

TR 16-251-256

R.612. Cassiterite concentration tests on lode material from the Royal George mine.

The Cornwall Coal Company requested that preliminary cassiterite concentration tests be conducted on a composite sample of lode material from the Royal George mine at the following sizes of grind:

- (1) 90% passing 44# (Test N1)
- (2) 90% passing 72# (Test N2)
- (3) 90% passing 100# (Test N3)
- (4) 90% passing 150# (Test N4)

In addition to the four tests above, a test designated N3A was undertaken, stage grinding through 100#.

The object of the tests was to determine through cassiterite concentrate grade and recovery, the optimum size of grind for this ore.

SAMPLE

The sample for concentration tests was prepared as follows:

Reg. No.	Sample No.	Footage ft in	Weight (kg)	% Sn	% Cu
692359	1	2 7	4.000	1.63	0.09
692360	2	4 7	9.066	(0.02)	0.01
692361	3	8 0	16.000	0.66	0.10
692362	4	2 5	4.832	0.20	0.03
692363	5	2 10	5.666	0.85	0.18
700617	-	-	39.564	(0.58)	(0.08)
692565	29	6 9	13.500	0.48	0.07
692566	30	2 1	4.166	(0.03)	0.01
692567	31	5 4	10.666	0.98	0.07
692571	35	4 7	9.066	0.67	0.07
700618	-	-	37.398	(0.62)	(0.04)
692553	17	5 2	10.334	0.65	0.07
692559	23	7 0	14.000	0.60	0.18
700619	-	-	24.334	(0.62)	(0.13)
692366	6	4 8	9.334	0.58	0.11
692367	7	4 0	8.000	0.09	0.02
692368	8	10 2	20.334	0.59	0.17
700620	-	-	37.668	(0.48)	(0.12)
700617	-	-	39.564	(0.58)	(0.08)
700618	-	-	37.398	(0.62)	(0.04)
700619	-	-	24.334	(0.62)	(0.13)
700620	-	-	37.668	(0.48)	(0.12)
R.612 Head	-	-	138.964	(0.57)	(0.09)

Analysis of the head sample gave the following results:

Sn 0.53%      Cu 0.11%      S 2.56%

METHOD USED

Length of Grind

To determine the grinding time to achieve the required sizes of grind, charges of 1 kg of ore at 70% solids were batch ground for periods of 3, 5, 10, 15, 20 and 30 minutes in a laboratory ball mill with a ball charge of 10 kg. Ball mill discharge was wet then dry screened to provide the following data:

Size	Grinding Time (minutes)					
	3		5		10	
	% Wt	Cum. % Wt	% Wt	Cum. % Wt	% Wt	Cum. % Wt
+22#	11.1	11.1	3.0	3.0	-	-
+44#	17.8	28.9	9.4	12.4	0.2	0.2
+60#	13.1	42.0	14.5	26.9	3.0	3.2
+85#	-	-	-	-	-	-
+100#	15.2	57.2	20.1	47.0	17.4	20.6
+120#	-	-	-	-	-	-
+150#	8.2	65.4	10.1	57.1	13.8	34.4
-150#	34.6	100.0	42.9	100.0	65.6	100.0
+200#	-	-	-	-	-	-
-200#	-	-	-	-	-	-
Head	100.0	-	100.0	-	100.0	-

Size	Grinding Time (minutes)					
	15		20		30	
	% Wt	Cum. % Wt	% Wt	Cum. % Wt	% Wt	Cum. % Wt
+22#	-	-	-	-	-	-
+44#	-	-	-	-	-	-
+60#	0.4	0.4	-	-	-	-
+85#	1.8	2.2	0.5	0.5	-	-
+100#	6.4	8.6	1.0	1.5	0.5	0.5
+120#	2.4	11.0	2.4	3.9	0.7	1.2
+150#	10.0	21.0	5.0	8.9	2.0	3.2
-150#	79.0	100.0	91.1	100.0	-	-
+200#	-	-	-	-	11.3	14.5
-200#	-	-	-	-	85.5	100.0
Head	100.0	-	100.0	-	100.0	-

From a graph of cumulative per cent weight retained versus grinding time the following grinding times were obtained for 1 kg of ore at 70% solids.

Test No.	Size of grind	Time Required (min.)
N1	90% passing 44#	5.6
N2	90% passing 72#	9.1
N3	90% passing 100#	13.0
N4	90% passing 150#	19.2

## Grinding

**Batch Grinding:** In Tests N1, N2 and N4, ten lots of 1 kg were combined after batch grinding, whilst N3 was conducted with only 5 batches of 1 kg. Test N1 ball mill discharge was wet screened on 44# and the screen oversize amounting to 1.104 kg was ground for a further period of 5.6 minutes (at approximately 70% solids) with the subsequent oversize being reduced in size to -44# by wet grinding using a pestle and mortar.

**Stage grinding (Test N3A):** A total of 5 kg of ore was stage ground at approximately 70% solids with a circulating load of 150% through a 100# screen. Final screen oversize was wet ground using a pestle and mortar.

