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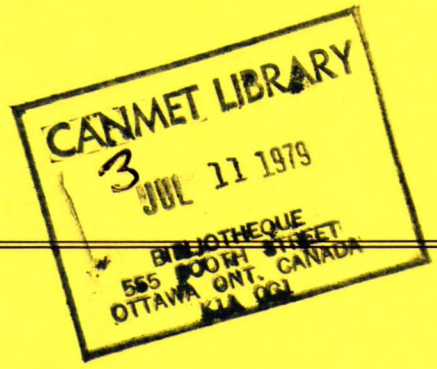

IMAGE ANALYSIS STUDY OF MILL PRODUCTS FROM BATCH TESTS ON BRUNSWICK MINING AND SMELTING MILL TAILINGS

W. PETRUK

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IMAGE ANALYSIS STUDY OF MILL PRODUCTS FROM BATCH TESTS ON BRUNSWICK MINING AND SMELTING MILL TAILINGS

by

W. Petruk*

ABSTRACT

An image analysis study was performed to determine the behaviour of sphalerite during laboratory batch tests on recovering zinc from a sample of Brunswick Mining and Smelting mill tailings containing 1.8 wt % zinc. A zinc concentrate grading 45.5 wt % zinc with a recovery of 62% had been obtained in the laboratory batch tests by regrinding to 80% minus 18 µm, floating a rougher concentrate, and cleaning five times. Image analysis studies of the products showed (1) that regrinding increased sphalerite liberation to 77.5% from 39%, (2) that 70% of the free and 35% of the unliberated sphalerite were recovered in the final concentrate, (3) that the free sphalerite grains lost in the rougher and first cleaner tails were all sizes, (4) that the free sphalerite grains lost in the second to fifth cleaner tails were smaller than 18 µm with most being smaller than 4 µm, and (5) that the unliberated sphalerite grains recovered in the final zinc concentrate were larger than 4 µm. These results explain why good recoveries were obtained from the reground mill tailings, and provide new data on the recovery of free and unliberated sphalerite from a low grade feed by conventional flotation.

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ANALYSE DE L'IMAGE DES PRODUITS MANUFACTURES A PARTIR D'ESSAIS CONTROLES SUR LES STERILES PROVENANT DE L'USINE BRUNSWICK MINING AND SMELTING

par

W. Petruk*

RESUME

On a effectué une étude par l'analyse de l'image afin de déterminer le comportement de la sphalérite pendant les essais en laboratoire sur la récupération du zinc d'un échantillon de stériles contenant 1.8% en poids de zinc et provenant de l'usine Brunswick Mining and Smelting. Un concentré de zinc, contenant 45.5% en poids de zinc et ayant une récupération de 62%, a été obtenu par des essais de laboratoire en broyant de nouveau de 80% moins 18 µm, en flottant un concentré plus grossier et en le nettoyant cinq fois. Les analyses d'image de ces produits ont démontré (1) que le rebroyage avait amélioré la libération de la sphalérite de 39 à 77.5%, (2) que 70% de la sphalérite libérée et 35% de la sphalérite non-libérée ont été récupérées dans le concentré final, (3) que les grains de sphalérite libérés et perdus dans les stériles grossiers du premier lavage étaient de toutes les dimensions, (4) que les grains de sphalérite libérés et perdus dans les stériles du deuxième au cinquième nettoyage étaient plus petits que 18 µm dont la plupart étaient plus petits que 4 µm et (5) que les grains de sphalérite non-libérés et récupérés dans le concentré de zinc final étaient plus gros que 4 µm. Ces résultats expliquent pourquoi on a obtenu de bonnes valeurs de récupération des stériles broyés de nouveau ainsi que de nouvelles données sur la récupération par la méthode de flottation classique de la sphalérite libérée et non-libérée provenant d'un alimentation à basse teneur.

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*Chercheur scientifique, Section de minéralogie, Laboratoire des sciences physiques, Laboratoires des sciences minérales, CANMET, Energie, Mines et Ressources Canada, Ottawa, Canada.

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INTRODUCTION

The mill of Brunswick Mining and Smelting Corporation Limited (BMS) in New Brunswick has a problem of high metal losses in the mill tailings. In 1975, the mill staff conducted a pilot-plant investigation to determine the feasibility of recovering zinc from the mill tailings and in 1976 installed a zinc tailings flotation circuit. Prior to its installation zinc content in the final mill tailings was about 1.8 wt %, which gave a zinc loss of about 15%; after installation, the zinc content and loss were reduced to about 1.2 wt % and 10% respectively.

During a visit to BMS in November 1975 by R.W. Bruce, G.O. Hayslip and the author, all of CANMET arrangements were made to ship about two tons of mill tailings produced before installing the zinc tailings circuit (1). The shipment was received at CANMET in January 1976. In April 1976, A. Stemerowicz of the Ore Processing Laboratory undertook an investigation of the BMS mill tailings to establish a method for improving zinc recoveries still further (2). The following procedure was used for conducting batch flotation tests: regrinding two 2,000-g samples of the tailings for one hour using two stages of pebble grinding, floating off a zinc rougher concentrate from each of the two samples, combining the two concentrates, and cleaning five times.

In March 1976, the author undertook an investigation with the objective of defining the behaviour of sphalerite during treatment of the BMS mill tailings and of predicting the ultimate possible zinc recovery. Image analysis was first performed on samples of the tailings shipment, both as received and after regrinding for one hour (3), and then on a set of mill products produced by A. Stemerowicz in his batch test 167-18 that had given good results. This report summarizes the image analysis data, interprets the behaviour of sphalerite during batch tests, and extrapolates results to predict the ultimate possible zinc recovery.

