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MINES BRANCH INVESTIGATION REPORT IR 61-97

**CONCENTRATION TESTS ON TWO SAMPLES
OF TUNGSTEN ORE FROM THE GREY RIVER
AREA, NEWFOUNDLAND, FOR AMERICAN
SMELTING AND REFINING COMPANY,
BUCHANS, NEWFOUNDLAND**

by

G. I. MATHIEU

MINERAL PROCESSING DIVISION

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CONCENTRATION TESTS ON TWO SAMPLES OF TUNGSTEN ORE
FROM THE GREY RIVER AREA, NEWFOUNDLAND, FOR AMERICAN SMELTING
AND REFINING COMPANY, BUCHANS, NEWFOUNDLAND

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G. I. Mathieu^A

SUMMARY OF RESULTS

The main constituents of this ore are wolframite, scheelite, sulphides and quartz. The sample marked "Vein No. 10" assayed 4.06% WO₃ and the sample marked "Vein No. 6" assayed 2.66% WO₃.

Using different methods of concentration, the following results were obtained on Vein No. 10 ore:

Test	Procedure	Product	Assays % WO ₃	Distn % WO ₃
8	Magnetic separation (Stearns) Flotation	Wolframite cl conc	66.0	52.0
		Scheelite recl "	52.0	26.4
9	Magnetic separation (Jones) Flotation	Wolframite cl conc	71.0	52.8
		Scheelite recl "	51.5	25.1
10	Magnetic separation (Jones) Flotation, fluorite separation	Wolframite cl conc	68.8	48.9
		Scheelite recl "	61.2	22.5
11	Gravity, magnetic separation Gravity, electro- static separation Flotation	Wolframite conc	71.2	48.6
		Scheelite table conc	67.2	24.6
		Scheelite flot cl conc	22.4	4.9

Similar tests were carried out on Vein No. 6 ore with the following results:

Test	Procedure	Product	Assays % WO ₃	Distn % WO ₃
15	Magnetic separation (Stearns) Flotation	Wolframite cl conc	53.6	42.0
		Scheelite recl "	68.8	30.5
16	Magnetic separation (Jones) Flotation	Wolframite cl conc	57.4	41.6
		Scheelite recl "	67.2	20.9
17	Magnetic separation (Jones), gravity Flotation	Wolframite cl conc	72.0	37.3
		Scheelite recl "	67.2	20.9
18	Gravity, magnetic separation Gravity, electro- static separation Flotation	Wolframite conc	75.2	29.7
		Scheelite table conc	65.6	25.9
		Scheelite flot cl conc	43.7	12.1

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INTRODUCTION

Shipment

A shipment of two samples from tungsten-bearing quartz veins was received on October 28, 1960. The two samples were marked "Vein No. 10" and "Vein No. 6" respectively, each weighing approximately 350 pounds. The shipment was submitted by Dr. E. A. Swanson, Chief Geologist, American Smelting and Refining Company, Buchans Unit, Buchans, Newfoundland.

Location of Property

The property from which these samples originated is located in the Grey River area, Newfoundland.

Nature of Investigation

This investigation was a study of the application of dry and wet high intensity magnetic separators in the treatment of a wolframite-scheelite ore. The main purpose of the investigation was to produce tungsten concentrates of commercial grade, i.e. assaying over 60% WO_3 , under 0.5% S and 0.05% P.

Sampling and Analysis

The two samples were crushed to -1 in. and cut into four parts. From one part of each sample approximately a half pound was riffled out for microscopic examination. The remainder was crushed to -20 M and head samples were cut out by conventional methods for analysis.

The chemical analysis gave the following results:

	<u>Vein No. 10</u>	<u>Vein No. 6</u>
Tungsten trioxide (WO ₃)	4.06 %	2.66 %
Iron (total Fe)	2.62	3.34
Manganese (Mn)	0.34	0.22
Sulphur (S)	0.71	2.50
Phosphorus (P)	0.08	0.04
Insoluble (Insol)	87.76	86.20

A spectrographic analysis* indicated the elements present in the following approximate order of decreasing abundance:

Vein No. 10

- I - Si, Fe, W, Al
- II - Zn, Mn, Pb, Ca, Cu
- III - Mg, Bi, Ti, Ni
- IV - Cr, Ag, Mo, Be

Vein No. 6

- I - Si, Fe, W, Al
- II - Mn, Mg, Ca
- III - Bi, Ni, Cu, Ti
- IV - Cr, Mo, Ag, V, Be

* From Internal Report MS-60-338 by E. Kranck, November 16, 1960.

MINERALOGICAL EXAMINATION^{*}

A portion of each head sample, crushed to -1 in., was submitted to the Mineralogical Section of the Mineral Sciences Division for routine microscopic examination and a determination of the ratio of wolframite to scheelite.

Procedure

Six polished sections were prepared from each sample and the minerals identified by means of microscopical and X-ray diffraction studies.

A -65+150 M portion of each sample was separated into fractions by means of heavy liquids and the Frantz magnetic separator. The resulting fractions were weighed and the minerals comprising them identified under the microscope. The mineral content of each fraction was then determined by X-ray diffractometer analyses and the ratios of scheelite to wolframite were calculated.

Results of Examination

The metallic minerals present in both samples are wolframite, pyrite, sphalerite, chalcopyrite and small amounts of pyrrhotite and galena. The non-metallic minerals in samples from Vein No. 6 are quartz and scheelite. Vein No. 10, in addition to quartz and scheelite, contained also fluorite and lepidolite.

