

# ORE DRESSING INVESTIGATIONS

TR16-244-250

R.594. Recovery of molybdenite from King Island scheelite ore. Part 1.

A sample of ore weighing about 100 kg was sent by King Island Scheelite Ltd for molybdenite recovery tests. The molybdenite content of the ore was much higher than the company's normal run of mine ore. Visual examination of the ore showed widespread occurrence of the molybdenite with some pieces measuring up to 6 mm across.

The King Island Scheelite Ltd practice was simulated as far as possible with regard to size of products in grinding and tabling.

## TEST WORK

The ore was crushed so that all passed a  $\frac{1}{2}$  inch screen. An assay sample was taken and pulverised.

A number of 1 kg samples were taken and grinding tests were conducted on these in the Warman laboratory ball mill to establish the times necessary to obtain 10% retained on 52, 60, 72, 85, 100 and 120# screens.

Flotation tests were conducted at the different sizings in the Denver D1 laboratory flotation machine. Attempts were made in these tests to float the molybdenite and pyrite in separate concentrates but these attempts were unsuccessful.

Details of the test conditions are given in Table 1.

A larger scale test, N10, was then conducted on a sample weighing over 10 kg. The  $\frac{1}{2}$  inch feed was hand-screened by a 25# screen. The screen oversize was crushed by rolls and the rolls discharge was re-screened on the 25# screen. This process was repeated until all the material was finer than 25#.

The ore was then wet screened on a 60# screen. The screen oversize was dried and screened on 30, 36, 44, 52 and 60# screens. From the weight distribution two size fractions were chosen for coarse sand table feed, viz. +36# and -36 +60#. The -60# material obtained was put with the undersize from the wet screening.

Each of the coarse sand table feed fractions was conditioned in a bucket with 0.5 lb/ton of sodium ethyl xanthate, 0.5 lb/ton of sulphuric acid and 0.2 lb/ton of kerosene with sufficient water to make a pulp with the consistency of a thick paste. The conditioned ore was subjected to table flotation to float off the coarse sulphides into the table tail. A laboratory size Wilfley table was fitted with air jets blowing on the surface of the table in the region along which the concentrate travels. Separation of the sulphide particles from the heavy mineral concentrate was fairly successful. Due to the limitations of the set-up, it was necessary to re-pass the heavy mineral concentrate several times over the table before the sulphides appeared to have been removed completely.

Table 1. TEST CONDITIONS

Test No.		N9	N8	N3	N4	N5	N2	N1
10% retained on screen	#	52	60	72	85	*	100	120
lime	lb/ton	0.5	0.5	-	-	0.5	-	-
sodium ethyl xanthate	lb/ton	0.5	0.5	-	-	0.5	-	-
sodium aerofloat	lb/ton	-	-	0.1	0.1	-	0.1	0.02
cresylic acid	lb/ton	-	-	-	-	-	-	0.02
Teric 401 (ICI reagent)	lb/ton	0.05	0.05	0.02	0.02	0.05	0.02	-
pH before flotation		-	-	-	-	9.5	-	-
flotation time	minutes	4	4	2	3	4	2	4
sodium aerofloat	lb/ton	-	-	-	-	-	-	0.02
sulphuric acid	lb/ton	3.7	3.7	-	-	3.7	-	-
flotation time	minutes	2	2	-	-	2	-	2
sodium ethyl xanthate	lb/ton	-	-	0.5	0.5	-	0.5	0.5
Teric 401	lb/ton	-	-	0.02	0.02	-	0.02	-
flotation time	minutes	-	-	3	4	-	3	5
pH at end of flotation		-	-	-	-	7.4	-	-

\*Test N5 had 7.8% retained on the 85# screen.

The table concentrate from each size fraction was dried and magnetically separated. The non-magnetic fractions were set aside as final concentrates and prepared for assay. The magnetic fractions joined the table middlings and table tailings and were stage ground for 5 minutes in the Warman laboratory ball mill with 2 kg charges at 75% solids. Ball mill discharge was wet screened on a 60# screen. The screen oversize was made up to 2 kg with new material, and the grinding and screening processes were repeated. The last three grinding charges were 2.150, 1.550 and 1.038 kg respectively. The 308 g of oversize material remaining from the last grinding charge was put with the -60# material obtained by grinding, and this ball mill product was combined with the undersize from the earlier 60# wet screening.

A number of batch flotation tests were conducted on this -60# feed using the Denver D1 laboratory flotation cell. The reagent conditions used in these tests were identical and were as follows:

0.5 lb/ton of sodium ethyl xanthate and 0.05 lb/ton of Teric 401 were added to the pulp; at the end of 5 minutes flotation, 0.5 lb/ton of lime, and a further 0.5 lb/ton of sodium ethyl xanthate and 0.02 lb/ton of Teric 401 were added, and flotation was resumed for a further 2 minutes.

