

TR16-257-267

R.618. Rock, sand and clay from Balfour: examination and tin concentration tests.

Four samples were submitted by K. Jaeger, Smithton, for examination and testing to determine suitable procedures for concentration of the contained tin. Mr Jaeger also requested suggestions as to what type of equipment would be required to implement the recommended concentration procedures. The samples were described as follows:

Reg. No. 702643. Sample No. 1. Rock: Surface to 0.87 m down; dump near shaft.

Reg. No. 702544. Sample No. 2. Sand: Just under surface; 'clayey' sand.

Reg. No. 702645. Sample No. 3. Sand: Just under surface.

Reg. No. 702747. Sample No. 4. No description. The sample consisted of three unlabelled bags. The following system of identification was adopted. A (separate bag) sand and clay; B (inside bag) sand and clay; C (outside bag) mostly clay.

PRELIMINARY EXAMINATION

Sample No. 1 (rock)

The sample was jaw crushed to approximately $-\frac{3}{8}$ inch and test and assay samples cut out by riffing.

Assay: 5.7% Sn

The $-\frac{3}{8}$ inch test sample was sized and the fractions submitted to heavy liquid sink/float separation at a specific gravity of 2.95.

Results of Sizing and Heavy Liquid Separation

Size/Product	% Wt	% Sn	% Sn recovery of individual sizes	
			% Sn Distn	
+5# F/T	38.9	3.70	25.9	60.5
S/K	3.4	27.6	16.9	39.5
+5# Comp.	42.3	5.62	42.8	100.0
+10# F/T	17.3	2.66	8.3	47.2
S/K	1.8	28.8	9.3	52.8
+10# Comp.	19.1	5.12	17.6	100.0
+22# F/T	12.4	2.55	5.7	46.3
S/K	1.0	36.8	6.6	53.7
+22# Comp.	13.4	5.11	12.3	100.0
+44# F/T	6.9	2.07	2.6	37.1
S/K	0.6	40.6	4.4	62.9
+44# Comp.	7.5	5.15	7.0	100.0
+60# F/T	2.8	1.77	0.9	36.0
S/K	0.2	45.6	1.6	64.0
+60# Comp.	3.0	4.69	2.5	100.0
-60# Untreated	14.7	6.72	17.8	-
Head	100.0	5.56	100.0	-

The results from this test indicate that grinding to -60# is required to achieve substantial liberation of the tin mineral from the gangue. However, a significant amount of free cassiterite was observed in the +5 and +10# sink fractions which could be recovered at a relatively coarse stage in crushing and grinding operations.

Sample No. 2 (sand)

The sample consisted of white easily dispersed sand with a few small pebbles. The sample was partly dried, crushed to break aggregates and samples for assay and testing cut out by riffing.

Assay: 0.96% Sn

Sizing Analysis

Fraction	% Wt	% Sn	% Sn Distn	Cumulative % Sn Distn
+22#	6.0	0.30	1.9	1.9
+52#	12.9	0.61	8.2	10.1
+100#	10.2	1.02	10.8	20.9
+200#	15.9	1.61	26.7	47.6
C/S1	2.3	14.8	35.4	83.0
C/S2	4.9	1.08	5.5	88.5
C/S3	6.4	0.66	4.4	92.9
C/S4	5.3	0.66	3.6	96.5
C/S5	2.5	0.52	1.4	97.9
C/S6	33.6	0.06	2.1	100.0
Head	100.0	0.96	100.0	-

The above sizing analysis shows that 88.5% of the tin is coarser than 18 μ m (C/S2). Most of this tin should be recoverable by gravity concentration.

The examination also shows that 33.6% of the total weight is finer than 12 μ m (equivalent quartz diameter). It should be possible to eliminate this fraction by hydrocyclone without loss of recoverable tin.

A slacking test in water showed that the material broke down without difficulty.

Visual examination indicated that the tin was substantially in the free state in all sizes.

Sample No. 3 (sand)

The sample is a white sand, similar to No. 2, somewhat coarser and containing significant quantities of rock fragments from 3 mm to 25 mm in size.

The preliminary examination consisted of drying, screening on $\frac{1}{8}$ inch mesh to eliminate rock, assay of $+\frac{1}{8}$ inch and $-\frac{1}{8}$ inch and sizing of $-\frac{1}{8}$ inch sand.

