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RESEARCH & DEVELOPMENT DIVISION REPORT

Report 83/157396

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Phase 1 Testwork - Liberation Study
Tasmanian Tungsten/Tin Ore

MICROFILMED

for

Abignano Limited

M. Lanyon

September 16, 1983

It is important to note that the results reported herein refer only to the sample tested. Although to the best of our knowledge the information conveyed by this report is correct, no legal responsibility will be accepted for its use.

CONTENTS

SUMMARY

* A sample of tungsten-bearing ore was examined to assess its liberation characteristics relative to gravity concentration.

* The sample contained 0.74% WO_3, 0.06% As and less than 0.01% SnO_2.

* The tungsten was present as wolframite and also scheelite.

* Heavy liquid separation produced a concentrate containing 93.7% of the tungsten at a grade of 42.2% WO_3.

* The tungsten minerals present were coarse and well-suited to primary concentration by gravity means.

* The upgrading of a primary concentrate to sales grade is likely to be a complex process. The presence of scheelite limits the extent to which high intensity magnetic separation can be used.

* There was no significant concentration of any tin minerals.

1. INTRODUCTION

The sample comes from a tungsten/tin prospect on Tasmania's west coast. Run-of-mine ore was said to consist of 3 parts greisenised granite, containing some sulphides, to one part mineralised quartz reef, the quartz reef consisting of 75% quartz, 10% tourmaline, 5% pyritic sulphides, 5% mica and 5% coarse wolframite.

The relative friability and low specific gravity of the reef and greisen material compared to the coarse wolframite suggested crushing followed by cycloning to remove low specific gravity waste prior to standard gravity concentration techniques.

2. AIM

This testwork looked at the liberation characteristics of the tungsten minerals in the ore, with the aim of indicating the tungsten recovery that might be obtained by gravity concentration processes. High intensity magnetic separation was added to improve the concentrate grade by separating the pyritic sulphides from the slightly magnetic wolframite.

3. PROCEDURE

The test procedure is shown diagramatically in Figure 1.

3.1 Sample Preparation

Approximately 68 kg of ore arrived on August 12, 1983 (Warman Laboratory Number R3882). After drying at 100°C it was crushed to pass a 6.8 mm screen, then riffle blended. A 5.5 kg sample was split out, from which 500 g was roll crushed to minus 2 mm to provide 150 g for the head assay. It was pulverised before analysis.

3.2 Heavy Liquid Separation

The 5 kg parcel of nominally minus 7 mm ore was wet screened on 0.3 mm. The undersize material was then deslimed by decantation and the slimes were collected, dried, weighed and assayed.

After drying, the +300 μm material was separated in 200 g batches in tetrabromoethane (TBE, sp. gr. 2.9), with a little agitation to reduce entrainment during the separation. The LIGHTS (floating material) were screened into a filter, drained and repeatedly washed with acetone. Any material not definitely settled within 5 minutes was classified as LIGHTS. The HEAVIES (sinking material) were similarly recovered, washed with acetone on a filter and dried, before repeating the heavy liquid separation procedure using diiodomethane (DIM, sp. gr. 3.3).

A similar procedure was applied to the deslimed minus 300 μm material, with smaller quantities being separated each time.

The TBE LIGHTS and DIM LIGHTS were screened at 2 mm, 1 mm, 850 μm, 500 μm, 250 μm and 106 μm.

3.3 High Intensity Magnetic Separation

The DIM HEAVIES product was screened at 2 mm, 1 mm and 500 μm. The +1 mm fractions were observed under ultra-violet light and then assayed for tungsten. The minus 1 mm DIM HEAVIES were separated into magnetics and non-magnetics using a high intensity induced roll magnetic separator. The non-magnetics tailing and the magnetic concentrates were each screened at 850 μm, 500 μm, 250 μm and 106 μm and the fractions pulverised for analysis.

All heavy liquid separation product size fractions were weighed and assayed for tungsten. Tin analyses were conducted on particular fractions of each product, representing those richest in tin.

4. RESULTS AND DISCUSSION

4.1 The Ore

The ore received from the tungsten/tin deposit was said to consist of one-quarter quartz reef containing 5% coarse wolframite, and a little tin. The ore assayed 0.74% WO_3, less than 0.01% SnO_2 and 0.06% As. The tungsten assay corresponds to approximately 0.9% wolframite.