SAMPLES

The shipment of tailings as received, was used for the initial investigation for which partial compositions are given in Table 1, mineral quantities in Table 2, and size distribution of the sulphide grains in the tailings as received and after regrinding for one hour in Fig. 1. The products from batch test 167-18 included two rougher tailings, the first to fifth cleaner tailings, and the final zinc concentrate. Chemical analyses and metal recoveries for all the products from this batch test were supplied by A. Stemerowicz and are given in Table 3.

Table 1 — Partial composition of BMS mill tailings*

Element	Wt %
Zn	1.79
Pb	0.95
Cu	0.15

*Supplied by A. Stemerowicz

Table 2 — Mineral composition in BMS tailings*

Mineral	Wt %
pyrite	69.4
sphalerite	3.1
galena	1.1
chalcopyrite	0.5
magnetite	3.8
pyrrhotite	trace
quartz	13.8
chlorite	7.7
calcite	0.2
dolomite	0.2
siderite	0.2
mica	trace

*From Petruk and Pinard, 1977

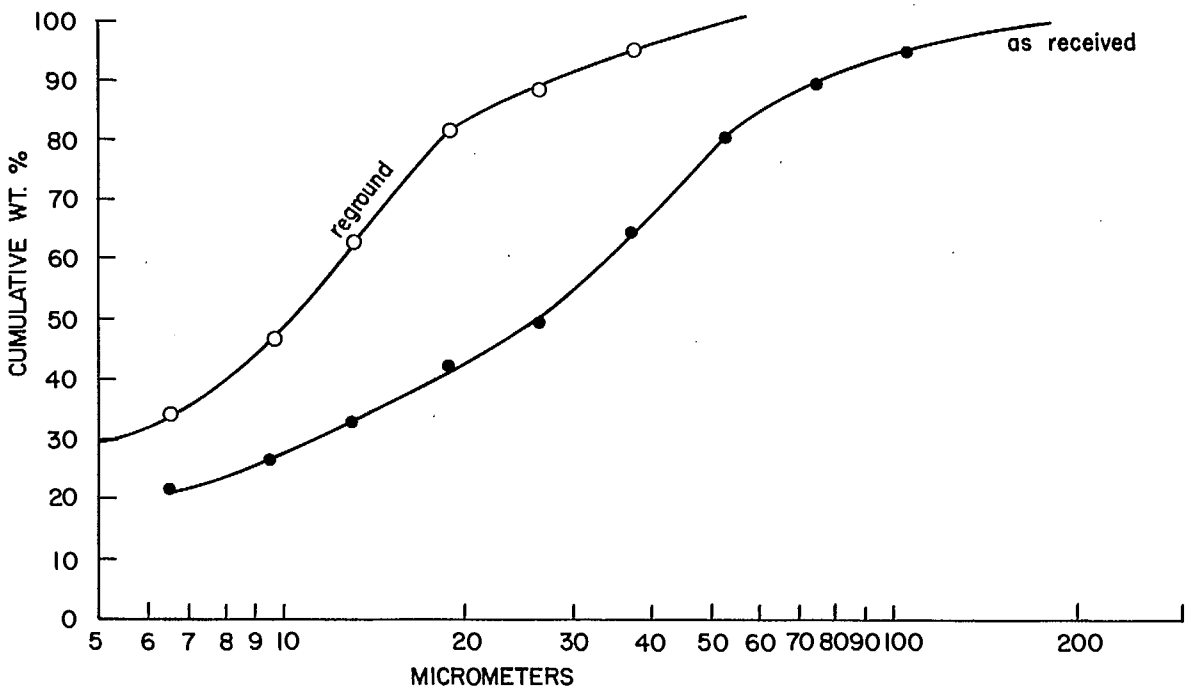


Fig. 1. - Size distribution of sulphide grains in BMS tailings as received and reground for one hour.

Table 3 — Results of zinc flotation on reground tailings*

Product	Wt %	Assays Wt %			Recoveries		
		Zn	Pb	Cu	Zn	Pb	Cu
Final zinc conc (5th cleaner conc)	2.53	45.48	3.34	1.57	62.0	9.2	26.7
5th cleaner tails	0.32	17.52	3.17	4.04	3.0	1.1	8.7
4th cleaner conc	2.85**	42.34**	3.32**	1.86**	65.0	10.3	35.4
4th cleaner tails	0.40	12.52	2.82	0.57	2.7	1.2	1.6
3rd cleaner conc	3.25**	38.67**	3.26**	1.71**	67.7	11.5	37.0
3rd cleaner tails	0.73	10.95	2.52	0.31	4.3	2.0	1.6
2nd cleaner conc	3.98**	33.59**	3.12**	1.45**	72.0	13.5	3B.6
2nd cleaner tails	2.54	2.39	1.64	0.30	3.3	4.5	5.1
1st cleaner conc	6.52**	21.43**	2.54**	1.01**	75.3	18.0	43.7
1st cleaner tails	14.69	1.00	1.19	0.14	7.9	19.0	13.9
Zn rougher conc	21.21**	7.28**	1.60**	0.41**	83.2	37.0	57.6
Zn rougher tails A	37.90	0.38	0.70	0.08	7.8	28.8	20.4
Zn rougher tails B	40.89	0.41	0.77	0.08	9.0	34.2	22.0
Feed	100.00	1.86**	0.92**	0.15**	100.0	100.0	100.0
Comb. final tails	97.47	0.72	0.86	0.11	37.7	90.8	71.5

* Data for test 167-18, supplied by A. Stemerowicz

**Calculated

METHOD OF INVESTIGATION

Polished sections were prepared from samples of the products from batch test 167-18. These were studied with an ore microscope to identify the minerals, and with a Quantimet 720 image analyzer to determine: (1) the percentages of free sphalerite (Fig. 2), (2) size distribution for the free sphalerite, unliberated sphalerite, and metallic mineral grains, (3) percentage of sphalerite in composite grains, and (4) surface exposure of attached sphalerite in composite grains (Fig. 3).

