective flotation at a grind of 77.5% minus 25 µm (500 mesh)												
Target bulk conc	27.54	30.0	10.75	0.68	64.4	35.6	95.3	86.6	76.7	92.8	12.1	80.7
Tailing (calcd)	72.46	0.57	0.63	0.08			4.7	13.4	23.3			
Feed (calcd)	100.00	8.67	3.42	0.25			100.0	100.0	100.0			
Bulk conc - 4	20.54	36.52	13.52	0.79	78.8	21.2	86.5	81.2	66.3	84.7	5.4	79.3
Bulk conc - 3	22.12	35.75	12.81	0.78	76.7	23.3	91.2	82.8	70.1	88.7	6.4	82.3
" " - 2	24.99	32.71	11.67	0.73	70.1	29.9	94.3	85.3	74.5	91.6	9.2	82.4
" " - 1	30.77	27.22	9.81	0.63	58.5	41.5	96.6	88.3	79.4	94.2	15.8	78.4
Zinc ro tail	69.23	0.43	0.58	0.073			3.4	11.7	20.6			
Test A-30 - Bulk flotation at a grind of 77.5% minus 25 µm (500 mesh)												
Target bulk conc	27.15	30.0	11.15	0.73	65.0	35.0	92.2	81.9	74.1	89.5	11.8	77.7
Tailing (calcd)	72.85	0.94	0.92	0.095			7.8	18.1	25.9			
Feed (calcd)	100.00	8.83	3.70	0.27			100.0	100.0	100.0			
Bulk conc - 3	23.55	33.78	12.25	0.80	72.7	27.3	90.1	78.1	70.5	86.8	8.0	78.8
" " - 2	26.71	30.44	11.29	0.74	65.8	34.2	92.1	81.6	73.7	89.1	11.4	77.7
" " - 1	30.94	26.74	10.12	0.67	58.2	41.8	93.7	84.7	77.2	91.3	16.1	75.2
Bulk ro conc	46.62	18.37	7.24	0.49	40.4	59.6	97.0	91.3	86.0	95.5	34.6	60.9
Bulk ro tail	53.38	0.50	0.60	0.07			3.0	8.7	14.0			

used. Compare test A-23 with A-21, Table 4.

3. When results are compared at the rougher flotation stage there is no significant difference in bulk flotation separation efficiency but zinc and copper tailing losses are appreciably higher for the coarser grind (Table 5). On the other hand, for selective flotation, an appreciably higher separation efficiency was obtained for the fine grind but there were no significant differences in zinc and lead tailing losses.
4. The most striking discrepancy in results is the large difference of plus 17.5% between separation efficiency obtained at the rougher flotation stage for selective flotation at the fine grind (A-21) and that obtained for bulk flotation at the same grind (A-30). This is probably due to the fact that pyrite depression is not adequate at the low pH of <10 employed in bulk flotation.

Table 4 - Comparison of recoveries obtained at various grinds for target bulk concentrate grade of 30% zinc

Test No.	Grind % -500m	Bulk Conc Production Method	Product	Wt %	Analysis %					Distribution %					Sep. Eff. %
					Zn	Pb	Cu	VM	GM	Zn	Pb	Cu	VM	GM	
A-21	77.5	Selective flotation	Target bulk conc	27.54	30.00	10.75	0.68	64.4	35.6	95.3	86.6	76.7	92.8	12.1	80.7
			Tailing (calcd)	72.46	0.57	0.63	0.08			4.7	13.4	23.3			
			Feed (calcd)	100.00	8.67	3.42	0.25			100.0	100.0	100.0			
A-22	63.5	Selective flotation	Target bulk conc	24.37	30.00	11.06	0.74	64.9	35.1	92.3	84.2	70.4	89.9	10.1	79.8
			Tailing (calcd)	75.63	0.80	0.67	0.093			7.7	15.8	29.6			
			Feed (calcd)	100.00	7.92	3.20	0.26			100.0	100.0	100.0			
A-23	57.0	Selective flotation	Target bulk conc	27.74	30.00	11.36	0.72	65.2	34.8	94.3	86.2	71.9	91.5	12.0	79.5
			Tailing (calcd)	72.26	0.70	0.70	0.11			5.7	13.8	28.1			
			Feed (calcd)	100.00	8.83	3.66	0.28			100.0	100.0	100.0			
A-27	57.0	Bulk flotation	Target bulk conc	25.79	29.51*	11.58	0.72	64.7	35.3	87.9	80.1	67.4	85.2	11.3	73.9
			Tailing (calcd)	74.21	1.42	1.00	0.12			12.1	19.9	32.6			
			Feed (calcd)	100.00	8.66	3.73	0.28			100.0	100.0	100.0			
A-30	77.5	Bulk flotation	Target bulk conc	27.15	30.00	11.15	0.73	65.0	35.0	92.2	81.9	74.1	89.5	11.8	77.7
			Tailing (calcd)	72.85	0.94	0.92	0.095			7.8	18.1	25.9			
			Feed (calcd)	100.00	8.83	3.70	0.27			100.0	100.0	100.0			

*Final bulk cleaner concentrate grade after 3 cleaning stages.

Table 5 - Comparison of rougher flotation results obtained at various grinds

Test No.	Grind % -500m	Bulk Conc Production Method	Product	Wt %	Analysis %					Distribution %					Sep. Eff. %
					Zn	Pb	Cu	VM	GM	Zn	Pb	Cu	VM	GM	
A-21	77.5	Selective flotation	Bulk rougher conc*	30.77	27.22	9.81	0.63	58.5	41.5	96.6	88.3	79.4	94.2	15.8	78.4
			Zn rougher tail	69.23	0.43	0.58	0.073			3.4	11.7	20.6			
			Feed (calcd)	100.00	8.67	3.42	0.25			100.0	100.0				
A-22	63.5	Selective flotation	Bulk rougher conc*	35.00	22.01	8.22	0.57	47.9	52.1	97.3	89.6	79.3	94.8	22.2	72.6
			Zn rougher tail	65.00	0.33	0.51	0.08			2.7	10.4	20.7			
			Feed (calcd)	100.00	7.92	3.20	0.25			100.0	100.0	100.0			
A-23	57.0	Selective flotation	Bulk rougher conc*	33.39	25.60	9.74	0.64	55.8	44.2	96.9	88.9	77.2	94.3	18.4	75.9
			Zn rougher tail	66.61	0.42	0.61	0.095			3.1	11.1	22.8			
			Feed (calcd)	100.00	8.83	3.66	0.28			100.0	100.0	100.0			
A-27	57.0	Bulk flotation	Bulk rougher conc	42.65	19.09	7.86	0.51	42.4	57.6	94.0	89.8	79.2	92.4	30.5	61.9
			Bulk rougher tail	57.35	0.91	0.66	0.10			6.0	10.2	20.8			
			Feed (calcd)	100.00	8.66	3.73	0.28			100.0	100.0	100.0			
A-30	77.5	Bulk flotation	Bulk rougher conc	46.62	18.37	7.24	0.49	40.4	59.6	97.0	91.3	86.0	95.5	34.6	60.9
			Bulk rougher tail	53.38	0.50	0.60	0.07			3.0	8.7	14.0			
			Feed (calcd)	100.00	8.83	3.70	0.27			100.0	100.0	100.0			

*Lead concentrate + zinc rougher concentrate.

SILVER RECOVERY IN BULK CONCENTRATE

Bulk concentrates, with the target grade of 30% zinc, and corresponding tailings were prepared for the five key tests evaluated in Table 4 and were submitted for gold and silver assays. Results are given in Table 6.

A silver recovery of about 85% was obtained for all tests except bulk flotation at the coarse grind (A-27). Most of the gold in every test was rejected to tailings, presumably because it was closely associated with pyrite.

EFFECT OF REGRINDING LEAD AND ZINC ROUGHER CONCENTRATES PRIOR TO CLEANING

Table 5 shows that in selective flotation the zinc and lead tailing losses did not differ appreciably for coarse and fine grinds. However, separation efficiency was lower for the coarse grind presumably because of the presence of a higher amount of middling particles. This suggested a coarse primary grind-rougher concentrate regrind combination as an alternative to a fine primary grind.

Table 7 compares results obtained employing selective flotation at a coarse primary grind with and without regrinding of lead and zinc rougher concentrates prior to cleaning and the results obtained at a fine primary grind. Figure 3 is a plot of bulk concentrate grade versus recovery for the three tests compared in Table 7.

By comparing the increase in zinc and lead content in the tailings when the zinc rougher tailing is adjusted to correspond to the target bulk concentrate grade, it can be seen that regrinding of the rougher concentrates prior to cleaning (A-25) is effective in reducing the zinc and lead tailing losses to the same level as those obtained for the fine primary grind (A-21). However, regrinding did not reduce the loss of copper to the tailing.

The much higher slope obtained for the test A-25 grade-recovery curve in Fig. 3 is a measure of the rapidity with which the lead and zinc concentrates making up the bulk concentrate are upgraded when the rougher concentrates are reground prior to cleaning.

Table 6 - Precious metals recovery in bulk concentrate for key tests

Test no.	Grind % minus 500 mesh	Bulk conc production method	Product	Wt %	Assay* g/t Ag	Assay* g/t Au	Distribution % Ag	Distribution % Au
		Selective	Target bulk conc	27.54	246.9	0.38	84.6	13.0
A-21	77.5	flotation	Tailing	72.46	17.1	0.96	15.4	87.0
			Feed (calcd)	100.00	80.6	0.79	100.0	100.0
		Selective	Target bulk conc	24.37	274.3	0.34	84.9	18.7
A-22	63.5	flotation	Tailing	75.63	15.8	0.48	15.1	81.3
			Feed (calcd)	100.00	78.9	0.45	100.0	100.0
		Selective	Target bulk conc	27.74	233.1	0.31	85.6	9.7
A-23	57.0	flotation	Tailing	72.26	15.1	1.10	14.4	90.3
			Feed (calcd)	100.00	75.4	0.89	100.0	100.0
		Bulk	Target bulk conc	25.79	315.4	0.31	81.8	19.4
A-27	57.0	flotation	Tailing	74.21	24.3	0.45	18.2	80.6
			Feed (calcd)	100.00	99.4	0.41	100.0	100.0
		Bulk	Target bulk conc	27.15	274.3	0.45	84.4	11.9
A-30	77.5	flotation	Tailing	72.85	18.9	1.23	15.6	88.1
			Feed (calcd)	100.00	88.1	1.03	100.0	100.0

* MSL, Chemical Laboratory

Table 7 - Comparison of results obtained using selective flotation at a coarse grind with and without regrinding of lead and zinc rougher concentrates prior to cleaning

Product	Wt %	Analysis % Zn	Pb	Cu	VM	GM	Distribution % Zn	Pb	Cu	VM	GM	Sep eff %
Test A-23, primary grind 57% minus 500 mesh, rougher concentrates cleaned without regrinding												
Target bulk conc	27.74	30.00	11.36	0.72	65.2	34.8	94.3	86.2	71.9	91.5	12.0	79.5
Tailing (calcd)	72.26	0.70	0.70	0.11			5.7	13.8	28.1			
Feed (calcd)	100.00	8.83	3.66	0.28			100.0	100.0	100.0			
Zinc rougher tail	66.61	0.42	0.61	0.095								
Test A-25, primary grind 57% minus 500 mesh, rougher concentrates reground prior to cleaning												
Target bulk conc	24.84	30.00	11.06	0.69	64.8	35.2	95.2	85.8	67.9	91.8	10.6	81.2
Tailing (calcd)	75.16	0.50	0.61	0.11			4.8	14.2	32.1			
Feed (calcd)	100.00	7.83	3.20	0.25			100.0	100.0	100.0			
Zinc rougher tail	70.98	0.41	0.57	0.10								
Test A-21, primary grind 77.5% minus 500 mesh, rougher concentrates cleaned without regrinding												
Target bulk conc	27.54	30.00	10.75	0.68	64.4	35.6	95.3	86.6	76.6	92.8	12.1	80.7
Tailing (calcd)	72.46	0.57	0.63	0.08			4.7	13.4	23.3			
Feed (calcd)	100.00	8.67	3.42	0.25			100.0	100.0	100.0			
Zinc rougher tail	69.23	0.43	0.58	0.073								

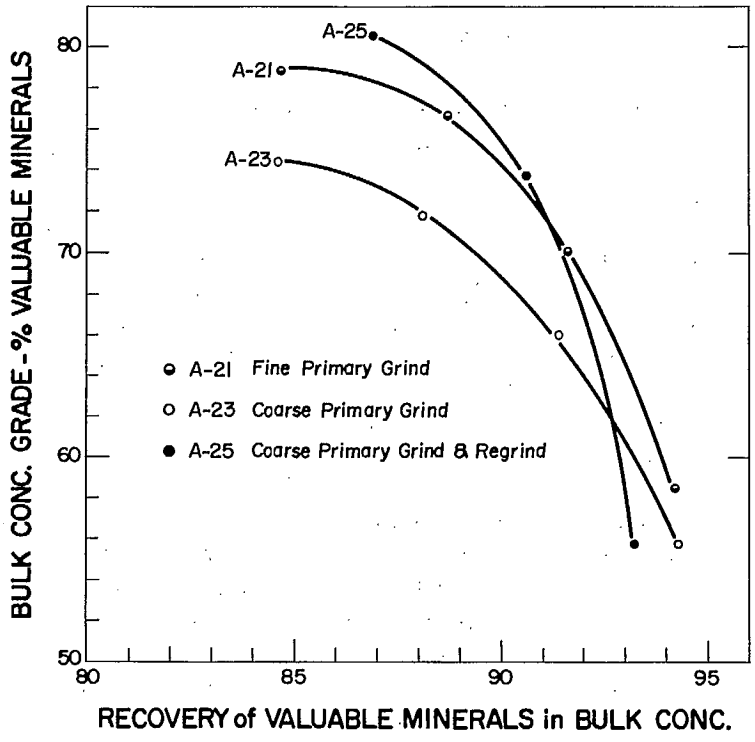

Fig. 3 - Comparison of grade-recovery curves for tests A-21, A-22 and A-23

GYPSUM VERSUS LIME IN BULK FLOTATION

Table 8 gives a comparison of bulk flotation results for two pairs of tests, A-7, A-9 and A-15, A-17, designed to test the effectiveness of gypsum as a pyrite depressant in place of lime. A grade-recovery curve is also shown in Fig. 4 for A-7 and A-9, in which the bulk rougher concentrate was cleaned several times.

In the first pair of tests, A-7 and A-9, there was no significant difference in results for the rougher flotation stage. During cleaning, the bulk rougher concentrate produced with gypsum in A-7 was upgraded at a slightly higher rate as seen by the comparison of the slope of curves in Fig. 4, but this was not considered significant. For A-15 and A-17, appreciably lower tailing losses were obtained with lime in A-15 but there was a large discrepancy between the calculated heads for zinc and lead.

Because gypsum did not exhibit any particular advantages over lime, further testing was not warranted.

EFFECT OF pH LEVELS IN BULK ROUGHER FLOTATION AND CLEANERS

The results of bulk rougher flotation conducted at high and low pH are compared in Table 9 and in Fig. 5 and 6 the results of cleaning bulk rougher concentrate at high and low pH are compared graphically. Figure 5 is a plot of lead recovery in successive cleaning stages whereas in Fig. 6 grade-recovery curves for zinc were drawn with the calculated grade-recovery combinations after each cleaning stage being used as points.

Table 8 - Comparison of results - gypsum versus lime in bulk flotation

Product	Wt %	Analysis %					Distribution %					Sep eff %
		Zn	Pb	Cu	VM	GM	Zn	Pb	Cu	VM	GM	
Test A-7, Gympsum added to grind, pH 9.0 - 8.7 during rougher flotation primary grind, 81% minus 500 mesh												
Bulk rougher conc	35.21	23.03	9.30	0.59	50.8	49.2	92.9	87.5	78.6	91.1	21.6	69.5
Bulk rougher tail	64.79	0.96	0.73	0.087			7.1	12.5	21.4			
Feed (calcd)	100.00	8.73	3.74	0.26			100.0	100.0	100.0			
Target bulk conc	25.89	30.00	11.83	0.70	65.7	34.3	88.9	81.8	68.9	86.5	11.1	75.4
Test A-9, Lime added to grind, pH 10.0 - 9.4 during rougher flotation primary grind, 81% minus 500 mesh												
Bulk rougher conc	36.28	22.62	9.40	0.62	50.3	49.7	93.4	88.6	83.1	91.9	22.5	69.4
Bulk rougher tail	63.72	0.92	0.69	0.07			6.6	11.4	16.9			
Feed (calcd)	100.00	8.79	3.85	0.27			100.0	100.0	100.0			
Target bulk conc	25.58	30.00	12.53	0.80	66.8	33.2	87.2	83.2	75.6	85.9	10.6	75.3
Test A-17, gypsum added to grind, pH 9.0 - 8.8 during rougher flotation primary grind, 77.5% minus 500 mesh												
Bulk rougher conc	35.15	23.22	8.65	0.59	50.4	49.6	93.8	83.0	78.7	90.8	21.7	69.1
Bulk rougher tail	64.85	0.83	0.96	0.087			6.2	17.0	21.3			
Feed (calcd)	100.00	8.70	3.66	0.26			100.0	100.0	100.0			
Test A-15, Lime added to grind, pH 9.8 - 9.4 during rougher flotation primary grind, 77.5% minus 500 mesh												
Bulk rougher conc	30.72	22.72	9.60	0.66	50.9	49.4	93.5	87.3	80.7	91.5	18.2	73.3
Bulk rougher tail	69.28	0.70	0.62	0.07			6.5	12.7	19.3			
Feed (calcd)	100.00	7.46	3.38	0.25			100.0	100.0	100.0			

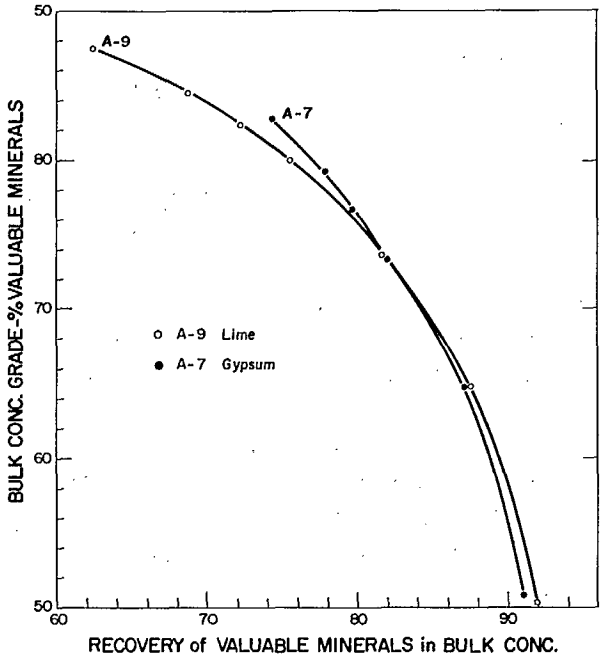

Fig. 4 - Comparison of grade-recovery curves for tests A-7 and A-9

The following pH values were used:

Roughers high pH - 11.35 at start to 10.3 at end of float; low pH 9.8 at start to 9.0 at end of float.

Cleaners high pH - 11 plus in each cleaning stage; low pH 9.85 in first cleaner to 8.6 in final.

As seen in Table 9, improved selectivity accompanied by lower zinc and lead tailing losses were obtained in tests using a high pH in the roughers (A-31 and A-32). Note the large weight of bulk rougher concentrate floated at a low pH in A-34 compared with the weight of concentrate floated in an identical test, A-30, conducted five months earlier. This difference is attributed to partial oxidation of sulphides resulting from the additional five-month storage time of the minus 10-mesh test feed samples. The effect of oxidation is to render pyrite more floatable at low pH.

In contrast to the effect of high pH in bulk rougher flotation which was beneficial, high pH in the cleaners resulted in severe depression of galena. This is dramatically illustrated in Fig. 5 by comparing lead recovery-cleaning stage curves for A-32 at a low pH and A-34 at a high pH. The difference is so great that the use of a high pH could be considered as a means of separating the lead from the zinc. Note, however, the much smaller difference between the curves for C-3A at a low pH and C-3B at a high pH. On the C sample, galena was depressed - cause unknown - even when the bulk rougher concentrate was cleaned at a low pH.