The rougher flotation concentrates were bulked, and a cleaning operation was attempted with no further reagent addition. A heavy non-selective froth formed carrying large sulphide flocs. The flocs contained both molybdenite and pyrite. Lime was added to raise the pH to 11 to try and depress pyrite, and flotation was again attempted, but there appeared to be no improvement in selectivity.

The whole of the rougher concentrate was then evaporated to dryness and subjected to heat on a hot plate until the sodium ethyl xanthate had been driven off. The rougher concentrate was then re-pulped and re-floated. Selective conditions were now in evidence and molybdenite floated off well. When flotation ceased, 2 drops of pine oil were added but only a little more molybdenite floated in subsequent flotation. The cleaner concentrate was re-floated. At the end of flotation 2 drops of pine oil were added and further flotation only yielded a little more molybdenite. The recleaner concentrate (-60# F3C) was the final molybdenite concentrate. The cleaner tailing (-60# F2T) appeared to be nearly all pyrite. The cleaner tailing and the recleaner tailing (-60# F3T) were prepared for assay.

The -60# rougher tail was wet screened on a 200# screen. The screen oversize was dried and screened on 85, 120 and 200# screens. The -200# material joined the undersize from the 200# wet screening. The +85#, -85 +120#, and -120 +200# fractions were separately concentrated on the Deister table. The table concentrates were each magnetically separated. The non-magnetics were set aside as final concentrates and prepared for assay. The magnetic fractions, the table middlings, and table tailings for each size range were prepared for assay.

The -200# material was treated by a number of identical batch flotation tests in the Denver D1 laboratory flotation cell. The reagent conditions used in these tests were as follows:

10 lb/ton of sodium carbonate and 4 lb/ton of sodium silicate were added and the pulp was conditioned for 5 minutes; 0.6 lb/ton of Cyanamid reagent R710 was added and 4 minutes flotation followed; a further 0.6 lb/ton of R710 was added and flotation was resumed for a further 3 minutes; the rougher concentrates were bulked and subjected to cleaner flotation for 4 minutes with no further reagent additions; the cleaner concentrate (-200# F2C) was prepared for assay without further treatment; the rougher tails (-200# F1T) were bulked and were prepared for assay as was the cleaner tail (-200# F2T).

A flow-sheet of the procedure used in test N10 is shown in Figure 80.

#### TEST RESULTS

The results of batch flotation tests at various grinds are shown in Table 2.

Reagent conditions in tests N1, N2, N3 and N4 were similar, and a comparison of the Mo assay and recovery figures for the total flotation concentrate shows that the results are also similar. Grade and recovery are somewhat inferior in test N1, but this was the first test and reagent additions and conditions were slightly modified in tests N2, N3 and N4 in the light of experience gained from test N1. It is probable that improved results could be obtained at this grind, viz. 10% +120#, with further experience, but a second test at this grind was not attempted because the company was interested in recovery at coarse grinds so that sliming of scheelite was minimised.

