Section 1: Ore Dressing Investigations

TR15_147_155

R. 602. Ore dressing tests for Ardlethan Tin N.L.

Six samples of ore were received from the Company. These were current mill feed, White Crystal Ore, three samples from the area of Western Mineralisation and a composite of the last three samples.

The area of Western Mineralisation is presently under development. Tests were required to:

(1) Obtain a comparison of the responses of this ore and current mill feed to concentration procedures similar to those used in the Ardlethan Mill, and

(2) Determine the differences in the grindabilities of the various types of ore.

HEAD ASSAYS

Reg. No.	Sample No.	Description	Assay % Sn	Cu
692252	A	Current Ardlethan Mill Feed	0.50	0.06
692253	B	White Crystal Ore	0.48	0.05
692254	C	*Western Mineralisation*		
		RL 700-600	0.30	0.10
692255	D	RL 600-500	0.69	0.20
692256	E	RL 500-400	0.75	0.15
692257	F	Composite	-	-

Sample F was not treated and was held pending the outcome of concentration tests on other samples.

TREATMENT METHODS

All samples were treated in a similar manner. The method was as follows:

Ore Preparation and Sampling

The whole samples were stage roll crushed to minus -18# ore. Samples for assay, sizing and grindability tests were obtained by riffling from the -18# ore.

Concentration

The -18# ore, after extraction of the required samples, was used for the concentration tests. The following procedure was adopted:

(a) The ore was sized by screening on 30, 52, 100 and 200#.

(*b*) The fractions were tabled separately to produce a low grade concentrate and a clean tailing.

(*c*) The low grade concentrate was retabled to a sulphide-cassiterite concentrate, a middling and a further small quantity of tailing which was added to the tailing from the first tabling.

(*d*) The three products from each sample were assayed for tin and copper and the metal balances calculated.

Concentrate Cleaning (Applicable to Samples A, C, D, E)

(*a*) Composites were made from the sulphide-cassiterite concentrates obtained as above.

(*b*) Each composite was ball mill ground to -85#, sulphides removed by cleaner froth flotation and the flotation tailing gravity concentrated to produce concentrates of about 50% Sn. In the case of Sample A the concentrate grade was too low (29.0% Sn) and this product was further concentrated by hand panning (Retabling was not feasible because of the small amount of concentrate available).

(*c*) The products were assayed and the tin and copper recoveries calculated.

Flotation Conditions

	Rougher	*Cleaner*
Sulphuric acid	0.6 lb/ton	0.2 lb/ton
Copper sulphate	0.2 lb/ton	-
Sodium ethyl xanthate	0.2 lb/ton	0.1 lb/ton
Potassium amyl xanthate	0.2 lb/ton	0.1 lb/ton
Flotation time	7 min.	5 min.

Grindability Tests

Bond's Equation $W = \frac{10\ Wi}{\sqrt{P}} - \frac{10\ Wi}{\sqrt{F}}$ was used for the determination of the relative grindabilities of the various types of ore. The necessary data were obtained as follows:

(*a*) From the sizing analyses of the -18# feed samples, curves were plotted to obtain the aperture at which 80% passes (F µm).

(*b*) Several 1 kg charges of Sample A (-18#) were ball mill ground with a fixed weight of water and balls for various times. The ground products were screened on 200# and a grinding time established to give a product 45-50% -200#.

(*c*) The product was then sized and a curve plotted to obtain the aperture at which 80% passes (P µm).

(*d*) Using the grinding time found for Sample A the procedure was repeated in duplicate on Samples B, C, D, E.

(*e*) From the data obtained it was possible to calculate relative work indices for Samples B, C, D and E after assigning an arbitrary value to Sample A.

Fixed Conditions for Grinding

Ball Mill	Warman 8 in x 8 in, 60 rpm.
Ore	1 kg
Water	430 g
Ball load	10 kg
Time (Found by experiment on Sample A)	6 min.