Wolframite occurs as irregular shaped grains that are up to

^{*} From Internal Report MS-61-65, by W. Petruk, July 27, 1961.

1.0 mm in diameter and as tabular grains that are up to 0.7 mm wide and several millimeters long. Some of the wolframite is intergrown with scheelite (see Figure 1), and some of it is cut by chalcopyrite veinlets. Most of it, however, is free.

The pyrite occurs as aggregates of fractured grains that range between 0.02 mm and 0.2 mm in diameter (see Figure 2). Many of the fractures are filled with minute chalcopyrite veinlets.

The sphalerite is present as irregular shaped grains that range between 0.05 mm and 1.0 mm in diameter. These grains contain pyrite inclusions, chalcopyrite veinlets, and pyrrhotite globules, (see Figure 3).

The chalcopyrite occurs as irregular shaped masses that are up to 0.5 mm in diameter, and as tiny veinlets cutting all other minerals (see Figure 4).

The pyrrhotite is present as globules in sphalerite and as tiny isolated grains in the ore. The galena is present as isolated grains that are up to 0.1 mm in diameter.

The scheelite occurs as irregular shaped grains that range between 0.02 mm and 1.0 mm in diameter, and as an intergrowth with the wolframite. In sample Vein No. 10 many of the scheelite grains are surrounded by lepidolite.

The samples submitted for examination did not contain any fluorite. However, a scheelite concentrate of Vein No. 10 (Test 9) obtained during the course of the investigation, contained fluorite and some lepidolite. Most of the fluorite and lepidolite grains in this concentrate were liberated from the scheelite.

The mineral content of the -65+150 M portion of each sample

was determined by the method outlined earlier, and the results are shown in Table 1. The ratios of scheelite to wolframite, calculated from these results, are 45:55 for the sample Vein No. 10 and 70:30 for the sample Vein No. 6.

TABLE 1
Distribution of the Minerals in Samples Vein No. 10
and Vein No. 6

Mineral	Percentage in Vein No. 10	Percentage in Vein No. 6
Quartz and lepidolite	92.3	
Quartz		89.8
Wolframite	3.1	1.1
Scheelite	2.5	2.6
Pyrite	1.6	6.0
Sphalerite and chalcopyrite	0.5	0.5
Pyrrhotite	trace	trace
Galena	-	trace
Fluorite	(?)	-
Total	100.0	100.0

Conclusion

The two samples studied contain wolframite, scheelite, sphalerite, and chalcopyrite, but only wolframite and scheelite are present in sufficient quantities to be of economic significance. The gangue in the sample of Vein No. 6 is nearly all quartz, but the gangue in the sample of Vein No. 10 is quartz, fluorite and lepidolite.

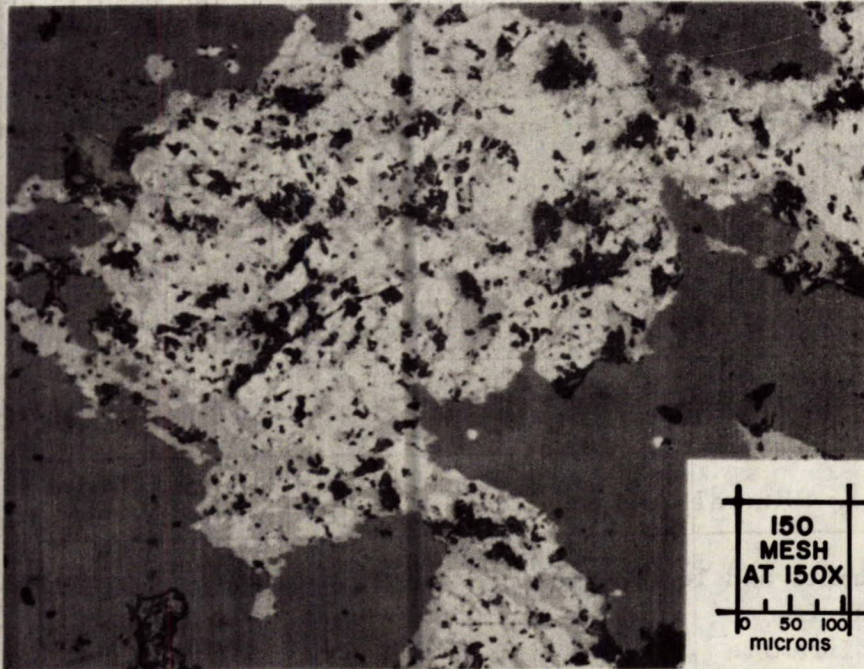


Figure 1 - Photomicrograph of a polished section showing a wolframite grain (light grey) intergrown with scheelite (medium grey). The darker grey background is quartz.