## Sizing and Classification

Ground ore was fed to a Geco classifier producing three spigot products and an overflow. In Test N1 the ore was screened on 60# prior to Geco classification.

## Primary Concentration

Sized and classified fractions were concentrated on a laboratory Deister table producing low grade tin, sulphide rich gravity concentrates.

## Sulphide Flotation

In all tests primary gravity concentrates were sampled, then combined for sulphide removal in a laboratory Denver flotation cell. Flotation conditions were as indicated below.

### Rougher Flotation

- (1) H<sub>2</sub>SO<sub>4</sub> to pH 5
- (2) CuSO<sub>4</sub> 0.75 lb/ton
- (3) Sodium ethyl xanthate
- (4) Potassium amyl xanthate 0.1 lb/ton
- (5) Flotation time - 8 minutes

### Cleaner Flotation

- (1) Sodium ethyl xanthate 0.2 lb/ton
- (2) Potassium amyl xanthate 0.2 lb/ton
- (3) Flotation time - 5 minutes

## Secondary Concentration

The flotation tailing was wet screened on one or more of the screens, 100, 200, 300# depending upon the size of grind of the test. The sized fractions were finally reconcentrated on the Deister table.

## TEST RESULTS

### Cassiterite Concentration

See Table 1.

Table 1. RESULTS OF CASSITERITE CONCENTRATION

Fraction	N1			N2			N3			N3A			N4		
	% Wt	% Sn	% Distn	% Wt	% Sn	% Distn	% Wt	% Sn	% Distn	% Wt	% Sn	% Distn	% Wt	% Sn	% Distn
+60# T/C	1.3	4.9	10.6	-	-	-	-	-	-	-	-	-	-	-	-
+60# T/T	19.6	0.14	4.5	-	-	-	-	-	-	-	-	-	-	-	-
+60#	20.9	(0.44)	15.1	-	-	-	-	-	-	-	-	-	-	-	-
No.1 Spigot T/C	1.8	12.6	37.6	2.5	9.5	40.4	2.2	7.68	29.7	2.0	9.91	33.6	0.6	19.5	19.1
No.1 Spigot T/T	12.1	0.21	4.2	17.6	0.12	3.6	8.9	0.08	1.2	10.9	0.04	0.7	2.9	0.07	0.3
No.1 Spigot	13.9	(1.81)	41.8	20.1	(1.29)	44.0	11.1	(1.59)	30.9	12.9	(1.57)	34.3	3.5	(0.34)	19.4
No.2 Spigot T/C	0.9	10.7	16.0	1.4	9.0	21.5	1.8	7.79	24.6	2.0	8.46	28.6	2.0	9.6	31.3
No.2 Spigot T/T	20.7	0.09	3.1	21.2	0.09	3.2	18.1	0.04	1.3	17.8	0.04	1.2	18.1	0.06	1.8
No.2 Spigot	21.6	(0.53)	19.1	22.6	(0.64)	24.7	19.9	(0.74)	25.9	19.8	(0.89)	29.8	20.1	(1.01)	33.1
No.3 Spigot T/C	0.6	9.1	9.1	0.8	8.3	11.3	1.3	8.25	18.9	1.1	7.39	13.8	1.0	9.6	15.7
No.3 Spigot T/T	20.2	0.12	4.0	18.9	0.07	2.3	16.9	0.04	1.2	15.6	0.03	0.8	21.8	0.03	1.1
No.3 Spigot	20.8	(0.38)	13.1	19.7	(0.40)	13.6	18.2	(0.63)	20.1	16.7	(0.52)	14.6	22.8	(0.45)	16.8
C/O T/C	0.8	3.0	4.0	1.4	3.3	7.9	1.7	3.11	9.3	1.3	4.72	10.4	0.9	5.7	8.4
C/O T/T	22.0	0.19	6.9	36.2	0.16	9.8	49.1	0.16	13.8	49.3	0.13	10.9	52.7	0.26	22.3
C/O	22.8	(0.29)	10.9	37.6	(0.28)	17.7	50.8	(0.26)	23.1	50.6	(0.25)	21.3	53.6	(0.35)	30.7
Head	100.0	(0.60)	100.0	100.0	(0.59)	100.0	100.0	(0.57)	100.0	100.0	(0.59)	100.0	100.0	(0.61)	100.0
Total Primary Concentrate	5.40	(8.62)	77.3	6.10	(7.80)	81.1	7.00	(6.71)	82.5	6.40	(7.97)	86.4	4.50	(10.1)	74.5
+100# T/C	0.17	60.9	17.4	-	-	-	-	-	-	-	-	-	-	-	-
+200# T/C	0.25	61.1	25.6	0.37	57.5	36.5	0.36	53.2	33.4	0.40	58.8	40.1	0.20	62.0	20.0
+300# T/C	0.09	58.2	8.8	0.17	58.6	17.1	0.10	55.8	9.7	0.18	33.5	10.3	0.17	64.2	17.6
-300# T/C	0.15	59.6	15.0	0.22	53.8	20.3	0.32	59.0	32.9	0.31	61.2	32.4	0.31	63.4	31.7
T/T	1.32	1.82	4.0	1.82	0.95	3.0	2.68	0.98	4.6	1.58	0.42	1.1	0.79	1.47	1.9
Sulphides	3.42	1.13	6.5	3.52	0.70	4.2	3.54	0.32	1.9	3.93	0.37	2.5	3.03	0.68	3.3
Total Primary Concentrate	5.40	(8.53)	77.3	6.10	(7.75)	81.1	7.00	(6.77)	82.5	6.40	(7.91)	86.4	4.50	(10.3)	74.5
Final Concentrate	0.66	(60.3)	66.8	0.76	(56.7)	73.9	0.78	(55.9)	76.0	0.89	(54.0)	82.8	0.68	(63.2)	69.3

