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FLOTATION TESTS ON A MOLYBDENITE ORE FROM UTUFORA MINES CO. LTD., LA MOTTE TOWNSHIP, QUEBEC

by

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SUMMARY OF RESULTS

The molybdenite ore submitted by Utufora Mines assayed 0.51% MoS_2, 0.025% Bi and 0.007% Cu. The molybdenite occurred mostly as masses free of impurities with the exception of a small amount of bismuthinite disseminated through the molybdenite grains.

Flotation of the ore, ground to 52% minus 200 mesh, recovered 94.1% of the molybdenite in a concentrate assaying 98.2% MoS_2, 0.38% Bi and 0.02% Cu.

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INTRODUCTION

Utufora Mines Co. Ltd. holds a molybenite property situated in the southwestern corner of La Motte township in northwestern Quebec. The ore reserves at the surface are estimated at 300,000 tons, and an additional 250,000 tons have been estimated from diamond drilling results.

Shipment

A shipment of 660 lb of molybdenite ore crushed to minus 1½ in. was received on August 24, 1963, from Mr. Gilles E. Huot, President, Utufora Mines Co. Ltd., 146 Main Street, Rouyn, Quebec.

Purpose of Investigation

Mr. Huot requested an investigation to determine:

(1) the percentage recovery of marketable grade molybdenite concentrate;

(2) analysis of molybdenite concentrate; and

(3) approximate milling cost.

Because of the low percentage of bismuth in the feed, Mr. Huot suggested that no attempt be made to recover the bismuth minerals.

Sampling and Analysis

The material as received was cut into two equal portions. One part was crushed to -10 m and a head sample was riffled out by conventional methods.

Chemical analysis of the head sample gave the following results:

TABLE 1

Chemical Analysis* of Head Sample

Molybdenite (MoS_2)	0.51%
Bismuth (Bi)	0.025%
Copper (Cu)	0.007%
Lead (Pb)	0.008%
Iron (Fe)	0.91%
Insoluble	95.8%

*From Internal Report MS-AC-63-1216.

A spectrographic analysis of a portion of the head sample detected the following elements listed in their approximate decreasing order of abundance.

TABLE 2

Spectrographic Analysis* of Head Sample

I	- Si, Na, Al (>1.0%)
II	- Fe, Mo, Mg (1.0-0.1%)
III	- Ca, Ti, Mn, Bi, Ni (0.1-0.01%)
IV	- Ba, Cr, Sn, Ca, Pb, Cu, Ag (<0.01%)

*From Internal Report MS-AC-63-1015.

MINERALOGICAL EXAMINATION*

A portion of the head sample was submitted to the Mineralogy Section of the Mineral Sciences Division for identification of the minerals.

The sample was screened and the -65 +200 m fraction was separated into sub-fractions by means of heavy liquids (specific gravities of 2.96, 3.33 and 3.70). A polished section was prepared from the 3.70 sink fraction and the minerals in it, as well as in the 2.96, 3.33 and 3.70 float fractions, were identified by means of microscopic and X-ray diffraction studies.

The metallic minerals in the ore are molybdenite, bismuthinite, native bismuth, chalcopyrite, argentite, stannite, magnetite, goethite and

*From Internal Report MS-63-107 by W. Petruk, Mineralogy Section, Mineral Sciences Division, October 30, 1963.

and pyrite. The non-metallic minerals are quartz, feldspar, muscovite, talc, a clay mineral, and a green amphibole.

Molybdenite is the principal metallic mineral. It occurs as masses and minute inclusions in gangue. Some molybdenite grains contain a few bismuthinite inclusions.

The bismuth-bearing minerals are bismuthinite and native bismuth. The bismuthinite, which accounts for about 80% of the total bismuth, occurs mostly as large free grains. The native bismuth is largely present as includions in chalcopyrite, galena and bismuthinite.

Small quantities of chalcopyrite, argentite and stannite were found in a gravity concentrate prepared by means of heavy liquids. Some grains of these minerals were free while the others were intergrown with each other and with pyrite.

The pyrite in the gravity concentrate was present as free grains and as inclusions in gangue.

DETAILS OF INVESTIGATION

A series of tests was made to study the liberation characteristics of the molybdenite. Then, a flotation test was made using additions of sodium cyanide with the purpose of reducing the impurities in the molybdenite concentrate, particularly the bismuth and the copper minerals. In the last two tests, the rougher concentrate was cleaned twice to produce a final molybdenite concentrate.

Tests 1, 2 and 3 - Effect of Grinding

In these tests, 2,000 g samples of ore, crushed to -10 mesh, were ground for 10, 20 and 30 min and floated using the procedure shown in Table 3.