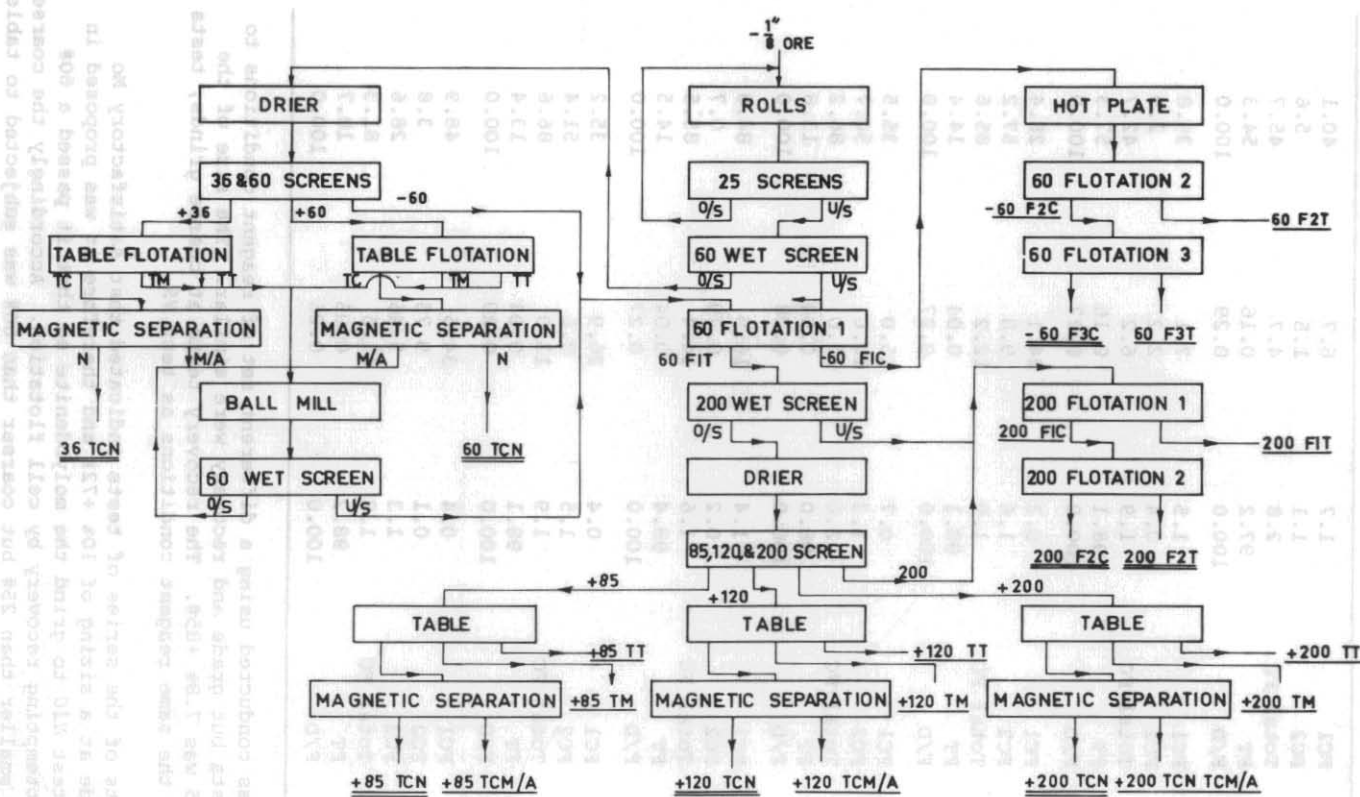


Figure 80. R.594. Flowsheet for test N10.

Table 2. BATCH FLOTATION TESTS

Test	Product	% Weight	Mo Assay %	Mo Distribution %
N9 10% +52#	FC1	1.7	6.7	40.1
	FC2	1.1	1.5	5.6
	Total FC	2.8	4.7	45.7
	FT	97.2	0.16	54.3
	F/D	100.0	0.29	100.0
N8 10% +60#	FC1	1.5	7.1	39.8
	FC2	0.4	2.2	2.9
	Total FC	1.9	6.2	42.7
	FT	98.1	0.16	57.3
	F/D	100.0	0.27	100.0
N3 10% +72#	FC1	0.3	24.1	28.4
	FC2	1.6	9.8	57.2
	Total FC	1.9	12.2	85.6
	FT	98.1	0.04	14.4
	F/D	100.0	0.27	100.0
N4 10% +85#	FC1	0.7	15.0	35.5
	FC2	1.3	10.6	50.7
	Total FC	2.0	12.0	86.2
	FT	98.0	0.04	13.8
	F/D	100.0	0.28	100.0
N5 7.8% +85#	FC1	1.4	16.9	84.8
	FC2	0.2	0.79	0.7
	Total FC	1.6	14.4	85.5
	FT	98.4	0.04	14.5
	F/D	100.0	0.27	100.0
N2 10% +100#	FC1	0.4	26.9	35.2
	FC2	1.5	9.6	51.4
	Total FC	1.9	13.0	86.6
	FT	98.1	0.04	13.4
	F/D	100.0	0.29	100.0
N1 10% +120#	FC1	0.4	34.5	48.9
	FC2	0.1	9.75	3.8
	FC3	1.3	5.46	28.6
	Total FC	1.8	11.6	81.3
	FT	98.2	0.05	18.7
	F/D	100.0	0.26	100.0

Test N5 was conducted using a different set of reagent conditions to the previous tests but grade and recovery were similar. The size of the grind in test N5 was 7.8% +85#. The recovery tests at coarse grinds, tests N8 and N9, used the same reagent conditions as test N5.

The results of the series of tests indicated that satisfactory Mo recovery was made at a sizing of 10% +72# and therefore it was proposed in a larger scale test N10 to grind the molybdenite so that it passed a 60# screen before attempting recovery by cell flotation. Accordingly the coarse sand table feed smaller than 25# but coarser than 60# was subjected to table flotation and the coarse sulphide particles floated off with the table tailing and together with the coarse table middlings was ground to pass the 60# screen.

The results of test N10 are shown in Table 3.