To determine whether the use of a high pH in the rougher had a subsequent detrimental effect in the cleaners, test A-30, at a low pH in both rougher and cleaners was compared with test A-32, at a high pH in rougher and a low pH in cleaners. From a comparison of the lead recovery-leaning stage curves for these two tests it can be seen that for A-30 a 3% higher lead recovery was obtained in the first cleaner. However, in the subsequent two cleaners the rate of decrease in lead recovery was slightly less for A-32 so that by the end of the third cleaner the differ-

Table 9 - Comparison of bulk rougher flotation results obtained at high and low pH

Test No.	Date tested	pH level	Product	Wt %	Analysis %					Distribution %					Sep. Eff. %
					Zn	Pb	Cu	VM	GM	Zn	Pb	Cu	VM	GM	
A-30	Dec.12/77	low	Bulk rougher conc	46.62	18.37	7.24	0.49	40.4	59.6	97.0	91.3	86.0	95.5	34.6	60.9
			Bulk rougher tail	53.38	0.50	0.60	0.07			3.0	8.7	14.0			
			Feed (calcd)	100.00	8.83	3.70	0.27			100.0	100.0	100.0			
A-31	Dec.12/77	high	Bulk rougher conc	43.80	19.68	7.39	0.54	42.9	57.1	97.9	91.4	85.7	95.9	31.1	64.8
			Bulk rougher tail	56.20	0.33	0.54	0.07			2.1	8.6	14.3			
			Feed (calcd)	100.00	8.80	3.54	0.27			100.0	100.0	100.0			
A-32	May 4/78	high	Bulk rougher conc	43.43	19.31	7.32	0.54	42.2	57.8	97.3	90.7	87.4	95.0	31.1	63.9
			Bulk rougher tail	56.57	0.41	0.58	0.06			2.7	9.3	12.6			
			Feed (calcd)	100.00	8.62	3.51	0.27			100.0	100.0	100.0			
A-34	May 8/78	low	Bulk rougher conc	60.57	14.05	5.22	0.39	30.6	69.4	97.2	92.5	88.0	96.0	46.3	49.7
			Bulk rougher tail	39.43	0.62	0.65	0.082			2.8	7.5	12.0			
			Feed (calcd)	100.00	8.75	3.42	0.27			100.0	100.0	100.0			

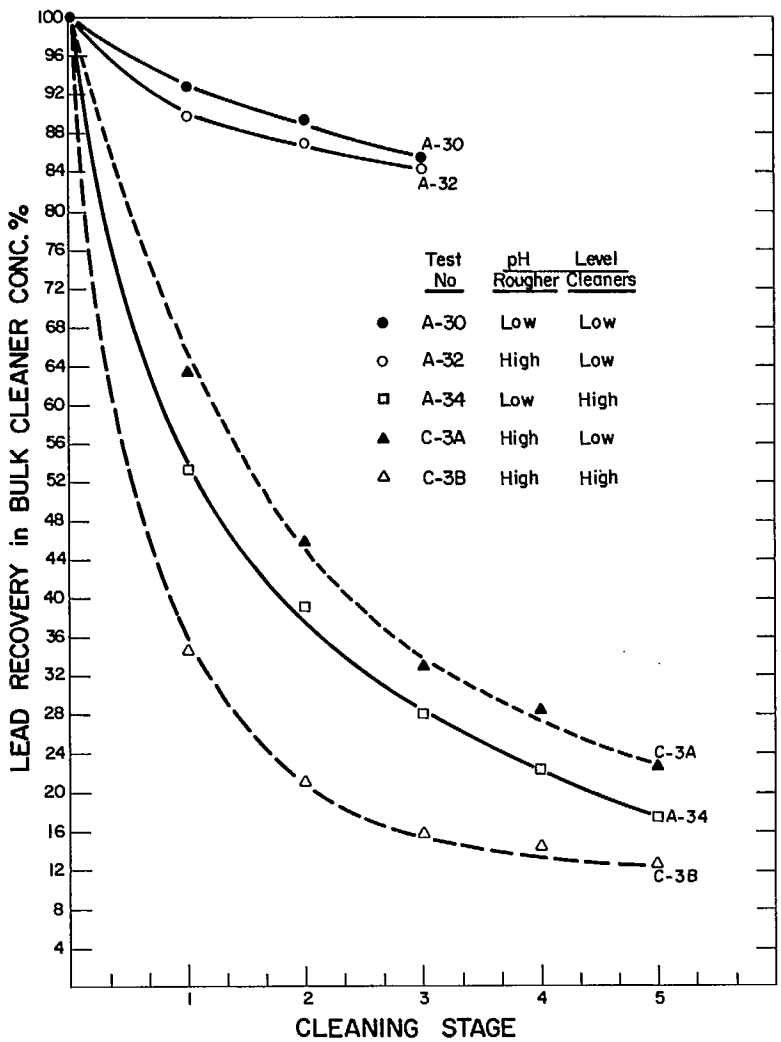

Fig. 5 - Plot of lead recovery versus cleaning stage for high and low pH in cleaners

ence in lead recoveries had narrowed to an insignificant 1.2%.

For zinc, use of high pH in bulk concentrate cleaning had an appreciable effect only in the third and subsequent stages. If all the grade-recovery curves for zinc in Fig. 6 were to be superimposed to start at the same bulk rougher concentrate grade, it can be seen that, except for A-30, there would be only small deviations in slope for the initial portion of the curve which includes the grade-recovery points obtained for the first two cleaners. As cleaning progresses however, a high pH in cleaning produces a higher concentrate grade before the curve flattens (compare C-3A with C-3B).

EFFECT OF pH LEVELS IN ZINC CLEANING

When carrying out selective flotation tests the standard procedure was to clean the zinc rougher concentrate without modifying the pH. Because of the carry-over of lime in the zinc rougher froth a pH of ~10.5 was obtained in the first cleaner. In the second and third cleaners the pH was reduced to values <10 by diluting with water. In A-26, lime was added to give a pH of 11.2-11.3 at the start of each cleaner. The higher pH had no significant effect on results as can be seen by comparing the lead recovery versus cleaning stage and zinc grade-recovery curves in Fig. 7.

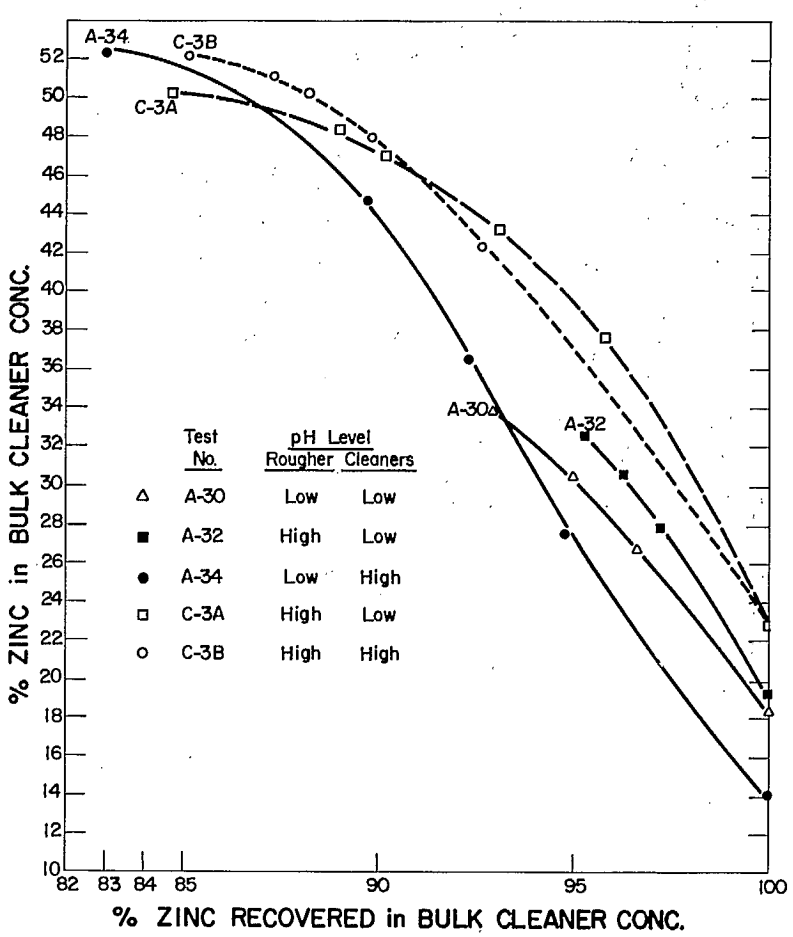

Fig. 6 - Comparison of zinc grade-recovery curves for high and low pH in bulk conc cleaners

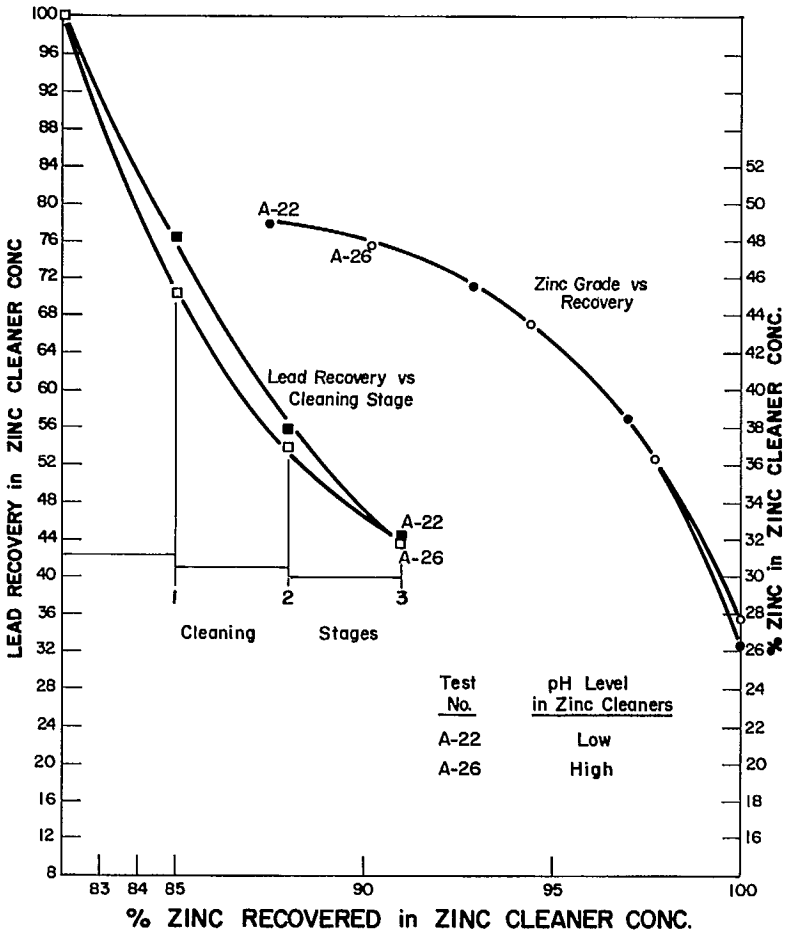

Fig. 7 - Comparison of lead recovery-cleaning stage and zinc grade-recovery curves for high and low pH in zinc cleaners.

EFFECT OF INCREASES IN COPPER SULPHATE ADDITION TO BULK FLOTATION

The standard amount of copper sulphate added for sphalerite activation in both bulk and selective flotation was 1 kg/t. Normally, adding copper sulphate at this rate is sufficient for sphalerite activation when floating an ore containing ~10% zinc. In some of the later tests copper sulphate was increased to 1.5 kg/t. A comparison of bulk flotation results using the two levels of copper sulphate shows that increasing copper sulphate to 1.5 kg/t resulted in a substantial reduction in zinc loss to the tailing without adversely affecting selectivity (Table 10).

COMPARISON OF RESULTS OBTAINED FOR THE VARIOUS ORE SAMPLES TESTED

Table 11 compares results obtained using bulk flotation on No. 1 shipment composite sample A with results using a similar procedure on bulk ore head sample B and No. 2 shipment head sample C. Included in the comparison are selective flotation results obtained for samples A and B.

The comparison shows there are large differences in the response of the three samples to the techniques employed. In samples A and B the different responses can be attributed to mineral surface oxidation in sample B. Surface oxidation enhances the floatability of pyrite while render-

Table 10 - Comparison of bulk rougher flotation results obtained for two levels of copper sulphate addition

Test No.	Grind % -500m	$CuSO_4$ addition lb/ton	Product	Wt %	Analysis %					Distribution %					Sep. Eff. %
					Zn	Pb	Cu	VM	GM	Zn	Pb	Cu	VM	GM	
A-28	77.5	2.0	Bulk rougher conc	46.83	14.95	6.52	0.43	33.6	66.4	92.4	90.0	79.1	91.3	37.6	53.7
			Bulk rougher tail	53.17	1.08	0.64	0.10			7.6	10.0	20.9			
			Feed (calcd)	100.00	7.57	3.39	0.25			100.0	100.0	100.0			
A-30	77.5	3.0	Bulk rougher conc	46.62	18.37	7.24	0.49	40.4	59.6	97.0	91.3	86.1	95.5	34.6	60.9
			Bulk rougher tail	53.38	0.50	0.60	0.07			3.0	8.7	13.9			
			Feed (calcd)	100.00	8.83	3.70	0.27			100.0	100.0	100.0			
C-1	57.0	2.0	Bulk rougher conc	27.61	30.10	8.14	0.62	61.4	38.6	88.7	62.4	69.6	82.7	13.4	69.3
			Bulk rougher tail	72.39	1.47	1.87	0.10			11.3	37.6	30.4			
			Feed (calcd)	100.00	9.38	3.60	0.25			100.0	100.0	100.0			
C-2	57.0	3.0	Bulk rougher conc	30.38	29.63	7.97	0.61	60.3	39.7	94.0	69.6	70.6	88.4	15.2	73.2
			Bulk rougher tail	69.62	0.82	1.52	0.11			6.0	30.4	29.4			
			Feed (calcd)	100.00	9.57	3.48	0.26			100.0	100.0	100.0			

Table 11 - Comparison of results obtained for various ore samples tested

Test No.	Grind % -500m	Ore sample	Product	Wt %	Analysis %					Distribution %					Sep. Eff. %
					Zn	Pb	Cu	VM	GM	Zn	Pb	Cu	VM	GM	
A-15	77.5	No.1 shipment -composite	Bulk rougher conc	30.72	22.72	9.60	0.66	50.9	49.1	93.5	87.3	80.7	91.5	18.2	73.3
			Bulk rougher tail	69.28	0.70	0.62	0.07			6.5	12.7	19.3			
			Feed (calcd)	100.00	7.46	3.38	0.25			100.0	100.0	100.0			
B-1	77.5	No.1 shipment -bulk ore head sample	Bulk rougher conc	57.68	12.69	4.40	0.46	27.6	72.4	92.4	89.9	86.9	91.6	50.5	41.1
			Bulk rougher tail	42.32	1.43	0.67	0.094			7.6	10.1	13.1			
			Feed (calcd)	100.00	7.92	2.82	0.30			100.0	100.0	100.0			
A-16	77.5	No.1 shipment -composite	Lead rougher conc	13.30	9.65	21.90	0.88			14.9	80.4	45.7			
			Zinc rougher conc	17.73	39.64	1.72	0.50			81.9	8.4	34.6			
			Zinc rougher tail	68.97	0.40	0.59	0.073			3.2	11.2	19.7			
			Feed (calcd)	100.00	8.59	3.62	0.26			100.0	100.0	100.0			
B-4	77.5	No.1 shipment -bulk ore head sample	Lead rougher conc	14.07	9.06	16.28	0.99			15.0	77.6	45.6			
			Zinc rougher conc	21.40	32.31	1.31	0.77			81.5	9.3	39.7			
			Zinc rougher tail	64.53	0.45	0.61	0.094			3.5	13.1	14.7			
			Feed (calcd)	100.00	8.48	3.01	0.41			100.0	100.0	100.0			
A-27	57	No.1 shipment -composite	Bulk rougher conc	42.65	19.09	7.86	0.51	42.4	57.6	94.0	89.8	79.2	92.4	30.5	81.9
			Bulk rougher tail	57.35	0.91	0.66	0.10			6.0	10.2	20.8			
			Feed (calcd)	100.00	8.66	3.73	0.28			100.0	100.0	100.0			
C-2	57	No.2 shipment -head sample	Bulk rougher conc	30.38	29.63	7.67	0.68	60.3	39.7	94.0	69.6	70.6	88.4	15.2	73.2
			Bulk rougher tail	69.62	0.82	1.52	0.11			6.0	30.4	29.4			
			Feed (calcd)	100.00	9.57	3.48	0.26			100.0	100.0	100.0			

ing sphalerite less floatable. The result is a deterioration in selectivity accompanied by a higher loss of zinc to the tailing. Note that for selective flotation (compare A-16 with B-4) the deterioration was not as great as for bulk flotation (A-15 versus B-1). In the selective flotation test on the oxidized sample B (B-4) the amount of cyanide added for pyrite depression during lead flotation was doubled from 0.2 to 0.4 g and copper sulphate was increased from 2.0 to 2.5 g. These increases alleviated the detrimental effects caused by surface oxidation.

In sample C, zinc selectivity improved to such an extent that it was possible to produce a bulk rougher concentrate close to the target grade of 30% zinc (compare C-2 with A-27). However, the loss of lead in the tailings was much higher than for any test conducted in sample A.

DISTRIBUTION OF METAL LOSSES IN TAILINGS BY SIZE FRACTIONS

The distribution of metal losses in the various size fractions of the tailings from selective and bulk flotation tests conducted at various grinds are compared in Tables 12, 13 and 14. The tailings are those corresponding to the target grade of 30% zinc and were prepared for size analysis by combining the final tailing with the lower-grade cleaner tailings left after the 30% zinc bulk concentrate had been composited.

The most striking feature of the tailings loss distribution is the high losses in the minus

Table 12 - Comparison of metal losses in various size fractions of tailings for bulk and selective flotation at various grinds

Test No.	Metal	% Metal Analysis in Size Fractions given in micrometers									
		+44	-44 +38	-38 +26.7	-26.7 +20.3	-20.3 +14.8	-14.8 +10.2	-10.2 +7.8	-7.8 +4.7	-4.7	Total
A-21, selective flotation at 77.5% - 500 mesh	Zn			0.51	0.35	0.26	0.25	0.24	0.33	1.48	0.50
	Pb			0.54	0.37	0.30	0.33	0.34	0.42	1.76	0.58
	Cu			0.078	0.064	0.044	0.046	0.046	0.058	0.16	0.072
A-22, selective flotation at 63.5% - 500 mesh	Zn	0.80	0.79	0.75	0.41	0.30	0.28	0.32	0.61	2.33	0.73
	Pb	0.70	0.72	0.66	0.35	0.28	0.28	0.30	0.39	1.70	0.59
	Cu	0.080	0.089	0.094	0.055	0.046	0.049	0.046	0.055	0.16	0.076
A-23, selective flotation at 57% - 500 mesh	Zn	0.77	0.69	0.62	0.33	0.27	0.26	0.27	0.46	2.19	0.65
	Pb	0.76	0.72	0.65	0.34	0.32	0.33	0.31	0.35	1.73	0.62
	Cu	0.089	0.096	0.098	0.062	0.053	0.051	0.053	0.060	0.16	0.082
A-27, bulk flotation at 57% - 500 mesh	Zn	1.33	1.21	1.04	0.48	0.33	0.33	0.46	1.40	5.43	1.39
	Pb	0.75	0.72	0.63	0.30	0.23	0.27	0.39	0.84	3.85	0.92
	Cu	0.085	0.094	0.087	0.055	0.046	0.049	0.53	0.094	0.30	0.10
A-30, bulk flotation at 77.5% - 500 mesh	Zn			0.48	0.36	0.27	0.26	0.29	0.44	2.94	0.77
	Pb			0.47	0.34	0.24	0.28	0.39	0.64	3.49	0.89
	Cu			0.071	0.060	0.042	0.049	0.051	0.073	0.25	0.09

Table 13 - Comparison of distribution of tailing losses by size fractions for bulk and selective flotation at various grinds

Test No.	Metal	% Distribution of Tailing Losses by Size Fractions (micrometers)									
		+44	-44 +38	-38 +26.7	-26.7 +20.3	-20.3 +14.8	-14.8 +10.2	-10.2 +7.8	-7.8 +4.7	-4.7	Total
A-21, selective flotation at 77.5% - 500 mesh	Zn			0.7	0.7	0.4	0.3	0.2	0.4	2.0	4.7
	Pb			1.9	1.7	1.1	1.1	0.5	1.3	5.8	13.4
	Cu			3.8	4.1	2.2	2.1	1.1	2.6	7.4	23.3
A-22, selective flotation at 63.5% - 500 mesh	Zn	0.2	0.4	1.8	0.8	0.4	0.3	0.2	0.7	2.9	7.7
	Pb	0.4	0.9	4.0	1.8	1.0	0.8	0.5	1.1	5.3	15.8
	Cu	0.7	1.6	8.3	4.2	2.2	2.1	1.0	2.2	7.3	29.6
A-23, selective flotation at 57.0% - 500 mesh	Zn	0.5	0.4	1.2	0.5	0.3	0.2	0.1	0.4	2.1	5.7
	Pb	1.2	1.2	3.1	1.3	0.8	0.7	0.4	0.8	4.3	13.8
	Cu	2.1	2.4	7.1	3.7	2.0	1.7	1.0	2.0	6.1	28.1
A-27, bulk flotation at 57.0% - 500 mesh	Zn	0.9	0.8	1.8	0.7	0.3	0.3	0.2	1.2	5.9	12.1
	Pb	1.3	1.2	2.6	1.1	0.5	0.6	0.4	1.8	10.4	19.9
	Cu	2.2	2.3	5.6	3.1	1.6	1.6	0.9	3.0	12.3	32.6
A-30, bulk flotation at 77.5% - 500 mesh	Zn			0.7	0.7	0.4	0.4	0.2	0.6	4.8	7.8
	Pb			1.4	1.4	0.8	0.9	0.6	1.8	12.2	19.1
	Cu			2.8	3.4	1.9	2.1	1.1	2.8	11.8	25.9

Table 14 - Summary of distribution of tailing losses by size fractions for bulk and selective flotation at various grinds

Size fraction range in micrometers	Distribution of zinc tailing losses, %				
	Test A-21 selective flotn 77.5% - 500m	Test A-22 selective flotn 63.5% - 500m	Test A-23 selective flotn 57% - 500m	Test A-27 bulk flotn 57% - 500m	Test A-30 bulk flotn 77.5% - 500m
Coarse, +44 to 26.7	0.7	2.4	2.1	3.5	0.7
Intermediate, -26.7 to +4.7	2.0	2.4	1.5	2.7	2.3
Slimes, -4.7	2.0	2.9	2.1	5.9	4.8
Total	4.7	7.7	5.7	12.1	7.8
	Distribution of lead tailing losses, %				
Coarse, +44 to +26.7	1.9	5.3	5.5	5.1	1.4
Intermediate, -26.7 to +4.7	5.7	5.2	4.0	4.4	5.5
Slimes, -4.7	5.8	5.3	4.3	10.4	12.2
Total	13.4	15.8	13.8	19.9	19.1
	Distribution of copper tailing losses, %				
Coarse, +44 to +26.7	3.8	10.6	11.6	10.1	2.8
Intermediate, -26.7 to +4.7	12.1	11.7	10.4	10.2	11.3
Slimes, -4.7	7.4	7.3	6.1	12.3	11.8
Total	23.3	29.6	28.1	32.6	25.9

4.7-µm slime fractions when compared with the low losses in the preceding size fractions from minus 26.7 to plus 4.7 µm (Table 12). Any further improvement in metal recoveries will therefore depend on developing a process which will increase the recovery of these slimed minerals.

