

*Dr. J. G. Conway*

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**MINES BRANCH INVESTIGATION REPORT IR 66-24**

**AN INVESTIGATION OF METALLURGICAL  
PROBLEMS AT PREISSAC MOLYBDENITE  
MINES LIMITED, CADILLAC,  
ABITIBI-EAST, QUEBEC.**

by

**G. I. MATHIEU**

*188*

**MINERAL PROCESSING DIVISION**

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MINES BRANCH INVESTIGATION REPORT IR-66-24

AN INVESTIGATION OF METALLURGICAL PROBLEMS  
AT PREISSAC MOLYBDENITE MINES LIMITED,  
CADILLAC, ABITIBI-EAST, QUEBEC.

by

G. I. Mathieu\*

SUMMARY OF RESULTS

This investigation was concerned with three main metallurgical problems being encountered during milling of the Preissac ore, namely, talc contamination in the molybdenite concentrate, low bismuth recovery, and lately a slight decrease in molybdenite recovery.

Talc appears sporadically in the Preissac ore. Whenever this occurs, the grade of the molybdenite final concentrate is reduced to an unacceptable level because of severe talc dilution. Several techniques were investigated to remove this contaminant from a typical concentrate (62% MoS<sub>2</sub>, 25% talc). The results of these are summarized below:

<u>Procedure</u>	<u>Concentrate Grade</u>		<u>Recovery</u>
	% MoS <sub>2</sub>	% Insol	% MoS <sub>2</sub>
Selective flotation with alum	75.2	14.0	75.7
Electrostatic separation	87.0	7.5	64.3
Elutriation and electrostatic separation	90.0	4.9	71.3

Most of the bismuth in the current Preissac ore occurs as bismuthinite. Separation of this mineral from pyrite (chief contaminant) by either selective flotation or gravity concentration was rather difficult and ineffective. Thus, further investigation on molybdenite-bismuthinite bulk flotation was undertaken. Even though near-complete recovery of both minerals was achieved by bulk flotation, only a partial bulk flotation proved to be practical in order to avoid severe pyrite dilution. This last technique complemented by secondary flotation of the remaining bismuthinite (and native bismuth whenever present in the ore) gave the best

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overall results as shown below:

<u>Procedure</u>	<u>MoS<sub>2</sub> - Bi Concentrate</u>			<u>Primary Tailing</u>	<u>Secondary Tailing</u>
	<u>% MoS<sub>2</sub></u>	<u>% Bi</u>	<u>% Fe</u>	<u>% Bi</u>	<u>% Bi</u>
Selective Flotation	88.8	1.5	0.4	0.038	0.030
Partial Bulk Flotation	82.1	4.3	1.2	0.020	0.008
Full Bulk Flotation	72.5	6.4	5.0	0.006	

Appreciable bismuthinite and coarse molybdenite were observed in the cleaner tailing from the primary circuit. By tabling and screening this cleaner tailing, it was possible to obtain a bismuth concentrate assaying 45% Bi and a molybdenite concentrate analysing 89% MoS<sub>2</sub>.

Screen and infrasizer analyses on the Preissac mill feed (classifier overflow) and on the mill tailing showed consistent high recovery of molybdenite in all sizes coarser than 10 microns. This clearly indicates that the recent decrease in molybdenite recovery cannot be attributed to excessive loss of coarse molybdenite.

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## INTRODUCTION

Preissac Molybdenite Mines Limited has been producing molybdenum and bismuth for nearly two years at its property, near Cadillac, Abitibi-East, Quebec. From an initial rate of 600 tons/day, the plant capacity was recently increased to 1200 tons/day. The mill flowsheet is similar to that shown on page 39 of Mines Branch Investigation Report IR-63-122.

### Purpose of Investigation

After the usual problems encountered during the start-up of the mill, three main metallurgical problems arose in the treatment of the Preissac ore. These were: (1) a reduction in molybdenite grade whenever talc schist appeared in the mill feed, (2) difficulty in achieving expected bismuth grade and recovery, and (3) a recent decrease in molybdenite recovery.