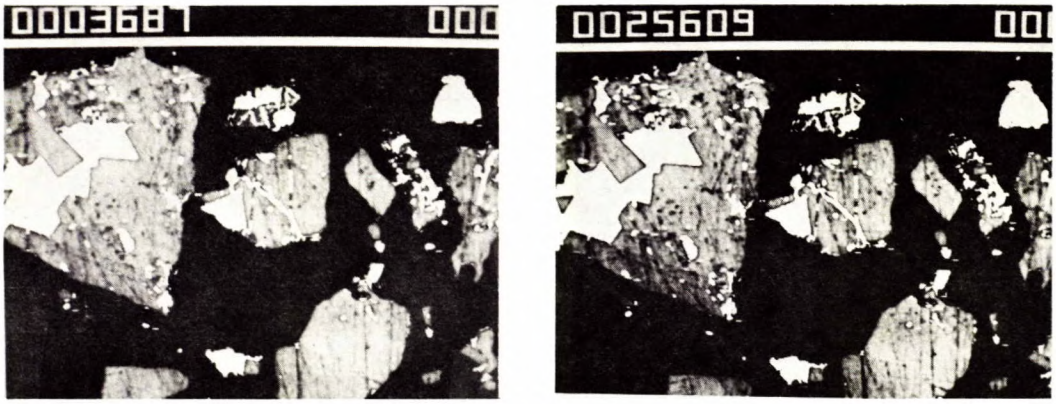


Fig. 2 - Image of grains in polished section as displayed on screen of image analyzer. At left, free sphalerite detected, shown in short horizontal lines at bottom of each grain, and number at top indicates number of picture points covered by grains. At right, unliberated sphalerite is shown in white with short horizontal lines below each unliberated grain in pyrite, shown in grey.

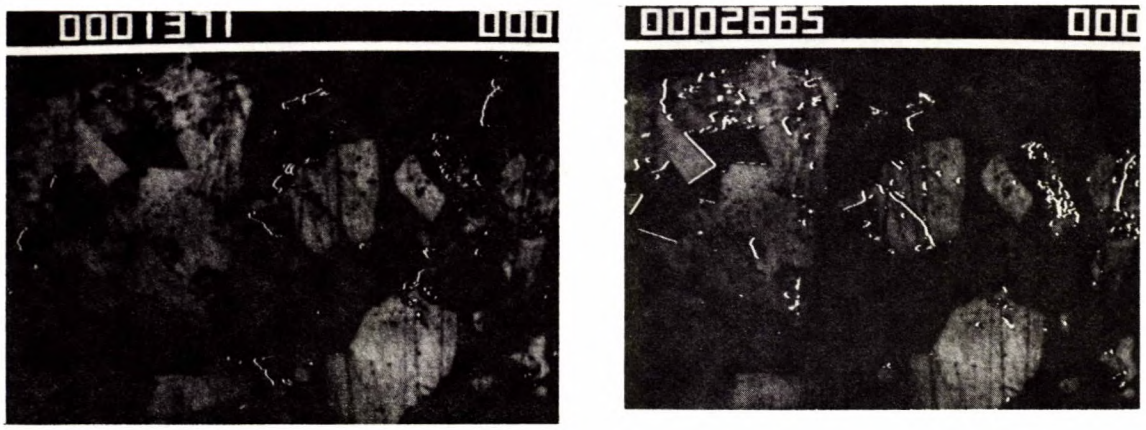


Fig. 3 - Exposure of sphalerite. View at left shows traces of exposed left hand faces of attached sphalerite grains; view at right shows traces of left hand side of sphalerite in contact with pyrite, in grey. The numbers are the total lengths of the respective traces in picture points.

RESULTS AND INTERPRETATIONS

Microscopical studies showed that the rougher and first cleaner tailings contained significant amounts of non-metallic minerals and pyrite, and minor amounts of free and unliberated sphalerite. The second, third, fourth and fifth cleaner tailings contained progressively less non-metallic minerals and progressively more sphalerite. The percentages of sphalerite in the tailings and zinc concentrates were calculated (Table 4) from the analyses of Table 3, column 3, by assuming that all the zinc occurred in sphalerite and that the sphalerite contained 60.5 wt % zinc (4).

The proportions of sphalerite that occurred as free grains in the tailings samples and in the final zinc concentrate were determined with the image analyzer, and were also calculated from the analyzed data for the feed, rougher concentrate and cleaner concentrates (Table 4, column 3). Recoveries of free and unliberated sphalerite were also calculated (Table 4).

Unliberated sphalerite occurs as a constituent of composite grains. The composite grains were analyzed to determine their average content and mean surface exposure of sphalerite (Table 5). The product of these two values divided by 10,000, was used to qualitatively describe the middling sphalerite. This figure was less than 0.03 for unliberated sphalerite in the rougher and first cleaner tails, each of which contained less than 1 wt % zinc; it was 0.08 to 0.15 for unliberated sphalerite in the second to fifth cleaner tails that contained 2.4 to 17.5 wt % zinc; and it was 0.20 for unliberated sphalerite in the final zinc concentrate that contained 45.5 wt % zinc.