Table 3. RESULTS OF TEST N10

Product	% Weight	Assay %		Distribution %	
		WO <sub>3</sub>	Mo	WO <sub>3</sub>	Mo
+36# TC N	0.19	69.5	2.4	9.0	1.6
-36# +60# TC N	0.18	72.6	2.6	8.9	1.6
-60# F3C	0.35	1.0	48.6	0.3	53.4
-60# F3T	0.10	1.2	6.3	0.1	1.9
-60# F2C	(0.45)	(1.1)	(39.1)	(0.4)	(55.3)
-60# F2T	1.42	0.80	1.5	0.7	6.6
-60# F1C	(1.87)	(0.86)	(10.5)	(1.1)	(61.9)
-60# +85# TC M/A	0.37	2.1	0.16	0.5	0.3
-60# +85# TC N	0.30	65.9	5.6	13.4	5.3
-60# +85# TM	16.64	0.19	0.05	2.2	2.5
-60# +85# TT	7.62	0.13	1.4	0.7	3.5
-85# +120# TC M/A	0.20	3.1	0.20	0.4	Trace
-85# +120# TC N	0.26	73.7	3.3	13.0	2.8
-85# +120# TM	5.59	0.10	0.08	0.4	1.3
-85# +120# TT	10.83	0.10	0.06	0.7	1.9
-120# +200# TC M/A	0.15	2.3	0.11	0.2	Trace
-120# +200# TC N	0.31	71.2	0.09	15.0	Trace
-120# +200# TM	3.53	0.34	0.07	0.8	0.6
-120# +200# TT	14.78	0.23	0.03	2.3	1.3
-200# F2C	6.14	6.62	0.02	27.6	0.3
-200# F2T	1.00	0.68	0.03	0.5	Trace
-200# F1C	(7.14)	(5.80)	(0.02)	(28.1)	(0.3)
-200# F1T	30.06	0.16	0.16	3.3	15.1
F/D (Calculated)	100.0	(1.47)	(0.32)	100.0	100.0

It was necessary to pass the coarse sand table concentrate several times over the flotation table due to limitations in the set-up, to ensure that the sulphides were substantially removed. In practice, it would be better to subject the concentrates from tabling to table flotation rather than table feed as was done in this test. This would reduce considerably the amount of material to be conditioned prior to table flotation.

The results in Table 3 show that the Mo content was high in the -60 +85# table concentrate non-magnetics and in the -85 +120# table concentrate non-magnetics. During the test, coarse particles of free molybdenite were noted in the flotation tailing from the -60# sulphide flotation. It is probable that table flotation of table concentrates down to 85# or even finer could more effectively recover the Mo at this size range for subsequent re-grinding and recovery by cell flotation.

A summary of the results from test N10 is given in Table 4.

Table 4. SUMMARY OF RESULTS FROM TEST N10

Products	% Weight	Assay %		Distribution %	
		WO <sub>3</sub>	Mo	WO <sub>3</sub>	Mo
TC N	1.24	70.5	2.9	59.3	11.3
Scheelite FC	7.38	6.62	0.02	27.6	0.3
Molybdenite FC	0.35	1.0	48.6	0.3	53.4
M/A, TM, Cleaner Tails	29.00	0.30	0.14	5.8	13.2
TT, Scheelite FT	63.29	0.16	0.11	7.0	21.8



# CONCLUSIONS

It is possible to produce a sale grade of molybdenite concentrate from King Island scheelite ore containing about 0.3% Mo. The concentrate of 48.6% Mo obtained is equivalent to 81% MoS<sub>2</sub>. The Mining Journal molybdenite price is quoted on a basis of 85% MoS<sub>2</sub>. Recovery of molybdenum in the concentrate was 53%.

The molybdenite grade and recovery in the rougher concentrate (-60# FlC) in test N10 was not as good as obtained in the earlier batch tests, and it is proposed to conduct further batch flotation tests to get better flotation response.

Another large scale test will be conducted in which all the ore will be ground to pass a 60# screen before concentration is attempted.

Product	# Weight	Assay % Mo	Distribution % Mo
TC N	1.34	70.2	2.8
Scheelite TC	7.36	0.02	27.6
Molybdenite TC	0.28	48.6	0.3
N.A. TC, Cleaner Tailings	22.00	0.30	2.8
FT, Scheelite FT	61.29	0.16	7.0

Table 4. SUMMARY OF RESULTS FROM TEST N10

A summary of the results from test N10 is given in Table 4.

The results in Table 3 show that the Mo content was high in the -60# table concentrate non-magnetic and in the -85 +130# table concentrate. During the test, coarse particles of fine molybdenite were noted in the flotation tailings from the -60# sulphide flotation. It is probable that table flotation of table concentrate down to 85# or even finer could more effectively recover the Mo at this size range for subsequent re-grinding and recovery by cell flotation.

It was necessary to pass the coarse sand table concentrate several times over the flotation table due to limitations in the set-up. To ensure that the sulphides were substantially removed. In practice, it would be better to subject the concentrates from table flotation rather than table feed as was done in this test. This would reduce considerably the amount of material to be conditioned prior to table flotation.