At the request of Mr. Bernard Joyal, Manager, Preissac Molybdenite Mines Limited, Cadillac, Abitibi-East, Quebec, and with the collaboration of Mr. Alan Kissock, Consultant, 40 Fifth Avenue, New York 11, N.Y., U.S.A., attempts were made to solve these problems by laboratory and plant scale experimental work. In this connection, the author made two field investigations at the Preissac mill, on March 2nd to 9th, 1965, and on July 30th to August 2nd, 1965, respectively.

### Sampling and Analysis

Various samples of ore and mill products were used for this investigation. These were either received from Preissac Molybdenite or taken in place during the field trips to the property. A description of the samples with pertinent head analyses are shown in Table 1.

TABLE 1

Description and Head Analysis of Samples

Product	Sample Weight lb	Date Received or taken	Head analysis* %			
			MoS <sub>2</sub>	Bi	Fe	Insol
Talcy ore	134	25- 5-63	0.44	0.070	0.9	94.0
Talc-laden concentrate	100	5-10-64	62.4	1.6	1.2	30.0
Current ore (talc-free)	100	6- 3-65	0.38	0.044	0.6	92.0
Plant table tailing	50	8- 3-65	1.1	5.1	41.5	9.2
Tailing from first molybdenite cleaner cell	10	1- 8-65	44.7	2.5	-	-
Classifier o'flow	5	1- 8-65	0.34	0.046	-	-
Molybdenite circuit tailing**	5	1- 8-65	0.04	0.025	-	-
Bismuth circuit tailing***	5	1- 8-65	0.04	0.013		

\* From Internal Reports MS-AC-63-377, 64-2037 and 65-552, and by Preissac Molybdenite Mines Limited.

\*\* Also designated as primary tailing.

\*\*\* Also designated as secondary tailing.

## OUTLINE OF INVESTIGATION PROCEDURES

Selective flotation was the first technique investigated for talc removal from molybdenite concentrate. Among several depressants tried, only alum proved to be of practical value. However, even in the best test with this reagent, it was not possible to upgrade the molybdenite concentrate to above 78% MoS<sub>2</sub>. Consequently, other techniques such as elutriation and electrostatic separation were also tried in order to obtain a more complete talc elimination.

The second part of the investigation was aimed at improving bismuth recovery in plant practice. Analysis of the mill circuit, including microscopic examination of various products, made it evident that the poor mill performance was largely due to the bismuth being present, mostly as bismuthinite, and to a lesser extent as native bismuth, which was the reverse to previous samples received from this property. Therefore, several techniques adaptable to this type of ore were investigated, namely, (1) selective flotation of bismuthinite from plant table tailing, (2) bulk flotation of bismuthinite with molybdenite, and (3) gravity concentration of bismuth from molybdenite cleaner tailing.

To determine the cause of the recent decrease in molybdenite recovery, screen and infrasizer analyses were made on the feed and tailing of the mill circuit. A device including tabling and screening was then tested as a possible means to increase the recovery of coarse molybdenite.

## DETAILS OF INVESTIGATION

### Part 1, Removal of Talc

#### i) Flotation techniques

The talc problem was first tackled by testing a series of possible depressants for elimination of this mineral from molybdenite concentrate. The products obtained in the various tests were examined microscopically and only the more promising tests were submitted for chemical analysis. The action of the reagents investigated is summarized in Table 2.



TABLE 2

Effect of Depressants on Talc and Molybdenite

Depressant	Remarks
Reagent 610 Sodium silicate Lime	No depressing effect on talc.
Reagent M-11 Guartec Caustic Starch	Slightly depressive on talc, but considerably on molybdenite
Locust bean Lignosol BD	Effective depressants for talc, but concentration is critical to avoid molybdenite depression.
Alum	Effective depressant for talc and less critical on molybdenite.

Since alum was the only practical selective depressant, details of tests will be confined to this chemical.

Tests 1 and 2

Two main tests were conducted with alum, one on the talc-bearing ore, the other on the talc-laden concentrate received from the Preissac mill. Flotation procedure and results obtained are summarized in Tables 3 and 4.