Size analyses were performed with the image analyzer for free sphalerite, unliberated

Table 4 — Sphalerite in mill products

Product	Wt %	Free	Recovery		
			Free %	Unliberated %	Total %
Final zinc conc (5th cleaner conc)	75.2	87**	54.1	7.9	62.0
5th cleaner tails	29.0	73**	2.2	0.8	3.0
4th cleaner conc	70.0	86	56.3*	8.7*	65.0*
4th cleaner tails	20.7	72**	1.9	0.8	2.7
3rd cleaner conc	63.9	86*	58.2*	9.5*	67.7*
3rd cleaner tails	18.1	61**	2.7	1.6	4.3
2nd cleaner conc	55.5	84*	60.9	11.1*	72.0*
2nd cleaner tails	4.0	80**	2.6	0.7	3.3
1st cleaner conc	35.4	84*	63.5	11.8	75.3*
1st cleaner tails	1.7	60**	4.8	3.1	7.9
Zinc rougher conc	12.0	82*	68.3	14.9*	83.2*
Zinc rougher tails A	0.6	62**	4.8	3.0	7.8
Zinc rougher tails B	0.7	49**	4.4	4.6	9.0
Feed	3.1	77.5*	77.0	22.5*	100.0*

* Calculated

**Corrected to account for attached grains that appear free in polished sections (5)

sphalerite, free pyrite, unliberated pyrite and all sulphide grains in the rougher and cleaner tails and in the zinc concentrate. The results are given in Table 6 as K_{80} – 80 wt % of the sphalerite occurred as grains smaller than the indicated size in μm – a size generally used in metallurgy, and K_{50}, the mean size, generally used for comparing grain sizes. This table shows that comparatively large free sphalerite grains were lost in the rougher and first cleaner tailings, intermediate-sized free sphalerite grains were lost in the fifth cleaner tailings and very small free sphalerite grains were lost in the second to fourth cleaner tailings. Size distribution for free sphalerite, sulphide grains, and all grains in the feed are plotted in Fig. 4.

The size analyses data for sphalerite were converted to absolute quantities for free and unliberated sphalerite within each size range in each test product on the basis of total sphalerite in the feed being 100% (Tables 7 and 8). The results were then plotted as frequency diagrams of absolute quantity vs size for the free and unliberated sphalerite in the feed and in the rougher and cleaner concentrates (Fig. 5). The difference between points on the curve for the feed and for the rougher concentrate is equal to the quantity of sphalerite within a specific size range which was lost in the rougher tailings. Similarly, the difference between points on each successive curve for the cleaner concentrates is equal to the sphalerite lost in each successive tailings. The

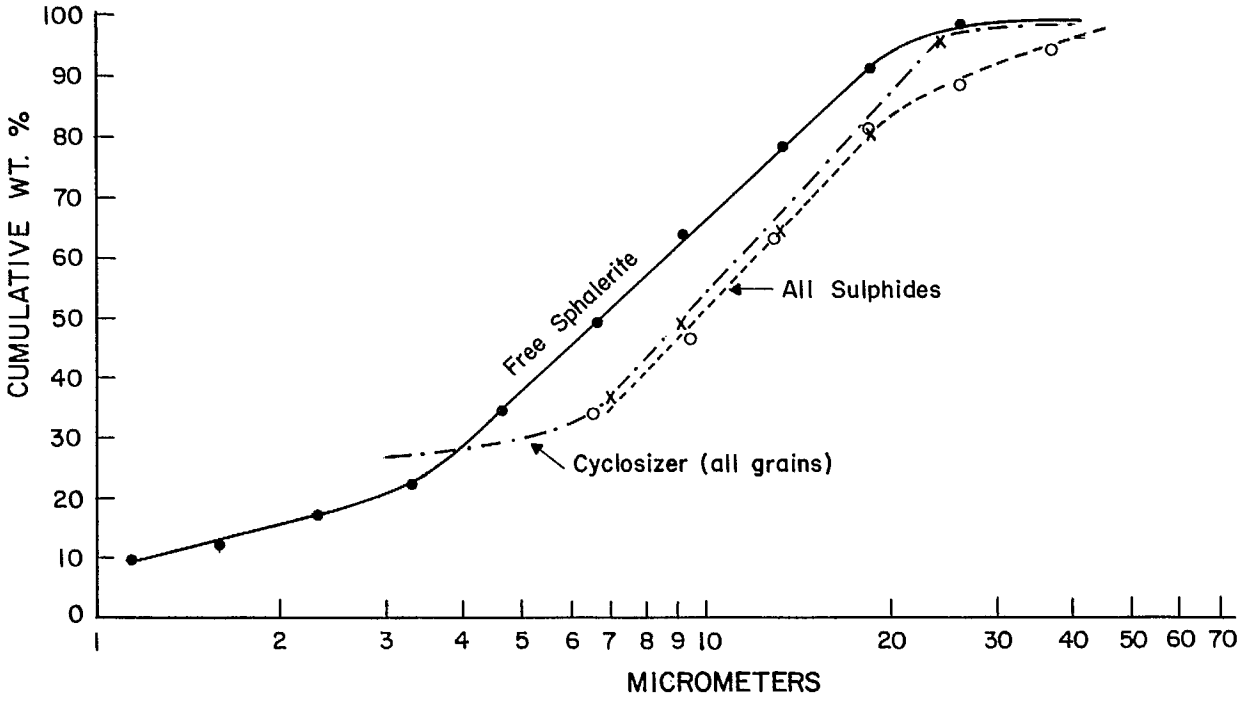


Fig. 4 - Size distribution of free sphalerite, sulphide grains and of all grains in the reground feed.