Result of $\frac{1}{8}$ inch screening

Product	% Wt	% Sn	% Sn Distn
'Rock' $+\frac{1}{8}$ inch	18.3	0.35	6.3
'Sand' $-\frac{1}{8}$ inch	81.7	1.16	93.7
Composite Head	100.0	1.01	100.0

Sizing Analysis of $-\frac{1}{8}$ inch sand

Fraction	Weight			% Sn Distn		% Sn Distn
	Ind.	O'all	% Sn	Ind.	O'all	O'all Cum.
+22	7.6	6.2	0.52	3.4	3.2	9.5 (includes $+\frac{1}{8}$ inch)
+52#	17.4	14.2	0.61	9.2	8.6	18.1
+100#	12.1	9.9	0.88	9.2	8.6	26.7
+200#	22.1	18.1	1.12	21.3	20.0	46.7
C/S1	6.6	5.4	6.42	36.5	34.2	80.9
C/S2	6.5	5.3	1.38	7.7	7.2	88.1
C/S3	8.3	6.8	0.85	6.1	5.7	93.8
C/S4	7.1	5.8	0.78	4.8	4.5	98.3
C/S5	3.0	2.4	0.57	1.5	1.4	99.7
C/S6	9.3	7.6	0.04	0.3	0.3	100.0
Head	100.0	81.7	1.16	100.0	93.7	-

Rock fragments account for 18.3% of the total sample and contain 6.3% of the total tin at an assay of 0.35% Sn. Crushing and grinding would be required for the recovery of this tin.

The $-\frac{1}{8}$ inch sand sizing shows that 87.3% of the tin in this fraction is coarser than 18 μ m and should be recoverable by gravity concentration.

The material breaks down easily in water and the tin is mostly in the free state in all sizes.

Sample No. 4, A, B, C (sand and clay)

Preliminary examinations consisted of drying, sampling for assay and test requirements, sizing and disintegration tests.

Assays: A 2.53% Sn; B 1.27% Sn; C 1.15% Sn

Sizing Analyses

The sizings (Table 1) show that in each sample more than 80% of the tin is in the recoverable size range and is substantially free in all sizes. Amounts ranging from 46% to 80% by weight of total sample are -12μ m and could be eliminated by cycloning without loss of recoverable tin.

Disintegration tests indicate that dispersion in water can be achieved by suitable agitation.

Summary and Conclusions

The samples can be divided into three types, namely rock, sand, and clay with sand; each of which requires a different procedure to get the ore into a slurry form from which concentration of the tin can take place.

Table 1. SIZING ANALYSES, SAMPLE No. 4

Fraction	A				B				C			
	% Wt	% Sn	% Sn Distn	% Sn Distn Cumulative	% Wt	% Sn	% Sn Distn	% Sn Distn Cumulative	% Wt	% Sn	% Sn Distn	% Sn Distn Cumulative
+22#	1.7	1.16	0.8	0.8	2.5	Trace	Trace	Trace	3.9	0.44	1.5	1.5
+52#	7.3	1.28	3.7	4.5	5.2	0.85	3.5	3.5	4.3	3.34	12.5	14.0
+100#	9.6	3.91	14.8	19.3	5.7	0.80	3.6	7.1	2.8	5.97	14.5	28.5
+200#	15.6	5.95	36.7	56.0	10.5	3.04	25.1	32.2	2.5	8.46	18.4	46.9
C/S1	5.2	15.50	31.9	87.9	6.2	9.91	48.4	80.6	1.4	24.9	30.3	77.2
C/S2	4.2	1.84	3.0	90.9	5.8	1.28	5.9	86.5	0.8	6.57	4.6	81.8
C/S3	4.1	1.24	2.0	92.9	7.8	0.72	4.4	90.9	0.9	5.55	4.4	86.2
C/S4	3.0	0.85	1.0	93.9	7.0	0.49	2.7	93.6	0.8	4.21	2.9	89.1
C/S5	1.3	0.53	0.3	94.2	2.9	0.44	1.0	94.6	0.4	2.61	0.9	90.0
C/S6	48.0	0.31	5.8	100.0	46.4	0.15	5.4	100.0	82.2	0.14	10.0	100.0
Head	100.0	2.53	100.0		100.0	1.27	100.0		100.0	1.15	100.0	

Slacking Tests in Water: A. Easily dispersed; B. Easily dispersed; C. Mostly clay - difficult to disperse, but dispersion can be achieved by suitable agitation.

These examinations clearly indicate the required treatment procedures.

The sizing analyses of the decomposed materials show that the tin occurs in the comparatively narrow size range of 150 μ m (100#) and 18 μ m (C/S2). Cassiterite in this size range is too fine for sluicing or streaming but is ideal for tabling operations.