TABLE 3

Reagents and Conditions of Flotation

Operation	Time min	Reagents	lb/ton	p.H
Test 1: Conditioning	5	Alum Sodium cyanide Sodium silicate Kerosene 1:1 Pine oil-Dowfroth 250	1.50 0.30 0.30 0.07 0.02	8.8
Rougher flotation	5	1:1 Pine oil-Dowfroth 250	0.02	8.7
Tests 1 and 2: Cleaner flotation	4	Alum Sodium cyanide Kerosene	0.20 0.05 0.02	8.4
Recleaner flotation	3	Alum Sodium cyanide	0.02 0.02	8.3

TABLE 4

Molybdenite Flotation Using Alum as Talc Depressant

Test	Product	Weight %	Analysis*		Distribution %
			MoS <sub>2</sub>	Insol	
1	MoS <sub>2</sub> recl conc	0.53	77.9	18.3	89.2
	MoS <sub>2</sub> recl tailing	0.18	10.0	-	3.9
	MoS <sub>2</sub> cl tailing	0.83	0.9	-	1.6
	Scav conc	1.31	0.4	-	1.1
	Flotn tailing	97.15	0.02	-	4.2
	Feed (calcd)	100.00	0.46	-	100.0
2	MoS <sub>2</sub> recl conc	59.5	75.2	14.0	75.7
	MoS <sub>2</sub> recl tailing	8.2	40.1	41.2	5.6
	MoS <sub>2</sub> cl tailing	32.3	34.2	46.8	18.7
	Feed (calcd)	100.0	59.1	26.8	100.0

\* From Internal Report MS-AC-144 and 351 and by Preissac Molybdenite Mines Limited.

Early tests with alum at the Preissac mill indicated that the concentration of this reagent was more critical in plant practice than in the laboratory. As a result, considerable molybdenite was lost in the tailing. Subsequent mill operation with carefully controlled minimum addition of alum was said to reduce this loss to a practical limit when considering the close association of some molybdenite with talc particles.

### ii) Electrostatic Separation

The conductivity characteristics of molybdenite (conductor) and talc (non-conductor) indicated that these minerals might be separated by electrostatic separation.

#### Test 3

A 150 g sample of talc-laden molybdenite concentrate was treated in a Carpc electrostatic separator set at 90 amperes with the following results.

TABLE 5

#### Talc Removal by Electrostatic Separation

Product	Weight %	Analysis*%		Distribution %	
		MoS <sub>2</sub>	Insol	MoS <sub>2</sub>	Insol
MoS <sub>2</sub> conc	46.1	87.0	7.5	64.3	11.2
Talc conc	53.9	41.3	45.2	35.7	88.8
Feed (calcd)	100.0	62.4	27.4	100.0	100.0

\* By Preissac Molybdenite Mines Limited.

Examination of the products showed fine talc loosely adhering to the molybdenite. That this reduced the efficiency of the separation was demonstrated by electrostatic tests on sized material where best results were obtained on coarser products.

### iii) Elutriation and Electrostatic Separation

To remove interfering fine talc, and so to improve the electrostatic separation, counter-current washing was used as a preliminary treatment.

#### Test 4

A 100 g sample of the talc-laden molybdenite concentrate was elutriated in a laboratory column and the u'flow was treated by electrostatic separation.

TABLE 6

Talc Removal by Elutriation and Electrostatic Separation

Product	Weight %	Analysis* %		Distribution %	
		MoS <sub>2</sub>	Insol	MoS	Insol
MoS <sub>2</sub> conc	50.5	90.0	4.9	71.3	9.9
Talc conc (e.s.s.)	36.6	35.2	46.5	20.4	68.1
Talc conc (o'flow)	12.9	40.6	42.6	8.3	22.0
Feed (calcd)	100.0	63.1	25.0	100.0	100.0

\* From Internal Report MS-AC-64-2093 and by Preissac Molybdenite Mines Limited.

Part 2, Bismuth Recoveryi) Data of Mill Operation

Preissac Molybdenite failed until recently to produce bismuth flotation concentrate of shipping grade (40% Bi). At first, this was attributed, partly to the low grade of the ore, but mainly to excessive cell capacity in the cleaning circuit. More recently, the mode of occurrence of the bismuth in the ore also proved to be an important factor.

In pilot plant operation, from an ore containing 0.06% Bi, flotation concentrates of 43% bismuth grade were floated at a ratio of concentration of about 1,400:1. In plant practice, with an ore containing only 0.03% Bi during early production, a ratio of 2,800:1 would have been necessary to produce a concentrate of similar grade. The difficulty in achieving this objective was complicated further by a serious shortcoming in the bismuth cleaner circuit.