Note the substantial decrease in metal losses to a-close-to optimum value in the minus 26.7, plus 20.3-µm fractions of the tailings. This indicates that the mineral liberation for the ore is within this size range. Although the fine 77.5% minus 500-mesh grind employed was coarser than the 100% minus 26.7-µm grind required for complete liberation, the losses in the incompletely liberated minus 38, plus 26.7-µm fraction of the tailings from this fine grind were relatively small (Table 13). It can therefore be concluded that a grind of 77.5% minus 500 mesh is fine enough to liberate most of the minerals to the extent that losses of middling particles to the tailings are negligible.

For all metals, higher losses were sustained in the minus 4.7-µm slime fraction of bulk flotation tailings than in the zinc rougher tailing from selective flotation. This difference is the main contributing factor to the lower metal recoveries obtained by bulk flotation. Unexpected was the lower zinc loss in the slime fraction of the fine tailings (A-21 and A-30) when compared with slime fraction losses in the coarser tailings (A-22, A-23 and A-27). For lead, the increase in loss to the slime fraction with an increase in fineness of grind was much lower than anticipated, and was greatly offset by the decrease of losses in the coarse fractions of the tailing.

SEPARATION EFFICIENCY BY SIZE FRACTIONS

A comparison of separation efficiencies obtained by size fractions for bulk and selective flotation at various grinds is given in Table 16. Table 15 compares bulk concentrate grades for the various size fractions. Metallurgical balances for all individual size fractions have been calculated and are given in Appendix A.

A few anomalies can be noted in Table 16. One is the lower separation efficiency obtained for the plus 38-µm fraction for bulk flotation at a coarse grind (compare A-27 with A-23). The other is the much lower separation efficiency obtained for the minus 4.7-µm slime fractions of the two bulk flotation tests. The highest separation efficiencies were achieved for the intermediate sizes from minus 20.3 µm to plus 7.8 µm.

CONCLUSIONS

The ore responds readily to conventional flotation techniques. By employing a fine grind of 77.5% minus 500 mesh it was possible to produce a zinc-lead-copper-silver bulk concentrate with the target of 30% zinc, and zinc, lead, copper and silver recoveries of 95.3, 86.6, 76.7 and 84.6% respectively. The combined recovery of the VM in the concentrate - sphalerite, galena and chalcopyrite - was 92.8%. These results were achieved by employing selective flotation for producing lead and zinc concentrates and then combining the two to form the bulk concentrate. Bulk or collective flotation of all the VM was not as effective. At the same fine grind as employed for selective flotation the VM recovery for bulk flotation was significantly lower at 89.5%.

For selective flotation is was demonstrated that a coarser primary grind of 57% minus 500 mesh followed by regrinding of the lead and zinc rougher concentrates prior to cleaning gave equivalent results to those obtained at the fine primary grind except that copper recovery was lower. In bulk flotation, a coarser primary grind resulted in a much higher loss of zinc in the final tailing. Therefore, for this method the coarser primary grind-regrind combination is not feasible.

From a study of the distribution of tailings losses by size fractions it can be concluded that a primary grind of 77.5% minus 500 mesh is adequate for mineral liberation.

The bulk of the metal losses were sustained in the minus 4.7-µm slime fractions of

the tailings. Therefore, as stated previously, any further improvement in metal recoveries will depend on developing a process which will increase the recovery of the slimed minerals.

Table 15 - Comparison of grade of various size fractions of target-grade bulk concentrate produced by bulk and selective flotation at various grinds

Test No.	% Ana.	Grade of Size Fractions given in micrometers									
		+44	-44 +38	-38 +26.7	-26.7 +20.3	-20.3 +14.8	-14.8 +10.2	-10.2 +7.8	-7.8 +4.7	-4.7	Total
A-21, selective flotation at 77.5% - 500 mesh	Zn			21.60	29.14	32.59	31.77	32.27	26.69	25.42	28.61
	Pb			18.59	9.56	8.89	11.01	11.63	9.56	11.76	11.12
	Cu			0.49	0.63	0.68	0.74	0.80	0.68	0.84	0.69
A-22, selective flotation at 63.5% - 500 mesh	Zn		28.81	23.40	28.92	30.76	34.11	35.44	26.03	29.60	28.62
	Pb		4.98	10.57	8.73	10.28	11.27	12.52	10.33	20.97	10.85
	Cu		0.59	0.51	0.60	0.68	0.80	0.91	0.77	1.17	0.70
A-23, selective flotation at 57% - 500 mesh	Zn	28.75	28.08	25.23	30.23	33.18	34.17	35.94	25.98	25.81	29.05
	Pb	4.96	5.42	9.74	9.03	10.54	12.07	13.36	10.66	18.68	10.36
	Cu	0.56	0.57	0.53	0.61	0.72	0.80	0.92	0.73	1.05	0.68
A-27, bulk flotation at 57% - 500 mesh	Zn	30.12	29.87	29.36	28.60	29.76	33.14	35.58	26.77	24.24	29.50
	Pb	4.10	5.05	7.74	9.16	10.95	12.50	13.61	10.82	19.36	10.02
	Cu	0.61	0.62	0.56	0.61	0.67	0.79	0.90	0.74	0.98	0.68
A-30, bulk flotation at 77.5% - 500 mesh	Zn			18.82	26.31	28.77	33.08	33.98	35.17	26.88	28.68
	Pb			11.08	8.25	9.53	11.05	12.75	12.01	13.86	10.69
	Cu			0.39	0.56	0.63	0.73	0.86	0.91	0.83	0.68

Table 16 - Comparison of separation efficiencies obtained by size fractions for bulk and selective flotation at various grinds

Test No.	Separation Efficiency %, for Size Fractions given in Micrometers										
	+44	-44 +38	-38 +26.7	-26.7 +20.3	-20.3 +14.8	-14.8 +10.2	-10.2 +7.8	-7.8 +4.7	-4.7	Total (calcd)	Total*
A-21, selective flotation at 77.5% - 500 mesh			79.6	82.4	84.9	85.1	85.2	75.9	66.0	79.7	80.7
A-22, selective flotation at 63.5% - 500 mesh		74.5	76.1	81.5	84.5	87.3	88.6	79.1	67.6	79.5	79.8
A-23, selective flotation at 57.0% - 500 mesh	75.2	75.4	74.8	81.9	85.6	87.0	89.2	80.2	66.0	78.9	79.5
A-27, bulk flotation at 57.0% - 500 mesh	60.9	72.8	74.8	81.1	83.4	87.1	87.6	72.1	37.6	73.5	73.9
A-30, bulk flotation at 77.5% - 500 mesh			75.1	78.4	82.6	86.6	87.2	85.3	52.1	78.8	77.7

*As determined

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1. Schultz, N.F. "Separation Efficiency"; SME Trans; Vol 274; March 1970.

APPENDIX A

FLOTATION TEST REPORTS AND METALLURGICAL BALANCES

List of Abbreviations

CM	ceramic ball mill
RM	rod mill
BM	ball mill
calcd	calculated
cl	cleaner
conc	concentrate
ro	rougher
tail	tailing
g	grams
in	inches
min	minutes
SA	soda ach

Dow Chemical Co reagents

z-11	sodium isopropyl xanthate
z-200	selective zinc collector, composition unknown
DF 250	Dowfroth 250, water soluble frother

Cyanamid of Canada reagent

242	Aerofloat 242, liquid dithiophosphate type collector

FLOTATION TEST REPORT

TEST NO. A-7	SAMPLE: No.2 Composite	DATE: Jan. 20, 1977
OBJECT OF TEST: To try bulk flotation with gypsum as pyrite depressant in place of lime.		CHARGE: 2000 g
		TESTED BY: G.L.

OPERATION	Time min	% Solids	pH	Unit used	Reagents, Grams									
					$CaSO_4$	Z-11	Z-200	242	$CuSO_4$	Lime	DF250			
Grinding 1	60	65	9.7	7x14 RM	14.0									
Filtering														
Filter cake wash														
Grinding 2	30	65	9.15	12in. BM										
Conditioning 1	10			Aerator										
" 2	5		8.05	Aerator		0.05	0.04	0.05						
" 3	10		9.0	1000-g cell					2.0	1.0				
Bulk rougher				" "										
Stage 1	1		9.0				0.04							
Stage 2	1		8.7					0.025						
Bulk cleaners														
No.1, Stage 1	1		8.7	500-g cell										
Stage 2	1										0.02			
No.2, Stage 1	1		8.6	500-g cell										
Stage 2	½										0.02			
No.3, Stage 1	1		8.7	250-g cell										
Stage 2	½										0.01			
No.4, Stage 1	1		8.8	250-g cell										
Stage 2	½										0.01			
No.5	1		8.7	250-g cell										

REMARKS:

METALLURGICAL BALANCE

TEST NO. A-7 | SAMPLE: No.2 Composite | DATE: Jan. 20/77

PRODUCT	WT %	ANALYSIS %							DISTRIBUTION %				
		Zn	Pb	Cu	VM	GM			Zn	Pb	Cu	VM	GM
Bulk conc.	17.64	38.16	14.72	0.76	82.8	17.2			77.1	69.4	51.0	74.3	3.8
Bulk cleaner tail 5	1.67	18.20	7.82	0.72					3.5	3.5	4.6		
" " " 4	1.09	14.20	6.36	0.62					1.8	1.8	2.6		
" " " 3	1.56	12.33	5.46	0.60					2.2	2.3	3.6		
" " " 2	4.47	9.79	4.58	0.48					5.0	5.5	8.2		
" " " 1	8.78	3.30	2.14	0.26					3.3	5.0	8.6		
Bulk rougher tail	64.79	0.96	0.73	0.087					7.1	12.5	21.4		
Feed (calculated)	100.00	8.73	3.74	0.26					100.0	100.0	100.0		
Calculated Analyses													
Bulk cl conc - 4th stage	19.31	36.43	14.12	0.76	79.2	20.8			80.6	72.9	55.6	77.8	5.0
" " " - 3rd stage	20.40	35.24	13.71	0.75	76.7	23.3			82.4	74.7	58.2	79.6	5.9
" " " - 2nd stage	21.96	33.62	13.12	0.74	73.3	26.7			84.6	77.0	61.8	81.9	7.3
" " " - 1st stage	26.43	29.59	11.68	0.70	64.8	35.2			89.6	82.5	70.0	87.1	11.6
Bulk rougher conc	35.21	23.03	9.30	0.59	50.8	49.2			92.9	87.5	78.6	91.1	21.6

REMARKS:

METALLURGICAL BALANCE

TEST NO. A-7 | SAMPLE: No.2 Composite | DATE: Jan. 20/77

Calculation of Target bulk conc and corresponding tailing

PRODUCT	WT %	ANALYSIS %							DISTRIBUTION %				
		Zn	Pb	Cu	VM	GM			Zn	Pb	Cu	VM	GM
Bulk cl conc - 2nd stage	21.96	33.62	13.12	0.74					84.6	77.0	61.8		
Bulk cl tail 2													
x 0.8792	3.93	9.79	4.58	0.48					4.3	4.8	7.1		
Target bulk conc	25.89	30.00	11.83	0.70	65.7	34.3			88.9	81.8	68.9	86.5	11.1
Bulk cl tail 2													
x 0.1208	0.54	9.79	4.58	0.48					0.7	0.7	1.1		
Bulk cl tail 1	8.78	3.30	2.14	0.26					3.3	5.0	8.6		
Bulk rougher tail	64.79	0.96	0.73	0.087					7.1	12.5	21.4		
Tailing	74.11	1.30	0.92	0.11					11.1	18.2	100.0		

REMARKS:

FLOTATION TEST REPORT

TEST NO. A-9	SAMPLE: No.2 Composite	DATE: Jan. 28, 1977
OBJECT OF TEST: Bulk flotation with lime as pyrite depressant.		CHARGE: 2000 g
		TESTED BY: G.L.

OPERATION	Time min	% Solids	pH	Unit used	Reagents, Grams									
					Lime	$CuSO_4$	Z-11	Z-200	242	DF250				
Grinding 1	60	65	9.75	7x14 RM	1.0									
Filtering														
Filter cake wash														
Grinding 2	30	65	9.1	12in. BM										
Conditioning 1	10			Aerator	1.25	2.0								
" 2	5		9.6	Aerator			0.05	0.04	0.05					
Bulk rougher				1000-g cell										
Stage 1	½		9.5					0.04						
Stage 2	½		10.0		0.1			0.02						
Stage 3	1		9.6						0.025					
Stage 4	1		9.4					0.02						
Bulk cleaners														
No.1, Stage 1	1½		9.5	500-g cell										
Stage 2	1									0.02				
No.2	2		9.3	500-g cell										
No.3	2		9.1	500-g cell										
No.4, Stage 1	1		9.1	250-g cell										
Stage 2	½									0.01				
No.5, Stage 1	1		9.0	250-g cell										
Stage 2	½									0.01				
No.6	1		8.9	250-g cell										
No.7	1		8.9	250-g cell										

REMARKS:

METALLURGICAL BALANCE

TEST NO. A-9 | SAMPLE: No.2 Composite | DATE: Jan.28/77

PRODUCT	WT %	ANALYSIS %*							DISTRIBUTION %				
		Zn	Pb	Cu	VM	GM			Zn	Pb	Cu	VM	GM
Bulk conc	12.55	39.13	18.72	1.06	89.9	10.1			55.9	61.0	49.2	56.8	1.6
Bulk cleaner tail 7	1.62	32.02	12.45	0.81					5.9	5.2	4.8		
" " " 6	1.98	30.58	9.14	0.66					6.9	4.7	4.8		
" " " 5	1.24	26.13	7.50	0.63					3.7	2.4	2.9		
" " " 4	1.36	23.92	6.58	0.60					3.7	2.4	3.0		
" " " 3	3.24	18.06	5.16	0.52					6.7	4.3	6.2		
" " " 2	4.83	11.25	3.41	0.35					6.2	4.3	6.3		
" " " 1	9.46	4.16	1.75	0.18					4.4	4.3	6.3		
Bulk rougher tail	63.72	0.92	0.69	0.07					6.6	11.4	16.5		
Feed (calculated)	100.00	8.79	3.85	0.27					100.0	100.0	100.0		
Calculated Analyses													
Bulk cl conc - 6th Stage	14.17	38.32	18.00	1.03	87.5	12.5			61.8	66.2	54.0	62.4	2.2
" " " - 5th Stage	16.15	37.37	16.92	0.99	84.5	15.5			68.7	70.9	58.8	68.7	3.1
" " " - 4th Stage	17.39	36.57	16.25	0.96	82.4	17.6			72.4	73.3	61.7	72.2	3.8
" " " - 3rd Stage	18.75	35.65	15.54	0.93	80.0	20.0			76.1	75.7	64.7	75.5	4.7
" " " - 2nd Stage	21.99	33.06	14.01	0.87	73.7	26.3			82.8	80.0	70.9	81.6	7.2
" " " - 1st Stage	26.82	29.13	12.10	0.78	64.8	35.2			89.0	84.3	77.2	87.5	11.8
Bulk rougher, conc	36.28	22.62	9.40	0.62	50.3	49.7			93.4	88.6	83.2	91.9	22.5

REMARKS: *By MSL, Chemical Laboratory, Internal Report MS-CL-77-43.

METALLURGICAL BALANCE

TEST NO. A-9 | SAMPLE: No.2 Composite | DATE: Jan. 20/77

Calculation of target bulk conc and corresponding tailing.

PRODUCT	WT %	ANALYSIS %							DISTRIBUTION %				
		Zn	Pb	Cu	VM	GM			Zn	Pb	Cu	VM	GM
Bulk cl conc - 2nd Stage	21.99	33.06	14.01	0.87					82.8	80.0	70.9		
Bulk cl tail 2													
x 0.7433	3.59	11.25	3.41	0.35					4.4	3.2	4.7		
Target bulk conc	25.58	30.00	12.53	0.80	66.8	33.2			87.2	83.2	75.6	85.9	10.6
Bulk cl tail 2													
x 0.2567	1.24	11.25	3.41	0.35					1.8	1.1	1.6		
Bulk cl tail 1	9.46	4.16	1.75	0.18					4.4	4.3	6.3		
Bulk rougher tail	63.72	0.92	0.69	0.07					6.6	11.4	16.5		
Tailing	74.42	1.50	0.87	0.09					12.8	16.8	24.4		

REMARKS:

FLOTATION TEST REPORT

TEST NO. A-15	SAMPLE: No.2 Composite	DATE: Aug. 23, 1977
OBJECT OF TEST: Bulk flotation using lime as pyrite depressant		CHARGE: 2000 g
		TESTED BY: T.F.B.

OPERATION	Time min	% Solids	pH	Unit used	Reagents, Grams									
					Lime	$CuSO_4$	Z-11	Z-200	242	DF250				
Grinding	90	65		7x14 RM	1.0									
Conditioning 1	10			Aerator	1.0	2.0								
" 2	5			Aerator			0.05	0.04	0.05					
Bulk roughers*				1000-g cell										
No.1	1		9.75**					0.02						
No.2	½								0.025					
No.3	1							0.02	0.025					
No.4	1							0.02						
No.5	2													
No.6	2									0.02				
No.7	2		9.75							0.02				

REMARKS: *Froth not skimmed with paddle but allowed to overflow at a constant pulp level of 1 inch below overflow lip - air volume to cell regulated at ¾ of maximum.