The rock sample obviously requires crushing and grinding and the heavy liquid separations of sized fractions indicate that grinding to -60# is needed to achieve substantial liberation of the tin. As with the other material, tables would be required for tin concentration. Some relatively coarse cassiterite is present and should be recovered by the use of a jig in the grinding circuit.

The sand samples require slurring by suitable agitation followed by screening at about 60# to eliminate material too coarse for the subsequent treatment of sizing and tabling. The +60# material requires crushing and/or grinding, sizing and tabling for maximum overall tin recovery. Sample No. 2 contains a considerable amount (33.6%) of very fine clay-like material which is removable by hydraulic cyclone without loss of recoverable tin.

Sample No. 4 (A, B, and C) which has an average clay content of 55% requires similar treatment to sands Nos. 2 and 3. Dispersion to slurry form is somewhat more difficult but can be achieved by suitably violent agitation.

The operations of sizing (by hydrosizer) and table concentration would be common to all samples.

CONCENTRATION TESTS

These tests were made along the lines indicated by the preliminary examinations detailed above.

Sample No. 1 (rock)

Crushing: The sample was jaw and roll crushed to approximately $-\frac{1}{8}$ inch.

Coarse tin recovery: The $-\frac{1}{8}$ inch ore was screened on 30 and 60# and the +30 and +60# fractions concentrated by jigging.

Grinding: The jig tailings were ball mill ground by closed circuit grinding to -60# and added to the -60# from the first screening.

Sizing: The -60# material was deslimed by hydraulic cyclone and the cyclone underflow fed to a three spigot Geco hydrosizer.

Concentration: The four hydrosizer products were concentrated separately by tabling to give concentrates middlings and tailings from the three spigot products, and concentrate and tailing only from the hydrosizer overflow.

Test Results

Product	% Wt	% Sn	% Sn Distn
+30# JC	1.41	48.7	12.4
-30 +60# JC	0.64	58.7	6.8
Total JC	2.05	(51.8)	19.2
S1 TC	3.51	52.9	33.6
TM	2.96	1.86	1.0
TT	16.73	1.29	3.9
S1 Composite	23.20	(9.17)	38.5
S2 TC	2.21	41.3	16.5
TM	6.44	1.74	2.0
TT	25.16	0.75	3.4
S2 Composite	33.81	(3.59)	21.9
S3 TC	1.14	32.4	6.7
TM	3.26	1.26	0.7
TT	15.54	0.58	1.6
S3 Composite	19.94	(2.51)	9.0
O/F TC	1.87	24.0	8.1
TT	12.67	1.38	3.2
O/F Composite	14.54	(4.29)	11.3
C O/F	6.46	0.06	0.1
Head	100.0	(5.53)	100.0

The test results may be summarised as follows:

Product	% Wt	% Sn	% Sn Distn
Total JC	2.05	51.8	19.2
Total TC	8.73	41.1	64.9
Total Concentrates	10.78	43.1	84.1
Middling	12.66	1.64	3.7
Tailing	76.56	0.88	12.2
Composite Head	100.0	5.53	100.0

Sample No. 2 (sand and clay)

Disintegration: Disintegration and dispersion was achieved without difficulty by moderate agitation in water.

Grinding: The dispersed pulp was wet screened on 60# and the +60# material stage ball mill ground to pass that screen.

Desliming: The pulp was deslimed by hydraulic cycloning. The clay fraction was almost completely removed in this operation.

Sizing and Concentration: The procedure used for Sample 1 was followed.

Test Results

Product	% Wt	% Sn	% Sn Distn
S1 TC	0.91	44.3	37.5
TM	2.33	0.24	0.5
TT	8.12	0.15	1.1
S1 Composite	11.36	(3.70)	39.1
S2 TC	0.70	38.0	24.7
TM	3.54	0.75	2.5
TT	15.59	0.11	1.6
S2 Composite	19.83	(1.53)	28.8
S3 TC	0.45	40.3	16.9
TM	1.70	0.31	0.5
TT	19.81	0.08	1.5
S3 Composite	21.96	(0.92)	18.9
O/F TC	0.15	29.7	4.2
TT	16.67	0.35	5.4
O/F Composite	16.82	(0.61)	9.6
C O/F	30.03	0.13	3.6
Composite Head	100.0	(1.07)	100.0

The test results may be summarised as follows:

Product	% Wt	% Sn	% Sn Distn
Total Concentrate	2.21	40.5	83.3
Total Middling	7.57	0.50	3.5
Total Tailing	90.22	0.16	13.2
Composite Head	100.0	1.07	100.0

Sample No. 3 (sand and rock)

Crushing: Rock fragments were removed by screening on $\frac{1}{8}$ inch # and then jaw and roll crushed to pass this size.