At Preissac, the bismuth rougher concentrate was cleaned in a series of six Denver No. 18 special cells. Although rated at 15 tons/cell/24 hrs, each of these cells was treating less than 2 tons/24 hrs. The subsequent excessive dilution resulted in unduly high bismuth reporting readily in the tailing of the cleaner circuit, and eventually in the mill tailing. The poor grade of the flotation concentrate was also attributed to the lack of adequate cleaning operation. Therefore, it was necessary to table the flotation concentrate in order to obtain a final product of marketable grade. However, this practice resulted in heavy bismuth losses in the table tailing.

To determine the cause of these losses, a microscopic examination was made by Dr. W. Petruk of the Mineral Sciences Division on a representative sample from the plant table tailing.

The results of this examination are summarized below:

- 1 - Mineral distribution was approximately as follows: bismuthinite (3.5%), native bismuth (1.5%), pyrite (90%) and gangue minerals (5%).
- 2 - Native bismuth occurred intergrown with bismuthinite.
- 3 - Pyrite was generally present as coarser particles than bismuthinite. It was concluded that both the fine texture and the small difference in specific gravity of bismuthinite in comparison to pyrite precluded further gravimetric methods for the separation of these minerals.

Contrary to expectation, mineralogical examination indicated that the most abundant bismuth mineral in the current Preissac ore was bismuthinite. Because native bismuth was suspected to be dominant in the ore originally treated in pilot plant work, new mineralogical studies were made on several samples from the two types of ore. These confirmed the mineralogical differences which are summarized below.

Pilot Plant Ore:\* "The native bismuth is present as free grains, up to 100 microns in size, and contains inclusions of bismuthinite. The bismuthinite is present mostly as inclusions in native bismuth".

Current Ore:\* "The bismuthinite is present largely as free grains and contains the native bismuth as inclusions."

In the light of these findings, further investigation aimed at separating bismuthinite and pyrite was indicated.

Remark: This problem was new and different to that previously resolved in pilot plant work i.e. the separation of native bismuth from pyrite by the selective depressing action of ammonium hydroxide.

#### ii) Selective Flotation of Bismuthinite from Table Tailing

As a possible means of recovering additional bismuth, differential flotation of bismuthinite from the Preissac table tailing was investigated. This research was aimed at finding an effective pyrite depressant which would not impair bismuthinite flotation. The results with the various reagents tested can be summarized as follows:

- 1 - Ammonium hydroxide at low concentration had little depressing effect on pyrite; as concentration increased, bismuthinite began to be depressed.
- 2 - Both sodium hydrosulphite and reagent 610 were found ineffective for pyrite depression.
- 3 - Lime depressed bismuthinite along with pyrite.
- 4 - Sodium cyanide depressed most of the pyrite without impairing seriously bismuthinite flotation.

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\* From Internal Report MS-65-64.

Because sodium cyanide gave by far the best separation of bismuthinite from pyrite, only the tests with this reagent will be reported in detail.

Test 5

A 1000 g sample was cut from the Preissac table tailing and floated in a Denver laboratory cell. Test procedure and results obtained are shown in Tables 7 and 8.

TABLE 7

Reagents and Conditions of Flotation

Operation	Time min	Reagents	lb/ton	pH
Conditioning	2	Sodium cyanide	0.10	8.6
Flotation	5	Xanthate Z - 6 Dowfroth 250	0.05 0.05	

TABLE 8

Selective Flotation of Bismuthinite from Table Tailing

Product	Weight %	Analysis* %	Distribution %
Bi conc	15.1	23.8	69.0
Flot tailing	84.9	1.9	31.0
Feed (calcd)	100.0	5.2	100.0

\* From Internal Report MS-AC-65-511.

A few other tests were made with sodium cyanide in attempts to improve on the above results, but no significant improvement was achieved. The difficulty in obtaining a better separation was attributed to two main factors, namely, the high ratio of pyrite to bismuthinite and the activation of some pyrite by xanthate Z - 6, despite the presence of sodium cyanide.

However, the floatability of bismuthinite in presence of sodium cyanide indicated that it should be possible to recover bismuthinite with molybdenite directly from the ore, while depressing the pyrite.

iii) Flotation of Bismuthinite with Molybdenite

In floating bismuthinite with molybdenite using xanthate Z - 6 and sodium cyanide, it was found that appreciable pyrite reported with the concentrate. To reduce this contaminant, a series of tests was made at increasing concentration of sodium cyanide and at decreasing concentration of xanthate Z - 6. These tests showed that by carefully controlling the amount of Z - 6, it was possible to reduce the pyrite to an acceptable level in a final molybdenite-bismuth concentrate.