**pH kept constant throughout test by small incremental additions of lime.

METALLURGICAL BALANCE

TEST NO. A-15	SAMPLE: No.2 Composite	DATE: Aug.23/77

PRODUCT	WT %	ANALYSIS %							DISTRIBUTION %				
		Zn	Pb	Cu	VM	GM			Zn	Pb	Cu	VM	GM
Bulk rougher conc 1	10.17	26.13	16.21	0.99	65.2	34.8			35.6	48.8	40.1	38.8	4.3
" " " 2	3.49	26.62	11.37	0.72	59.6	40.4			12.4	11.7	10.0	12.2	1.7
" " " 3	6.00	26.59	7.43	0.58	54.6	45.4			21.4	13.2	13.8	19.2	3.3
" " " 4	3.30	25.96	5.78	0.54	51.6	48.4			11.5	5.7	7.1	10.0	1.9
" " " 5	2.93	18.97	4.36	0.42	37.8	62.2			7.5	3.8	4.9	6.4	2.2
" " " 6	3.53	8.33	3.09	0.26	18.2	81.8			3.9	3.2	3.6	3.7	3.5
" " " 7	1.30	7.11	2.36	0.22	15.2	84.8			1.2	0.9	1.2	1.2	1.3
Bulk rougher tail	69.28	0.70	0.62	0.07	2.1	97.9			6.5	12.7	19.3	8.5	81.8
Feed (calculated)	100.00	7.46	3.38	0.25	17.0	83.0			100.0	100.0	100.0	100.0	100.0
Calculated Analyses													
Bulk ro conc 1 and 2	13.66	26.25	14.97	0.92	63.8	36.2			48.0	60.5	50.1	51.0	6.0
" " " 1 to 3	19.66	26.36	12.67	0.82	60.9	39.1			69.4	73.7	63.9	70.0	9.3
" " " 1 to 4	22.96	26.30	11.68	0.78	59.6	40.4			80.9	79.4	71.0	80.1	11.2
" " " 1 to 5	25.89	25.47	10.85	0.74	57.1	42.9			88.3	83.2	75.9	86.5	13.4
" " " 1 to 6	29.42	23.41	9.92	0.68	52.5	47.5			92.3	86.4	79.5	90.4	16.9
" " " 1 to 7	30.72	22.72	9.60	0.66	50.9	49.1			93.5	87.3	80.7	91.5	18.2

REMARKS:

FLOTATION TEST REPORT

TEST NO. A-16	SAMPLE: No.2 Composite	DATE: Aug. 24, 1977
OBJECT OF TEST: Selective flotation - preliminary test.		CHARGE: 2000 g
		TESTED BY: G.L.

OPERATION	Time min	% Solids	pH	Unit used	Reagents, Grams									
					SA	NaCN	Z-11	242	DF250	Lime	$CuSO_4$	Z-200		
Grinding	90	65	10.1	7x14 RM	2.0	0.2	0.04	0.04						
Conditioning	20			Aerator	0.5									
Lead roughers														
No.1	½		9.7					0.025						
No.2	1								0.02					
No.3	1		9.5				0.025							
No.4	1		9.3						0.02					
Zinc conditioning	10		11.0							2.25	2.0			
Zinc roughers														
No.1	½						0.025					0.04		
No.2	1											0.02		
No.3	1											0.02		
No.4	1		10.3						0.02			0.02		

REMARKS:

METALLURGICAL BALANCE

TEST NO. A-16	SAMPLE: No.2 Composite	DATE: Aug.24/77

PRODUCT	WT %	ANALYSIS %							DISTRIBUTION %				
		Zn*	Pb	Cu					Zn	Pb	Cu		
Lead rougher conc 1	2.72	6.32	42.40	1.23					2.0	31.8	13.1		
" " " 2	5.08	9.62	23.33	0.97					5.7	32.7	19.3		
" " " 3	3.10	11.15	13.52	0.71					4.0	11.6	8.6		
" " " 4	2.40	11.53	6.45	0.50					3.2	4.3	4.7		
Zinc rougher conc 1	9.47	48.51	1.18	0.54					53.5	3.1	20.0		
" " " 2	5.38	36.97	2.13	0.50					23.2	3.2	10.5		
" " " 3	1.80	18.70	2.68	0.39					3.9	1.3	2.7		
" " " 4	1.08	10.00	2.79	0.34					1.3	0.8	1.4		
Zinc rougher tail	68.97	0.40	0.59	0.073					3.2	11.2	19.7		
Feed (calculated)	100.00	8.59	3.62	0.26					100.0	100.0	100.0		
Calculated Analyses													
Combined lead ro conc	13.30	9.65	21.90	0.88					14.9	80.4	45.7		
Combined zinc ro conc	17.73	39.64	1.72	0.50					81.8	8.4	34.6		

REMARKS: *By MSL, Chemical Laboratory, Internal Report MS-CL-77-487.

FLOTATION TEST REPORT

TEST NO. A-17	SAMPLE: No.2 Composite	DATE: Aug. 25, 1977
OBJECT OF TEST: Bulk flotation using gypsum as pyrite depressant in place of lime – to compare with test A-15.		CHARGE: 2000 g
		TESTED BY: T.F.B.

OPERATION	Time min	% Solids	pH	Unit used	Reagents, Grams									
					$CaSO_4$	Z-11	Z-200	242	$CuSO_4$	Lime	DF250			
Grinding	90	65	8.1	7x14 RM	14.0									
Conditioning 1	10			Aerator										
" 2	5			Aerator		0.05	0.04	0.05						
" 3	10		9.45	1000-g cell					2.0	1.0				
Bulk roughers*														
No.1	½		9.0**	1000-g cell										
No.2	1						0.04							
No.3	1							0.025						
No.4	1						0.02							
No.5	2										0.02			
No.6	2										0.02			
No.7	2		9.0								0.02			

REMARKS: * Froth removal by overflow method as in Test A-15.
**pH control as in Test A-15.

METALLURGICAL BALANCE

TEST NO. A-17	SAMPLE: No.2 Composite	DATE: Aug.25/77

PRODUCT	WT %	ANALYSIS %							DISTRIBUTION %				
		Zn	Pb	Cu	VM	GM			Zn	Pb	Cu	VM	GM
Bulk rougher conc 1	7.42	37.09	14.32	0.69	80.3	19.7			31.6	29.0	19.4	30.5	1.8
" " " 2	15.24	27.32	8.41	0.66	57.1	42.9			47.9	35.0	38.1	44.6	8.1
" " " 3	4.94	15.03	6.62	0.57	34.4	65.6			8.5	8.9	10.7	8.7	4.0
" " " 4	2.60	8.81	5.31	0.43	22.0	78.0			2.6	3.8	4.2	2.9	2.5
" " " 5	2.52	6.43	4.80	0.36	17.2	82.8			1.9	3.3	3.4	2.2	2.6
" " " 6	1.55	4.59	4.28	0.30	13.5	86.5			0.8	1.8	1.8	1.1	1.7
" " " 7	0.88	4.54	4.80	0.33	14.1	85.9			0.5	1.2	1.1	0.7	1.0
Bulk rougher tail	64.85	0.83	0.96	0.087	2.8	97.2			6.2	17.0	21.3	9.3	78.3
Feed (calculated)	100.0	8.70	3.66	0.26	19.5	80.5			100.0	100.0	100.0	100.0	100.0
Calculated Analyses													
Bulk ro conc 1 and 2	22.66	30.52	10.35	0.67	64.8	35.2			79.5	64.0	57.4	75.2	9.9
" " " 1 to 3	27.60	27.75	9.68	0.65	59.4	40.6			88.0	73.0	68.1	84.0	13.9
" " " 1 to 4	30.20	26.12	9.30	0.63	56.0	44.0			90.7	76.7	72.3	86.7	16.5
" " " 1 to 5	32.72	24.60	8.96	0.61	53.1	46.9			92.5	80.0	75.8	89.0	19.1
" " " 1 to 6	34.27	23.70	8.74	0.60	51.3	48.7			93.4	81.8	77.6	90.1	20.7
" " " 1 to 7	35.15	23.22	8.65	0.59	50.4	49.6			93.8	83.0	78.7	90.8	21.7

REMARKS:

FLOTATION TEST REPORT

TEST NO. A-21	SAMPLE: No.2 Composite	DATE: Nov. 2, 1977
OBJECT OF TEST: Selective flotation as in Test A-16, but lead and zinc rougher concentrates cleaned.		CHARGE: 2000 g
		TESTED BY: G.L.

OPERATION	Time min	% Solids	pH	Unit used	Reagents, Grams									
					SA	NaCN	Z-11	242	DF250	Lime	CuSO4	Z-200		
Grinding	90	65	10.1	7x14 RM	2.0	0.2	0.04	0.04						
Conditioning	20		9.9	Aerator	0.5									
Lead roughers														
Stage 1	½		9.7	1000-g cell				0.025						
Stage 2	1								0.02					
Stage 3	1						0.025							
Stage 4	1		9.2						0.02					
Lead cleaners*														
No.1	1		9.4	250-g cell										
No.2	1			" "										
No.3	1			" "										
Zinc conditioning	10		10.5	1000-g cell						3.0	2.0			
Zinc roughers				" "										
Stage 1	½		11.0				0.025			0.5		0.04		
Stage 2	1											0.02		
Stage 3	1											0.02		
Stage 4	1		10.5									0.02		

REMARKS: *Lead cleaner tailings filtered and added to zinc conditioning step.

FLOTATION TEST REPORT

TEST NO. A-21	SAMPLE: No.2 Composite	DATE: Nov. 2, 1977
OBJECT OF TEST:		CHARGE:
		TESTED BY:

OPERATION	Time min	% Solids	pH	Unit used	Reagents, Grams									
										DF-250				
Zinc cleaners														
No.1, Stage 1	½		10.1	500-g cell										
Stage 2	½									0.01				
Stage 3	1									0.01				
No.2, Stage 1	½		9.7	500-g cell										
Stage 2	½									0.01				
Stage 3	½									0.01				
No.3	1		9.5	250-g cell										

REMARKS:

METALLURGICAL BALANCE

TEST NO. A-21 | SAMPLE: No.2 Composite | DATE: Nov. 2/77

	PRODUCT	WT %	ANALYSIS %							DISTRIBUTION %				
			Zn	Pb	Cu	VM	GM			Zn	Pb	Cu	VM	GM
1	Lead conc	7.56	11.38	33.57	1.38					9.9	74.2	42.5		
2	Zinc conc	12.98	51.16	1.85	0.45					76.6	7.0	23.8		
3	Zinc cleaner tail 3	1.58	25.69	3.49	0.59					4.7	1.6	3.8		
4	" " " 2	2.87	9.31	2.91	0.38					3.1	2.5	4.4		
5	" " " 1	5.78	3.49	1.77	0.21					2.3	3.0	4.9		
	Zinc rougher tail	69.23	0.43	0.58	0.073					3.4	11.7	20.6		
	Feed (calculated)	100.00	8.67	3.42	0.25					100.0	100.0	100.0		
	Calculated Analyses													
	Products 1 and 2	20.54	36.52	13.52	0.79	78.8	21.2			86.5	81.2	66.3	84.7	5.4
	" 1 to 3	22.12	35.75	12.81	0.78	76.7	23.3			91.2	82.8	70.1	88.7	6.4
	" 1 to 4	24.99	32.71	11.67	0.73	70.1	29.9			94.3	85.3	74.5	91.6	9.2
	" 1 to 5	30.77	27.22	9.81	0.63	58.5	41.5			96.6	88.3	79.4	94.2	15.8

REMARKS:

METALLURGICAL BALANCE

TEST NO. A-21 | SAMPLE: No.2 Composite | DATE: Nov.2/77

Calculation of target bulk conc and corresponding tailing

PRODUCT	WT %	ANALYSIS %							DISTRIBUTION %				
		Zn	Pb	Cu	VM	GM			Zn	Pb	Cu	VM	GM
Lead conc and													
1st Stage zinc cl conc*	24.99	32.71	11.67	0.73					94.3	85.3	74.5		
Zinc cleaner tail 1													
x 0.4412	2.55	3.49	1.77	0.21					1.0	1.3	2.2		
Target bulk conc	27.54	30.00	10.75	0.68	64.4	35.6			95.3	86.6	76.7	92.8	12.1
Zinc cleaner tail 1													
x 0.5588	3.23	3.49	1.77	0.21					1.3	1.7	2.7		
Zinc rougher tail	69.23	0.43	0.58	0.073					3.4	11.7	20.6		
Tailing	72.46	0.57	0.63	0.08					4.7	13.4	23.3		

REMARKS: *Products 1 to 4 on Sheet 1.

FLOTATION TEST REPORT

TEST NO. A-22	SAMPLE: No.2 Composite	DATE: Nov. 7, 1977
OBJECT OF TEST: Selective flotation - repeat of Test A-21 but with grinding time reduced from 90 to 60 min.		CHARGE: 2000 g
		TESTED BY: G.L.

OPERATION	Time min	% Solids	pH	Unit used	Reagents, Grams									
					SA	NaCN	Z-11	242						
Grinding	60	65	9.8	7x14 RM	2.0	0.2	0.04	0.04						
Lead roughers) as														
Lead cleaners) in														
Zinc roughers) Test														
Zinc cleaners) A-21														

REMARKS:

METALLURGICAL BALANCE

TEST NO. A-22 | SAMPLE: No.2 Composite | DATE: Nov. 7/77

	PRODUCT	WT %	ANALYSIS %							DISTRIBUTION %				
			Zn	Pb	Cu	VM	GM			Zn	Pb	Cu	VM	GM
1	Lead conc	10.05	11.13	24.28	1.23					14.1	76.2	49.1		
2	Zinc conc	11.79	48.89	1.64	0.43					72.8	6.0	20.1		
3	Zinc cleaner tail 3	1.63	21.60	2.53	0.25					4.5	1.3	1.6		
4	" " " 2	3.18	8.12	2.25	0.25					3.3	2.2	3.2		
5	" " " 1	8.35	2.50	1.50	0.16					2.6	3.9	5.3		
	Zinc rougher tail	65.00	0.33	0.51	0.08					2.7	10.4	20.7		
	Feed (calculated)	100.00	7.92	3.20	0.26					100.0	100.0	100.0		
	Calculated Analyses													
	Products 1 and 2	21.84	31.51	12.06	0.80	68.7	31.3			86.9	82.2	69.2	85.1	8.3
	" 1 to 3	23.47	30.83	11.40	0.76	66.8	33.2			91.4	83.5	70.8	88.8	9.5
	" 1 to 4	26.65	28.12	10.31	0.70	60.8	39.2			94.7	85.7	74.0	91.8	12.7
	" 1 to 5	35.00	22.01	8.20	0.57	47.9	52.1			97.3	89.6	79.3	94.8	22.2

REMARKS:

METALLURGICAL BALANCE

TEST NO. A-22	SAMPLE: No.2 Composite	DATE: Nov. 7/77

Calculation of target bulk conc and corresponding tailing.

PRODUCT	WT %	ANALYSIS %							DISTRIBUTION %				
		Zn	Pb	Cu	VM	GM			Zn	Pb	Cu	VM	GM
Lead conc and													
2nd stage zinc cl conc*	23.47	30.83	11.40	0.76					91.4	83.5	70.8		
Zinc cleaner tail 2													
x 0.2830	0.90	8.12	2.25	0.25					0.9	0.7	0.4		
Target bulk conc	24.37	30.00	11.06	0.74	64.9	35.1			92.3	84.2	70.4	89.9	10.1
Zinc cleaner tail 2													
x 0.7170	2.28	8.12	2.25	0.25					2.4	1.5	3.6		
Zinc cleaner tail 1	8.35	2.50	1.50	0.16					2.6	3.9	5.3		
Zinc rougher tail	65.00	0.33	0.51	0.08					2.7	10.4	20.7		
Tailing	75.63	0.80	0.67	0.093					7.7	15.8	29.6		

REMARKS: *Products 1 to 3 on Sheet 1.

FLOTATION TEST REPORT

TEST NO. A-23	SAMPLE: No.2 Composite	DATE: Nov. 8, 1977
OBJECT OF TEST:	Selective flotation - repeat of Test A-21 but with grinding time reduced from 90 to 45 min.	CHARGE: 2000 g
		TESTED BY: G.L.

OPERATION	Time min	% Solids	pH	Unit used	Reagents, Grams									
					SA	NaCN	Z-11	242						
Grinding	45	65	9.5	7x14 RM	2.0	0.2	0.04	0.04						
Lead roughers) as														
Lead cleaners) in														
Zinc roughers) Test														
Zinc cleaners) A-21														

REMARKS:

METALLURGICAL BALANCE

TEST NO. A-23 | SAMPLE: No.2 Composite | DATE: Nov.8/77

	PRODUCT	WT %	ANALYSIS %							DISTRIBUTION %				
			Zn	Pb	Cu	VM	GM			Zn	Pb	Cu	VM	GM
1	Lead conc	9.01	11.37	31.00	1.34					11.6	76.4	43.5		
2	Zinc conc	13.42	49.14	1.68	0.44					74.7	6.2	21.3		
3	Zinc cleaner tail 3	1.78	20.60	2.74	0.40					4.2	1.3	2.6		
4	" " " 2	3.14	10.17	2.48	0.37					3.6	2.1	4.2		
5	" " " 1	6.04	4.03	1.76	0.26					2.8	2.9	5.6		
	Zinc rougher tail	66.61	0.42	0.61	0.095					3.1	11.1	22.8		
	Feed (calculated)	100.00	8.83	3.66	0.28					100.0	100.0	100.0		
	Calculated Analyses													
	Products 1 and 2	22.43	33.97	13.46	0.80	74.4	25.6			86.3	82.6	64.8	84.6	7.1
	" 1 to 3	24.21	32.99	12.67	0.77	71.8	28.2			90.5	83.9	67.4	88.1	8.5
	" 1 to 4	27.35	30.37	11.50	0.73	66.0	34.0			94.1	86.0	71.6	91.4	11.6
	" 1 to 5	33.39	25.60	9.74	0.64	55.8	44.2			96.9	88.9	77.2	94.3	18.4

REMARKS:

METALLURGICAL BALANCE

TEST NO. A-23	SAMPLE: No.2 Composite	DATE: Nov.8/77

Calculation of target bulk conc and corresponding tailing.

PRODUCT	WT %	ANALYSIS %							DISTRIBUTION %				
		Zn	Pb	Cu	VM	GM			Zn	Pb	Cu	VM	GM
Lead conc and													
1st stage zinc cl conc*	27.35	30.37	11.50	0.73					94.1	86.0	71.6		
Zinc cleaner tail 1													
x 0.0646	0.39	4.03	1.76	0.26					0.2	0.2	0.3		
Target bulk conc	27.74	30.00	11.36	0.72	65.2	34.8			94.3	86.2	71.9	91.5	12.0
1st stage zinc cl conc													
x 0.9354	5.65	4.03	1.76	0.26					2.6	2.7	5.3		
Zinc rougher tail	66.61	0.42	0.61	0.095					3.1	11.1	22.8		
Tailing	72.26	0.70	0.70	0.11					5.7	13.8	28.1		

REMARKS: *Products 1 to 4 on Sheet 1

FLOTATION TEST REPORT

TEST NO. A-25 | SAMPLE: No.2 Composite | DATE: Nov. 28, 1977

OBJECT OF TEST: Selective flotation at a coarse grind followed by regrinding of rougher concentrates prior to cleaning. | CHARGE: 200 g | TESTED BY: G.L.

OPERATION	Time min	% Solids	pH	Unit used	Reagents, Grams									
					SA	NaCN	Z-11	242	DF250	Lime	$CuSO_4$	Z-200		
Grinding	45	65	9.8	7x14 RM	2.0	0.2	0.04	0.04						
Conditioning	20				0.5									
Lead roughers														
Stage 1	½		9.85	1000-g cell				0.025						
Stage 2	1								0.02					
Stage 3	1						0.025		0.02					
Lead ro conc regrind*	30	50		8-in CM**	0.5	0.2								
Lead cleaners***														
No.1 Stage 1	½		9.95	500-g cell										
Stage 2	1		9.5	250-g cell				0.02						
No.2	1													
Zinc conditioning	10		11.25	1000-g cell						2.5	2.0			
Zinc roughers				1000-g cell										
Stage 1	½		10.9				0.025					0.04		
Stage 2	1											0.02		
Stage 3	1								0.02			0.02		
Stage 4	1											0.02		
Zinc ro conc regrind*	30	50		8-in CM**						0.5	0.5			

REMARKS: * Rougher conc filtered, filterate used for repulping to 50% S in regrinding.
**with 5000 g -½-in ceramic balls.
***Lead cleaner tailings filtered and added to zinc conditioning step.