TEST RESULTS

Primary Concentration

Table 1. SAMPLE A, Reg. No. 692252

Product	% Wt	Assays		Distribution %	
		% Sn	% Cu	Sn	Cu
+ 52# TC	2.0	4.11	0.16	15.6	5.6
100# TC	0.9	6.57	0.24	11.2	3.9
200# TC	0.9	8.55	0.30	14.5	4.8
-200# TC	0.6	8.40	0.22	9.5	2.3
Total TC	4.4	(6.10)	(0.21)	50.8	16.6
+ 30# TM	4.1	1.91	0.10	14.8	7.2
52# TM	5.5	0.38	0.04	4.0	3.9
100# TM	1.1	0.20	0.04	0.4	0.7
200# TM	1.0	0.53	0.10	0.9	1.8
-200# TM	1.3	0.28	0.08	0.7	1.8
Total TM	13.0	(0.85)	(0.07)	20.8	15.4
+ 30# TT	27.8	0.21	0.04	11.0	19.6
52# TT	18.6	0.16	0.03	5.6	9.9
100# TT	11.4	0.19	0.04	4.1	8.1
200# TT	10.2	0.08	0.04	1.6	7.2
-200# TT	14.6	0.22	0.09	6.1	23.2
Total TT	82.6	(0.18)	(0.05)	28.4	68.0
Total TC	4.4	(6.10)	(0.21)	50.8	16.6
Total TM	13.0	(0.85)	(0.07)	20.8	15.4
Total TT	82.6	(0.18)	(0.05)	28.4	68.0
Head	100.0	(0.53)	(0.06)	100.0	100.0
Assay Head		0.50	0.06		

Table 2. SAMPLE B, Reg. No. 692253

Product	% Wt	Assays % Sn	Assays % Cu	Distribution % Sn	Distribution % Cu
+ 52# TC	1.7	3.73	0.24	12.9	8.9
100# TC	1.6	4.20	0.25	13.7	8.7
200# TC	0.6	8.18	0.23	10.0	3.0
-200# TC	0.9	6.42	0.18	11.8	3.5
Total TC	4.8	(4.95)	(0.23)	48.4	24.1
+ 30# TM	4.7	1.40	0.12	13.4	12.1
52# TM	3.3	0.45	0.05	3.0	3.7
100# TM	2.0	0.43	0.05	1.7	2.2
200# TM	1.1	0.83	0.16	1.9	3.9
-200# TM	1.2	0.25	0.08	0.6	2.2
Total TM	12.3	(0.82)	(0.09)	20.6	24.1
+ 30# TT	25.0	0.22	0.02	11.2	10.8
52# TT	20.6	0.18	0.02	7.5	8.9
100# TT	13.7	0.11	0.02	3.1	5.9
200# TT	8.7	0.09	0.02	1.6	3.7
-200# TT	14.9	0.25	0.07	7.6	22.5
Total TT	82.9	(0.18)	(0.03)	31.0	51.8
Total TC	4.8	(4.95)	(0.23)	48.4	24.1
Total TM	12.3	(0.82)	(0.09)	20.6	24.1
Total TT	82.9	(0.18)	(0.03)	31.0	51.8
Head	100.0	(0.49)	(0.05)	100.0	100.0
Assay Head		0.48	0.05		

Table 3. SAMPLE C, Reg. No. 692254

Product	% Wt	Assays % Sn	Assays % Cu	Distribution % Sn	Distribution % Cu
+ 52# TC	1.5	4.09	0.60	18.9	9.0
100# TC	0.8	5.99	1.08	14.8	8.6
200# TC	0.5	7.29	1.82	11.2	9.0
-200# TC	0.4	6.73	2.16	8.3	8.6
Total TC	3.2	(5.39)	(1.10)	53.2	35.2
+ 30# TM	4.3	1.57	0.23	20.8	9.8
52# TM	3.3	0.17	0.10	1.7	3.3
100# TM	1.5	0.21	0.13	1.0	2.0

Table 3 - continued

Product	% Wt	Assays % Sn	Assays % Cu	Distribution % Sn	Distribution % Cu
+200# TM	1.3	0.10	0.14	0.4	1.8
-200# TM	0.9	0.11	0.16	0.3	1.4
Total TM	11.3	(0.70)	(0.16)	24.2	18.3
+ 30# TT	28.0	0.10	0.05	8.6	13.9
52# TT	22.4	0.08	0.04	5.5	9.0
100# TT	13.0	0.07	0.03	2.8	3.9
200# TT	7.5	0.03	0.03	0.7	2.3
-200# TT	14.6	0.11	0.12	5.0	17.4
Total TT	85.5	(0.09)	(0.06)	22.6	46.5
Total TC	3.2	(5.39)	(1.10)	53.2	35.2
Total TM	11.3	(0.70)	(0.16)	24.2	18.3
Total TT	85.5	(0.09)	(0.06)	22.6	46.5
Head	100.0	(0.32)	(0.10)	100.0	100.0
Assay Head		0.30	0.10		