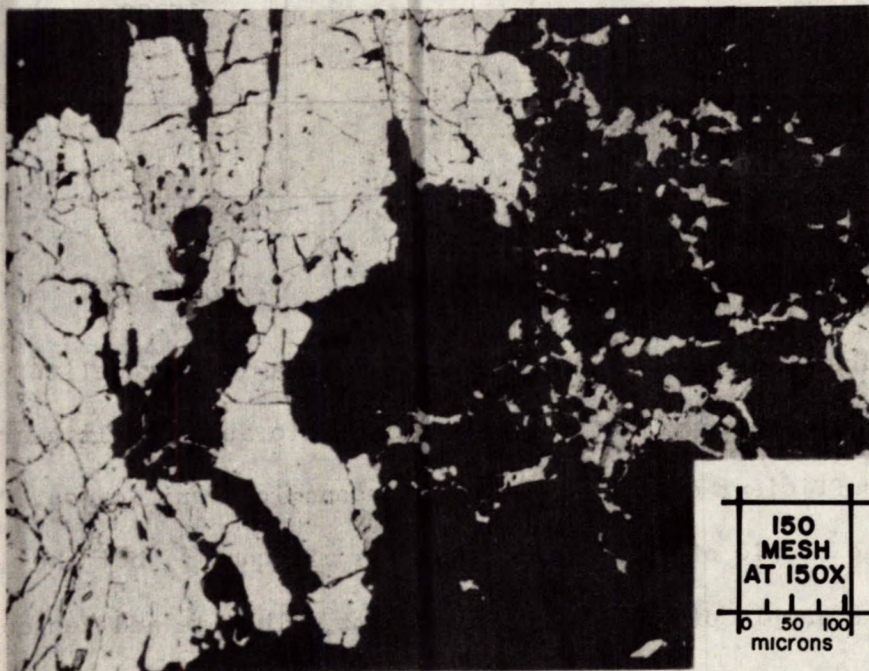


Figure 2 - Photomicrograph of a polished section showing fractured pyrite (white) with chalcopyrite (greyish-white) filling some of the fractures.

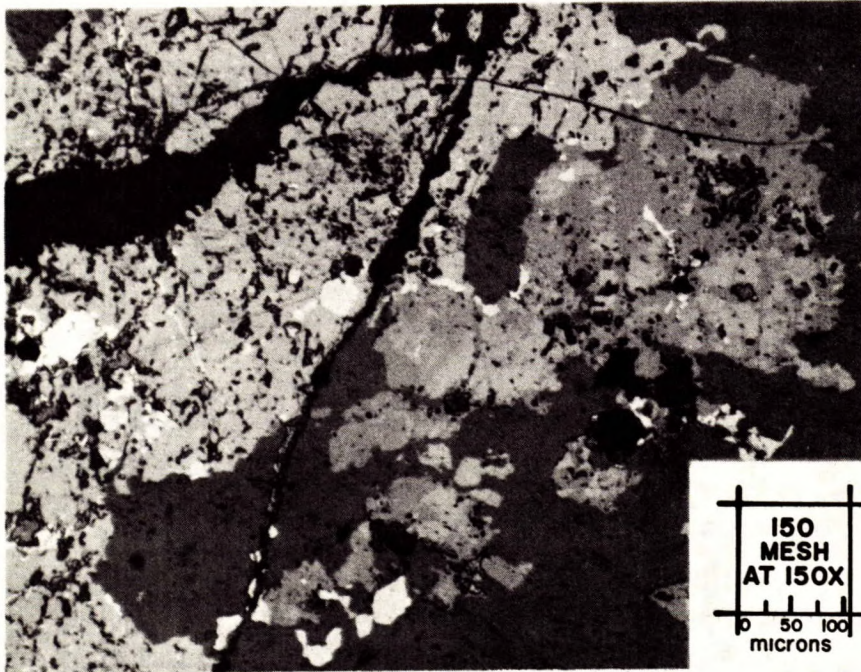


Figure 3 - Photomicrograph of a polished section showing sphalerite at the left side of the photograph. This sphalerite contains pyrite inclusions (white), small pyrrhotite globules (greyish-white), and fine chalcopyrite veinlets (greyish-white). The dark grey grain at the right side of the photograph is scheelite which contains an intergrowth of wolframite (medium grey).

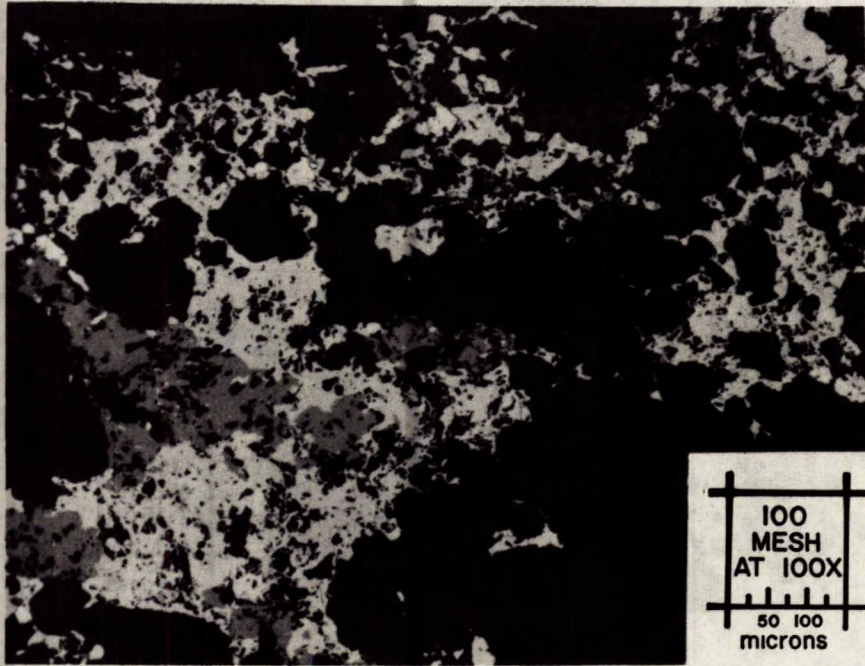


Figure 4 - Photomicrograph of a polished section showing chalcopyrite masses and veinlets (white) in the gangue (black). The grey mineral is sphalerite.

