

## R.616. Concentration tests on ore from Mt Pelion wolfram mine

Twenty samples of outcropping lode material were received from Scamander Mining Corporation N.L. for determinations of tungstic oxide and tin. These samples, numbered 1 to 20 now bear Department of Mines registered numbers 700855 to 700874 inclusive.

The company requested concentration tests to determine the probable recoveries of tungsten and tin.

The sample for research was made up as a composite of equal weights of the above samples. The amounts required were cut by riffing from the bulk samples which had been jaw crushed to approximately -1 in prior to the extraction of the assay samples.

## SAMPLE PREPARATION

Visual examination of the ore indicated that substantial liberation of the wolfram ore could be achieved by comparatively coarse crushing.

The composite sample was therefore stage jaw crushed to  $-\frac{3}{8}$  in, thoroughly mixed and riffled into two halves. One half (about 100 lb) was set aside for the major ore dressing test work. The other half was further divided by riffing to provide an assay head sample and a small sample (about 6 lb) for preliminary testing, involving screening and heavy liquid separations.

## Head Sample Assays

Tungstic oxide	1.53%	Tin	0.15%
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## TEST WORK

*Preliminary Test N1: Heavy liquid separations of  $\frac{1}{8}$  in ore*

This test was undertaken to determine the coarsest size range at which sensible concentration of the ore could be achieved (table 1).

Procedure involved screening the  $-\frac{3}{8}$  in ore on  $\frac{1}{4}$  in,  $\frac{1}{8}$  in, 16# and 30# and submitting the fractions coarser than 30# to heavy liquid sink/float separations at specific gravities of 2.70 and 2.95.

The test results indicate that crushing to  $-\frac{3}{8}$  in is sufficient to allow the discarding of a relatively barren tailing in the coarsest fraction examined, i.e.  $-\frac{3}{8}$  in +  $\frac{1}{4}$  in. However, the concentration ratio of wolfram and tin do not approach those obtained in the treatment of the next finest fraction, i.e.  $-\frac{1}{4}$  in +  $\frac{1}{8}$  in.

Moreover, the result was obtained under ideal conditions, i.e. heavy liquid separation and it seemed unlikely that this could be reproduced by jiggling of the fraction.

A trial jiggling of  $-\frac{3}{8}$  in +  $\frac{1}{4}$  in ore was undertaken and visual observation indicated that good recovery could be achieved only by taking a large volume of low grade concentrate. This was not considered desirable in view of the subsequent operations necessary for concentrate upgrading.

In view of the above considerations, it was decided to conduct the experimental work on ore crushed to  $-\frac{1}{4}$  in.

Table 1. RESULTS OF PRELIMINARY TEST N1

Fraction	Wt	Per Cent		% Distribution		Observations
		WO <sub>3</sub>	Sn	WO <sub>3</sub>	Sn	
- $\frac{3}{8}$ in + $\frac{1}{4}$ in F/T 2.7 S/K 2.7	19.6	0.07	Nil	0.9	Nil	Near-clean quartz
	1.8	6.14	0.82	7.4	8.7	No free wolfram
Comp. - $\frac{3}{8}$ in + $\frac{1}{4}$ in	21.4	(0.58)	(0.07)	8.3	8.7	
- $\frac{1}{8}$ in + $\frac{1}{4}$ in F/T 2.7 F/T 2.95 S/K 2.95	35.5	0.15	0.01	3.6	2.1	Near-clean quartz
	1.7	1.66	0.33	1.9	3.2	Many composites
	1.1	36.4	1.99	26.7	12.9	50% free wolfram
Comp. - $\frac{1}{8}$ in + $\frac{1}{4}$ in	38.3	(1.26)	(0.08)	32.2	18.2	
- $\frac{1}{8}$ in +16# F/T 2.7 F/T 2.95 S/K 2.95	20.2	0.08	0.01	1.1	1.2	Near-clean quartz
	0.6	1.35	0.33	0.3	1.2	Some WO <sub>3</sub> composites and Fe oxides
	1.1	41.4	4.79	30.4	30.9	70% free wolfram
Comp. - $\frac{1}{8}$ in +16#	21.9	(2.17)	(0.26)	31.8	33.3	
-16# +30# F/T 2.7 F/T 2.95 S/K 2.95	7.0	0.07	0.01	0.3	0.4	Clean quartz
	0.1	3.25	0.57	0.2	0.3	Some composites and Fe oxides
	0.5	40.8	4.44	13.6	13.1	70% free wolfram
Comp. -16# +30#	7.6	(2.79)	(0.31)	14.1	13.8	
-30# Untreated	10.8	1.88	0.41	13.6	26.0	
Composite Head	100.0	(1.50)	(0.17)	100.0	100.0	