Table 4. SAMPLE D, Reg. No. 692255

Product	% Wt	Assays % Sn	Assays % Cu	Distribution % Sn	Distribution % Cu
+ 52# TC	1.8	8.80	1.79	21.6	15.6
100# TC	1.0	9.65	2.34	13.2	11.3
200# TC	0.8	11.0	3.22	12.0	12.5
-200# TC	0.4	12.9	3.13	7.1	6.1
Total TC	4.0	(9.86)	2.35	53.9	45.5
+ 30# TM	3.7	3.61	0.89	18.2	16.0
52# TM	4.6	0.46	0.18	2.9	4.0
100# TM	1.7	0.33	0.14	0.8	1.2
200# TM	1.1	0.22	0.20	0.3	1.1
-200# TM	1.0	0.50	0.23	0.7	1.1
Total TM	12.1	(1.39)	(0.40)	22.9	23.4
+ 30# TT	28.5	0.25	0.06	9.7	8.3
52# TT	21.5	0.18	0.06	5.3	6.2
100# TT	11.5	0.12	0.05	1.9	2.8
200# TT	8.8	0.10	0.06	1.2	2.6
-200# TT	13.6	0.27	0.17	5.1	11.2

Table 4 - continued

Product	% Wt	Assays % Sn	Assays % Cu	Distribution % Sn	Distribution % Cu
Total TT	83.9	(0.20)	(0.08)	23.2	31.1
Total TC	4.0	(9.86)	(2.35)	53.9	45.5
Total TM	12.1	(1.39)	(0.40)	22.9	23.4
Total TT	83.9	(0.20)	(0.08)	23.2	31.1
Head	100.0	(0.73)	(0.21)	100.0	100.0
Assay Head		0.69	0.20		

Table 5. SAMPLE E, Reg. No. 692256

Product	% Wt	Assays % Sn	Assays % Cu	Distribution % Sn	Distribution % Cu
+ 52# TC	1.6	9.74	1.27	19.7	14.6
100# TC	0.8	10.1	1.72	10.2	9.9
200# TC	0.4	17.9	3.21	9.1	9.2
-200# TC	0.5	14.7	2.62	9.3	9.3
Total TC	3.3	(11.57)	(1.82)	48.3	43.0
+ 30# TM	4.9	3.19	0.38	19.8	13.3
52# TM	5.2	0.48	0.10	3.2	3.7
100# TM	1.2	0.36	0.08	0.5	0.7
200# TM	1.0	0.28	0.15	0.3	1.1
-200# TM	1.3	0.38	0.25	0.6	2.3
Total TM	13.6	(1.42)	(0.22)	24.4	21.1
+ 30# TT	27.9	0.33	0.04	11.6	8.0
52# TT	21.9	0.23	0.05	6.4	7.9
100# TT	10.8	0.19	0.05	2.6	3.9
200# TT	7.7	0.11	0.06	1.1	3.3
-200# TT	14.8	0.30	0.12	5.6	12.8
Total TT	83.1	(0.26)	(0.06)	27.3	35.9
Total TC	3.3	(11.57)	(1.82)	48.3	43.0
Total TM	13.6	(1.42)	(0.22)	24.4	21.1
Total TT	83.1	(0.26)	(0.06)	27.3	35.9
Head	100.0	(0.79)	(0.14)	100.0	100.0
Assay Head		0.75	0.15		

Concentrate Cleaning

Table 6. CONCENTRATE CLEANING RESULTS

Sample	Product	% Wt	Assays % Sn	Assays % Cu	Distribution % Sn	Distribution % Cu
	Pan Conc.	10.7	41.8		74.9	
A	Pan Tail.	5.8	5.36		5.2	
692252	FT Total TC	16.5	29.0	0.07	80.1	5.8
	FT Total TT	70.6	1.63	0.05	19.2	17.5
	FC	12.9	0.31	1.20	0.7	76.7
	Composite	100.0	5.98	0.20	100.0	100.0
	FT Total TC	8.6	47.2	0.32	77.8	2.4
C	FT Total TT	56.7	1.78	0.09	19.4	4.5
692254	FC	34.7	0.42	3.14	2.8	93.1
	Composite	100.0	5.21	1.17	100.0	100.0
	FT Total TC	18.4	49.5	0.16	88.8	1.2
D	FT Total TT	54.3	1.79	0.08	9.5	1.9
692255	FC	27.3	0.65	8.27	1.7	96.9
	Composite	100.0	10.26	2.33	100.0	100.0
	FT Total TC	20.6	48.7	0.12	86.1	1.4
E	FT Total TT	68.8	2.22	0.08	13.1	3.0
692256	FC	10.6	0.90	16.4	0.8	95.6
	Composite	100.0	11.66	1.82	100.0	100.0

Grindability

Bond's Equation $$W = \frac{10\ Wi}{\sqrt{P}} - \frac{10\ Wi}{\sqrt{F}}$$

Where W = work input in kWh/short ton of feed

P = size of product in µm (80% passes P µm aperture)

F = size of feed in µm (80% passes F µm aperture)

Wi = work index

In comparative tests W is constant.

$$Wi = K \frac{\sqrt{P}\ \sqrt{F}}{(\sqrt{F}-\sqrt{P})}$$ where K = constant

An arbitrary value of 25 for Wi was assigned to Sample A and using the values for P and F the value of K was calculated at 0.878.