DETAILS OF INVESTIGATION

Preliminary tests were carried out on Vein No. 10 to find the best method of obtaining a high grade wolframite concentrate, using high intensity magnetic separation (Tests 1 to 6). Similar tests were also carried out on Vein No. 6 (Tests 12 and 13).

To increase the overall recovery of the tungsten, tests were carried out in which a scheelite concentrate was floated from the tailing of the magnetic separation. This procedure was used in Tests 7 to 10 on Vein No. 10 and in Tests 14 to 17 on Vein No. 6.

Gravity concentration tests on the samples from each vein completed the investigation.

Test 1, Vein No. 10

A 2000 g sample of this ore, ground finer than 20 M, was fed to a Stearns dry high intensity magnetic separator set at 3 amperes. A wolframite concentrate and a tailing were produced.

Results of Test 1

Product	Weight %	Assays % WO ₃	Distn % WO ₃
Wolframite conc	3.4	53.00	42.7
Tailing	96.6	2.50	57.3
Feed (calcd)	100.0	4.22	100.0

It was noted that some magnetite particles present in this ore were adhering to the rotating wheel and reduced the efficiency of the separation. A preliminary magnetic separation on a low intensity separator should eliminate this problem.

Test 2, Vein No. 10

A 2000 g sample of ore, ground to -20 M, was treated on a Ball-Norton separator to take off the magnetite particles. The rejects were fed to a Stearns magnetic separator set at 3 amperes.

Results of Test 2

Product	Weight %	Assays % WO ₃	Distn % WO ₃
Magnetite conc	0.1	3.71	0.1
Wolframite conc	3.2	53.00	42.0
Tailing	96.7	2.42	57.9
Feed (calcd)	100.0	4.04	100.0

Test 3, Vein No. 10

The procedure was the same as Test 2, except that the wolframite concentrate was cleaned once on a Stearns magnetic separator, set at 3 amperes, to improve the wolframite grade.

Results of Test 3

Product	Weight %	Assays % WO ₃	Distn % WO ₃
Magnetite conc	0.1	2.99	0.1
Wolframite cl conc	3.8	57.00	48.1
Wolframite cl tail	0.7	6.30	1.0
Tailing	95.4	2.40	50.8
Feed (calcd)	100.0	4.50	100.0

Test 4, Vein No. 10

This test was similar to Test 3, except that the ore was passed over a Stearns separator twice to improve the tungsten recovery, before the cleaning operation.

Results of Test 4

Product	Weight %	Assays % WO ₃	Distn % WO ₃
Magnetite conc	0.1	3.84	0.1
Wolframite cl conc	4.2	54.50	48.6
Wolframite cl tail	1.0	12.90	2.7
Tailing	94.7	2.42	48.6
Feed (calcd)	100.0	4.71	100.0

Test 5, Vein No. 10

The procedure was the same as for Test 4, except that the wolframite concentrate was reground to all -48 M before cleaning, to improve the grade by obtaining a better liberation of the wolframite particles.

Results of Test 5

Product	Weight %	Assays % WO ₃	Distn % WO ₃
Magnetite conc	0.1	2.66	0.1
Wolframite cl conc	4.1	63.00	52.7
Wolframite cl tail	1.2	14.55	3.6
Tailing	94.6	2.26	43.6
Feed (calcd)	100.0	4.90	100.0

A microscopic examination of the tailing indicated that the main tungsten mineral in this product was scheelite. Examination of the tailing under an ultra-violet lamp confirmed this observation.

Test 6, Vein No. 10

A 500 g sample of this ore, ground to -20 M, was fed to a Jones high intensity wet magnetic separator at 0, 5, 10 and 25 amperes. The tailing from each pass was fed to the machine at the next higher amperage setting. This test was done to determine the optimum conditions for wolframite concentration on a high intensity wet magnetic separator.

Results of Test 6

Product	Weight %	Assays % WO ₃	Distn % WO ₃
Jones conc at 0 amp	2.0	7.00	3.1
Jones conc at 5 amp	5.0	40.80	44.7
Jones conc at 10 amp	3.1	19.20	13.0
Jones conc at 25 amp	2.1	14.30	6.6
Jones tailing	87.8	1.70	32.6
Feed (calcd)	100.0	4.57	100.0

The highest grade concentrate, obtained at 5 amperes, could be improved to a commercial grade by a cleaning stage.

Test 7, Vein No. 10

Wolframite Concentration:

A 2000 g sample of ore, ground finer than 20 M, was fed to a Ball-Norton dry magnetic separator. The tailing from the Ball-Norton was circulated twice on a Stearns high intensity separator set at 3

amperes and cleaned on the same machine at 1.5 amperes.

Scheelite Concentration:

A 1000 g sample was cut out from the tailing of the high intensity magnetic separation and ground for 10 min to 32% -200 M.