Test N2: Jig and table concentration of  $-\frac{1}{4}$  in ore

**Crushing.** The  $-\frac{3}{8}$  in ore sample (about 100 lb) was screened on  $\frac{1}{4}$  in and the  $-\frac{3}{8}$  in  $+\frac{1}{4}$  in fraction stage roll crushed to pass the  $\frac{1}{4}$  in screen.

**Sizing.** The  $-\frac{1}{4}$  in ore was sized by wet screening on the following screens:  $\frac{1}{8}$  in, 16, 30, 60, 100, and 200#.

**Primary concentration**

(1) **Jigging.** The fractions coarser than 30# were concentrated by jigging. Operations involved jigging twice to simulate a two compartment jig, the first jigging producing a concentrate and the second a middling and tailing.

The  $-\frac{1}{4}$  in  $+\frac{1}{8}$  in fraction was treated on a 6 in x 4 in Denver jig and the other two fractions on a Denver No. 1M 2 in x  $1\frac{1}{4}$  in jig.

In the case of the  $-\frac{1}{4}$  in  $+\frac{1}{8}$  in fraction, the concentrate was of rather low grade due to the limited quantity of feed failing to establish an adequate bed in the 6 in x 4 in jig. This concentrate was upgraded to a realistic figure by treatment in heavy liquid at specific gravity 2.95. The float from this operation was added to the jig middling.

Jig conditions are given in Table 2.

Table 2. JIG CONDITIONS

Feed size	Stroke (in)	Hutch Water	Ragging	Jig type
$-\frac{1}{4}$ in $+\frac{1}{8}$ in				
1st stage	$\frac{3}{8}$	6 gal/min/ft <sup>2</sup>	7/16 in nut wads	6 in x 4 in
2nd stage	$\frac{1}{2}$	6 gal/min/ft <sup>2</sup>	7/16 in nut wads	6 in x 4 in
$-\frac{1}{8}$ in +16#				
1st stage	5/16	1 l/min (total)	$\frac{3}{8}$ in steel shot	No. 1M 2 in x $1\frac{1}{4}$ in
2nd stage	3/16	1 l/min (total)	$\frac{3}{8}$ in steel shot	No. 1M 2 in x $1\frac{1}{4}$ in
-16 +30#				
1st stage	3/16	0.6 l/min (total)	$\frac{1}{4}$ in and $\frac{1}{8}$ in	No. 1M 2 in x $1\frac{1}{4}$ in
2nd stage	$\frac{1}{8}$	0.6 l/min (total)	steel shot	

NOTE: Ragging to a total depth of about 2 in was used in each case and was made up of equal volumes of steel as shown above and pyrrhotite particles of similar size.

(2) **Tabling.** Fractions finer than 30# were concentrated separately by tabling. Middlings were retreated once and the overall treatment resulted in two products, concentrate and tailing, from each fraction.