FLOTATION TEST REPORT

TEST NO. A-25 | SAMPLE: No.2 Composite | DATE: Nov. 28, 1977

OBJECT OF TEST: | CHARGE: | TESTED BY:

OPERATION	Time min	% Solids	pH	Unit used	Reagents, Grams									
								242	DF250	Lime		Z-200		
Zinc cleaners														
No.1, Stage 1	½		9.6	1000-g cell								0.02		
Stage 2	1								0.02			0.02		
Stage 3	1								0.02			0.02		
Stage 4	1		8.9					0.025						
No.2	1½		9.2	500-g cell						0.06				

REMARKS:

METALLURGICAL BALANCE

TEST NO. A-25 | SAMPLE: No.2 Composite | DATE: Nov.28/77

	PRODUCT	WT %	ANALYSIS %							DISTRIBUTION %				
			Zn	Pb	Cu	VM	GM			Zn	Pb	Cu	VM	GM
1	Lead conc	5.96	9.67	37.27	0.97					7.4	69.3	22.8		
2	Zinc conc	12.80	50.81	3.08	0.68					83.1	12.3	34.4		
3	Zinc cleaner tail 2	2.61	11.50	3.41	0.72					3.8	2.8	7.4		
4	" " " 1	7.65	2.06	1.23	0.24					2.0	2.9	7.3		
	Zinc rougher tail	70.98	0.41	0.57	0.10					3.7	12.7	28.1		
	Feed (calculated)	100.00	7.83	3.20	0.25					100.0	100.0	100.0		
	Calculated Analyses													
	Products 1 and 2	18.76	37.74	13.94	0.77	81.2	18.8			90.5	81.6	57.2	86.9	4.2
	" 1 to 3	21.37	34.54	12.66	0.77	74.4	25.6			94.3	84.4	64.6	90.7	6.6
	" 1 to 4	29.02	25.97	9.64	0.63	56.2	43.8			96.3	87.3	71.9	93.1	15.4

REMARKS:

METALLURGICAL BALANCE

TEST NO. A-25 | SAMPLE: No.2 Composite | DATE: Nov. 28/77

Calculation of target bulk conc and corresponding tailing.

PRODUCT	WT %	ANALYSIS %							DISTRIBUTION %				
		Zn	Pb	Cu	VM	GM			Zn	Pb	Cu	VM	GM
Lead conc and													
1st stage zinc cl conc*	21.37	34.54	12.66	0.77					94.3	84.4	64.6		
Zinc cleaner tail 1													
x 0.4536	3.47	2.06	1.23	0.24					0.9	1.4	3.3		
Target bulk conc	24.84	30.00	11.06	0.69	64.8	35.2			95.2	85.8	67.9	91.8	10.6
Zinc cleaner tail 1													
x 0.5464	4.18	2.06	1.23	0.24					1.1	1.5	4.0		
Zinc rougher tail	70.98	0.41	0.57	0.10					3.7	12.7	28.1		
Tailing		0.50	0.61	0.11					4.8	14.2	32.1		

REMARKS: *Products 1 to 3 on Sheet 1.

FLOTATION TEST REPORT

TEST NO. A-26	SAMPLE: No.2 Composite	DATE: Nov.30, 1977
OBJECT OF TEST: Selective flotation - repeat of Test A-22 but employed a high pH in the zinc cleaners.		CHARGE: 2000 g
		TESTED BY: G.L.

OPERATION	Time min	% Solids	pH	Unit used	Reagents, Grams									
					Lime	DF250								
Grinding) as														
Lead roughers) in														
Lead cleaners) Test														
Zinc roughers) A-22														
Zinc cleaners														
No.1, Stage 1	½		11.3	500-g cell	0.25									
Stage 2	½					0.01								
Stage 3	1		10.7			0.01								
No.2, Stage 1	½		11.25	500-g cell	0.2									
Stage 2	½					0.01								
Stage 3	½		10.8			0.01								
No.3	1		11.2	250-g cell	0.1									

REMARKS:

METALLURGICAL BALANCE

TEST NO. A-26 | SAMPLE: No.2 Composite | DATE: Nov.30/77

	PRODUCT	WT %	ANALYSIS %							DISTRIBUTION %				
			Zn	Pb	Cu	VM	GM			Zn	Pb	Cu	VM	GM
1	Lead conc	8.60	11.37	32.36	1.30					11.1	77.4	43.5		
2	Zinc conc	14.30	47.72	1.36	0.49					77.5	5.4	27.3		
3	Zinc cleaner tail 3	2.09	15.08	2.60	0.31					3.6	1.5	2.5		
4	" " " 2	3.91	6.36	2.34	0.24					2.8	2.5	3.7		
5	" " " 1	6.94	2.56	1.53	0.14					2.0	3.0	3.8		
	Zinc rougher tail	64.16	0.41	0.57	0.077					3.0	10.2	19.2		
	Feed (calculated)	100.00	8.81	3.60	0.26					100.0	100.0	100.0		
	Products 1 and 2	22.90	35.19	13.00	0.79	76.0	24.0			88.6	82.8	70.8	88.8	6.8
	" 1 to 3	24.99	32.48	12.13	0.75	70.3	29.7			92.2	84.3	73.3	89.6	9.2
	" 1 to 4	28.90	28.95	10.81	0.68	62.8	37.2			95.0	86.9	77.0	92.6	13.4
	" 1 to 5	35.84	23.84	9.01	0.58	51.8	48.2			97.0	89.8	80.8	94.7	21.5

REMARKS:

METALLURGICAL BALANCE

TEST NO. A-26 | SAMPLE: No.2 Composite | DATE: Nov.30/77

Calculation of target bulk conc and corresponding tailing.

PRODUCT	WT %	ANALYSIS %							DISTRIBUTION %				
		Zn	Pb	Cu	VM	GM			Zn	Pb	Cu	VM	GM
Lead conc and													
2nd stage zinc cl conc*	24.99	32.48	12.13	0.75					92.2	84.3	73.3		
Zinc cleaner tail 2													
x 0.6701	2.62	6.36	2.34	0.24					1.9	1.7	2.5		
Target bulk conc	27.61	30.00	11.20	0.71	65.0	35.0			94.1	86.0	75.8	91.5	12.0
Zinc cleaner tail 2													
x 0.3299	1.29	6.36	2.34	0.24					0.9	0.8	1.2		
Zinc cleaner tail 1	6.94	2.56	1.53	0.14					2.0	3.0	3.8		
Zinc rougher tail	64.16	0.41	0.57	0.077					3.0	10.2	19.2		
Tailing	72.39	0.72	0.69	0.086					5.9	14.0	24.2		

REMARKS:

*Products 1 to 3 on Sheet 1.

FLOTATION TEST REPORT

TEST NO. A-27	SAMPLE: No.2 Composite	DATE: Dec.5/77
OBJECT OF TEST: To try bulk flotation at a coarse grind using lime as pyrite depressant.		CHARGE: 2000 g
		TESTED BY: G.L.

OPERATION	Time min	% Solids	pH	Unit used	Reagents, Grams									
					Lime	$CuSO_4$	Z-11	Z-200	242	DF250				
Grinding	45	65	9.3	7x14 RM	1.0									
Conditioning 1	10			Aerator	1.5	2.0								
" 2	5		9.3				0.05	0.04	0.05					
Bulk roughers				1000-g cell										
Stage 1	½		9.9		0.2									
Stage 2	½		9.5					0.04						
Stage 3	½		9.8		0.13				0.025					
Stage 4	1½		9.3					0.04						
Bulk cleaners														
No.1, Stage 1	1		9.3	1000-g cell										
Stage 2	1									0.02				
No.2, Stage 1	1		9.1	500-g cell										
Stage 2	1									0.02				
No.3	1½		9.1	500-g cell										

REMARKS:

METALLURGICAL BALANCE

TEST NO. A-27 | SAMPLE: No.2 Composite | DATE: Dec.5/77

PRODUCT	WT %	ANALYSIS %							DISTRIBUTION %				
		Zn	Pb	Cu	VM	GM			Zn	Pb	Cu	VM	GM
Bulk conc	25.79	29.51	11.58	0.72	64.7	35.3			87.9	80.1	67.4	85.2	11.3
Bulk cleaner tail 3	3.38	5.30	3.77	0.29					2.1	3.4	3.6		
" " " 2	2.05	3.40	2.44	0.22					0.8	1.3	1.6		
" " " 1	11.43	2.46	1.63	0.16					3.2	5.0	6.6		
Bulk rougher tail	57.35	0.91	0.66	0.10					6.0	10.2	20.8		
Feed (calculated)	100.00	8.66	3.73	0.28					100.0	100.0	100.0		
Calculated Analyses													
Bulk cl conc 2nd Stage	29.17	26.70	10.68	0.67	58.7	41.3			89.9	83.5	70.9	87.5	15.0
" " " 1st Stage	31.22	25.17	10.13	0.64	55.6	44.4			90.7	84.9	72.5	88.7	17.2
Bulk rougher conc	42.65	19.09	7.86	0.51	42.4	57.6			94.0	89.8	79.2	92.4	30.5

REMARKS:

METALLURGICAL BALANCE

TEST NO. A-27 | SAMPLE: No.2 Composite | DATE: Dec.5/77

Calculation of target bulk conc and corresponding tailing.

PRODUCT	WT %	ANALYSIS %							DISTRIBUTION %				
		Zn	Pb	Cu	VM	GM			Zn	Pb	Cu	VM	GM
Target bulk conc taken as final bulk conc	25.79	29.51	11.58	0.72	64.7	35.3			87.9	80.1	67.4	85.2	11.3
Bulk cleaner tail 3	3.38	5.30	3.77	0.29					2.1	3.4	3.6		
" " " 2	2.05	3.40	2.44	0.22					0.8	1.3	1.6		
" " " 1	11.43	2.46	1.63	0.16					3.2	5.0	6.6		
Bulk rougher tail	57.35	0.91	0.66	0.10					6.0	10.2	20.8		
Tailing	74.21	1.42	1.00	0.12					12.1	19.9	32.6		

REMARKS:

FLOTATION TEST REPORT

TEST NO. A-28	SAMPLE: No.2 Composite	DATE: Dec.6, 1977
OBJECT OF TEST: Bulk flotation at a fine grind - comparison test for A-27.		CHARGE: 2000 g
		TESTED BY: G.L.

OPERATION	Time min	% Solids	pH	Unit used	Reagents, Grams									
					Lime									
Grinding	90	65	10.0	7x14 RM	1.0									
Bulk roughers) as in														
Bulk cleaners) Test A27														

REMARKS:

METALLURGICAL BALANCE

TEST NO. A-28	SAMPLE: No.2 Composite	DATE: Dec.6/77

PRODUCT	WT %	ANALYSIS %							DISTRIBUTION %				
		Zn	Pb	Cu	VM	GM			Zn	Pb	Cu	VM	GM
Bulk conc	22.85	25.87	11.64	0.70	58.5	41.5			78.1	78.4	62.8	77.6	11.5
Bulk cleaner tail 3	3.57	9.93	2.65	0.27									
" " " 2	3.26	3.76	1.75	0.19									
" " " 1	17.15	3.56	1.41	0.15									
Bulk rougher tail	53.17	1.08	0.64	0.10									
Feed (calculated)	100.00	7.57	3.39	0.25									
Bulk cl conc 2nd Stage	26.42	23.72	10.43	0.64	53.4	46.4			82.7	81.2	66.6	81.9	14.9
Bulk cl conc 1st Stage	29.68	21.52	9.47	0.59	48.5	51.5			84.4	82.8	69.0	83.5	18.5
Bulk rougher conc	46.83	14.95	6.52	0.43	33.6	66.4			92.4	90.0	79.1	91.3	37.6

REMARKS:

FLOTATION TEST REPORT

TEST NO. A-30	SAMPLE: No.2 Composite	DATE: Dec.12, 1977
OBJECT OF TEST: Bulk flotation at a fine grind as in Test A-28 but with an increase in $CuSO_4$ addition from 2.0 to 3.0 g		CHARGE: 2000 g
		TESTED BY: G.L.

OPERATION	Time min	% Solids	pH	Unit used	Reagents, Grams									
					Lime	$CuSO_4$	Z-11	Z-200	242	DF250				
Grinding	90	65	10.0	7x14 RM	1.0									
Conditioning 1	10			Aerator	2.5	3.0								
" 2	5			Aerator			0.05	0.04	0.05					
Bulk roughers				1000-g cell										
Stage 1	½		9.8				0.05	0.04						
Stage 2	1							0.04						
Stage 3	¾							0.02						
Stage 4	¾		9.1					0.02						
Bulk cleaners														
No.1, Stage 1	1		9.3	1000-g cell										
Stage 2	1									0.02				
No.2	2		9.2	500-g cell										
No.3	2		8.9	500-g cell										

REMARKS:

METALLURGICAL BALANCE

TEST NO. A-30	SAMPLE: No.2 Composite	DATE: Dec.12/77

PRODUCT	WT %	ANALYSIS %							DISTRIBUTION %				
		Zn	Pb	Cu	VM	GM			Zn	Pb	Cu	VM	GM
Bulk conc	23.55	33.78	12.25	0.80	72.7	27.3			90.1	78.1	70.5		
Bulk cleaner tail 3	3.16	5.53	4.13	0.28					2.0	3.5	3.3		
" " " 2	4.23	3.42	2.72	0.22					1.6	3.1	3.5		
" " " 1	15.68	1.84	1.56	0.15					3.3	6.6	8.8		
Bulk rougher tail	53.38	0.50	0.60	0.07					3.0	8.7	13.9		
Feed (calculated)	100.00	8.83	3.70	0.27					100.0	100.0	100.0		
Calculated Analyses													
Bulk cl conc 2nd Stage	26.71	30.44	11.29	0.74	65.8	34.2			92.1	81.6	73.7	89.1	11.4
" " " 1st Stage	30.94	26.74	10.12	0.67	58.2	41.8			93.7	84.7	77.2	91.3	16.1
Bulk rougher conc	46.62	18.37	7.24	0.49	40.4	59.6			97.0	91.3	86.0	95.5	34.6

REMARKS:

TEST NO. A-30	SAMPLE: No.2 Composite	DATE: Dec.12/77

Calculation of target bulk conc and corresponding tailing.

PRODUCT	WT %	ANALYSIS %							DISTRIBUTION %				
		Zn	Pb	Cu	VM	GM			Zn	Pb	Cu	VM	GM
Bulk cl conc 2nd Stage	26.71	30.44	11.29	0.74					92.1	81.6	73.7		
Bulk cl tail 2													
x 0.1040	0.44	3.42	2.72	0.22					0.1	0.3	0.4		
Target bulk conc	27.15	30.00	11.15	0.73	65.0	35.0			92.2	81.9	74.1	89.5	11.8
Bulk cl tail 2													
x 0.8960	3.79	3.42	2.72	0.22					1.5	2.8	3.2		
Bulk cl tail 1	15.68	1.84	1.56	0.15					3.3	6.6	8.8		
Bulk rougher tail	53.38	0.50	0.60	0.07					3.0	8.7	13.9		
Tailing	72.85	0.94	0.92	0.095					7.8	18.1	25.9		

REMARKS:

FLOTATION TEST REPORT

TEST NO. A-31	SAMPLE: No.2 Composite	DATE: Dec.12, 1977
OBJECT OF TEST: Bulk flotation - to try high pH in roughers and cleaners.		CHARGE: 2000 g
		TESTED BY: G.L.

OPERATION	Time min	% Solids	pH	Unit used	Reagents, Grams									
					Lime	$CuSO_4$	Z-11	Z-200	242	DF250				
Grinding	90	65	10.15	7x14 RM	2.0									
Conditioning 1	10			Aerator	3.0	3.0								
" 2	5		10.3	Aerator			0.05	0.04	0.05					
Bulk roughers				1000-g cell										
Stage 1	½		11.35		0.48		0.05	0.04						
Stage 2	1							0.04						
Stage 3	¾							0.02						
Stage 4	¾							0.02						
Bulk cleaners														
No.1, Stage 1	1		11.3	1000-g cell	0.36									
Stage 2	1		11.0							0.02				
No.2, Stage 1	1		11.4	500-g cell	0.25									
Stage 2	1		11.0							0.02				
No.3	2		11.5	500-g cell	0.20									

REMARKS:

METALLURGICAL BALANCE

TEST NO. A-31	SAMPLE: No.2 Composite	DATE: Dec.12/77

PRODUCT	WT %	ANALYSIS %							DISTRIBUTION %				
		Zn	Pb	Cu	VM	GM			Zn	Pb	Cu	VM	GM
Bulk conc	16.30	46.73	6.36	0.87	87.7	12.3			86.5	29.3	51.8	72.9	2.5
Bulk cleaner tail 3	3.83	11.08	21.04	0.72					4.8	22.8	10.1		
" " " 2	5.03	6.14	16.22	0.52					3.5	23.0	9.5		
" " " 1	18.64	1.44	3.10	0.21					3.1	16.3	14.3		
Bulk rougher tail	56.20	0.33	0.54	0.07					2.1	8.6	14.3		
Feed (calculated)	100.0	8.80	3.54	0.27					100.0	100.0	100.0		
Calculated Analyses													
Bulk cl conc 2nd Stage	20.13	39.95	9.15	0.84	79.6	20.4			91.3	52.1	61.8	81.8	5.1
" " " 1st Stage	25.16	33.19	10.57	0.78	69.8	30.2			94.8	75.1	71.4	89.6	9.5
Bulk rougher conc	43.80	19.68	7.39	0.54	42.9	57.1			97.9	91.4	85.7	95.9	31.1

REMARKS:

METALLURGICAL BALANCE

TEST NO. A-31 | SAMPLE: No.2 Composite | DATE: Dec.12/77

Calculation of target bulk conc and corresponding tailing.

PRODUCT	WT %	ANALYSIS %							DISTRIBUTION %				
		Zn	Pb	Cu	VM	GM			Zn	Pb	Cu	VM	GM
Bulk cl conc 1st Stage	25.16	33.19	10.57	0.78					94.8	75.1	71.4		
Bulk cl tail 1													
x 0.1508	2.81	1.44	3.10	0.21					0.5	2.5	2.1		
Target bulk conc	27.97	30.00	9.82	0.72	63.4	36.6			95.3	77.6	73.5	90.5	12.7
Bulk cl tail 1													
x 0.8492	15.83	1.44	3.10	0.21					2.6	13.8	12.2		
Bulk rougher tail	56.20	0.33	0.54	0.07					2.1	8.6	14.3		
Tailing	72.03	0.57	1.10	0.10					4.7	22.4	26.5		

REMARKS:

FLOTATION TEST REPORT

TEST NO. A-32	SAMPLE: No.2 Composite	DATE: May 4, 1978
OBJECT OF TEST: Bulk flotation - to try high pH in roughers followed by low pH in cleaners.		CHARGE: 2000 g
		TESTED BY: G.L.

OPERATION	Time min	% Solids	pH	Unit used	Reagents, Grams									
					DF250									
Grinding) as in														
Bulk roughers) Test A31														
Bulk cleaners														
No.1, Stage 1	1		9.85	1000-g cell										
Stage 2	1		9.55		0.02									
No.2, Stage 1	1		9.6	500-g cell										
Stage 2	1		9.2		0.02									
No.3	2		9.2	500-g cell										

REMARKS:

METALLURGICAL BALANCE

TEST NO. A-32 | SAMPLE: No.2 Composite | DATE: May 4/78

PRODUCT	WT %	ANALYSIS %							DISTRIBUTION %				
		Zn	Pb	Cu	VM	GM			Zn	Pb	Cu	VM	GM
Bulk conc	24.55	32.55	10.92	0.82	69.2	30.8			92.7	76.5	75.0	88.0	9.4
Bulk cleaner tail 3	1.86	4.81	4.30	0.30					1.0	2.3	2.1		
" " " 2	2.90	2.60	3.15	0.22					0.9	2.6	2.4		
" " " 1	14.12	1.64	2.31	0.15					2.7	9.3	7.9		
Bulk rougher tail	56.57	0.41	0.58	0.06					2.7	9.3	12.6		
Feed (calculated)	100.00	8.62	3.51	0.27					100.0	100.0	100.0		
Calculated Analyses													
Bulk cl conc 2nd Stage	26.41	30.60	10.45	0.78	65.3	34.7			93.7	78.8	77.1	89.4	11.4
" " " 1st Stage	29.31	27.83	9.73	0.73	59.8	40.2			94.6	81.4	79.5	90.8	14.6
Bulk rougher conc	43.43	19.31	7.32	0.54	42.2	57.8			97.3	90.7	87.4	95.0	31.1

REMARKS:

METALLURGICAL BALANCE

TEST NO. A-32 | SAMPLE: No.2 Composite | DATE: May 4/78

Calculation of target bulk conc and corresponding tailing.

PRODUCT	WT %	ANALYSIS %							DISTRIBUTION %				
		Zn	Pb	Cu	VM	GM			Zn	Pb	Cu	VM	GM
Bulk cl conc 2nd Stage	26.41	30.60	10.45	0.78					93.7	78.8	77.1		
Bulk cl tail 2													
x 0.1966	0.57	2.60	3.15	0.22					0.2	0.4	0.5		
Target bulk conc	26.98	30.00	10.30	0.77	64.1	35.9			93.9	79.2	77.6	89.6	12.0
Bulk cl tail 2													
x 0.8034	2.33	2.60	3.15	0.22					0.7	2.2	1.9		
Bulk cl tail 1	14.12	1.64	2.31	0.15					2.7	9.3	7.9		
Bulk rougher tail	56.57	0.41	0.58	0.06					2.7	9.3	12.6		
Tailing	73.02	0.72	1.00	0.082					6.1	20.8	22.4		

REMARKS:

FLOTATION TEST REPORT

TEST NO. A-34	SAMPLE: No.2 Composite	DATE: May 8, 1978
OBJECT OF TEST: Bulk flotation - to try standard low pH in roughers followed by high pH in cleaners.		CHARGE: 2000 g
		TESTED BY: G.L.