Grinding: The $\frac{1}{8}$ inch ore was wet screened on 60# and the +60# fraction stage ball mill ground to pass this mesh.

Sizing and Concentration: The procedure used for Sample 1 was followed.

Test Results

Product	% Wt	% Sn	% Sn Distn
S1 TC	0.59	43.3	22.4
TM	3.78	0.08	0.3
TT	8.52	0.10	0.9
S1 Composite	12.89	(1.68)	23.6
S2 TC	0.54	39.3	23.1
TM	3.75	0.12	0.5
TT	17.05	0.07	1.3
S2 Composite	21.34	(1.07)	24.9
S3 TC	0.55	41.4	24.8
TM	1.88	0.34	0.7
TT	33.86	0.14	5.2
S3 Composite	36.29	(0.78)	30.7
O/F TC	0.20	32.4	7.1
TT	29.28	0.43	13.7
O/F Composite	29.48	(0.65)	20.8
Composite Head	100.0	(0.92)	100.0

The test results may be summarised as follows:

Product	% Wt	% Sn	% Sn Distn
Total Concentrate	1.88	37.8	77.4
Total Middling	9.41	0.15	1.5
Total Tailing	88.71	0.22	21.1
Composite Head	100.0	0.92	100.0

Sample No. 4, A, B, C (clay)

Sample: The sample for testing was made up of equal weights of the samples A, B and C and described elsewhere in this report.

Disintegration: Disintegration and dispersion was achieved by relatively violent agitation in water. The addition of 5 lb/ton of sodium silicate as a dispersant was found beneficial.

Recovery of Coarse Tin: The pulp was screened on 7, 22 and 60# and the +22 and +60# fraction jigged separately to recover any coarse tin present. The +7# material was not treated and the +22 +60# jig tailings were not further treated.

Desliming: The -60# pulp was deslimed by hydraulic cycloning. The clay fraction was almost completely removed by this operation.

Sizing and Concentration: The procedure used for Sample 1 was followed.

Test Results

Product	% Wt	% Sn	% Sn Distn
+7#	2.24	0.45	0.6
-7 +22# JC	0.12	12.3	0.9
JT	4.03	0.43	1.1
-7 +22# Comp.	4.15	(0.77)	2.0
-22 +60# JC	0.24	41.0	6.1
JT	5.53	0.69	2.4
-22 +60# Comp.	5.77	(2.39)	8.5
S1 TC	1.63	54.9	55.2
TM	0.73	0.68	0.3
TT	3.47	0.21	0.4
S1 Comp.	5.83	(15.5)	55.9
S2 TC	0.51	41.9	13.2
TM	0.33	0.53	0.1
TT	5.79	0.07	0.3
S2 Comp.	6.63	(3.32)	13.6
S3 TC	0.39	40.5	9.7
TM	0.34	0.61	0.1
TT	7.46	0.10	0.5
S3 Comp.	8.19	(2.03)	10.3
O/F TC	0.05	58.4	1.8
TT	5.07	0.73	2.3
O/F Comp.	5.12	(1.31)	4.1
C O/F	62.07	0.13	5.0
Comp. Head	100.0	(1.62)	100.0

The test results may be summarised as follows:

Product	% Wt	% Sn	% Sn Distn
Total JC	0.36	31.8	7.0
Total TC	2.58	50.2	79.9
Total Concentrate	2.94	48.0	86.9
Total Middling	1.40	0.64	0.5
Total Tailing	93.42	0.21	12.0
+7# Untreated	2.24	0.45	0.6
Composite Head	100.0	1.62	100.0