Table 3. RESULTS OF PRIMARY CONCENTRATION

Fraction/Product	Per Cent			% Distribution		% Recovery Individual fraction	
	Wt	WO <sub>3</sub>	Sn	WO <sub>3</sub>	Sn	WO <sub>3</sub>	Sn
- $\frac{1}{8}$ in + $\frac{1}{4}$ in JC JM JT	0.88	54.7	1.66	28.1	7.8	83.6	37.7
	5.58	0.64	0.06	2.1	1.8		
	41.37	0.14	0.05	3.4	11.1		
Comp. - $\frac{1}{8}$ in + $\frac{1}{4}$ in	47.83	(1.20)	(0.08)	33.6	20.7		
- $\frac{1}{8}$ in +16# JC JM JT	0.93	60.1	4.30	32.7	21.4	90.3	69.5
	0.46	4.01	0.63	1.1	1.6		
	28.95	0.14	0.05	2.4	7.8		
Comp. - $\frac{1}{8}$ in +16#	30.34	(2.04)	(0.19)	36.2	30.8		
-16# +30# JC JM JT	0.35	60.1	6.48	12.3	12.1	86.0	52.4
	0.30	9.02	1.32	1.6	2.1		
	9.26	0.08	0.18	0.4	8.9		
Comp. -16# +30#	9.91	(2.47)	(0.44)	14.3	23.1		
-30# +60# TC TT	0.23	52.3	7.04	7.0	8.7	94.6	84.5
	5.12	0.12	0.06	0.4	1.6		
Comp. -30# +60#	5.35	(2.36)	(0.36)	7.4	10.3		
-60# +100# TC TT	0.18	39.1	6.43	4.1	6.2	97.6	79.4
	2.87	0.05	0.10	0.1	1.6		
Comp. -60# +100#	3.05	(2.35)	(0.47)	4.2	7.8		
-100# +200# TC TT	0.09	33.2	5.80	1.7	2.8	96.8	82.3
	1.10	0.09	0.10	Trace	0.6		
Comp. -100# +200#	1.19	(2.59)	(0.54)	1.7	3.4		
-200# TC TT	0.06	48.8	8.22	1.7	2.6	65.4	66.7
	2.27	0.67	0.11	0.9	1.3		
Comp. -200#	2.33	(1.93)	(0.32)	2.6	3.9		
Comp. Head	100.00	(1.71)	(0.19)	100.0	100.0		

The results of primary concentration are given in Table 3 and are summarised below:

Products	Per Cent			% Distribution	
	Wt	WO <sub>3</sub>	Sn	WO <sub>3</sub>	Sn
Total Primary JC	2.16	57.9	3.54	73.1	41.3
Total Primary TC	0.56	44.0	6.77	14.5	20.3
Total Primary JM	6.34	1.28	0.16	4.8	5.5
Total Primary T	90.94	0.14	0.07	7.6	32.9

The application of jig and table concentration in the indicated size range has resulted in good recoveries of the economic minerals in mixed concentrates of satisfactory grades.

In view of the results of the heavy liquid separations (Test N1), tin recovery in the coarsest fraction ( $-\frac{1}{4}$  in  $+\frac{1}{2}$  in) is unexpectedly low. This is probably due to the finer nature of the tin mineralisation whereby cassiterite quartz composites in the fine end of this size range tend to enter the jig tailing. These remarks apply in a lesser degree to the finer fractions also.

These losses would not occur under the ideal conditions of heavy liquid separation.

#### Test N2: Middling retreatment

The jig middling was roll crushed to -30#; sizing and tabling the sized fractions were as in the tabling in the primary operations.

*Procedure.* Each jig middling was roll crushed to -30# and a small assay sample extracted by riffing. A composite middling sample was then made up in proportion to the weights recovered in primary concentration.

This sample was then wet screened on 60, 100 and 200# and the sized fractions tabled separately. Concentrates and tailings were combined to give one retreatment concentrate and tailing.

#### Theoretical Composition of the Middling

Fraction/Product	Per Cent			% Distribution	
	Wt	WO <sub>3</sub>	Sn	WO <sub>3</sub>	Sn
$-\frac{1}{4}$ in $+\frac{1}{2}$ in JM	5.58	0.64	0.06	2.1	1.8
$-\frac{1}{8}$ in $+\frac{1}{16}$ in JM	0.46	4.01	0.63	1.1	1.6
-16# +30# JM	0.30	9.02	1.32	1.6	2.1
Total JM	6.34	1.28	0.16	4.8	5.5

#### Treatment Results

Product	Per Cent			% Distribution	
	Wt	WO <sub>3</sub>	Sn	WO <sub>3</sub>	Sn
Total TC	0.17	41.0	6.20	4.3	4.7
Total TT	6.17	0.14	0.03	0.5	0.8
Total JM	6.34	1.24	0.19	4.8	5.5

The retreatment operations have resulted in significant overall recovery increases of 4.3% tungstic oxide and 4.7% tin.