Tests 6, 7 and 8

Flotation procedure and results of typical tests when varying Z - 6 concentration are shown in Tables 9 and 10.

TABLE 9

Reagents and Conditions of Flotation

Operation	Time min	Reagents	lb/ton	pH
Conditioning	3	Sodium cyanide	0.10	9.2-9.6
		Sodium silicate	0.10	
		Kerosene	0.10	
		Xanthate Z - 6 :		
		Test 6	0.01	
Rougher flotation	5	1:1 Pine oil-Dowfroth 250	0.06	9.1-9.4
		Scavenger flotation		
		Kerosene	0.03	
Scavenger flotation	5	1:1 Pine oil-Dowfroth 250	0.02	8.8-9.2
		Xanthate Z - 6 :		
		Test 6	0.004	
		Test 7	0.007	
		Test 8	0.010	
Cleaner flotation	4	Sodium cyanide	0.04	9.2-9.4
		Kerosene	0.03	
		1:1 Pine oil - Dowfroth 250	0.02	
		Xanthate Z - 6 :		
		Test 6	0.004	
Recleaner flotation	3	Sodium cyanide	0.02	8.9-9.3
		Xanthate Z - 6 :		
		Test 6	0.002	
		Test 7	0.003	
		Test 8	0.005	

TABLE 10

Flotation of Bismuthinite with Molybdenite on Laboratory Scale

Test	Product	Weight %	Analysis * %				Distribution %	
			MoS <sub>2</sub>	Bi	Fe	Insol	MoS <sub>2</sub>	Bi
6	MoS <sub>2</sub> - Bi recl conc	0.45	83.3	3.68	0.35	8.0	92.9	41.2
	MoS <sub>2</sub> - Bi recl tailing	0.31	3.5	0.57	-	-	2.7	4.5
	MoS <sub>2</sub> - Bi cl tailing	1.16	0.14	0.08	-	-	0.4	2.2
	Scav conc	1.45	0.31	0.52	-	-	1.1	18.6
	Flot tailing	96.63	0.012	0.014	-	-	2.9	33.5
	Feed (calcd)	100.00	0.40	0.040	-	-	100.0	100.0
7	MoS <sub>2</sub> - Bi recl conc	0.45	79.0	6.45	1.52	7.8	90.8	61.1
	MoS <sub>2</sub> - Bi recl tailing	0.13	6.4	0.61	-	-	2.1	1.7
	MoS <sub>2</sub> - Bi cl tailing	1.14	0.31	0.17	-	-	0.9	4.0
	Scav conc	1.33	0.43	0.46	-	-	1.5	12.8
	Flot tailing	96.95	0.019	0.10	-	-	4.7	20.4
	Feed (calcd)	100.00	0.39	0.047	-	-	100.0	100.0
8	MoS <sub>2</sub> - Bi recl conc	0.46	72.5	6.40	5.0	9.1	87.0	67.3
	MoS <sub>2</sub> - Bi recl tailing	0.38	5.8	0.75	-	-	5.7	6.6
	MoS <sub>2</sub> - Bi cl tailing	1.50	0.45	0.22	-	-	1.7	7.5
	Scav conc	1.52	0.34	0.15	-	-	1.3	5.3
	Flot tailing	96.14	0.017	0.006	-	-	4.3	13.3
	Feed (calcd)	100.00	0.38	0.044	-	-	100.0	100.0

\* From Internal Report MS-AC-63-648 and by Preissac Molybdenite Mines Limited.



The encouraging results obtained in the above tests prompted a trial of this technique in plant practice. For this purpose, the only change made in the Preissac mill was to add various amounts of xanthate Z-6 to the molybdenite circuit. The bismuth circuit was left unchanged in the hope of recovering the remaining bismuth. The data for the plant scale investigation are summarized in Table 11, which shows the total addition of xanthate Z-6 with the resulting analyses of the MoS<sub>2</sub>-Bi concentrate. In the more important tests, the tailing from the molybdenite circuit (primary tailing) and from the bismuth circuit (secondary tailing) were sampled and analysed.