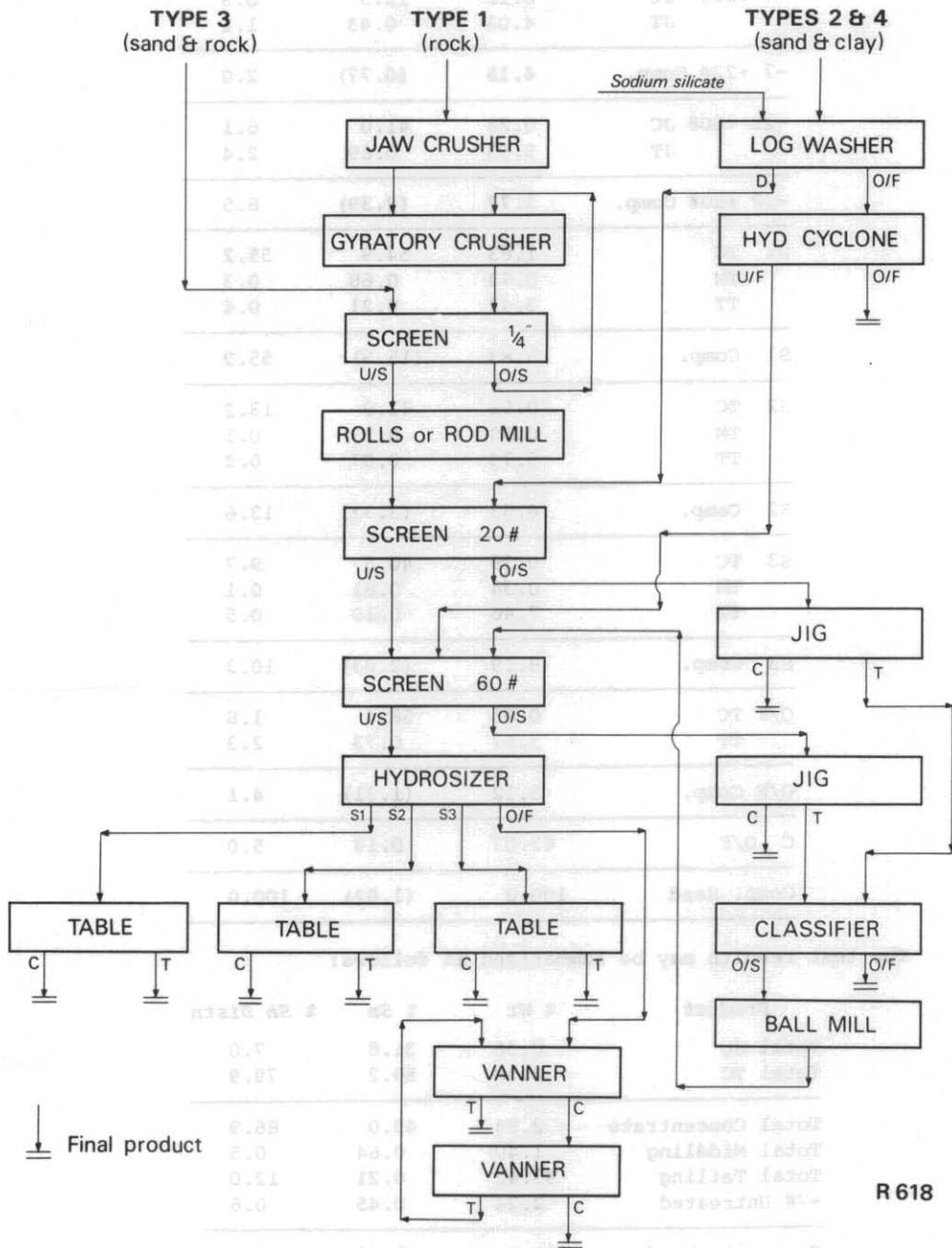


Figure 81. R.618 flowsheet.

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Summary of Concentration Tests

The tests have not been taken beyond the stage of primary concentration but the work done demonstrates the feasibility of producing tin concentrates by the method described.

Tin recoveries range from 77 to 87% in primary concentrates assaying from 38 to 48% tin.

It is expected that sale grade concentrates would be produced from primary concentrates by sizing and gravity concentration with not more than 5% depreciation in overall recoveries. Products from upgrading operations would need to be recirculated to primary concentrating units.

The amounts of tin in most middling products are not really significant and could be regraded as tailings.

An alternative procedure would be to take finished concentrates in primary operations together with higher grade middlings requiring further treatment. This procedure would have the merit of not requiring a separate concentrate dressing plant. Middlings and coarse tailings would be reground and join new feed for sizing and concentration.

CONCLUSION

Preliminary tests, including sizing, heavy liquid sink/float separations and disintegration tests, have indicated suitable treatment methods for the material.

Application of the indicated methods on a laboratory scale has resulted in high recoveries of tin in moderate grade concentrates suitable for further treatment.

No apparent difficulties were encountered in the methods applied and commercial treatment on similar lines should give similar results.

The type of equipment required in commercial beneficiation of the material is broadly stated in the flow sheet (fig. 81) although this should not be regarded in any way as a specification for final treatment.

TEST RESULTS

Sixing Analysis of 150 Roll Crushed Ore

Sample	Sn %	Zn %	Fe %	Flotation
150-1	31.8	0.23	52.4	70
150-2	32.4	0.31	41.7	82
150-3	12.9	0.36	41.7	100
150-4	14.7	0.43	37.7	100
150-5	2.0	0.23	52.4	100
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Concentrate Head	100.0	0.24	100.0	