The ore was found to contain scheelite, (calcium tungstate) as well as wolframite (iron-manganese tungstate),the scheelite being observable as fluorescent grains under ultra-violet light. Scheelite is generally considered a friable mineral whereas wolframite is less friable than the host rock. Both minerals, as shown below, are of higher specific gravity than the host rock.

Mineral	Specific Gravity	Hardness
wolframite	7.0 to 7.5	5 to 5.5
scheelite	5.9 to 6.1	4.5 to 5
pyritic sulphides	5	6
tourmaline	3.0 to 3.25	7 to 7.5
mica	2.76 to 3.10	2 to 2.5
quartz	2.66	7.0
greisenised granite	2.6 to 2.9	-
ore average	2.8	-
TBE	2.9	
DIM	3.3	

4.2 Heavy Liquid Separation - Theory

The densities of the heavy liquids tetrabromoethane (TBE) and diiodomethane (DIM) are 2.9 and 3.3 respectively. Thus on the basis of separating grains of pure minerals, a TBE separation of this ore's constituents will remove as TBE LIGHTS the quartz, granite and some mica. Separation of the TBE HEAVIES in DIM will then remove as DIM LIGHTS the tourmaline and remaining mica, leaving as DIM HEAVIES a concentrate containing wolframite, scheelite, pyritic sulphides, and if present, minerals of the garnet family.

Composite particles, depending on the ratio of each mineral, will report to the sink or float product, losing recovery of tungsten to the LIGHTS or decreasing the grade of the HEAVIES, until the particles are fine enough to consist of the pure minerals. Thus the information on the coarsest size at which breaking of composites and liberation of individual grains is significant, is obtained by observation and assay of the product size fractions after TBE and DIM separations of the crushed ore.

The results obtained are presented in four tables illustrating different aspects which will be discussed in more detail.

4.3 Liberation

Table 1 presents the size analyses of the 5 kg test parcel and the tungsten distribution according to size fraction. This table was constructed from the weights and assays of the various test products and shows that the tungsten mineralisation has tended to remain in the coarser fractions and is relatively more resistant to grinding compared to the gangue minerals. The head assay calculated from all the products came out at 1.08% WO_3 which is significantly higher than the actual assay of 0.74% WO_3. The actual assay is the more reliable figure.

Table 2 presents the distribution of tungsten to the various specific gravity fractions and the distribution of tungsten in the DIM HEAVIES to several sub-fractions. The particular feature of these results is that over 90% of the tungsten reports to the +3.3 sp. gr. fraction at a grade of 42% WO_3; also 70% of the tungsten is associated with +1 mm particles.

Further liberation data is presented in Table 3 which gives the sizing and assay for each specific gravity fraction and the tungsten distribution within each specific gravity fraction relative to particle size. Also given in Table 3 is the sizing and assays for the magnetic and non-magnetic portions of the minus 1 mm DIM HEAVIES.

Table 4 is an alternative presentation of the Table 3 data but calculated to show the weight and tungsten distribution of the specific gravity fractions within each size fraction.

Significant points brought out in Tables 3 and 4 are:

- the preference for the tungsten distribution in the DIM HEAVIES to be biased to the coarser size fractions. Thus 88.2% of the tungsten in the DIM HEAVIES is in particles coarser than 500 μm. This characteristic is consistent with wolframite mineralisation.

- the assays of the TBE LIGHTS presents the liberation in a different way. Each fraction except the fine sands contains only 0.02 to 0.04% WO_3 indicative of almost complete liberation of tungsten from 90% of the gangue.

- the DIM HEAVIES decrease in grade in the finer sizes due apparently to increased liberation of heavy non-tungsten minerals.

- the tungsten assays of the NON-MAGNETIC heavies are relatively high indicative of the presence of scheelite.

- the tungsten assays of the MAGNETIC heavies are between 17% and 50% WO_3 which means that the wolframite contents range 20 to 60% so there must be present a significant quantity of composite particles and/or heavy non-tungsten magnetic minerals.

4.4 Mineralogical Examination

The +0.5 mm grains of DIM HEAVIES were observed to contain many composites. As well as wolframite and pyritic sulphides there was a considerable amount of a white mineral which fluoresced under ultra-violet light and was obviously scheelite. It is estimated that the scheelite could account for 30% of the tungsten present. Composites were similarly visible in the fine high intensity magnetic separator products.