The cumulative results of primary concentration and middling retreatment are shown in the following table.

Product	Per Cent			% Distribution	
	Wt	WO <sub>3</sub>	Sn	WO <sub>3</sub>	Sn
Total JC	2.16	57.9	3.54	73.1	41.3
Total TC	0.73	43.8	6.64	18.8	25.0
Total Crude C	2.89	54.3	4.32	91.9	66.3
Total T	97.11	0.15	0.06	8.1	33.7

**Test N2. Final concentrate treatment**

The mixed crude gravity concentrates require treatment by magnetic separation to produce separate concentrates of wolfram and tin.

**Procedure.**

(1) *Jig Concentrates.* The coarse concentrates were lightly crushed to -7#, and, after extraction of small assay samples, were combined in proportions of the weights recovered to make a composite jig concentrate. This was screened on 16 and 30# and the fractions separately treated on a laboratory Rapid magnetic separator.

The products were combined to give a magnetic product (final wolfram concentrate) and a non-magnetic product (low grade tin concentrate).

(2) *Table Concentrates.* These were combined into a composite in proportion to their weights and magnetically separated as above, but without prior sizing.

The results of these operations are shown in the following tables:

**Jig Concentrates**

Product	Per Cent			% Distribution	
	Wt	WO <sub>3</sub>	Sn	WO <sub>3</sub>	Sn
M/S M/A	1.71	68.8	0.10	72.4	0.8
M/S N	0.45	2.49	19.5	0.7	40.5
Total JC	2.16	55.0	4.11	73.1	41.3

**Table Concentrates**

Product	Per Cent			% Distribution	
	Wt	WO <sub>3</sub>	Sn	WO <sub>3</sub>	Sn
M/S M/A	0.49	66.0	0.20	18.6	0.5
M/S N	0.24	1.55	19.4	0.2	24.5
Total TC	0.73	44.8	6.51	18.8	25.0

The final metallurgical balance is as follows:

Product	Per Cent			% Distribution	
	Wt	WO <sub>3</sub>	Sn	WO <sub>3</sub>	Sn
Final Wolfram C	2.20	68.1	0.12	91.0	1.3
Low Grade Tin C	0.69	2.16	19.5	0.9	65.0
Final Total T	97.11	0.15	0.06	8.1	33.7

Magnetic separation of the crude concentrate has resulted in a good separation of wolfram and tin. Overall recovery of 91% of the tungstic oxide in sale grade concentrates is considered satisfactory and should be expected considering the coarse nature of the mineralisation.

Examination of the tin product shows the presence of some sulphides and also the tungsten mineral, scheelite, which is non-magnetic and would naturally report to the tin product by the treatment methods used. Virtually all the contained WO<sub>3</sub> in the tin product is present as scheelite. This and the sulphides could be removed by batch flotation processes and the tin product brought to sale grade by gravity concentration. The work has not been extended to investigate this aspect of treatment.

#### SUMMARY

The application of jig and table concentration to ore crushed to  $-\frac{1}{4}$  in has resulted in good recoveries of the economic minerals in crude mixed concentrates.

Retreatment of jig middlings gives a significant increase in overall recoveries.

Magnetic separation of crude concentrate results in the production of sale grade wolfram concentrates and lower grade tin products suitable for further treatment.

Crude jig concentrates require crushing to approximately -7# before magnetic separation.

The tungstic oxide in the tin products is present as scheelite.

#### CONCLUSIONS

Crushing to  $-\frac{1}{4}$  in is sufficient for almost complete liberation of quartz from the valuable constituents. Substantial liberation would probably occur at sizes much coarser than this giving an opportunity for the consideration of heavy media separation in a pre-concentration stage.

In commercial treatment, fine grinding would be unnecessary except possibly in the treatment of the minor quantity of tin products.

High recoveries can be achieved by comparatively simple methods of treatment involving crushing, sizing, jig and table concentration, and magnetic separation of crude concentrates. This would result in the production of sale grade wolfram concentrate. More sophisticated methods would be required for the production of sale grade tin concentrates.