OPERATION	Time min	% Solids	pH	Unit used	Reagents, Grams									
					Lime	$CuSO_4$	Z-11	Z-200	242	DF250				
Grinding	90	65	10.0	7x14 RM	1.0									
Conditioning 1	10			Aerator	2.0	3.0								
" 2	5			Aerator			0.05	0.04	0.05					
Bulk roughers				1000-g cell										
Stage 1	½		9.8		0.70		0.05	0.04						
Stage 2	1							0.04						
Stage 3	¾							0.02						
Stage 4	¾		9.0					0.02						
Bulk cleaners														
No.1, Stage 1	1		11.3	1000-g cell	1.15									
Stage 2	1									0.02				
No.2	2		11.5	500-g cell	0.30									
No.3	2		11.45	500-g cell	0.20									
No.4	1½		11.5	250-g cell	0.10									
No.5	1		11.5	250-g cell										

REMARKS:

METALLURGICAL BALANCE

TEST NO. A-34 | SAMPLE: No.2 Composite | DATE: May 8/78

PRODUCT	WT %	ANALYSIS %							DISTRIBUTION %				
		Zn	Pb	Cu	VM	GM			Zn	Pb	Cu	VM	GM
Bulk conc	13.49	52.33	4.14	1.04	95.0	5.0			80.7	16.3	52.2	66.4	0.8
Bulk cleaner tail 5	1.61	23.27	9.11	0.79					4.3	4.3	4.7		
" " " 4	1.99	9.71	9.06	0.53					2.2	5.3	3.9		
" " " 3	4.42	5.02	8.04	0.29					2.5	10.4	4.8		
" " " 2	9.90	2.12	5.13	0.17					2.4	14.9	6.2		
" " " 1	29.16	1.54	4.85	0.15					5.1	41.3	16.2		
Bulk rougher tail	39.43	0.62	0.65	0.082					2.8	7.5	12.0		
Feed (calculated)	100.0	8.75	3.42	0.27					100.0	100.0	100.0		
Calculated Analyses													
Bulk cl conc 4th Stage	15.10	49.23	4.67	1.01	90.4	9.6			85.0	20.6	56.9	70.7	1.8
" " " 3rd Stage	17.09	44.63	5.18	0.96	83.1	16.9			87.2	25.9	60.8	73.6	3.4
" " " 2nd Stage	21.51	36.49	5.77	0.82	69.9	30.1			89.7	36.3	65.6	77.9	8.0
" " " 1st Stage	31.41	25.66	5.57	0.61	51.0	49.0			92.1	51.2	71.8	83.0	19.1
Bulk rougher conc	60.57	14.05	5.22	0.39	30.6	69.4			97.2	92.5	88.0	96.0	52.0

REMARKS:

METALLURGICAL BALANCE

TEST NO. A-34 | SAMPLE: No.2 Composite | DATE: May 8/78

Calculation of target bulk conc and corresponding tailing

PRODUCT	WT %	ANALYSIS %							DISTRIBUTION %				
		Zn	Pb	Cu	VM	GM			Zn	Pb	Cu	VM	GM
Bulk cl conc 2nd Stage	21.51	36.49	5.77	0.82					89.7	36.3	65.6		
Bulk cleaner tail 2													
x 0.5061	5.01	2.12	5.13	0.17					1.2	7.5	3.1		
Target bulk conc	26.52	30.00	5.65	0.70	58.5	41.5			90.9	43.8	68.7	80.4	13.6
Bulk cleaner tail 2													
x 0.4939	4.89	2.12	5.13	0.17					1.2	7.4	3.1		
Bulk cleaner tail 1	29.16	1.54	4.85	0.15					5.1	41.3	16.2		
Bulk rougher tail	39.43	0.62	0.65	0.082					2.8	7.5	12.0		
Tailing	73.48	1.08	2.61	0.115					9.1	56.2	31.3		

REMARKS:

FLOTATION TEST REPORT

TEST NO. B-1	SAMPLE: No.1 Shipment bulk ore sample	DATE: Sept. 13/77
OBJECT OF TEST: Bulk flotation using lime as pyrite depressant - to compare with Test A-15 on No.2 Composite ore sample.		CHARGE: 2000 g
		TESTED BY: G.L.

OPERATION	Time min	% Solids	pH	Unit used	Reagents, Grams									
					Lime	$CuSO_4$	Z-11	Z-200	242	DF250				
Grinding	90	65	9.9	7x14 RM	1.0									
Conditioning 1				Aerator	1.0	2.0								
" 2				Aerator			0.05	0.04	0.05					
Bulk roughers*														
No.1	1		9.7**		0.5			0.02						
No.2	½								0.025					
No.3	1						0.05	0.02						
No.4	1							0.02						
No.5	1						0.025							
No.6	1									0.02				
No.7	1		9.7											

REMARKS: *Froth allowed to overflow at a constant pulp level of 1 in. below overflow lip - air volume to cell regulated at ¾ of maximum.
**pH kept constant throughout test by small incremental additions of lime.

METALLURGICAL BALANCE

TEST NO. B-1	SAMPLE: No.1 Shipment bulk ore sample	DATE: Sept.13/77

PRODUCT	WT %	ANALYSIS %							DISTRIBUTION %				
		Zn	Pb	Cu	VM	GM			Zn	Pb	Cu	VM	GM
Bulk rougher conc 1	21.16	11.88	7.83	0.75					31.7	58.8	52.3		
" " " 2	4.62	17.82	7.85	0.56					10.4	12.9	8.5		
" " " 3	15.24	15.63	1.89	0.27					30.1	10.2	13.6		
" " " 4	4.94	14.93	1.83	0.31					9.3	3.2	5.1		
" " " 5	5.48	10.46	1.26	0.22					7.2	2.4	4.0		
" " " 6	3.62	5.22	1.10	0.17					2.4	1.4	2.0		
" " " 7	2.62	3.81	1.11	0.16					1.3	1.0	1.4		
Bulk rougher tail	42.32	1.43	0.67	0.094					7.6	10.1	13.1		
Feed (calculated)	100.00	7.92	2.82	0.30					100.0	100.0	100.0		
Calculated Analyses													
Bulk ro conc 1 and 2	25.78	14.12	7.83	0.72	34.6	65.4			42.1	71.6	60.9	51.3	20.4
" " " 1 to 3	41.02	13.94	5.63	0.55	31.3	68.7			72.2	81.8	74.4	73.9	34.1
" " " 1 to 4	45.96	14.05	5.85	0.59	31.9	68.1			81.5	85.1	79.5	84.3	37.9
" " " 1 to 5	51.44	13.67	4.80	0.49	29.7	70.3			88.7	87.5	83.4	87.9	43.8
" " " 1 to 6	55.06	13.11	4.55	0.47	28.6	71.4			91.1	88.9	85.5	90.6	47.6
" " " 1 to 7	57.68	12.69	4.40	0.46	27.6	72.4			92.4	89.9	86.9	91.6	50.5

REMARKS:

FLOTATION TEST REPORT

TEST NO. B-4	SAMPLE: No.1 Shipment bulk ore sample	DATE: Sept.16, 1977
OBJECT OF TEST: Selective flotation on "B" sample - to compare with Test A-16 on the No.2 Composite ore sample.		CHARGE: 2000 g
		TESTED BY: G.L.

OPERATION	Time min	% Solids	pH	Unit used	Reagents, Grams									
					SA	NaCN	Z-11	242	DF250	Lime	$CuSO_4$	Z-200		
Grinding	90	65	9.9	7x14 RM	5.0	0.40	0.04	0.04						
Conditioning	20		9.4	Aerator			0.025							
Lead roughers				1000-g cell										
No.1	½		9.4						0.01					
No.2	1		9.3					0.025						
No.3	1		9.2						0.01					
No.4	1		9.1											
Zinc conditioning	10		11.0							2.75	2.5			
Zinc roughers														
No.1	½		11.0				0.025					0.04		
No.2	1		10.8									0.02		
No.3	1		10.6									0.02		
No.4	1		10.5						0.02					

REMARKS:

METALLURGICAL BALANCE

TEST NO. B-4	SAMPLE: No.1 Shipment bulk ore sample	DATE: Sept.16/77

PRODUCT	WT %	ANALYSIS %			DISTRIBUTION %		
		Zn	Pb	Cu	Zn	Pb	Cu
Lead rougher conc 1	2.50	6.94	24.51	2.13	2.0	20.4	12.9
" " " 2	5.18	8.81	22.72	1.31	5.4	39.1	16.5
" " " 3	4.19	10.19	10.04	1.25	5.0	14.0	12.7
" " " 4	2.20	9.92	5.57	0.65	2.6	4.1	3.5
Zinc rougher conc 1	11.09	42.84	0.97	0.97	56.0	3.5	26.1
" " " 2	5.02	35.05	1.49	0.70	20.7	2.5	8.5
" " " 3	2.97	10.27	1.91	0.46	3.6	1.9	3.3
" " " 4	2.32	4.26	1.80	0.32	1.2	1.4	1.8
Zinc rougher tail	64.53	0.45	0.61	0.094	3.5	13.1	14.7
Feed (Calculated)	100.00	8.48	3.01	0.41	100.0	100.0	100.0
Calculated Analyses							
Combined lead ro conc	14.07	9.06	16.28	1.34	15.0	77.6	45.6
Combined zinc ro conc	21.40	32.31	1.31	0.77	81.5	9.3	39.7

REMARKS:

FLOTATION TEST REPORT

TEST NO. C-1	SAMPLE: No.2 Shipment head sample	DATE: May 9, 1978
OBJECT OF TEST: Bulk flotation at a coarse grind using lime as pyrite depressant – to compare with Test A-27 on the No.2 Composite ore sample		CHARGE: 2000 g
		TESTED BY: G.L.

OPERATION	Time min	% Solids	pH	Unit used	Reagents, Grams									
					Lime	$CuSO_4$	Z-11	Z-200	242	DF250				
Grinding	45	65	9.0	7x14 RM	1.0									
Conditioning 1	10			Aerator	1.5	2.0								
" 2	5			Aerator			0.05	0.04	0.05					
Bulk roughers				1000-g cell										
Stage 1	½		9.8											
Stage 2	½		9.5					0.04						
Stage 3	½		9.8		0.13				0.025					
Stage 4	1½		9.3					0.04						
Bulk cleaners														
No.1, Stage 1	1		9.4	1000-g cell										
Stage 2	1									0.02				
No.2, Stage 1	1		9.3	500-g cell										
Stage 2	1									0.02				
No.3	1		9.2	500-g cell										
	1½													

REMARKS:

METALLURGICAL BALANCE

TEST NO. C-1	SAMPLE: No.2 Shipment head sample	DATE: May 9/78

PRODUCT	WT %	ANALYSIS %							DISTRIBUTION %				
		Zn	Pb*	Cu	VM	GM			Zn	Pb	Cu	VM	GM
Bulk conc	17.39	43.81	9.32	0.78	86.0	14.0			81.3	45.0	55.3	73.0	2.9
Bulk cleaner tail 3	1.47	13.33	12.80	0.62					2.1	5.2	3.7		
" " " 2	1.40	7.05	6.79	0.38					1.1	2.7	2.2		
" " " 1	7.35	5.41	4.67	0.28					4.2	9.5	8.4		
Bulk rougher tail	72.39	1.47	1.87	0.10					11.3	37.6	30.4		
Feed (calculated)	100.00	9.38	3.60	0.25					100.0	100.0	100.0		
Calculated Analyses													
Bulk cl conc 2nd Stage	18.86	41.43	9.59	0.77	82.4	17.6			83.4	50.2	59.0	75.8	4.2
" " " 1st Stage	20.26	39.06	9.40	0.74	78.1	21.9			84.5	52.9	61.2	77.2	5.6
Bulk rougher conc	27.61	30.10	8.14	0.62	61.4	38.6			88.7	62.4	69.6	82.7	13.4

REMARKS: *By MSL, Chemical Laboratory, Internal Report MS-CL-78-279.

FLOTATION TEST REPORT

TEST NO. C-2	SAMPLE: No.2 Shipment head sample	DATE: May 9, 1978
OBJECT OF TEST: Bulk flotation as in Test C-1 but increased $CuSO_4$ addition from 2.0 to 3.0 g		CHARGE: 2000 g
		TESTED BY: G.L.

OPERATION	Time min	% Solids	pH	Unit used	Reagents, Grams									
					Lime	$CuSO_4$	Z-11	Z-200	242					
Grinding	45	65	9.0	7x14 RM	1.0									
Conditioning - 1	10			Aerator	2.5	3.0								
" - 2	5			Aerator			0.05	0.04	0.05					
Bulk roughers) as in														
Bulk cleaners) Test C-1														

REMARKS:

METALLURGICAL BALANCE

TEST NO. C-2	SAMPLE: No.2 Shipment head sample	DATE: May 9/78

PRODUCT	WT %	ANALYSIS %							DISTRIBUTION %				
		Zn	Pb	Cu	VM	GM			Zn	Pb	Cu	VM	GM
Bulk conc	17.67	44.31	7.67	0.68	84.7	15.3			81.8	38.9	46.1	72.3	3.4
Bulk cleaner tail 3	2.57	16.91	13.68	0.72					4.5	10.1	7.1		
" " " 2	1.65	9.03	12.55	0.59					1.6	6.0	3.7		
" " " 1	8.49	6.19	5.99	0.42					6.1	14.6	13.7		
Bulk rougher tail	69.62	0.82	1.52	0.11					6.0	30.4	29.4		
Feed (calculated)	100.00	9.57	3.48	0.26					100.0	100.0	100.0		
Calculated Analyses													
Bulk cl conc 2nd Stage	20.24	40.83	8.43	0.69					86.3	49.0	53.2	78.0	5.2
" " " 1st Stage	21.89	38.43	8.74	0.68					87.9	55.0	56.9	80.5	6.6
Bulk rougher conc	30.38	29.63	7.97	0.61					94.0	69.6	70.6	88.5	15.2

REMARKS:

FLOTATION TEST REPORT

TEST NO. C-3 | SAMPLE: No.2 Shipment head sample | DATE: May 10, 1978

OBJECT OF TEST: Bulk flotation - to determine the effect of high pH versus low pH in bulk cleaners. | CHARGE: 4000 g | TESTED BY: G.L.

OPERATION	Time min	% Solids	pH	Unit used	Reagents, Grams									
					Lime	$CuSO_4$	Z-11	Z-200	242	DF250				
Grinding	60	65	9.8	7x14 RM	2.0									
Conditioning 1	10			Aerator	2.0	3.0								
" 2	5		10.3	Aerator			0.05	0.04	0.05					
Bulk rougher				1000-g cell										
Stage 1	½		11.3		0.50		0.05	0.04						
Stage 2	1							0.04						
Stage 3	¾							0.02						
Stage 4	¾		10.3					0.02						
Bulk cleaners "A"														
low pH														
No.1, Stage 1	1			1000-g cell										
Stage 2	½									0.02				
Stage 3	½									0.02				
No.2 Stage 1	½			500-g cell										
Stage 2	½									0.02				
Stage 3	1									0.02				
No.3 Stage 1	1			500-g cell										
Stage 2	1									0.02				
No.4 Stage 1	1		8.9	250-g cell										
Stage 2	½									0.02				
No.5	1		8.8	250-g cell										

REMARKS: 2-2000 gram lots ground and floated separately - rougher conc combined, mixed and riffled wet into two portions for cleaning.

FLOTATION TEST REPORT

TEST NO. C-3	SAMPLE: No.2 Shipment head sample	DATE: May 10, 1978
OBJECT OF TEST:		CHARGE:
		TESTED BY:

OPERATION	Time min	% Solids	pH	Unit used	Reagents, Grams									
					Lime	DF250								
Bulk cleaners "B"														
High pH														
No.1, Stage 1	½			1000-g cell	0.85									
Stage 2	½					0.04								
Stage 3	1					0.02								
No.2, Stage 1	½			500-g cell	0.30									
Stage 2	½					0.02								
Stage 3	1					0.02								
No.3, Stage 1	½			500-g cell	0.30									
Stage 2	½					0.02								
Stage 3	1					0.02								
No.4, Stage 1	1			250-g cell	0.10									
Stage 2	½					0.02								
No.5	1			250-g cell	-									

REMARKS:

METALLURGICAL BALANCE

TEST NO. C-3	SAMPLE: No.2 Shipment head sample	DATE: May 10/78

PRODUCT	WT %	ANALYSIS %							DISTRIBUTION %				
		Zn	Pb	Cu					Zn	Pb	Cu		
Bulk cleaners "A"													
Bulk conc	38.96	50.19	3.94	0.58					84.7	22.7	45.7		
Bulk cleaner tail 5	3.57	27.76	10.87	0.77					4.3	5.8	5.5		
" " " 4	1.95	17.31	15.78	0.83					1.4	4.6	3.3		
" " " 3	5.27	11.36	16.38	0.74					2.7	12.8	7.9		
" " " 2	8.97	6.91	12.94	0.60					2.7	17.2	10.8		
" " " 1	41.28	2.37	6.04	0.32					4.2	36.9	26.8		
Feed (bulk ro conc calcd)	100.00	23.08	6.75	0.45					100.0	100.0	100.0		
Calculated Analyses													
Bulk cl conc 4th Stage	42.53	48.31	4.52	0.60					89.0	28.5	51.2		
" " " 3rd Stage	44.48	46.95	5.01	0.61					90.4	33.1	54.5		
" " " 2nd Stage	49.75	43.18	6.22	0.62					93.1	45.9	62.4		
" " " 1st Stage	58.72	37.64	7.24	0.62					95.8	63.1	73.2		

REMARKS:

METALLURGICAL BALANCE

TEST NO. C-3 | SAMPLE: No.2 Shipment head sample | DATE: May 10/78

PRODUCT	WT %	ANALYSIS %							DISTRIBUTION %				
		Zn	Pb	Cu					Zn	Pb	Cu		
Bulk cleaners "B"													
Bulk conc	37.11	52.16	2.36	0.46					85.1	12.7	37.6		
Bulk cleaner tail 5	1.73	28.40	6.55	0.92					2.2	1.6	3.4		
" " " 4	1.09	18.92	9.91	0.86					0.9	1.5	2.0		
" " " 3	2.71	13.71	13.38	0.80					1.6	5.3	4.9		
" " " 2	7.15	8.85	12.99	0.64					2.8	13.5	10.1		
" " " 1	50.21	3.35	8.97	0.38					7.4	65.4	42.0		
Feed (bulk ro conc calcd)	100.00	22.74	6.89	0.45					100.0	100.0	100.0		
Calculated Analyses													
Bulk cl conc 4th Stage	38.84	51.11	2.55	0.48					87.3	14.3	41.0		
" " " 3rd Stage	39.93	50.23	2.75	0.49					88.2	15.8	43.0		
" " " 2nd Stage	42.64	47.90	3.42	0.51					89.8	21.1	47.9		
" " " 1st Stage	49.79	42.29	4.80	0.53					92.6	34.6	58.0		
Bulk rougher conc*	41.38	22.91	6.82	0.47					97.5	85.0	79.6		
Bulk rougher tail**	58.62	0.42	0.85	0.085					2.5	15.0	20.4		
Feed	100.00	9.73	3.32	0.24					100.0	100.0	100.0		

REMARKS: *mean of calculated values
**by analysis

Table A-1a - Size analysis of two-stage grind on No. 2 composite ore sample - 60 min in 7 x 14 rod mill followed by 30 min in 12-in. dia ball mill

Size Fraction	Mean dia micrometers	% Retained	Cumulative % Retained	Cumulative % Passing
400 mesh	38	1.8	1.8	98.2
Cone 1	28.3	9.2	11.0	89.0
Cone 2	21.5	17.0	28.0	72.0
Cone 3	15.7	15.8	43.8	56.2
Cone 4	10.8	15.8	59.6	40.4
Cone 5	8.3	9.3	68.9	31.1
-Cone 5	-8.3	15.1	84.0	16.0
Slimes	5.0	16.0	100.0	
Total		100.0		
Cyclosizer feed temperature: 20°C Elutriation: Settling time 60 min, temp. 20°C				

Table A-1b - Size analysis of 90 min rod mill grind on No. 2 composite ore sample

Size Fraction	Mean dia micrometers	% Retained	Cumulative % Retained	Cumulative % Retained
400 mesh	38	2.4	2.4	97.6
Cone 1	28.3	11.4	13.8	86.2
Cone 2	21.5	18.7	32.5	67.5
Cone 3	15.7	15.8	48.3	51.7
Cone 4	10.8	14.6	62.9	37.1
Cone 5	8.3	7.5	70.4	29.6
-Cone 5	-8.3	16.0	86.4	13.6
Slimes	5.0	13.6	100.0	
Total		100.0		
Cyclosizer feed temperature: 20°C Elutriation: Settling time 60 min, temp. 20°C				