Samples of the coarse DIM HEAVIES and minus 1 mm MAGNETICS AND NON-MAGNETICS have been retained. A full mineralogical examination should be conducted on these to identify the minerals and composite proportions present before more tests are proposed to upgrade the DIM HEAVIES.

4.5 Tin Distribution

Tin assays of the specific gravity fractions were 0.01% Sn or less. There is thus no tin of commercial significance in the sample. (See Table 5).

4.6 Process for Tungsten Recovery

The practical implications of the results of the liberation study are that the ore, as represented by this sample, would be well-suited to gravity processing for beneficiation of the tungsten minerals. The test results indicate that one could expect to recover close to 90% of the tungsten in a primary gravity circuit. As a significant proportion of the tungsten mineralisation is coarse, a process involving jigs and table concentrators would seem to be the preferred approach.

While the primary recovery aspects of the sample appear well defined by this preliminary test programme, the matter of concentrate grade is not so clear. For tungsten concentrate to be marketable without penalty, a minimum grade of 65% WO_3 is usually required and specific elements such as molybdenum, tin, arsenic, sulphur and phosphorus attract penalties. The DIM HEAVIES averaged 42% WO_3 so there is obviously need for further up-grading and it would be a matter of additional testwork to determine the best approach. It is clear from the testwork that the application of magnetic separation to further up-grading is not clear-cut since the tungsten mineralisation is both scheelite and wolframite. Ultimately the concentrate cleaning process is likely to be relatively complex and would include re-crushing or regrinding the coarse primary concentrate, screening, further gravity concentration, magnetic separation, high tension separation and perhaps flotation. There would inevitably be some loss of tungsten values in concentrate cleaning and this could amount to 10% or more of the tungsten.