A scheelite concentrate was then floated as follows:

Reagents and Conditions

Operation	Reagents lb/ton	Time Min	pH
Grinding	Na ₂ CO ₃ - 1.00	10	
	R-301 - 0.10		
	R-208 - 0.10		
Sulphide conditioning	CuSO ₄ - 1.00	5	8.2
	Na ₂ SiO ₃ - 1.00		
	R-301 - 0.10		
	Pine oil - 0.08		
Sulphide flotation		5	
Scheelite conditioning	Emcol X25- 0.20	5	7.6
Scheelite rougher flotation	Orso - 0.40	5	
Scheelite cleaner flotation	Na ₂ SiO ₃ - 0.20	5	

Results of Test 7

Product	Weight %	Assays % WO ₃	Distn % WO ₃
Magnetite conc	0.1	2.60	0.1
Wolframite cl conc	4.5	58.80	55.5
Wolframite cl tail	1.0	15.40	3.2
Sulphide conc	2.6	1.67	0.9
Scheelite cl conc	3.1	44.00	28.6
Scheelite cl tail	3.0	6.30	4.0
Flotation tail	85.7	0.43	7.7
Feed (calcd)	100.0	4.77	100.0

It was observed that the froth was brittle due to an excess of Na_2SiO_3 . A higher pH, in the scheelite conditioning, and an additional cleaning operation might improve the scheelite concentrate grade.

Test 8, Vein No. 10

Wolframite concentration:

A 2000 g sample of ore, ground finer than 20 M, was passed through a Ball-Norton magnetic separator. The rejects were fed to a Stearns separator set at 3 amperes and cleaned at 1.5 amperes on the same machine.

Scheelite concentration:

A 1000 g sample, cut from the tailing of the high intensity magnetic separation, was ground for 10 min and floated as follows:

Reagents and Conditions

Operation	Reagents	lb/ton	Time Min	pH
Grinding	Na_2CO_3	- 0.50	10	
	R-301	- 0.20		
	R-208	- 0.20		
Sulphide conditioning	CuSO_4	- 1.00	5	6.8
	Na_2SiO_3	- 0.40		
	R-301	- 0.10		
	Pine oil	- 0.08		
Sulphide flotation			5	
Scheelite conditioning	Na_2CO_3	- 0.10	5	8.6
	NaCN	- 0.10		
	Emcol X25	- 0.20		
Scheelite flotation	Orso	- 0.40	5	
Scheelite cl flotation	Na_2SiO_3	- 0.20	5	
	NaCN	- 0.02		
	Orso	- 0.10		
Scheelite recl flotation	Na_2SiO_3	- 0.20	3	
	Orso	- 0.10		

Results of Test 8

Product	Weight %	Assays %			Distn % WO ₃
		WO ₃	S	P	
Magnetite conc	0.1	2.54			0.1
Wolframite cl conc	3.1	66.00	0.21	0.03	52.0
Wolframite cl tail	0.7	13.80			2.5
Sulphide conc	3.7	3.68			3.4
Scheelite recl conc	2.0	52.00	0.21	0.06	26.4
Scheelite recl tail	0.4	37.00			3.8
Scheelite cl tail	2.6	8.48			5.6
Flotation tail	87.4	0.28			6.2
Feed (calcd)	100.0	3.93			100.0

Test 9, Vein No. 10

Wolframite concentration:

A 2000 g sample of ore was ground finer than 20 M and passed twice through a Jones magnetic separator set at 5 amperes. The two concentrates produced were combined and cleaned at 5 amperes on the same machine. The middling and the cleaner tailing were combined with the final tailing for subsequent treatment for scheelite recovery.

Scheelite concentration:

The scheelite was concentrated by flotation as in Test 8, except that the ore was differentially ground as follows: +35 M, 15 min; -35 M to +65 M, 10 min; -65 M to +100 M, 5 min. The -100 M fraction was not ground. A screen test indicated the grind to be 46% -200 M. This method reduced the amount of slimes produced.

Results of Test 9

Product	Weight %	Assays %			Distn % WO ₃
		WO ₃	S	P	
Magnetite conc	0.1	2.71			0.1
Wolframite cl conc	2.9	71.00	0.23	0.03	52.8
Sulphide conc	3.5	4.60			4.1
Scheelite recl conc	1.9	51.50	0.25	0.07	25.1
Scheelite recl tail	0.3	34.10			2.6
Scheelite cl tail	2.2	6.80			3.8
Flotation tail	89.1	0.50			11.5
Feed (calcd)	100.0	3.90			100.0

A microscopic examination of the scheelite recleaner concentrate indicated that the main impurity was fluorite.

Test 10, Vein No. 10

Wolframite concentration:

The procedure was the same as for Test 9, except that the wolframite cleaner tailing was not added to the final tailing.

Scheelite concentration:

The procedure was the same as for Test 8, except that a fluorite concentrate was floated from the scheelite recleaner concentrate, using 0.03 lb of Quebracho per ton of ore to depress the scheelite.

Results of Test 10

Product	Weight	Assays %			Distn %
	%	WO ₃	S	P	WO ₃
Magnetite conc	0.1	2.30			0.1
Wolframite cl conc	2.9	68.80	0.34	N.D.*	48.9
Wolframite cl tail	1.9	15.20			7.1
Sulphide conc	1.9	5.28			2.5
Fluorite conc	0.4	38.80			3.8
Scheelite recl conc	1.5	61.20	0.33	0.02	22.5
Scheelite recl tail	0.4	40.60			4.0
Scheelite cl tail	2.7	7.04			4.6
Flotation tail	88.2	0.30			6.5
Feed (calcd)	100.0	4.08			100.0

* none detected

The separation of fluorite from scheelite resulted in the production of a commercial grade of scheelite concentrate.

A few other tests were carried out in an attempt to depress fluorite with citric acid and barium chloride, but without success.