TABLE 11

Flotation of Bismuthinite with Molybdenite on Plant Scale

Part 1: Analysis

Test	Z-6 lb/ton	Analysis* %						
		MoS <sub>2</sub> -Bi Concentrate					Tailing	
		MoS <sub>2</sub>	Bi	Fe	Cu	Insol	MoS <sub>2</sub> circuit Bi	Bi circuit Bi
9	0.000	88.8	1.5	0.4	0.08	5.5	0.038	0.030
10	0.003	86.5	2.8	0.6	0.10	6.0	-	-
11	0.005	85.1	3.1	1.0	0.11	6.3	0.032	0.021
12	0.008	84.5	3.3	0.8	0.12	6.4	-	-
13	0.014	82.1	4.3	1.2	0.17	6.0	0.020	0.008
14	0.019	78.2	3.2	2.2	0.13	8.0	-	-
15	0.025	78.1	5.0	2.2	0.16	6.6	-	-
16	0.036	75.8	5.5	3.7	0.19	5.3	-	-
17	0.048	76.2	4.3	3.8	0.21	5.3	-	-
18	0.072	72.5	6.1	3.4	0.19	7.7	-	-

\* By Preissac Molybdenite Mines Limited.

Part 2: Recovery

Test	Bismuth Recovery* %		
	MoS <sub>2</sub> circuit	Bi circuit	Total
9	15.6	17.7	33.3
11	28.9	24.4	53.3
13	53.3	26.7	80.0

\* Calculated by difference from a feed of 0.045% Bi.

The plant scale investigation confirmed that it is not possible to recover all the bismuth with the molybdenite, without lowering the grade of the concentrate to an unacceptable level. Consequently, a secondary bismuth circuit should be always necessary to recover remaining bismuthinite, and possibly native bismuth whenever this mineral occurs in the ore.

iv) Gravity Concentration of Bismuth from Flotation Cleaner Tailing

During the above plant scale work, it was observed that a fair quantity of bismuth reported in the tailing from the molybdenite cleaner cells. This prompted an investigation to determine if a shipping grade concentrate of bismuth could be removed at this point of the circuit by gravimetric method.

Test 19

A representative sample (1,000 g) of the tailing from the first cleaner cell of the molybdenite circuit was treated on a Deister laboratory table with the following results.

TABLE 12

Gravity Concentration of Bismuth

Product	Weight %	Analysis* %		Distribution %	
		MoS <sub>2</sub>	Bi	MoS <sub>2</sub>	Bi
Bi conc	1.3	5.0	46.3	0.1	25.3
Table tailing	98.7	45.1	1.8	99.9	74.7
Feed (calcd)	100.0	44.6	2.4	100.0	100.0

\* From Internal Report MS-AC-65-865.

Part 3, Survey of Molybdenite Circuit

i) Molybdenite Recovery in Sized Fractions

Recently, an appreciable decrease in molybdenite recovery was observed at Preissac mill. According to Mr. Joyal, Manager, this could be attributed to the resistance of coarse particles to flotation. However, further investigation was necessary to draw more definite conclusions. For this purpose, screen and infrasizer tests were done on various mill products.

Test 20

Samples of 500 g were cut from the classifier overflow and the molybdenite circuit tailing. These were sized carefully and all the fractions obtained were analysed for molybdenite.

From these analyses, it was possible to calculate the recovery in each fraction as shown in Table 13.

TABLE 13

Molybdenite Recovery in Sized Fractions

Size	Weight * %	Analysis ** % MoS <sub>2</sub>		Recovery *** % MoS <sub>2</sub>
		O'flow	Tailing	
+ 35 m	7.0	0.31	0.052	83.6
- 35+ 48	9.0	0.31	0.032	89.7
- 48+ 65	12.6	0.33	0.034	89.7
- 65+100	13.9	0.33	0.032	90.3
-100+150	13.6	0.27	0.024	91.1
-150+200	7.9	0.37	0.017	95.4
-200+ 40 μ	10.9	0.55	0.040	92.7
- 40+ 20	12.4	0.40	0.037	90.7
- 20+ 10	6.4	0.20	0.030	85.0
- 10	6.3	0.14	0.080	42.9
Feed (calcd)	100.0	0.34	0.036	89.4

\* Average % weight from o'flow and tailing.