With this value of K the Wi values relative to 25 were calculated for the other samples. These are:

Sample	A	B	C	D	E
Wi	25	26.3	26.4	25.6	25.9

The grindability of all samples is very similar.

Sizings

Table 7. SIZINGS OF FEED SAMPLES

Size		A		B		C		D		E	
#	µm	% Wt	% Wt Cum.	% Wt	% Wt Cum.	% Wt	% Wt Cum.	% Wt	% Wt Cum.	% Wt	% Wt Cum.
+22	+710	5.4	5.4	4.9	4.9	5.9	5.9	5.7	5.7	6.6	6.6
25	600	9.4	14.8	8.1	13.0	8.9	14.8	8.4	14.1	8.7	15.3
30	500	14.7	29.5	14.1	27.1	14.1	28.9	14.6	28.7	14.3	29.6
36	420	10.8	40.3	10.5	37.6	10.5	39.4	10.3	39.0	10.3	39.9
44	355	6.7	47.0	6.9	44.5	7.0	46.4	6.8	45.8	6.7	46.6
52	300	6.6	53.6	6.4	50.9	6.5	52.9	6.5	52.3	6.5	53.1
100	150	18.6	72.2	19.8	70.7	19.9	72.8	20.0	72.3	19.7	72.8
200	75	10.7	82.9	11.7	82.4	11.3	84.1	11.5	83.8	11.5	84.3
-200	-75	17.1	100.0	17.6	100.0	15.9	100.0	16.2	100.0	15.7	100.0
		100.0		100.0		100.0		100.0		100.0	

Table 8. SIZINGS OF PRODUCT SAMPLES

Size		A		B		C		D		E	
#	µm	% Wt	% Wt Cum.	% Wt	% Wt Cum.	% Wt	% Wt Cum.	% Wt	% Wt Cum.	% Wt	% Wt Cum.
+52	+300	1.7	1.7	2.1	2.1	2.2	2.2	2.1	2.1	2.4	2.4
60	250	3.5	5.2	3.9	6.0	4.1	6.3	3.9	6.0	4.1	6.5
72	210	3.7	8.9	4.0	10.0	4.4	10.7	4.0	10.0	4.2	10.7
85	180	7.2	16.1	7.7	17.7	7.5	18.2	7.3	17.3	7.5	18.2
100	150	9.9	26.0	10.2	27.9	10.1	28.3	10.0	27.3	10.1	28.3
150	105	14.9	40.9	15.8	43.7	15.2	43.5	15.6	42.9	15.3	43.6
200	75	11.9	52.8	12.5	56.2	11.5	55.0	12.1	55.0	11.6	55.2
-200	-75	47.2	100.0	43.8	100.0	45.0	100.0	45.0	100.0	44.8	100.0
		100.0		100.0		100.0		100.0		100.0	

Analyses of Final Concentrates

	Assays %					
Sample/Product	*Sn*	*Cu*	*S*	*Fe*	*Pb*	WO_3
C 692254						
Total TC	47.2	0.32	2.85	5.65	0.12	0.15
D 692255						
Total TC	49.5	0.16	1.81	6.93	0.10	0.44
E 692256						
Total TC	48.7	0.12	0.62	6.54	0.04	0.36

Samples of the above three concentrates have been forwarded to the Australian Mineral Development Laboratories for qualitative spectrographic analysis.

Silver Content of Sulphide Concentrates

Sample/Product	*Silver, oz/ton*
A 692252 FC	7.0
C 692254 FC	3.3
D 692255 FC	7.3
E 692256 FC	13.8

COMMENTS

The test work has been restricted to that suggested by the company to provide comparative figures of tin recoveries from the various types of ore.

No attempt has been made to achieve optimum recoveries, which involves retreatment of all middlings including the +30# material from which no concentrate was made.

All samples show a fairly similar response to concentration procedures in the rougher stages.

Some difficulty was experienced in obtaining an acceptable grade of final concentrate from current mill feed (Sample A). The reason for this is beyond the scope of this investigation and has therefore not been determined. However, the results indicate that rougher concentrates from Western Mineralisation ore are significantly easier to upgrade than the current mill feed.

The grindabilities of all samples were found to be similar.