FIGURE 1

Schematic Test Procedure

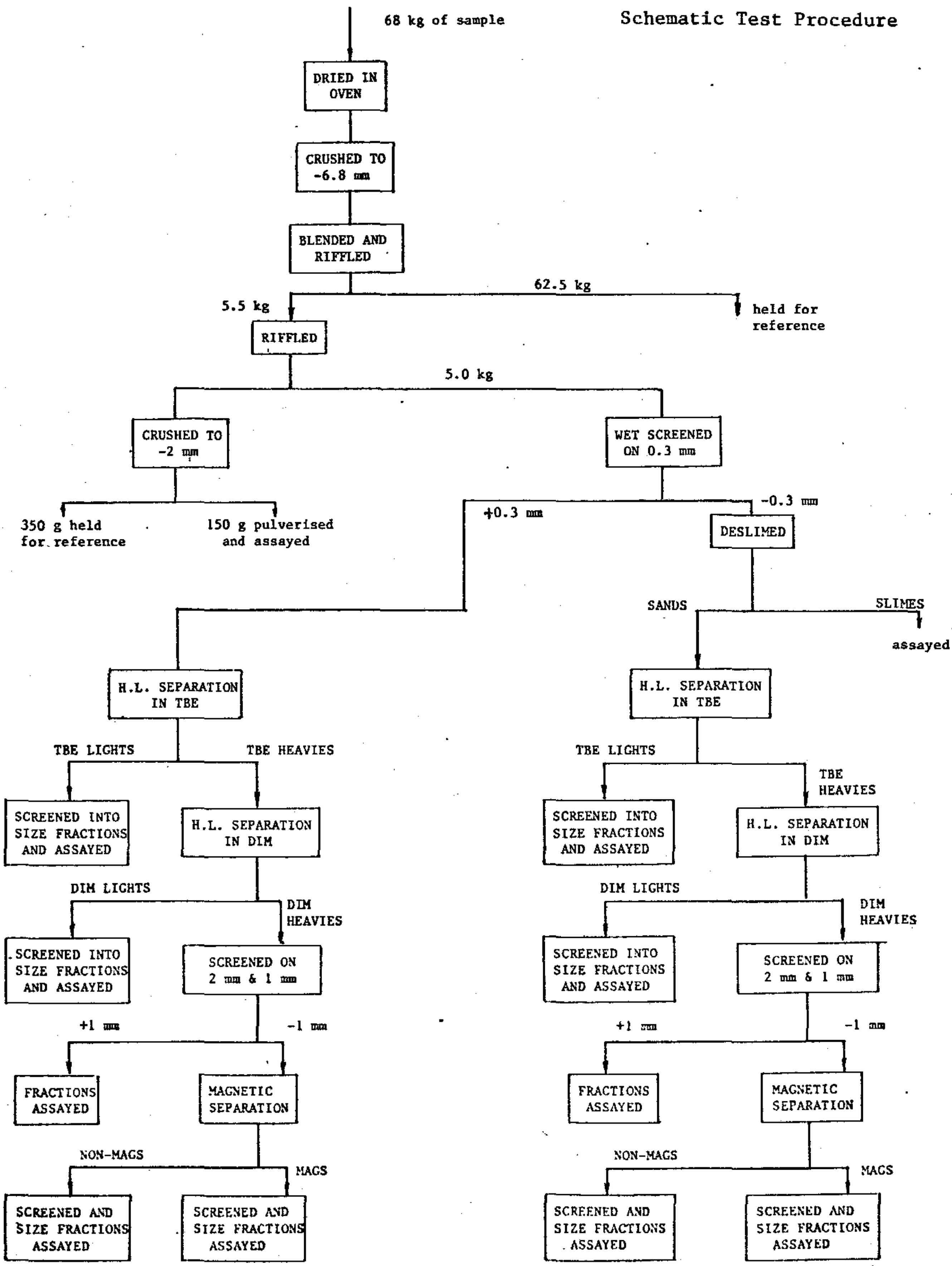

TABLE 1

Distribution of tungsten in the crushed
sample with respect to particle size

size fraction µm	weight % retained	cumulative weight % passing	assay % WO_3 (calc)	tungsten distribution %	
				fractional	cumulative passing
-7000 +2000	43.6	56.4	1.44	58.4	41.6
-2000 +1000	17.5	38.9	1.03	16.7	24.9
-1000 + 500	12.2	26.7	1.00	11.3	13.6
- 500 + 250	8.4	18.3	0.63	4.9	8.7
- 250 + 106	7.5	10.8	0.57	3.9	4.8
- 106 +slimes	3.9	6.9	0.89	3.2	1.6
slimes	6.9	-	0.25	1.6	-
total	100	-	1.08	100	-

TABLE 2

Distribution of tungsten with respect to
specific graivty fractions.
(Sample crushed to -6.8 mm)

fraction	sp. gr.	weight %	% WO_3	distribution WO_3 %
DIM heavies *	+3.3	2.39	42.2	93.74
DIM lights (mids)	-3.3 +2.9	2.65	0.63	1.56
TBE lights	-2.9	88.06	0.04	3.10
slimes	not separated	6.90	0.25	1.60
feed	100	100	(1.08)	100

* DIM HEAVIES			
+2 mm	1.06	56.8	55.68
+1 mm	0.38	46.0	16.02
magnetics	0.36	27.2	9.01
non-magnetics	0.60	23.2	13.03
total DIM heavies	2.39	(42.2)	93.74

brackets indicate calculated assays

4.79015.

TABLE 3

Sizing of the specific gravity fractions
and the distribution of tungsten within
the specific gravity fractions