Sulphide Flotation Concentrates

Test No.	% Wt	% Cu	% As
N1	3.42	0.93	-
N1 Head	100.0	(0.03)	
N2	3.52	1.10	-
N2 Head	100.0	(0.04)	
N3	3.54	1.20	-
N3 Head	100.0	(0.04)	
N3A	3.93	1.17	-
N3A Head	100.0	(0.05)	
N4	3.03	1.00	0.50
N4 Head	100.0	(0.03)	(0.26)

Summary of Gravity Concentration

Test No.	Size of Grind	Primary Concentration		Secondary Concentration	
		% Sn	% Recovery	% Sn	% Recovery
N1	90% Passing 44#	8.62	77.3	60.3	66.8
N2	90% Passing 72#	7.80	81.1	56.7	73.9
N3	90% Passing 100#	6.71	82.5	55.9	76.0
N3A	100% Passing 100#	7.97	86.4	54.5	82.8
N4	90% Passing 150#	10.1	74.5	63.2	69.3

SUMMARY

From the results obtained it can be seen that recovery increases as the size of grind decreases, but not to a very significant degree. The high grade and recovery obtained at the size of grind of 90% passing 150# was an unexpected anomaly, as overgrinding of the cassiterite present was considered to be likely. It would seem that the rather ideal conditions in a laboratory test have greatly enhanced the concentration of the 90% -150# ground ore.

As expected, stage grinding through 100# gave the highest recovery. This test has an increase of 6.8% recovery from its corresponding batch test at a similar grade of tin. Therefore by batch grinding to 90% -100#, approximately 6.8% of the total cassiterite present has been overground beyond the limits of recovery.

Conventional sulphide removal after primary gravity concentration did not present any problem even at the coarsest size of grind, however the presence of high concentrations of arsenic in the sulphide concentrate should be noted. The size of grind did not greatly affect the quantity of copper in the sulphide concentrates and in all tests, copper recovery was below 50%. No attempt was made to upgrade the copper sulphides present in the sulphide concentrate.

Regrinding of primary gravity tailings has not been undertaken in this preliminary series of tests and consequently recovery figures stated are reasonably conservative.

CONCLUSION

Whilst grinding to only -44# may be desirable to effect the release of coarse cassiterite without overgrinding, further primary tailing grinding to -150# is essential to obtain maximum recovery.

As there is little difference in recovery at sizes of grind down to 100#, and bearing in mind that tailings should only be rejected at -150#, it will be an economic consideration as to the primary size of grind ultimately chosen.

Test No.	Size of Grind	Primary Concentration % Recovery	Secondary Concentration % Recovery
W1	90# passing 44#	83.7	60.3
W2	90# passing 75#	78.0	55.8
W3	90# passing 100#	82.9	57.9
W3A	100# passing 100#	88.4	62.8
W4	90# passing 150#	74.8	59.3

Summary of Results

Test No.	Size of Grind	Primary Concentration % Recovery	Secondary Concentration % Recovery
W1	90# passing 44#	83.7	60.3
W2	90# passing 75#	78.0	55.8
W3	90# passing 100#	82.9	57.9
W3A	100# passing 100#	88.4	62.8
W4	90# passing 150#	74.8	59.3

SUMMARY

From the results obtained it can be seen that recovery increases as the size of grind decreases, but not to a very significant degree. The high grade and recovery obtained at the size of grind of 90# passing 150# was an unexpected anomaly, as overgrinding of the cassiterite present was considered to be likely. It would seem that the rather ideal conditions in a laboratory test have greatly enhanced the concentration of the 90# -150# ground ore.

As expected, stage grinding through 100# gave the highest recovery. This test has an increase of 6.5% recovery from the corresponding batch test at a similar grade of fin. Therefore by batch grinding to 90# -100#, approximately 6.5% of the total cassiterite present has been overground beyond the limits of recovery.

Conventional sulphide removal after primary gravity concentration did not present any problem even at the coarsest size of grind, however the presence of high concentrations of arsenic in the sulphide concentrate should be noted. The size of grind did not greatly affect the quantity of copper in the sulphide concentrates and in all tests, copper recovery was below 50%. No attempt was made to upgrade the copper sulphides present in the sulphide concentrates.

Regrinding of primary gravity tailings has not been undertaken in this preliminary series of tests and consequently recovery figures stated are reasonably conservative.