\*\* By Preissac Molybdenite Mines Limited.

\*\*\* Calculated by difference.

ii) Gravity Concentration of Molybdenite from Flotation Cleaner Tailing

When tabling the tailing from the molybdenite cleaner circuit, it was observed that appreciable coarse molybdenite along with finer pyrite appeared in the middling band. This suggested that a high grade molybdenite concentrate could be obtained from this product by screening.

Test 21

To simulate this procedure, a laboratory test was made on a 1,000 g sample taken from the molybdenite first cleaner tailing. This material was fed to a Deister table from which the middling band discharged on a 65 mesh vibrating screen. Three products were retained, namely, a bismuth concentrate (top band on table), a molybdenite concentrate (over-size from the middling band) and a tailing (undersize from the middling band plus table tailing). Analyses of these products and corresponding distribution are shown in Table 14.

TABLE 14

Concentration of Coarse Molybdenite by Tabling and Screening

Product	Weight %	Analysis * %		Distribution %	
		MoS <sub>2</sub>	Bi	MoS <sub>2</sub>	Bi
MoS <sub>2</sub> conc (+65 m)	15.7	89.7	0.2	31.5	1.2
Bi conc	1.4	7.6	45.0	0.2	25.4
Tailing	82.9	36.8	2.2	68.3	73.4
Feed (calcd)	100.0	44.7	2.5	100.0	100.0

\* From Internal Report MS-AC-65-865.

## SUMMARY AND CONCLUSIONS

The sporadic occurrence of talc in the Preissac ore presents a major problem, because of the inherent floatability of this mineral and of its tendency to coat molybdenite flakes. Furthermore, the kerosene which is used to float the molybdenite also proved to be an effective talc collector.

The usual technique for treating talc-bearing sulphide ore consists of primary talc flotation by an hydrocarbon, but this could not be used because molybdenite is also readily floated by this type of collector. Therefore, the elimination of talc by flotation methods necessitates the discovery of a selective depressant for this contaminant. Several chemicals, including lime, sodium silicate, Reagent 610, Guartec, caustic, starch, Reagent M-11, locust bean, Lignosol BD and alum, were investigated for this purpose. Most of these either failed to depress talc or showed depressing effect on molybdenite, except alum, which succeeded in upgrading a talc-laden concentrate from 62% MoS<sub>2</sub> to 75% MoS<sub>2</sub> in laboratory scale test.

In plant practice with recirculation, alum concentration proved to be rather critical and only minimum addition of this reagent was permissible to avoid considerable loss of molybdenite. However, it was found that the addition of alum in small amounts, was successful in improving the molybdenite grade from 35% to 75%, without an appreciable loss of molybdenite, whenever the talc content in the ore is not particularly high. This concentrate does not meet normal market specifications (85% to 90% MoS<sub>2</sub>), but it could be used either as is, or mixed with higher grade material for ferromolybdenum production at Preissac plant, or sold to companies specialized in leaching low grade molybdenite concentrate.

The only possible means found to upgrade a talc-laden concentrate to 90% MoS<sub>2</sub> consists of elutriation followed by electrostatic treatment of the underflow fraction. However, application of such a technique in plant practice would be rather difficult because of the necessity of feeding carefully dried material

to the electrostatic separator.

Either cleaner flotation with alum or elutriation plus electrostatic separation would necessitate recirculation of talc-rich intermediate products. Consequently, to avoid a talc build-up in the molybdenite circuit, fresh talc-bearing ore should be fed only intermittently in relatively small lots. A last pertinent comment on this matter is that a decrease in molybdenite recovery should be expected when treating talcy ore, because the talc adheres and sometimes is associated with molybdenite particles, and also because of a heavy recirculation of molybdenite-rich middlings.

The company encountered great difficulties in producing bismuth concentrate of acceptable grade and recovery by selective flotation. This was first attributed to low grade ore (0.02% to 0.03% Bi in early production) and to the excessive cell capacity of the cleaner bismuth circuit. From analytical results received periodically from Preissac laboratory, it was found that an appreciable increase in both grade and recovery was achieved when the bismuth content in the ore approached 0.05% Bi, and particularly when smaller cleaner cells were installed. Even under these conditions, it was not possible to produce a direct shipping concentrate (40% Bi) by flotation and further tabling was necessary to obtain the required grade, notwithstanding heavy bismuth loss via table tailing.