Table A-1c - Size analysis of 60 min rod mill grind on No. 2 composite ore sample

Size Fraction	Mean dia micrometers	% Retained	Cumulative % Retained	Cumulative % Passing
325 mesh	45	3.6	3.6	96.4
400 mesh	38	6.4	10.0	90.0
Cone 1	28.3	17.8	27.8	72.2
Cone 2	21.5	19.3	47.1	52.9
Cone 3	15.7	13.0	60.1	39.0
Cone 4	10.8	11.6	71.7	28.3
Cone 5	8.3	6.6	78.3	21.7
-Cone 5	-8.3	21.7	100.0	
Total		100.0		
Cyclosizer feed temperature: 20°C Elutriation not carred out				

Table A-1d - Size analysis of 45 min rod mill grind on No. 2 composite ore sample

Size Fraction	Mean dia micrometers	% Retained	Cumulative % Retained	Cumulative % Passing
325 mesh	45	8.4	8.4	91.6
400 mesh	38	9.5	17.9	82.1
Cone 1	28.3	17.2	35.1	64.9
Cone 2	21.5	17.3	52.4	47.6
Cone 3	15.7	11.5	63.9	36.1
Cone 4	10.8	10.6	74.5	25.5
Cone 5	8.3	6.0	80.5	19.5
-Cone 5	-8.3	19.5	100.0	
Total		100.0		
Cyclosizer feed temperature: 20°C Elutriation not carried out				

Table A-2 - Warman cyclosizer particle sizes

Size Fraction	Calibration S.G. 2.65	Pyrite S.G. 5.1	Sphal S.G. 4.0	Galena S.G. 7.5	Mean S.G. 4.0*
Cyclosizer Feed Temperature 20°C					
Cone 1	40.6	24.3	28.3	19.3	28.3
Cone 2	30.9	18.5	21.5	14.7	21.5
Cone 3	22.5	13.4	15.7	10.7	15.7
Cone 4	15.5	9.3	10.8	7.4	10.8
Cone 5	11.9	7.1	8.3	5.7	8.3
Cyclosizer Feed Temperature 25°C					
Cone 1	38.3	22.9	26.7	18.2	26.7
Cone 2	29.1	17.4	20.3	13.9	20.3
Cone 3	21.2	12.6	14.8	10.1	14.8
Cone 4	14.6	8.8	10.2	7.0	10.2
Cone 5	11.2	6.7	7.8	5.4	7.8

* As determined for the No. 2 Composite Ore Sample

Table A-3 - Particle size in slimes fraction obtained by beaker elutriation

Temp	Settling Time min	Stokes Equivalent Spherical Diameter*			
		Pyrite S.G. 5.1	Sphal S.G. 4.0	Galena S.G. 7.5	Mean S.G. 4.0
20	60	4.3	5.0	3.4	5.0
25	60	4.0	4.7	3.2	4.7

* $$d = \sqrt{\frac{v18\eta}{g(D_1 - D_2)}}$$

where d = particle diameter (cm)
v = free falling velocity (cm/sec)
η = fluid viscosity (poise)
g = acceleration due to gravity (cm/sec^2)
D_1 = particle density (g/cc)
D_2 = fluid density (g/cc)

Table A-4a - Metal distribution by size fractions in target bulk concentrate produced by selective flotation at a grind of 77.5% -500 mesh, test A-21

Size fraction	Mean dia µm	Wt % retained	Analysis, %			Distribution, %		
			Zn	Pb	Cu	Zn	Pb	Cu
No. 1 cone u'flow	26.7	10.97	21.60	18.59	0.49	8.3	18.3	7.8
No. 2 " "	20.3	20.96	29.14	9.56	0.63	21.4	18.0	19.2
No. 3 " "	14.8	16.24	32.59	8.89	0.68	18.5	13.0	16.0
No. 4 " "	10.2	14.63	31.77	11.01	0.74	16.2	14.5	15.7
No. 5 " "	7.8	7.92	32.27	11.63	0.80	8.9	8.3	9.2
No. 5 Cone o'flow	<7.8	15.45	26.69	9.56	0.68	14.4	13.3	15.2
Slimes	<4.7	13.83	25.42	11.76	0.84	12.3	14.6	16.9
Total		100.00	28.61	11.12	0.69	100.0	100.0	100.0

Table A-4b - Metal distribution by size fractions in tailing from selective flotation at a grind of 77.5% -500 mesh, test A-21

Size Fraction	Mean dia µm	Wt % retained	Analysis, %			Distribution, %		
			Zn	Pb	Cu	Zn	Pb	Cu
No. 1 Cone µ-flow	26.7	15.04	0.51	0.54	0.078	15.4	13.9	16.2
No. 2 " "	20.3	20.06	0.35	0.37	0.064	14.1	12.7	17.8
No. 3 " "	14.8	15.65	0.26	0.30	0.044	8.2	8.1	9.6
No. 4 " "	10.2	14.08	0.25	0.33	0.046	7.1	8.0	9.0
No. 5 " "	7.8	7.08	0.24	0.34	0.046	3.4	4.1	4.6
No. 5 Cone o'flow	<7.8	12.77	0.33	0.42	0.058	9.1	9.9	11.1
Slimes	<4.7	14.32	1.48	1.76	0.16	42.7	43.2	31.7
Total		100.00	0.50	0.58	0.072	100.0	100.0	100.0

Table A-4c - Metal distribution by size fractions in flotation feed to test 21, selective flotation at a grind of 77.5% -500 mesh

Size fraction	Mean dia µm	Wt %* retained	Analysis, %*			Distribution, %		
			Zn	Pb	Cu	Zn	Pb	Cu
No. 1 Cone u-flow	26.7	13.92	5.08	4.46	0.17	8.6	17.8	9.9
No. 2 " "	20.3	20.31	8.53	2.98	0.22	21.2	17.3	18.7
No. 3 " "	14.8	15.81	9.40	2.73	0.22	18.2	12.4	14.5
No. 4 " "	10.2	14.23	9.18	3.35	0.24	16.0	13.7	14.3
No. 5 " "	7.8	7.31	9.79	3.71	0.27	8.7	7.8	8.2
No. 5 Cone o'flow	<7.8	14.23	8.20	3.15	0.24	14.3	12.9	14.3
Slimes	<4.7	14.19	7.49	4.45	0.34	13.0	18.1	20.1
Total		100.00	8.18	3.49	0.24	100.0	100.0	100.0

* Calculated

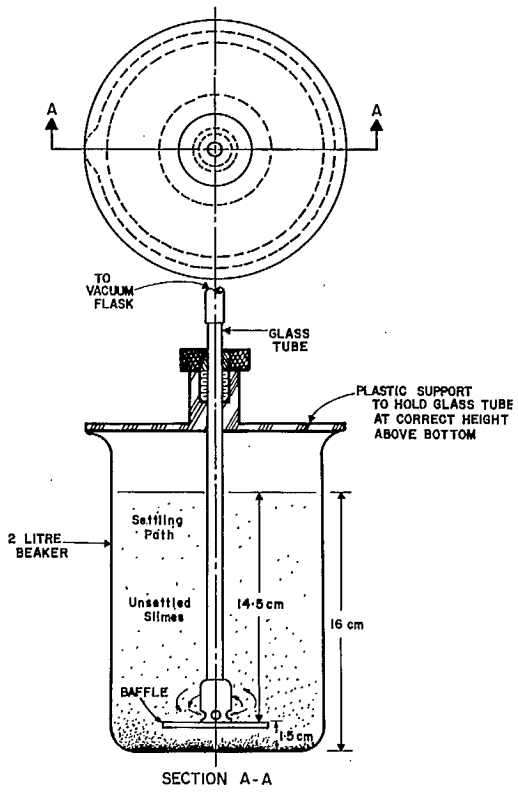

Fig. A-1 - Elutriation apparatus used to obtain slimes fraction before cyclosizing

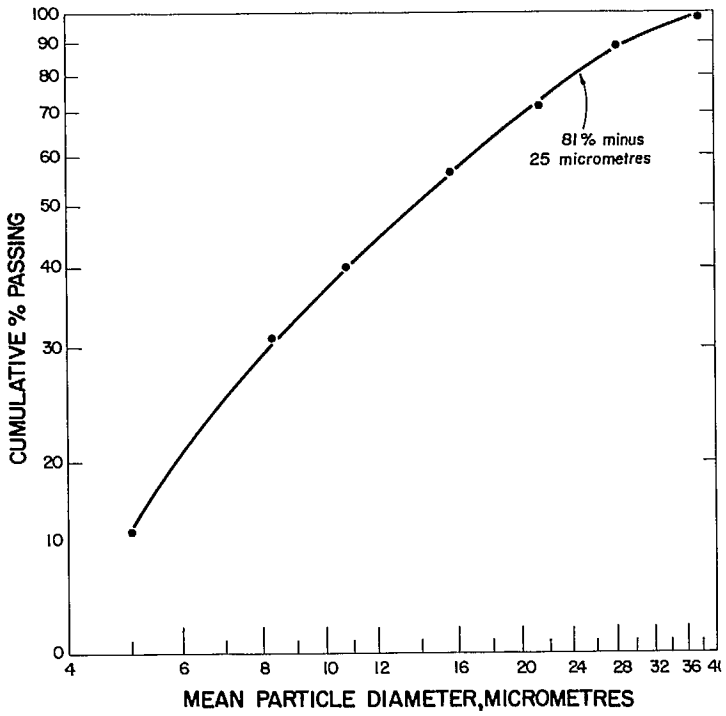

Fig. A-2 - Plot of size distribution for two-stage grinding, 60 min in 7 x 14 RM followed by 30 min in 12-in. dia BM

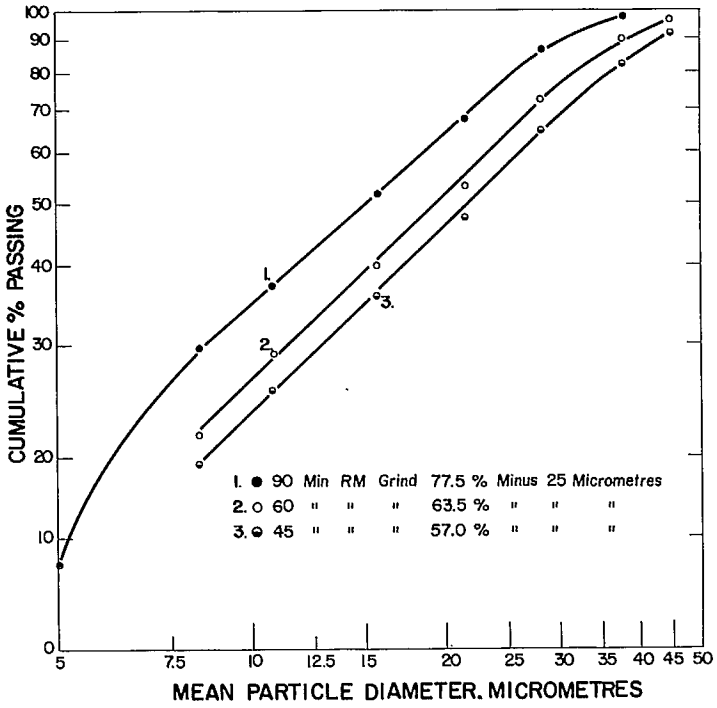

Fig. A-3 - Plot of size distribution for single-stage grinding in 7 x 14 RM

Table A-5a - Metal distribution by size fractions in target bulk concentrate produced by selective flotation at a grind of 63.5% -500 mesh, test A-22

Size fraction	Mean dia µm	Wt % retained	Analysis, %			Distribution, %		
			Zn	Pb	Cu	Zn	Pb	Cu
plus 400 mesh	38	4.65	28.81	4.98	0.59	4.7	2.1	4.0
No.1 Cone u'flow	26.7	23. 02	23.40	10.57	0.51	18.8	22.4	16.9
No.2 " "	20.3	22.23	28.92	8.7	0.60	22.5	17.9	19.2
No.3 " "	14.8	13.70	30.76	10.28	0.68	14.7	13.0	13.4
No.4 " "	10.2	11.63	34.11	11.27	0.80	13.8	12.1	13.4
No.5 " "	7.8	5.91	35.44	12.52	0.91	7.3	6.8	7.7
No.5 Cone o'Flow	<7.8	10.96	26.03	10.33	0.77	10.0	10.4	12.1
Slimes	<4.7	7.90	29.60	20.97	1.17	8.2	15.3	13.3
TOTAL		100.00	28.62	10.85	0.70	100.0	100.0	100.0

Table A-5b - Metal distribution by size fractions in tailing from selective flotation at a grind of 63.5% -500 mesh, test A-22

Size fraction	Mean dia µm	Wt % retained	Analysis, %			Distribution, %		
			Zn	Pb	Cu	Zn	Pb	Cu
plus 325 mesh	45	2.20	0.80	0.70	0.080	2.4	2.6	2.3
plus 400 mesh	38	4.75	0.79	0.72	0.089	5.2	5.8	5.6
No.1 Cone o'flow	26.7	22.60	0.75	0.66	0.094	23.4	25.4	28.0
No.2 " "	20.3	19.44	0.41	0.35	0.055	11.0	11.6	14.1
No.3 " "	14.8	12.53	0.30	0.28	0.046	5.2	6.0	7.6
No.4" "	10.2	10.84	0.28	0.28	0.049	4.2	5.2	7.0
No.5" "	7.8	5.69	0.32	0.30	0.046	2.5	2.9	3.4
No.5 Cone o'flow	<7.8	10.25	0.61	0.39	0.055	8.6	6.8	7.4
Slimes	<4.7	11.70	2.33	1.70	0.16	37.5	33.7	24.6
TOTAL		100.00	0.73	0.59	0.076	100.0	100.0	100.0

Table A-5c - Metal distribution by size fractions in flotation feed to test A-22, selective flotation at a grind of 63.5% -500 mesh

Size fraction	Mean dia µm	Wt % * retained	Analysis, %*			Distribution, %		
			Zn	Pb	Cu	Zn	Pb	Cu
plus 400 mesh	38	6.39	5.76	1.47	0.18	4.9	3.0	5.1
No.1 Cone u'flow	26.7	22.70	6.16	3.11	0.20	18.7	22.9	20.0
No.2 " "	20.3	20.12	8.08	2.61	0.20	21.7	17.0	17.7
No.3 " "	14.8	12.82	8.33	2.89	0.21	14.2	12.0	11.8
No.4 " "	10.2	11.03	8.97	3.10	0.24	13.2	11.1	11.7
No.5 " "	7.8	5.74	9.12	3.36	0.26	7.0	6.2	6.5
No.5 Cone o'flow	< 7.8	10.42	7.13	2.94	0.24	9.9	9.9	11.0
Slimes	< 4.7	10.78	7.20	5.14	0.34	10.4	17.9	16.2
TOTAL		100.00	7.49	3.09	0.23	100.0	100.0	100.0

* Calculated

Table A-6a - Metal distribution by size fractions in target bulk concentrate produced by selective flotation at a grind of 57% -500 mesh, test A-23

Size fraction	Mean dia µm	Wt % retained	Analysis, %		Distribution, %			
			Zn	Pb	Cu	Zn	Pb	Cu
plus 325 mesh	45	4.90	28.75	4.96	0.56	4.8	2.3	
plus 400 mesh	38	6.75	28.08	5.42	0.57	6.5	3.5	5.7
No.1 Cone u'flow	26.7	24.74	25.23	9.74	0.53	21.5	23.3	19.3
No.2 " "	20.3	19.53	30.23	9.03	0.61	20.3	17.0	17.6
No.3 " "	14.8	11.65	33.18	10.54	0.72	13.3	11.8	12.4
No.4 " "	10.2	9.91	34.17	12.07	0.80	11.7	11.6	11.7
No.5 " "	7.8	5.13	35.94	13.36	0.92	6.3	6.6	7.0
No.5 Cone o'flow	< 7.8	9.67	2598	10.66	0.73	8.7	10.0	10.4
Slimes	< 4.7	7.72	25.81	18.68	1.05	6.9	13.9	11.9
TOTAL		100.00	29.05	10.36	0.68	100.0	100.0	100.0

Table A-6b - Metal distribution by size fractions in tailing from selective flotation at a grind of 57% -500 mesh, test A-23

Size fraction	Mean dia µm	Wt % retained	Analysis,%			Distribution,%		
			Zn	Pb	Cu	Zn	Pb	Cu
plus 325 mesh	45	7.05	0.77	0.76	0.089	8.3	8.7	7.6
plus 400 mesh	38	7.45	0.69	0.72	0.096	7.9	8.7	8.7
No.1 Cone u'flow	26.7	21.37	0.62	0.65	0.098	20.3	22.5	25.4
No.2 " "	20.3	17.32	0.33	0.34	0.062	8.7	9.6	3.0
No.3 " "	14.8	10.92	0.27	0.32	0.053	4.5	5.7	7.0
No.4 " "	10.2	9.67	0.26	0.33	0.051	3.8	5.2	6.0
No.5 " "	7.8	5.27	0.27	0.31	0.053	2.2	2.6	3.4
No.5 Cone o'flow	< 7.8	9.73	0.46	0.35	0.060	6.8	5.5	7.1
Slimes	< 4.7	11.22	2.19	1.73	0.16	37.5	31.5	21.8
TOTAL		100.00	0.65	0.62	0.082	100.0	100.0	100.0

Table A-6c - Metal distribution by size fractions in flotation feed to test A-23, selective flotation at a grind of 57% -500 mesh

Size fraction	Mean dia µm	Wt % * retained	Analysis, %*			Distribution,%		
			Zn	Pb	Cu	Zn	Pb	Cu
plus 325 mesh	45	6.45	6.66	1.64	0.19	5.0	3.2	4.9
plus 400 mesh	38	7.26	7.76	1.93	0.22	6.6	4.2	6.4
No.1 Cone u'flow	26.7	22.31	8.19	3.45	0.23	21.4	23.2	20.6
No.2 " "	20.3	17.93	9.36	2.97	0.23	19.7	16.0	16.5
No.3 " "	14.8	11.12	9.83	3.29	0.25	12.8	11.0	11.2
No.4 " "	10.2	9.74	9.83	3.64	2.26	11.2	10.7	10.2
No.5 " "	7.8	5.23	9.97	3.86	0.29	6.1	6.1	6.1
No.5 Cone o'flow	<7.8	9.71	7.51	3.20	0.25	8.6	9.3	9.3
Slimes	<4.7	10.25	7.13	5.27	0.35	8.6	16.3	14.4
TOTAL		100.00	8.53	3.32	0.25	100.0	100.0	100.0

*Calculated

Table A-7a - Metal distribution by size fractions in target bulk concentrate produced by bulk flotation at a grind of 57% -500 mesh, test A-27

Size fraction	Mean dia µm	Wt % retained	Analysis, %			Distribution, %		
			Zn	Pb	Cu	Zn	Pb	Cu
plus 325 mesh	45	2.65	30.12	4.10	0.61	2.7	1.1	2.4
plus 400 mesh	38	2.15	29.87	5.05	0.62	6.2	3.1	5.6
No. 1 Cone u'flow	26.7	26.11	29.36	7.74	0.56	26.0	20.2	21.7
No. 2 " "	20.3	21.01	28.60	9.16	0.61	20.4	19.2	19.0
No. 3 " "	14.8	12.64	29.76	10.95	0.67	12.7	13.8	12.5
No. 4 " "	10.2	10.78	33.14	12.50	0.79	12.1	13.5	12.6
No. 5 " "	7.8	5.52	35.58	13.61	0.90	6.7	7.5	7.4
No. 5 Cone o'flow	<7.8	8.92	26.77	10.82	0.74	8.1	9.6	9.8
Slimes	<4.7	6.22	24.24	19.36	0.98	5.1	12.0	9.0
TOTAL		100.00	29.50	10.02	0.68	100.0	100.0	100.0

Table A-7b - Metal distribution by size fractions in tailing from bulk flotation at a grind of 57% -500 mesh, test A-27

Size fraction	Mean dia µm	Wt % retained	Analysis,%			Distribution,%		
			Zn	Pb	Cu	Zn	Pb	Cu
plus 325 mesh	45	8.10	1.33	0.75	0.085	7.8	6.6	6.9
plus 400 mesh	38	7.25	1.21	0.72	0.094	6.6	5.9	7.2
No.1 Cone u'flow	26.7	19.33	1.04	0.63	0.087	14.5	13.3	17.0
No.2 " "	20.3	16.90	0.48	0.30	0.055	5.8	5.5	9.4
No.3 " "	14.8	10.88	0.33	0.23	0.046	2.6	2.7	5.0
No.4 " "	10.2	9.75	0.33	0.27	0.049	2.3	2.9	4.8
No.5 " "	7.8	5.29	0.46	0.39	0.053	1.8	2.2	2.8
No.5 " "	7.8	9.76	1.40	0.84	0.094	9.9	8.9	9.2
Slimes	< 4.7	12.44	5.43	3.85	0.30	48.7	52.0	37.7
TOTAL		100.00	1.39	0.92	0.10	100.0	100.0	100.0