Test 11, Vein No. 10

A 2000 g sample of ore was stage ground finer than 50 M and transferred to a flotation cell. A sulphide concentrate was floated as follows:

Reagents and Conditions

Operation	Reagents lb/ton	Time Min	pH
Sulphide conditioning	Na ₂ CO ₃ - 0.40	5	6.9
	CuSO ₄ - 1.00		
	Na ₂ SiO ₃ - 0.20		
	R-301 - 0.10		
	Aerofloat 208 - 0.10		
	Pine oil - 0.04		
Sulphide rougher flotation		5	

The flotation tailing was tabled on a Deister table. The concentrate produced was passed through a Stearns high intensity magnetic separator set at 2 amperes to separate the wolframite from the scheelite. The scheelite concentrate was fed to a Carpc electrostatic separator to produce a second sulphide concentrate, which was added to the sulphide flotation concentrate.

To increase the tungsten extraction, a scheelite concentrate was floated from the table tailing as follows:

Reagents and Conditions

Operation	Reagents	lb/ton	Time Min	pH
Scheelite conditioning	Na ₂ CO ₃	- 0.20	5	8.6
	Na ₂ SiO ₃	- 0.20		
	NaCN	- 0.10		
	Emcol X25	- 0.20		
Scheelite rougher flotation	Orso	- 0.40	5	
Scheelite cleaner flotation	Na ₂ SiO ₃	- 0.10	5	
	Orso	- 0.05		

Results of Test 11

Product	Weight %	Assays %			Distn % WO ₃
		WO ₃	S	P	
Magnetite conc	0.1	1.68			0.1
Wolframite conc	2.8	71.20	0.21	N.D.	48.6
Sulphide conc	2.1	9.44			4.8
Scheelite table conc	1.5	67.20	0.11	tr	24.6
Scheelite flot cl conc	0.9	22.40			4.9
Scheelite cl tail	1.3	7.28			2.3
Flotation tail	91.3	0.66			14.7
Feed (calcd)	100.0	4.10			100.0

Test 12, Vein No. 6

This test was similar to Test 5, in which the wolframite was concentrated by a high intensity dry magnetic separator.

Results of Test 12

Product	Weight %	Assays % WO ₃	Distn % WO ₃
Magnetite conc	0.1	1.86	0.1
Wolframite c1 conc	2.2	50.00	39.7
Wolframite c1 tail	1.5	4.40	2.4
Tailing	96.2	1.67	57.8
Feed (calcd)	100.0	2.77	100.0

Test 13, Vein No. 6

This test was similar to Test 6, in which the wolframite was concentrated by a high intensity wet magnetic separator.

Results of Test 13

Product	Weight %	Assays % WO ₃	Distn % WO ₃
Jones conc at 0 amp	2.1	3.68	2.1
Jones conc at 5 amp	3.0	28.40	23.3
Jones conc at 10 amp	2.9	18.00	14.3
Jones conc at 25 amp	2.2	8.00	4.8
Jones tailing	89.8	2.26	55.5
Feed (calcd)	100.0	3.66	100.0

Test 14, Vein No. 6

This test was similar to Test 7. The wolframite in the ore was concentrated by high intensity dry magnetic separation and the scheelite was floated.

Results of Test 14

Product	Weight %	Assays % WO ₃	Distn % WO ₃
Magnetite conc	0.1	1.52	0.1
Wolframite cl conc	2.1	48.00	35.4
Wolframite cl tail	1.3	15.80	7.2
Sulphide conc	10.5	1.71	6.3
Scheelite cl conc	2.3	34.00	27.5
Scheelite cl tail	5.7	2.40	4.8
Flotation tail	78.0	0.68	18.7
Feed (calcd)	100.0	2.84	100.0

Test 15, Vein No. 6

This test was similar to Test 8.

Results of Test 15

Product	Weight %	Assays %			Distn % WO ₃
		WO ₃	S	P	
Magnetite conc	0.1	3.90			0.1
Wolframite cl conc	2.3	53.60	4.05	0.03	42.0
Wolframite cl tail	1.3	9.60			4.3
Sulphide conc	8.3	1.76			5.0
Scheelite recl conc	1.3	68.80	0.85	0.08	30.5
Scheelite recl tail	0.4	23.20			3.2
Scheelite cl tail	3.9	4.40			5.8
Flotation tail	82.4	0.33			9.1
Feed (calcd)	100.0	2.94			100.0

Test 16, Vein No. 6

Wolframite Concentration:

A 2000 g sample of this ore was passed through a Ball-Norton magnetic separator and twice through a Jones separator set at 10 amperes. The wolframite concentrate was cleaned once on the Jones machine set at 5 amperes.

Scheelite Concentration:

The flotation of the scheelite was the same as in Test 10, except that 0.01 lb of formic acid/ton of ore was added to the recleaner flotation to depress apatite. The scheelite recleaner concentrate was fed to a Carpc electrostatic separator to remove the remaining sulphide minerals, which were then added to the sulphide flotation concentrate.

Results of Test 16

Product	Weight %	Assays %			Distn % WO ₃
		WO ₃	S	P	
Magnetite conc	0.1	1.86			0.1
Wolframite cl conc	2.1	57.40	2.62	0.001	41.6
Wolframite cl tail	3.6	11.92			14.8
Sulphide conc	7.3	2.26			5.7
Scheelite recl conc	0.9	67.20	.46	0.02	20.9
Scheelite recl tail	0.7	25.20			6.1
Scheelite cl tail	5.1	2.36			4.2
Flotation tail	80.2	0.24			6.6
Feed (calcd)	100.0	2.90			100.0

A microscopic examination indicated that the main impurity present in the wolframite recleaner concentrate was pyrophyllite, an aluminum silicate. This mineral should be easily eliminated by gravity concentration.