size fraction µm	FEED weight %	FEED assay % WO_3	FEED WO_3 dist %	TBE LIGHTS wt % of TBE lights	TBE LIGHTS assay % WO_3	TBE LIGHTS WO_3 dist of TBE lights	DIM LIGHTS (TBE HEAVIES) wt % of DIM lights	DIM LIGHTS (TBE HEAVIES) assay % WO_3	DIM LIGHTS (TBE HEAVIES) WO_3 dist of DIM lights	DIM HEAVIES wt % of DIM heavies	DIM HEAVIES assay % WO_3	DIM HEAVIES WO_3 dist of DIM heavies	NON-MAGNETICS (DIM HEAVIES) wt % of non-mags treated	NON-MAGNETICS (DIM HEAVIES) assay % WO_3	NON-MAGNETICS (DIM HEAVIES) WO_3 dist of non-mags treated	MAGNETICS (DIM HEAVIES) wt % of magnetics treated	MAGNETICS (DIM HEAVIES) assay % WO_3	MAGNETICS (DIM HEAVIES) WO_3 dist of magnetics treated
-6800 +2000	43.6	1.44	58.4	47.9	0.04	50.6	14.4	3.2	72.4	44.1	56.0	59.4	NS	-	-	NS	-	-
-2000 +1000	17.5	1.03	16.7	19.1	0.03	15.1	9.9	0.71	11.0	15.7	46.0	17.1	NS	-	-	NS	-	-
-1000 +850	4.1			4.5	0.02	2.4	3.1	0.28	1.4				20.5	37.1	32.7			
		1.00*	11.3							14.0	35.3*	11.7				10.5	50.6	19.6
-850 +500	8.1			8.7	0.03	6.9	7.7	0.20	2.4				28.6	30.7	37.9			
-500 +250	8.4	0.63*	4.9	8.9	0.03	7.0	14.5	0.09	2.1	8.3	25.3*	5.0	21.0	18.9	17.1	19.6	37.0	26.6
-250 +106	7.5	0.57*	3.9	7.4	0.03	5.9	27.0	0.07	3.0	9.4	17.7*	3.9	18.4	9.3	7.4	32.0	25.8	30.4
-106 +slimes	3.9	0.89*	3.2	3.5	0.13	12.1	23.4	0.21	7.7	8.5	14.5*	2.9	11.5	10.0	4.9	37.9	16.8	23.4
slimes	6.9	0.25	1.6	NS	-	-	NS	-	-	NS	-	-	NS	-	-	NS	-	-
TOTALS OF FRACTION				100		100	100		100	100		100	100		100	100		100
TOTAL FEED	100	1.08*	100		0.04*			0.63*			42.21*			23.2*			27.2*	
% OF FEED		(0.74)		88.0		3.1	2.7		1.6	2.4		93.7	0.6		13.0	0.36		9.0

* indicates calculated assays

NS indicates "not separated"

Note: tungsten and weight distributions are percentages of each specific gravity or magnetic fraction

TABLE 4

Alternative presentation of Table 3 showing the weight and tungsten distribution of the specific gravity fractions within each size fraction

size fraction μm	FEED			TBE LIGHTS			DIM LIGHTS TBE HEAVIES			DIM HEAVIES			NON-MAGNETICS			MAGNETICS		
	weight %	assay % WO_3	WO_3 dist %	weight % of size	assay % WO_3	WO_3 dist % of size	weight % of size	assay % WO_3	WO_3 dist % of size	weight % of size	assay % WO_3	WO_3 dist % of size	weight % of size	assay % WO_3	WO_3 dist % of size	weight % of size	assay % WO_3	WO_3 dist % of size
-6800 +2000	43.6	1.44*	58.4	96.7	0.04	2.7	0.9	3.2	1.9	2.4	56.0	95.4	NS	-	-	NS	-	-
-2000 +1000	17.5	1.03*	16.7	96.4	0.03	2.8	1.5	0.71	1.0	2.1	46.0	96.2	NS	-	-	NS	-	-
-1000 +500	12.2	1.00*	11.3	94.9	0.03*	2.6	2.3	0.22*	0.5	2.7	35.3*	96.9	0.3	33.4	81.3	1.4	50.6	15.6
-500 +250	8.4	0.63*	4.9	93.1	0.03	4.5	4.6	0.09	0.6	2.3	25.3*	94.9	0.8	18.9	45.7	1.5	37.0	49.2
-250 +106	7.5	0.57*	3.9	87.4	0.03	4.6	9.6	0.07	1.2	3.0	17.7*	94.2	1.5	9.3	24.4	1.5	25.8	69.8
-106+slimes	3.9	0.89*	3.2	79.1	0.13	11.6	15.7	0.21	3.7	5.2	14.5*	84.7	3.4	10.0	19.8	1.8	16.8	64.9
slimes	6.9	0.25	1.6	NS	-	-	NS	-	-	NS	-	-	NS	-	-	NS	-	-
TOTAL FEED	100	1.08*	100	88.0	0.04*	3.1	2.7	0.63*	1.6	2.4	42.21*	93.7	0.6	23.2*	13.0	0.36	27.2*	9.0

* indicates calculated assays

NS indicates "not separated"

<u>Note</u>: tungsten and weight distributions are percentages of each size fraction

TABLE 5

Tin assays of specific gravity fractions

Product	size fraction assayed	tin assay % SnO_2
slimes		0.01
TBE lights	(+2 mm)	<0.01
DIM lights	(+2 mm)	<0.01
DIM lights	(−106 μm)	<0.01
DIM heavies	(+2 mm)	<0.01
head		<0.01

< : less than