Table 5 — Unliberated sphalerite in mill products

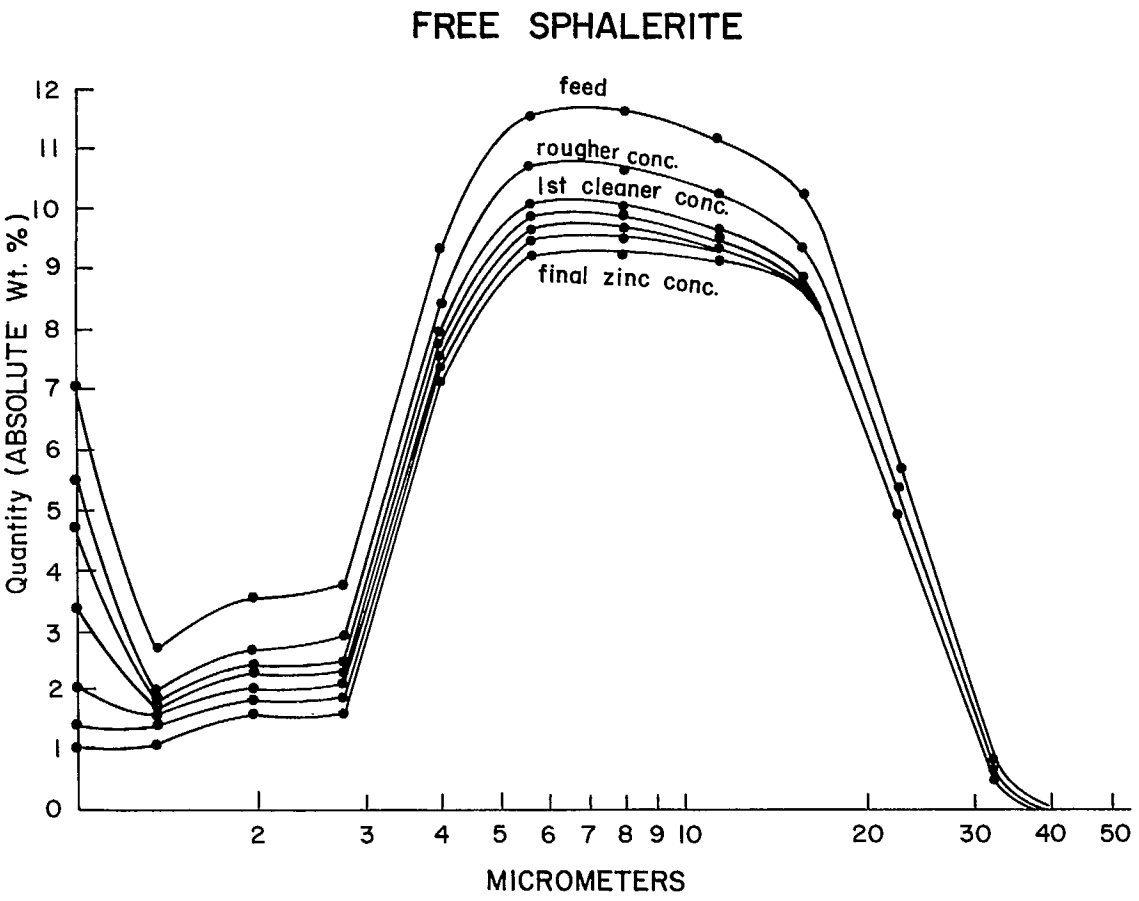
Product	Wt %	Recovery (absolute wt %)	Wt % in composite grains (a)	Surface exposure %* (b)	$\frac{a \times b}{10,000}$
Final zinc conc (5th cl. conc)	9.8	7.9	28.0	70.0	0.20
5th cleaner tails	7.8	0.8	15.0	62.7	0.09
4th cleaner conc	9.8	8.7			
4th cleaner tails	5.8	0.8	23.0	54.0	0.12
3rd cleaner conc	8.9	9.5			
3rd cleaner tails	7.1	1.6	22.0	70.0	0.15
2nd cleaner conc	8.9	11.1			
2nd cleaner tails	0.8	0.7	21.0	36.0	0.08
1st cleaner conc	5.7	11.8			
1st cleaner tails	0.7	3.2	3.5	62.0	0.02
Zinc rougher conc	2.2	14.9			
Zinc rougher tails A	0.2	3.0	4.5	70.0	0.03
Zinc rougher tails B	0.4	4.6	3.5	70.0	0.02
Feed	0.7	22.5			

*Determined with image analyzer

Table 6 - Size analysis data

	Free sphalerite, µm		Unliberated sphalerite, µm		Free pyrite, µm		Attached pyrite, µm		All metallics, µm	
Product	K_{80}	K_{50}	K_{80}	K_{50}	K_{80}	K_{50}	K_{80}	K_{50}	K_{80}	K_{50}
Zinc conc.	15.0	8.0	18.0	9.0	11.0	5.5	15.0	9.0	13.5	7.3
5th cleaner tails	8.0	3.2	11.0	4.5	9.2	5.2	15.0	9.0	13.7	7.0
4th cleaner tails	4.5	1.7	7.5	3.8	7.2	3.6	12.5	7.2	10.0	5.0
3rd cleaner tails	4.5	1.4	11.0	5.0	8.0	4.0	11.0	7.0	11.0	5.0
2nd cleaner tails	4.5	<1.0	2.0	<1.0	7.7	3.9	11.7	7.5	12.0	6.6
1st cleaner tails	13.5	5.7	19.0	7.2	8.5	4.0	16.0	9.0	14.0	7.2
Rougher tails A	14.0	3.7	7.4	1.0	14.0	8.0	20.0	12.0	21.0	13.0
Rougher tails B	10.0	4.2	7.5	2.1	17.0	8.9	20.5	12.3	19.5	12.0
Rougher conc*	14.0	6.8	15.5	7.2						
Rougher tails*	11.5	4.0	7.5	1.7						
Feed*	14.0	6.7	14.0	5.5					18.0	9.4