Test 17, Vein No. 6

A portion of the wolframite cleaner concentrate produced in Test 16 was superpanned to take off the pyrophyllite. Tabling or jigging should do a similar operation when a sufficient amount of concentrate is available.

Results of Test 17

Product	Weight %	Assays %			Distn % WO ₃
		WO ₃	S	P	
Magnetite conc	0.1	1.86			0.1
Wolframite cl conc	1.5	72.00	1.69	0.001	37.3
Superpan tail	0.6	20.60			4.3
Wolframite cl tail	3.6	11.92			14.8
Sulphide conc	7.3	2.26			5.7
Scheelite recl conc	0.9	67.20	0.46	0.02	20.9
Scheelite recl tail	0.7	25.20			6.1
Scheelite cl tail	5.1	2.36			4.2
Flotation tail	80.2	0.24			6.6
Feed (calcd)	100.0	2.90			100.0

These results were calculated on the basis of the original 2000 g sample of ore.

Test 18, Vein No. 6

This test was similar to Test 11, except that the ore was ground to -80 M before tabling and the wolframite was separated from the scheelite on a Jones separator set at 5 amperes.

Results of Test 18

Product	Weight %	Assays %			Distn % WO ₃
		WO ₃	S	P	
Magnetite conc	0.2	1.18			0.1
Wolframite conc	1.0	75.20	0.34	tr	29.7
Sulphide conc	7.7	2.91			8.8
Scheelite table conc	1.0	65.60	0.29	0.01	25.9
Scheelite flot cl conc	0.7	43.70			12.1
Scheelite cl tail	2.4	6.28			6.0
Flotation tail	87.0	0.51			17.4
Feed (calcd)	100.0	2.54			100.0

This test showed that the pyrophyllite was eliminated from the wolframite, when the tungsten minerals were first collected by gravity concentration.

A microscopic examination indicated that the high loss of tungsten in the sulphide concentrate and the scheelite flotation tailing was attributable to the intimate association of wolframite particles with pyrite and quartz. The finer grinding in this test lowered the sulphur content of the final wolframite concentrate by reducing the amount of fine pyrite attached to the wolframite particles.

CONCLUSIONS

Vein No. 10 consists of a scheelite-wolframite ore containing 4.06% WO_3 . The only important metallic constituent is pyrite, while the gangue is composed of quartz and lepidolite. A small amount of fluorite was observed in a scheelite flotation concentrate.

A flowsheet, including a high intensity wet magnetic concentration on a Jones separator and selective flotation, produced a wolframite concentrate assaying 68.8% WO_3 , 0.34% S, and a scheelite flotation concentrate assaying 61.2% WO_3 , 0.33% S, and 0.02% P, with a total recovery 71.4% WO_3 (Test 10). No phosphorus was detected in the wolframite concentrate. A fluorite separation by selective flotation was necessary to get the WO_3 final grade of the scheelite concentrate over 60%.

The same ore submitted to tabling and high intensity magnetic separation (Test 11), after a sulphide flotation, produced a wolframite concentrate assaying 71.2% WO_3 , 0.21% S, and a scheelite table concentrate assaying 67.2% WO_3 . The total WO_3 recovery was 73.2%. Phosphorus was not detected in the wolframite concentrate and only in trace amounts in the scheelite concentrate. It was necessary to pass the scheelite table concentrate through a Carpco electrostatic separator to remove some remaining sulphide particles. This process reduced the sulphur content from over 1% to 0.11% in this concentrate.

Vein No. 6 contained 2.66% WO_3 and a larger amount of pyrite than Vein No. 10. Its gangue was nearly all quartz. Some pyrophyllite was also observed in the wolframite concentrates.