A thorough survey of the bismuth circuit at the plant was then undertaken as a first step in solving this problem. Mineralogical examination of several mill products showed that most of the bismuth in the ore currently being treated at Preissac plant occurs as bismuthinite. This represents a major difference from earlier pilot plant studies in which most of the bismuth occurred as the native metal. As this new type of ore did not respond to the established procedure, further investigation was indicated to improve the treatment method.

A series of tests was made on the plant table tailing in an attempt to find a pyrite depressant which would not interfere with bismuthinite flotation. Of several reagent tests, only sodium cyanide gave encouraging results. Bulk flotation of bismuthinite and molybdenite was then tried using kerosene, xanthate Z-6 and sodium cyanide. Although near-complete recovery of both minerals can be obtained when using Z-6 liberally, this practice is not recommended because of excessive dilution by pyrite as shown below:

Product	Analysis %			Distribution %	
	MoS <sub>2</sub>	Bi	Fe	MoS <sub>2</sub>	Bi
MoS <sub>2</sub> - Bi conc	72.5	6.4	5.0	91.3	77.0
Flot tailing	0.033	0.010	-	8.7	23.0

Note: These figures include an estimated 50% recovery from the middling products.

A more promising method for improving the bismuth recovery consists of partial bulk flotation using starvation amount of Z-6 to avoid severe pyrite dilution, followed by secondary flotation of the remaining bismuth minerals and tabling of the concentrate. A typical plant scale test along these lines gave the following results:

<u>Product</u>	<u>Analysis %</u>			<u>Distribution %</u>	
	MoS <sub>2</sub>	Bi	Fe	MoS <sub>2</sub>	Bi
MoS <sub>2</sub> - Bi conc	82.1	4.3	1.2	90.5	53.3
MoS <sub>2</sub> circuit tailing	0.036	0.020	-	9.5	46.7
Bi circuit tailing	-	0.008	-	-	20.0

Note: Whenever native bismuth occurs in the ore, the necessity of the secondary circuit is more imperative because this mineral, once depressed by sodium cyanide in the primary circuit, needs reactivation by sulphuric acid for subsequent flotation.

Bulk flotation with starvation amount of collector was continued for several days in plant operation. Concentrates averaging 82.6 MoS<sub>2</sub> and 3.5% Bi were produced, showing that at least 40% of the bismuth was readily recoverable with molybdenite without impairing the grade. However, because of lack of assay data, it was not possible to calculate the bismuth recovery in the secondary circuit during the same period.

A decrease in molybdenite recovery in recent plant operation was attributed to loss of coarse molybdenite. However, screen and infrasizer analyses of mill products showed that most of the molybdenite loss occurred in the minus 10 micron size. This is illustrated by the following table:

<u>Size</u>	<u>Weight %</u>	<u>MoS<sub>2</sub> Recovery %</u>
+35mesh	7.0	83.6
-35+48 "	9.0	89.7
-48+65 "	12.6	89.7
-65+40micron*	46.3	92.0
-40+20 "	12.4	90.7
-20+10 "	6.4	85.0
-10 "	6.3	42.9

\* Combined fractions

During the investigation at the Preissac plant, it was observed that appreciable bismuth and coarse molybdenite reported with the cleaner tailing from the molybdenite circuit. To recover at least a portion of these values, a sample of this cleaner tailing was treated by tabling and screening with the following results:

<u>Product</u>	<u>Grade</u>	<u>Recovery</u>
Bi conc	45.0% Bi	25.4%
MoS <sub>2</sub> conc	89.7% MoS <sub>2</sub>	31.5%

Even these modest recoveries would justify the installation of tabling and screening facilities, because such a low cost operation would permit recovery of two finished concentrates, not otherwise recoverable with any certainty by recirculation.

To summarize, the results of this investigation indicated that:

- (1) Alum was the only reagent found which offered some hope of selectively depressing the talc.
- (2) Partial bulk flotation followed by secondary flotation of the remaining bismuth minerals proved to be a good technique for improving bismuth recovery.
- (3) Tabling and screening of the molybdenite cleaner tailing should increase both molybdenite and bismuth recovery and at the same time produce two finished concentrate.

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