*Calculated



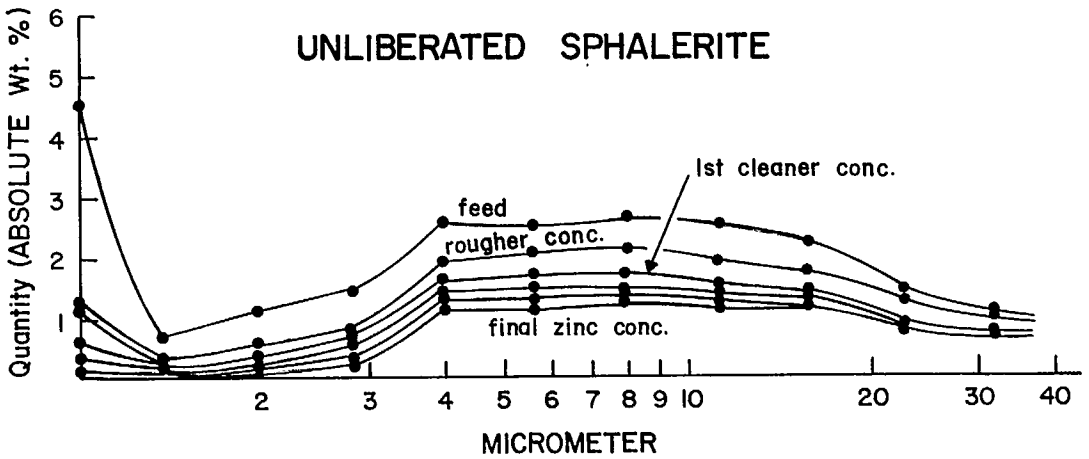


Fig. 5 - Frequency diagrams showing absolute quantities of sphalerite vs size

Table 7 - Size distribution of free sphalerite within size ranges in mill products

Size range µm	Wt % of feed	Rougher		1st cleaner		2nd cleaner		3rd cleaner		4th cleaner		5th cleaner	
		tail %	conc* %	tail %	conc* %	tail %	conc* %	tail %	conc* %	tail %	conc* %	tail %	conc* %
37.0-26.0	0.83	0.24	0.59	0.05	0.54		0.54		0.54		0.54		0.54
26.0-18.6	5.67	0.42	5.25	0.38	4.87		4.87		4.87		4.87		4.87
18.6-13.1	10.20	0.82	9.38	0.52	8.86	0.11	8.75		8.75		8.75	0.09	8.66
13.1- 9.3	11.15	0.91	10.24	0.62	9.62	0.13	9.49	0.05	9.44		9.44	0.24	9.20
9.3- 6.6	11.51	0.91	10.60	0.57	10.03	0.16	9.87	0.24	9.63	0.19	9.44	0.24	9.20
6.6- 4.6	11.55	0.91	10.64	0.62	10.02	0.13	9.89	0.24	9.65	0.19	9.46	0.26	9.20
4.6- 3.3	9.37	0.91	8.46	0.52	7.94	0.24	7.70	0.21	7.49	0.19	7.30	0.26	7.04
3.3- 2.3	3.82	0.91	2.91	0.43	2.48	0.15	2.33	0.24	2.09	0.21	1.88	0.26	1.62
2.3- 1.6	3.57	0.87	2.70	0.24	2.46	0.13	2.33	0.24	2.09	0.21	1.88	0.26	1.62
1.6- 1.15	2.70	0.71	1.99	0.14	1.85	0.10	1.75	0.21	1.54	0.20	1.34	0.26	1.08
-1.15	7.08	1.57	5.51	0.67	4.84	1.50	3.34	1.20	2.14	0.74	1.40	0.32	1.08
Total	77.45	9.18	68.27	4.76	63.51	2.65	60.86	2.63	58.23	1.93	56.30	2.19	54.11

*Calculated from image analysis data and metal recoveries on basis of total sphalerite in feed being 100%.

Table 8 - Size distribution of unliberated sphalerite within size ranges in mill products

Size range µm	Feed*	Rougher		1st cleaner		2nd cleaner		3rd cleaner		4th cleaner		5th cleaner	
		tails %	conc* %	tails %	conc* %	tails %	conc* %	tails %	conc* %	tails %	conc* %	tails %	conc* %
37.0-26.0	1.02	0.03	0.99	0.28	0.71		0.71	0.08	0.63		0.63		0.63
26.0-18.6	1.43	0.19	1.24	0.35	0.89		0.89	0.08	0.81		0.81	0.02	0.79
18.6-13.1	2.24	0.46	1.78	0.35	1.43	0.01	1.42	0.08	1.34		1.34	0.08	1.26
13.1- 9.3	2.42	0.52	1.90	0.35	1.55	0.02	1.53	0.17	1.36	0.07	1.29	0.11	1.18
9.3- 6.6	2.64	0.52	2.12	0.35	1.77	0.03	1.74	0.25	1.49	0.12	1.37	0.11	1.26
6.6- 4.6	2.56	0.52	2.04	0.35	1.69	0.03	1.66	0.25	1.41	0.12	1.29	0.11	1.18
4.6- 3.3	2.52	0.57	1.95	0.35	1.60	0.02	1.58	0.17	1.41	0.12	1.29	0.11	1.18
3.3- 2.3	1.41	0.55	0.86	0.32	0.54	0.03	0.51	0.12	0.39	0.12	0.27	0.11	0.16
2.3- 1.6	1.08	0.54	0.53	0.19	0.34	0.03	0.31	0.05	0.26	0.12	0.14	0.06	0.08
1.6- 1.15	0.79	0.52	0.27	0.06	0.21	0.03	0.18	0.03	0.15	0.05	0.10	0.02	0.08
- 1.15	4.45	3.19	1.26	0.22	1.04	0.46	0.58	0.39	0.19	0.04	0.15	0.06	0.09
Total	22.55	7.61	14.94	3.17	11.77	0.66	11.11	1.67	9.44	0.76	8.68	0.79	7.89