High intensity magnetic separation on a Jones separator

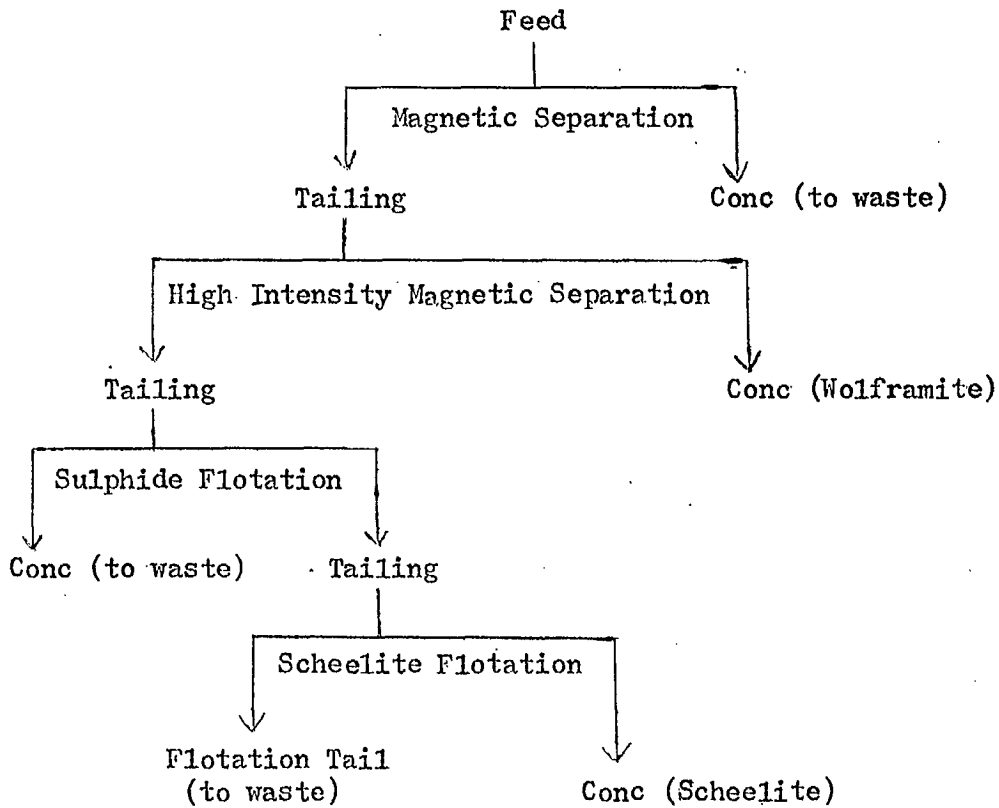
followed by gravity separation produced a wolframite concentrate assaying 72.0% WO_3 , 1.69% S and 0.001% P. Gravity separation was used to remove the pyrophyllite present in the wolframite concentrate, increasing the grade from 57.4% to 72.0% WO_3 . The sulphide content in the wolframite concentrate should be eliminated by flotation, but the amount of concentrate produced during the investigation was insufficient for confirmatory tests. A scheelite concentrate was floated from the tailing obtained from magnetic separation. This concentrate was treated on a Carpcoc electrostatic separator to reduce the sulphur content. After this operation, the scheelite concentrate assayed 67.2% WO_3 , 0.46% S and 0.02% P. The total tungsten recovery in these concentrates was only 58.2% (Test 17), but a recirculation of the middling products should increase the overall recovery.

The same ore submitted to a tabling operation and a high intensity magnetic separation produced a wolframite concentrate, assaying 75.2% WO_3 , 0.34% S and a trace of phosphorus, and a scheelite concentrate, assaying 65.6% WO_3 and 0.01% P (Test No. 18). The scheelite concentrate was passed through a Carpcoc electrostatic separator to reduce its sulphur content to 0.29%.

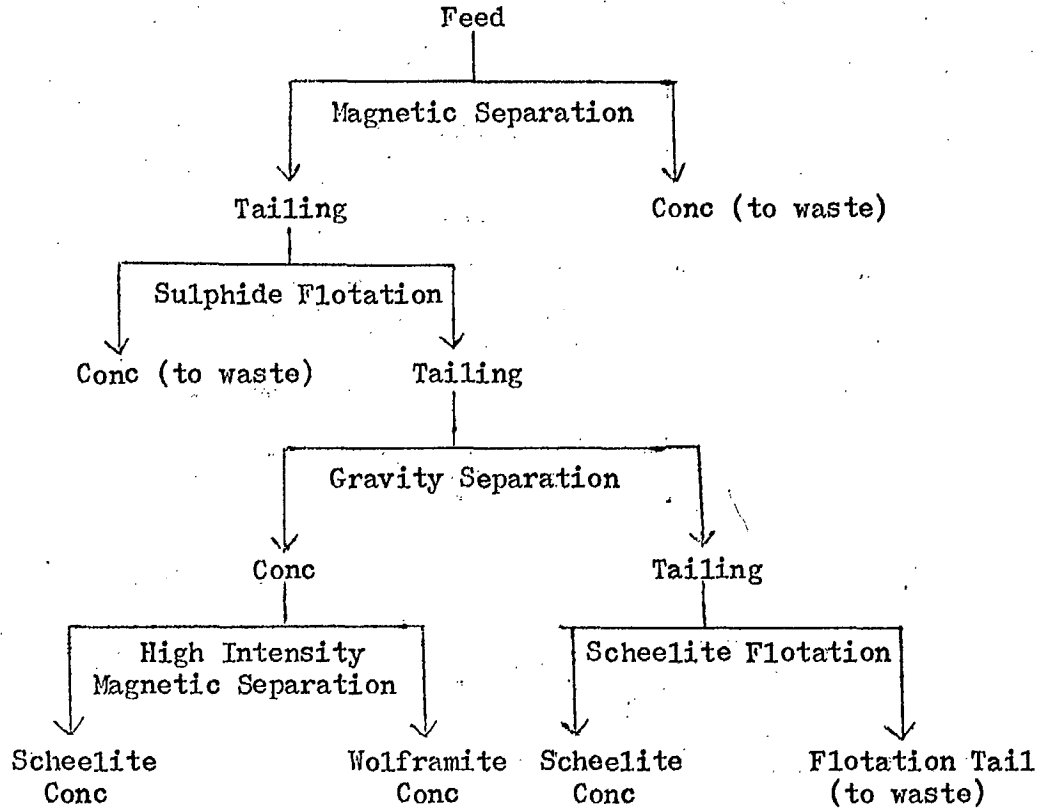
The main problem in the treatment of these two ores was the separation of fluorite from scheelite in the sample from Vein No. 10 and the pyrophyllite removal in the sample from Vein No. 6. Also the loss of tungsten in the tailing was quite high in both samples. Attempts to reduce this loss using a higher amperage setting, a longer grinding time and a longer flotation time, were tried unsuccessfully.

The following simplified flowsheets illustrate two alternative methods for the concentration of the tungsten minerals present in the two samples of ore.

Flowsheet No. 1



Flowsheet No. 2



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