Table A-7c - Metal distribution by size fractions in flotation feed to test 27, bulk flotation at a grind of 57% -500 mesh

Size fraction	Mean dia µm	Wt % * retained	Analysis,%*			Distribution,%		
			Zn	Pb	Cu	Zn	Pb	Cu
plus 325 mesh	45	6.69	4.27	1.09	0.14	3.3	2.2	3.8
plus 400 mesh	38	7.19	7.53	1.68	0.21	63	3.7	6.1
No.1 Cone u'flow	26.7	21.08	10.09	2.90	0.24	24.6	18.7	20.4
No.1 " "	20.3	17.96	8.96	2.97	0.22	18.6	16.3	15.9
No.3 " "	14.8	11.33	8.79	3.31	0.23	11.5	11.5	10.5
No.4 " "	10.2	10.02	9.44	3.67	0.25	11.3	11.3	10.1
No.5 " "	7.8	5.35	9.81	3.91	0.28	6.4	6.4	6.1
No.5 Cone o'flow	< 7.8	9.54	7.51	3.25	0.25	9.5	9.5	9.6
Slimes	< 4.7	10.84	8.21	6.15	0.40	20.4	20.4	17.5
TOTAL		100.00	8.63	3.27	0.25	100.0	100.0	100.0

* Calculated

Table A-8a - Metal distribution by size fractions in target bulk concentrate produced by bulk flotation at a grind of 77.5% -500 mesh, test A-30

Size fraction	Mean dia µm	Wt % retained	Analysis,%			Distribution,%		
			Zn	Pb	Cu	Zn	Pb	Cu
No.1 Cone u'flow	26.7	12.47	18.82	11.08	0.39	8.2	12.9	7.2
No.2 " "	20.3	23.45	26.31	8.25	0.56	21.5	18.1	19.4
No.3 " "	14.8	17.37	28.77	9.53	0.63	17.4	15.5	16.2
No.4 " "	10.2	14.72	38.08	11.05	0.73	17.0	15.2	15.9
No.5 " "	7.8	7.54	33.98	12.75	0.86	8.9	9.0	9.6
No.5 Cone o'flow	< 7.8	14.07	35.17	12.01	0.91	17.3	15.8	18.9
Slimes	< 4.7	10.38	26.88	13.86	0.83	9.7	13.5	12.8
TOTAL		100.00	28.68	10.69	0.68	100.0	100.0	100.0

Table A-8b - Metal distribution by size fractions in tailing from bulk flotation at a grind of 77.5% -500 mesh, test A-30

Size fraction	Mean dia µm	Wt % retained	Analysis,%			Distribution,%		
			Zn	Pb	Cu	Zn	Pb	Cu
No.1 Cone u'flow	26.7	13.55	0.48	0.47	0.071	8.5	7.2	10.8
No.2 " "	20.3	19.19	0.36	0.34	0.060	9.0	7.4	13.0
No.3 " "	14.8	15.80	0.27	0.24	0.042	5.5	4.3	7.5
No.4 " "	10.2	14.55	0.26	0.28	0.049	4.9	4.6	8.0
No.5 " "	7.8	7.51	0.29	0.39	0.051	2.8	3.3	4.3
No.5 Cone o'flow	<7.8	13.19	0.44	0.64	0.073	7.5	9.5	10.8
Slimes	<4.7	6.21	2.94	3.49	0.25	61.8	63.7	45.6
TOTAL		100.00	0.77	0.89	0.09	100.0	100.0	100.0

Table A-8c - Metal distribution by size fractions in flotation feed to test A-30 selective flotation at a grind of 77.5% -500 mesh

Size fraction	Mean dia µm	Wt % * retained	Analysis, % *			Distribution,%		
			Zn	Pb	Cu	Zn	Pb	Cu
No.1 Cone u'flow	26.7	13.26	5.16	3.18	0.15	8.2	11.9	8.0
No.2 " "	20.3	20.34	8.48	2.82	0.22	20.7	16.2	18.0
No.3 " "	14.8	16.22	8.55	2.94	0.21	16.6	13.4	13.7
No.4 " "	10.2	14.60	9.25	3.23	0.24	16.2	13.3	14.1
No.5 " "	7.8	7.52	9.46	3.76	0.27	8.5	8.0	8.2
No.5 Cone o'flow	<7.8	13.43	10.32	3.87	0.31	16.6	14.6	16.8
Slimes	<4.7	14.63	7.55	5.49	0.36	13.2	22.6	21.2
TOTAL		100.00	8.35	3.55	0.25	100.0	100.0	100.0

* Calculated

Table A-9a - Metallurgical balance by size fractions for test A-21 selective flotation at a grind of 77.5% -500 mesh

Size fraction	Product	Wt %	Analysis, %					Distribution, %					Sep Eff, %
			Zn	Pb	Cu	VM	GM	Zn	Pb	Cu	VM	GM	
No.1 Cone u'flow 26.7 µm	Target bulk conc	21.69	21.60	18.59	0.49	58.9	41.1	92.1	90.5	63.5	90.0	10.4	79.6
	Tailing	78.31	0.51	0.54	0.078			7.9	9.5	36.5			
	Feed (calcd)	100.00	5.08	4.46	0.17			100.0	100.0	100.0			
No.2 Cone u'flow 20.3 µm	Target bulk conc	28.41	29.14	9.56	0.63	61.4	38.6	97.1	91.1	79.6	95.8	13.4	82.4
	Tailing	71.59	0.35	0.37	0.064			2.9	8.9	20.4			
	Feed (calcd)	100.00	8.53	2.98	0.22			100.0	100.0	100.0			
No.3 Cone u'flow 14.8 µm	Target bulk conc	28.27	32.59	8.89	0.68	66.6	33.4	98.0	92.1	85.9	96.6	11.7	84.9
	Tailing	71.73	0.26	0.30	0.044			2.0	7.9	14.1			
	Feed (calcd)	100.00	9.40	2.73	0.22			100.0	100.0	100.0			
No.4 Cone u'flow 10.2 µm	Target bulk conc	28.32	31.77	11.01	0.74	67.8	32.2	98.0	92.9	86.4	96.5	11.4	85.1
	Tailing	71.68	0.25	0.33	0.046			2.0	7.1	13.6			
	Feed (calcd)	100.00	9.18	3.35	0.24			100.0	100.0	100.0			
No.5 Cone u'flow 7.8 µm	Target bulk conc	29.82	32.27	11.63	0.80	69.5	30.5	98.3	93.6	88.1	96.8	11.6	85.2
	Tailing	70.18	0.24	0.34	0.046			1.7	6.4	11.9			
	Feed (calcd)	100.00	9.79	3.71	0.27			100.0	100.0	100.0			
No.5 Cone o'flow <7.8 µm	Target bulk conc	29.87	26.69	9.56	0.68	57.5	42.5	97.2	90.7	83.3	95.4	15.5	79.9
	Tailing	70.13	0.33	0.42	0.058			2.8	9.3	16.7			
	Feed (calcd)	100.00	8.20	3.15	0.24			100.0	100.0	100.0			
Slimes <4.7 µm	Target bulk conc	26.85	23.86	11.76	0.84	55.8	44.2	85.5	71.0	65.8	80.6	14.6	66.0
	Tailing	73.15	1.48	1.76	0.16			14.5	29.0	34.2			
	Feed (calcd)	100.00	7.49	4.45	0.34			100.0	100.0	100.0			

Table A-9b - Metallurgical balance by size fractions for test A-22 selective flotation at a grind of 63.5% -500 mesh

Size fraction	Product	Wt %	Analysis, %					Distribution, %					Sep Eff, %
			Zn	Pb	Cu	VM	GM	Zn	Pb	Cu	VM	GM	
plus 400 mesh 38 µm	Target bulk conc	17.73	28.81	4.98	0.59	55.5	44.5	88.7	60.2	59.6	83.4	8.9	74.5
	Tailing	82.27	0.79	0.71	0.086			11.3	39.8	40.4			
	Feed (calcd)	100.00	5.76	1.47	0.18			100.0	100.0	100.0			
No.1 Cone u'flow 26.7 µm	Target bulk conc	24.71	23.40	10.57	0.51	52.7	47.3	93.9	84.0	64.0	89.8	13.7	76.1
	Tailing	75.29	0.75	0.66	0.094			6.1	16.0	36.0			
	Feed (calcd)	100.00	6.16	3.11	0.20			100.0	100.0	100.0			
No.2 Cone u'flow 20.3 µm	Target bulk conc	26.92	28.92	8.73	0.60	60.0	40.0	96.2	90.2	80.0	94.5	13.0	81.5
	Tailing	73.08	0.41	0.35	0.055			3.8	9.8	20.0			
	Feed (calcd)	100.00	8.08	2.61	0.20			100.0	100.0	100.0			
No.3 Cone u'flow 14.8 µm	Target bulk conc	26.06	30.76	10.28	0.68	65.2	34.8	97.8	92.8	83.9	95.5	11.0	84.5
	Tailing	73.94	0.30	0.28	0.046			2.7	7.2	16.1			
	Feed (calcd)	100.00	8.33	2.89	0.21			100.0	100.0	100.0			
No.4 Cone u'flow 10.2 µm	Target bulk conc	25.69	34.11	11.27	0.80	72.2	27.8	97.7	93.3	85.0	96.1	8.8	87.3
	Tailing	74.31	0.28	0.28	0.049			2.3	6.7	15.0			
	Feed (calcd)	100.00	8.97	3.10	0.24			100.0	100.0	100.0			
No.5 Cone u'flow 7.8 µm	Target bulk conc	25.07	35.44	12.52	0.91	76.2	23.8	97.4	93.3	86.9	96.0	7.4	88.6
	Tailing	74.93	0.32	0.30	0.046			2.6	6.7	13.1			
	Feed (calcd)	100.00	9.12	3.36	0.26			100.0	100.0	100.0			
No.5 Cone u'flow <7.8 µm	Target bulk conc	25.63	26.03	10.33	0.77	57.5	42.5	93.6	90.1	82.8	92.1	13.0	79.1
	Tailing	74.37	0.61	0.39	0.055			6.4	9.9	17.2			
	Feed (calcd)	100.00	7.13	2.94	0.24			100.0	100.0	100.0			
Slimes <4.7 µm	Target bulk conc	17.87	29.60	20.97	1.17	76.9	23.1	73.4	72.9	61.4	72.7	5.1	67.6
	Tailing	82.13	2.33	1.70	0.16			26.6	27.1	38.6			
	Feed (calcd)	100.00	7.20	5.14	0.34			100.0	100.0	100.0			

Table A-9c - Metallurgical balance by size fractions for test A-23
selective flotation at a grind of 57% -500 mesh

Size fraction	Product	Wt %	Analysis %					Distribution, %					Sep Eff, %
			Zn	Pb	Cu	VM	GM	Zn	Pb	Cu	VM	GM	
plus 325 mesh 45 µm	Target bulk conc	21.06	28.75	4.96	0.56	55.2	44.8	90.9	62.6	62.2	86.1	10.9	75.2
	Tailing	78.94	0.77	0.76	0.089			9.1	36.5	37.4			
	Feed (calcd)	100.00	6.66	1.64	0.19			100.0	100.0	100.0			
plus 400 mesh 38 µm	Target bulk conc	25.80	28.08	5.42	0.57	54.7	45.3	93.4	72.4	67.4	89.3	13.9	75.4
	Tailing	74.20	0.69	0.72	0.096			6.6	27.6	32.6			
	Feed (calcd)	100.00	7.76	1.93	0.22			100.0	100.0	100.0			
No.1 Cone u'flow 26.7 µm	Target bulk conc	30.77	25.23	9.74	0.53	54.9	45.1	94.8	86.9	70.6	91.8	17.0	74.8
	Tailing	69.23	0.62	0.65	0.098			5.2	13.1	29.4			
	Feed (calcd)	100.00	8.19	3.48	0.23			100.0	100.0	100.0			
No.2 Cone u'flow 20.3 µm	Target bulk conc	30.21	30.23	9.03	0.61	62.6	37.4	97.5	92.0	81.0	96.0	14.1	81.9
	Tailing	69.79	0.33	0.34	0.062			2.5	8.0	9.0			
	Feed (calcd)	100.00	9.36	2.97	0.23			100.0	100.0	100.0			
No.3 Cone u'flow 14.8 µm	Target bulk conc	29.06	33.18	10.54	0.72	69.6	30.4	98.1	93.1	84.8	96.8	11.2	85.6
	Tailing	70.94	0.27	0.32	0.053			1.9	6.9	15.2			
	Feed (calcd)	100.00	9.83	3.29	0.25			100.0	100.0	100.0			
No.4 Cone u'flow 10.2 µm	Target bulk conc	28.23	34.17	12.07	0.80	73.2	26.8	98.1	93.5	86.1	96.6	9.6	87.0
	Tailing	71.77	0.26	0.33	0.051			1.9	6.5	13.9			
	Feed (calcd)	100.00	9.83	3.64	0.26			100.0	100.0	100.0			
No.5 Cone u'flow 7.8 µm	Target bulk conc	27.20	35.94	13.36	0.92	78.0	22.0	98.0	94.2	86.7	96.9	7.7	89.2
	Tailing	72.80	0.27	0.31	0.053			2.0	5.8	13.3			
	Feed (calcd)	100.00	9.97	3.86	0.29			100.0	100.0	100.0			
No.5 Cone o'flow <7.8 µm	Target bulk conc	27.61	25.98	10.66	0.73	57.7	42.3	95.6	92.1	82.3	94.3	14.1	80.2
	Tailing	72.39	0.46	0.35	0.060			4.4	7.9	7.7			
	Feed (calcd)	100.00	7.51	3.20	0.25			100.0	100.0	100.0			
Slimes <4.7 µm	Target bulk conc	20.90	25.81	18.68	1.05	67.6	32.4	75.7	74.0	63.3	74.4	8.4	66.0
	Tailing	79.10	2.19	1.73	0.16			24.3	26.0	36.6			
	Feed (calcd)	100.00	7.13	5.27	0.35			100.0	100.0	100.0			

Table A-9d - Metallurgical balance by size fractions for test A-27
bulk flotation at a grind of 57% -500 mesh

Size fraction	Product	Wt %	Analysis, %					Distribution, %					Sep Eff, %
			Zn	Pb	Cu	VM	GM	Zn	Pb	Cu	VM	GM	
plus 325 mesh 45 µm	Target bulk conc	10.20	30.12	4.10	0.61	56.7	43.3	72.0	38.3	44.9	65.7	4.8	60.9
	Tailing	89.80	1.33	0.75	0.085			28.0	61.7	55.1			
	Feed (calcd)	100.00	4.27	1.09	0.14			100.0	100.0	100.00			
plus 400 mesh 38 µm	Target bulk conc	22.06	29.87	5.05	0.62	57.4	42.6	87.5	66.5	65.1	83.9	11.1	72.8
	Tailing	77.94	1.21	0.72	0.094			12.5	33.5	34.9			
	Feed (calcd)	100.00	7.53	1.68	0.21			100.0	100.0	100.0			
No.1 Cone u'flow 26.7 µm	Target bulk conc	31.95	29.36	7.74	0.56	59.4	40.6	93.0	85.2	75.1	91.2	16.4	74.8
	Tailing	68.05	1.04	0.63	0.087			7.0	14.8	24.9			
	Feed (calcd)	100.00	10.09	2.90	0.24			100.0	100.0	100.0			
No.2 Cone u'flow 20.3 µm	Target bulk conc	30.17	28.60	9.16	0.61	60.1	39.9	96.3	93.0	82.7	95.9	14.8	81.1
	Tailing	69.83	0.48	0.30	0.055			2.7	7.0	17.3			
	Feed (calcd)	100.00	8.96	2.97	0.22			100.0	100.0	100.0			
No.3 Cone u'flow 14.8 µm	Target bulk conc	28.76	29.76	10.95	0.67	64.2	35.8	97.3	95.1	85.5	96.1	12.7	83.4
	Tailing	71.24	0.33	0.23	0.046			2.7	4.9	14.5			
	Feed (calcd)	100.00	8.79	3.31	0.23			100.0	100.0	100.0			
No.4 Cone u'flow 10.2 µm	Target bulk conc	27.76	33.14	12.50	0.79	71.9	28.1	97.5	94.7	86.1	96.9	9.8	87.1
	Tailing	72.24	0.33	0.27	0.049			2.5	5.3	13.9			
	Feed (calcd)	100.00	9.44	3.67	0.25			100.0	100.0	100.0			
No.5 Cone u'flow 7.8 µm	Target bulk conc	26.62	35.58	13.61	0.90	77.6	22.4	96.6	92.7	86.0	95.2	7.6	87.6
	Tailing	73.38	0.46	0.39	0.053			3.4	7.3	14.0			
	Feed (calcd)	100.00	9.81	3.91	0.28			100.0	100.0	100.0			
No.5 Cone u'flow <7.8 µm	Target bulk conc	24.10	26.77	10.82	0.74	59.2	40.8	85.9	80.4	71.4	83.9	11.8	72.1
	Tailing	75.90	1.40	0.84	0.094			14.1	19.6	28.6			
	Feed (calcd)	100.00	7.51	3.25	0.25			100.0	100.0	100.0			
Slimes <4.7 µm	Target bulk conc	14.80	24.24	19.36	0.98	65.6	34.4	31.5	46.6	36.2	44.1	6.5	37.6
	Tailing	85.20	5.43	3.85	0.30			68.5	53.4	63.8			
	Feed (calcd)	100.00	8.21	6.15	0.40			100.0	100.0	100.0			

Table A-9e - Metallurgical balance by size fractions for test A-30 bulk flotation at a grind of 77.5% -500 mesh

Size fraction	Product	Wt %	Analysis %					Distribution, %					Sep Eff, %
			Zn	Pb	Cu	VM	GM	Zn	Pb	Cu	VM	GM	
No.1 Cone u'flow 26.7 µm	Target bulk conc	25.54	18.82	11.08	0.39	45.3	54.7	93.1	89.0	65.3	91.1	16.1	75.1
	Tailing	74.46	0.48	0.47	0.071			6.9	11.0	34.7			
	Feed (calcd)	100.00	5.16	3.18	0.15			100.0	100.0	100.0			
No.2 Cone u'flow 20.3 µm	Target bulk conc	31.29	26.31	8.25	0.56	55.0	45.0	97.1	91.7	81.0	95.6	17.2	78.4
	Tailing	68.71	0.36	0.34	0.060			2.9	8.3	19.0			
	Feed (calcd)	100.00	8.48	2.82	0.22			100.0	100.0	100.00			
No.3 Cone u'flow 14.8 µm	Target bulk conc	29.06	28.77	9.53	0.63	60.8	39.2	97.8	94.2	86.0	96.5	13.9	82.6
	Tailing	70.94	0.27	0.24	0.042			2.2	5.8	14.0			
	Feed (calcd)	100.00	8.55	2.94	0.21			100.0	100.0	100.0			
No.4 Cone u'flow 10.2 µm	Target bulk conc	27.38	33.08	11.05	0.73	70.0	30.0	98.0	93.7	84.9	96.8	10.2	86.6
	Tailing	72.62	0.26	0.28	0.049			2.0	6.3	15.1			
	Feed (calcd)	100.00	9.25	3.23	0.24			100.0	100.0	100.0			
No.5 Cone u'flow 7.8 µm	Target bulk conc	27.23	33.98	12.75	0.86	73.8	26.2	97.8	92.4	86.3	96.2	9.0	87.2
	Tailing	72.77	0.29	0.39	0.051			2.2	7.6	13.7			
	Feed (calcd)	100.00	100.00	3.76	0.27			100.0	100.0	100.0			
No.5 Cone u'flow <7.8 µm	Target bulk conc	28.45	35.17	12.01	0.91	75.1	24.9	96.9	88.2	83.2	94.5	9.2	85.3
	Tailing	71.55	0.44	0.64	0.073			3.1	11.8	16.8			
	Feed (calcd)	100.00	10.32	3.87	0.31			100.0	100.0	100.0			
Slimes <4.7 µm	Target bulk conc	19.27	26.88	13.86	0.83	63.2	36.8	68.6	48.7	44.2	61.2	9.1	52.1
	Tailing	80.73	2.94	3.49	0.25			31.4	51.3	55.8			
	Feed (calcd)	100.00	7.55	5.49	0.36			100.0	100.0	100.0			

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