*Calculated from image analysis data and metal recoveries on basis of total sphalerite in feed being 100%.

top curve shows that most of the free and unliberated sphalerite grains in the feed were from 3 to 25 μm and minus 1 μm in diameter respectively. The curve for the final zinc concentrate shows that most of the minus 1-μm grains, and indeed much of the minus 3-μm free sphalerite, was lost in the rougher and cleaner tailings.

To further evaluate size distribution of the sphalerite, the quantity of both free and unliberated sphalerite in the feed was made equal to 100% for each size range and the percentage removed in the successive tailings was subtracted from 100% to give values for sphalerite in the successive concentrates. These were plotted as frequency diagrams (Fig. 6). The curve for sphalerite in the final zinc concentrate shows that recovery of free sphalerite was 85% for grains 13.1 to 26 μm in diameter; that recovery dropped linearly to 75% for grains of 3.6 to 4.6 μm; dropped sharply to 42% for 1.15 to 3.6 μm and was 15% for minus 1.15 μm. A similar evaluation shows a lower recovery of unliberated sphalerite with nearly all the minus 3-μm unliberated sphalerite having been discarded (Fig. 6).

The curves in Fig. 6 show that free sphalerite grains of all sizes were lost in the rougher and first cleaner tailings. On the other hand, the free sphalerite lost in the second to fifth cleaner tailings was negligible in the coarser sizes but increased below 4 μm.

The percentages of free and unliberated sphalerite grains within each size range recovered in each cleaner concentrate from the feed to each cleaner, were calculated from the image analysis data and are listed in Tables 9 and 10. The results show that 96 to 97% of the free sphalerite of all sizes in the feed to each of the second, third, fourth and fifth cleaning stages, was recovered in the resulting concentrates. Lower recoveries were obrained in the rougher and first cleaner concentrates. The recovery of free sphalerite in all flotation cells was highest for grains larger than 3.3 μm in diameter and lowest for those of minus 1.15 μm. Recovery of unliberated sphalerite was not as systematic as recovery of free sphalerite. For example, the recovery of unliberated sphalerite from the second cleaner was abnormally high at 94% but this was offset by a low recovery of 85% from the third cleaner stage.

DISCUSSION AND CONCLUSIONS

Regrinding the BMS mill tailings from an initial fineness of 80% minus 54 μm to 80% minus 18 μm increased sphalerite liberation to 77.5% from 39% (3) and made it possible to produce a zinc concentrate with a grade of 45.5 wt % zinc with a recovery of 62%. Absolute zinc losses according to size in the tailings were as follows:

(1) plus 4.6-μm free sphalerite grains: 7% in the rougher and first cleaner tailings, plus 2.3% in the second to fifth cleaner tailings;
(2) 1.15 to 4.6-μm free sphalerite: 4.7% in the rougher and first cleaner tailings, plus 3.4% in the second to fifth cleaner tailings;
(3) plus 4.6-μm unliberated sphalerite: 4.3% in the rougher and first cleaner tailings, plus 1.5% in the second to fifth cleaner tailings;
(4) minus 1.15 μm free sphalerite: 2.2% in the rougher and first cleaner tailings, plus 3.8% in the second to fifth cleaner tailings;
(5) minus 4.6 μm unliberated sphalerite: 6.5% in the rougher and first cleaner tailings, plus 2.1% in the second to fifth cleaner tailings.

It is estimated that on recirculation in a continuous plant operation, up to 75% of the plus 4.6-μm free sphalerite 40% of the 1.15 to 4.6-μm free sphalerite, and 50% of the plus 4.6-μm unliberated sphalerite would be recovered. This would mean possible improvements of about 7%, 3%, and 3% in these size ranges respectively for a maximum of 13% higher recovery than was obtained in the batch test. Hence, it is predicted that the ultimate zinc recovery from the BMS mill tailings reground to 80% minus 18 μm could be 75% in a concentrate grading 40 to 45 wt % zinc. The zinc content in the final tailings would thus be about 0.6 wt % and the zinc tailings loss would be about 5% of the zinc in the mill feed. The ultimate zinc recovery would be lower for coarser grinds.

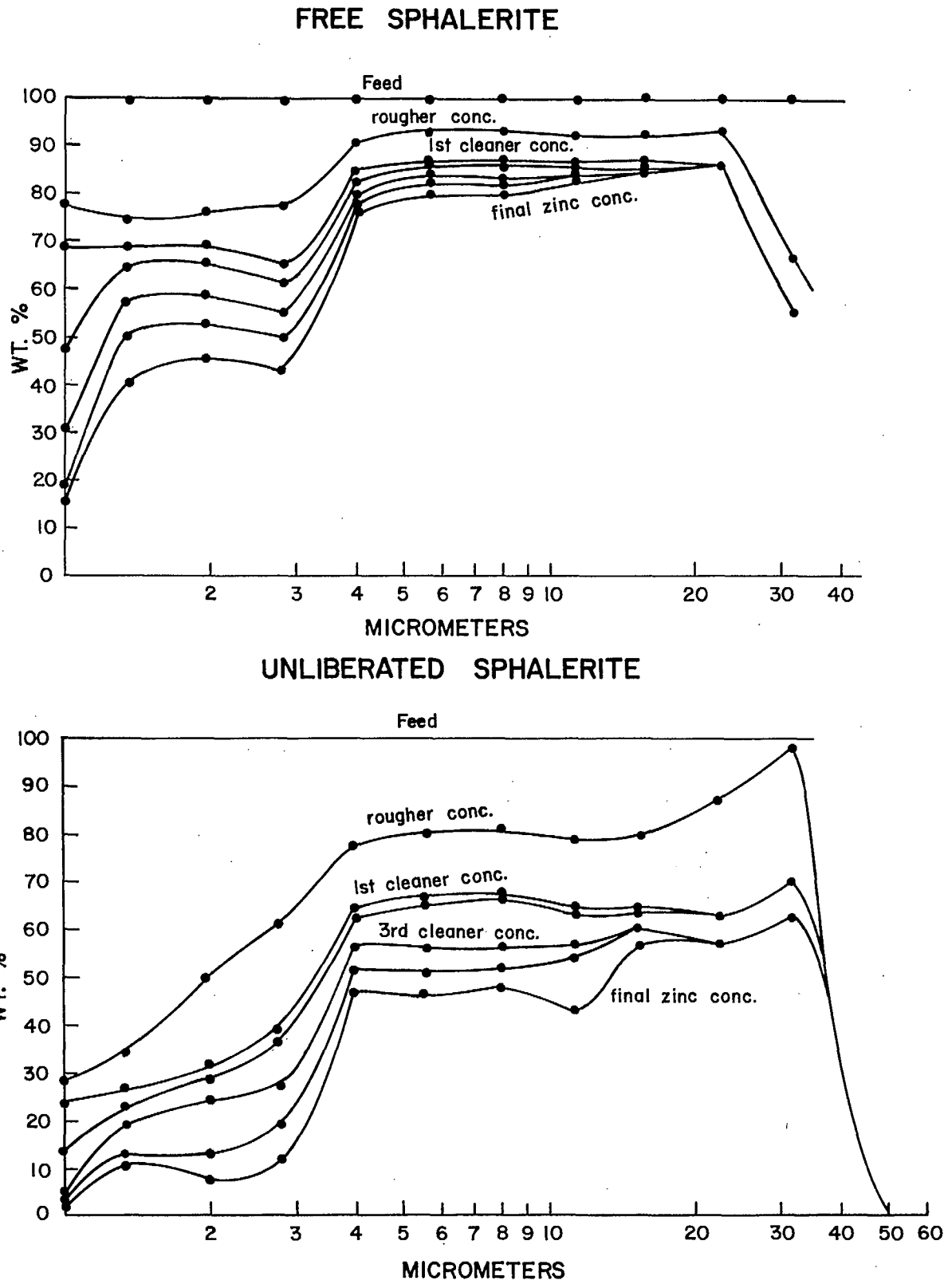


Fig. 6 - Frequency diagrams for sphalerite on basis of wt % at each size interval

Table 9 - Recovery of free sphalerite in zinc concentrates

Size range µm	Rougher conc from feed conc	1st cleaner conc from rougher conc	2nd cleaner conc from 1st cleaner conc	3rd cleaner conc from 2nd cleaner conc	4th cleaner conc from 3rd cleaner conc	5th cleaner conc from 4th cleaner conc	5th cleaner conc from feed conc
37.0-26.0	71	92	100	100	100	100	65
26.0-18.6	93	93	100	100	100	100	86
18.6-13.1	92	94	99	100	100	100	85
13.1- 9.3	92	94	99	99	100	97	83
9.3- 6.6	92	95	98	98	98	97	80
6.6- 4.6	92	94	99	98	98	97	80
4.6- 3.3	90	94	97	97	97	96	75
3.3- 2.3	76	85	94	90	90	86	42
2.3- 1.6	76	91	95	90	90	86	45
1.6- 1.15	74	93	95	88	87	81	40
- 1.15	78	88	69	64	65	77	15
all sizes	88	93	96	96	97	96	70

Table 10 - Recovery of unliberated sphalerite in zinc concentrates

Size range µm	Rougher conc from feed conc	1st cleaner conc from rougher conc	2nd cleaner conc from 1st cleaner conc	3rd cleaner conc from 2nd cleaner conc	4th cleaner conc from 3rd cleaner conc	5th cleaner conc from 4th cleaner conc	5th cleaner conc from feed conc
37.0-26.0	97	72	100	89	100	100	62
26.0-18.6	87	72	100	91	100	98	55
18.6-13.1	79	80	99	94	100	94	56
13.1- 9.3	79	82	99	88	95	91	49
9.3- 6.6	80	83	98	86	92	92	48
6.6- 4.6	80	83	98	85	91	91	46
4.6- 3.3	77	82	99	89	91	91	47
3.3- 2.3	61	63	94	76	69	59	11
2.3- 1.6	49	64	91	84	54	57	7
1.6- 1.15	34	78	86	83	67	80	10
- 1.15	28	83	56	33	79	60	2
all sizes	66	79	94	85	92	91	35

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