TABLE 3

Flotation Reagents and Conditions

Operation	Time min	Reagents	lb/ton	pH
Grinding		Kerosene	0.12	
Conditioning	3	1:1 Pine oil-Dowfroth 250	0.04	8.1
MoS_2 rougher flotation	8	1:1 Pine oil-Dowfroth 250	0.02	8.0
MoS_2 cleaner flotation	4	Kerosene	0.03	7.8
		1:1 Pine oil-Dowfroth 250	0.02	

TABLE 4

Flotation Results After 10, 20 and 30 min Grinding

Test	Product	Weight %	Analysis* %			Distribution %
			MoS_2	Bi	Cu	MoS_2
1	MoS_2 cl conc	0.56	90.2	0.72	0.35	91.9
	MoS_2 cl tailing	0.30	3.20	-	-	1.8
28% -200 m	Flotn tailing	99.14	0.035	-	-	6.3
	Feed (calcd)	100.00	0.55	-	-	100.0
2	MoS_2 cl conc	0.57	86.4	0.60	0.20	95.2
	MoS_2 cl tailing	0.59	0.90	-	-	1.0
52% -200 m	Flotn tailing	98.84	0.020	-	-	3.8
	Feed (calcd)	100.00	0.52	-	-	100.0
3	MoS_2 cl conc	0.55	86.4	0.69	0.14	93.7
	MoS_2 cl tailing	0.68	1.07	-	-	1.4
68% -200 m	Flotn tailing	98.77	0.025	-	-	4.9
	Feed (calcd)	100.00	0.52	-	-	100.0

*From Internal Report MS-AC-63-1216 and 1252.

The highest molybdenite recovery was obtained after grinding for 20 minutes to 52% -200 mesh.

Test 4 - Effect of Sodium Cyanide

In this test, a sample of the ore was ground 20 minutes to 52% -200 mesh, and floated following the procedure described in Table 3, except that sodium cyanide additions of 0.3 and 0.1 lb/ton of ore were made to the conditioning and cleaner flotation stages respectively. The corresponding pH values were increased to 9.7 and 9.8.

TABLE 5

Flotation Results Using NaCN

Product	Weight %	Analysis* %			Distribution %
		MoS_2	Bi	Cu	MoS_2
MoS_2 cl conc	0.53	90.4	0.40	0.07	95.1
MoS_2 cl tail	0.52	1.35	-	-	1.4
Flotn tailing	98.95	0.018	-	-	3.5
Feed (calcd)	100.0	0.50	-	-	100.0

*From Internal Report MS-AC-63-1276.

Test 5 - Effect of Recleaning

This test was similar to Test 4 (i.e. an addition of sodium cyanide to the conditioning stage and to the cleaner flotation), except that a 4000 g sample was used and the final concentrate was recleaned without additional reagents.

TABLE 6

Flotation Results After Recleaning

Product	Weight %	Analysis* %			Distribution %
		MoS_2	Bi	Cu	MoS_2
MoS_2 recl conc	0.50	95.8	0.36	0.04	93.6
MoS_2 recl tailing	0.10	20.4	0.94	0.10	2.0
MoS_2 cl tailing	0.38	0.70	-	-	0.5
Flotn tailing	99.02	0.020	-	-	3.9
Feed (calcd)	100.00	0.51	-	-	100.0

*From Internal Report MS-AC-63-1276.

Test 6 - Effect of B.H.B. Frother

This test was similar to Test 5 except that a 10:1 Butanol High Boiler (BHB) - Normal Butanol mixture was used instead of the 1:1 pine oil-Dowfroth 250. The BHB gave a more brittle froth.

TABLE 7

Flotation Results Using B.H.B. Frother

Product	Weight %	Analysis* %			Distribution %
		MoS_2	Bi	Cu	MoS_2
MoS_2 recl conc	0.51	98.2	0.38	0.02	94.1
MoS_2 recl tailing	0.10	15.4	0.64	0.06	1.4
MoS_2 cl tailing	0.46	0.68	-	-	0.6
Flotn tailing	98.93	0.021	-	-	3.9
Feed (calcd)	100.00	0.53	-	-	100.0

*From Internal Report MS-AC-63-1276.

Analysis, Examination and Sizing of MoS_2 Concentrates

A portion of the molybdenite concentrates produced in Tests 5 and 6 was analyzed spectrographically and the following elements were detected in the approximate order of decreasing abundance.

TABLE 8

Spectrographic Analysis* of MoS_2 Concentrates

I	-	MoS_2, Si (> 1.0%)
II	-	Fe, Bi, Mg (1.0 - 0.1%)
III	-	Al, Ca, Cu, Pb (0.1 - .01%)
IV	-	Ca, Mn, Ag, Zn (< 0.01%)

*From Internal Report MS-AC-63-1036.

A mineralogical examination of the molybdenite concentrates produced in Tests 5 and 6 revealed that the bismuth present in these concentrates occurs as tiny particles of bismuthinite varying from 5 to 20 microns in size. About one half of these particles are free while the other half are enclosed in the molybdenite grains and cannot be liberated by ordinary mechanical means.

The fine free particles of bismuthinite present in the final molybdenite concentrate were mechanically entrained by the large flakes of molybdenite despite two cleaning stages at high dilution. Past experience has shown that mechanical entrainment will occur even to a greater extent at the normal dilution of a plant circuit. Consequently, further reduction of the bismuth content of the molybdenite concentrate by physical means is not practical in bench scale tests.

To obtain more information about the size of the bismuth minerals contained in the molybdenite concentrates, the remaining fraction of the concentrates produced in Tests 5 and 6 were submitted to a screen test.

TABLE 9

Size Analysis of MoS_2 Concentrates

Size	Weight %	Analysis* %		Distribution %	
		MoS_2	Bi	MoS_2	Bi
+100 m	48.6	99.3	0.07	49.9	5.6
-100 +200 m	25.7	97.2	0.21	25.7	8.9
-200 +325 m	13.3	93.4	0.87	12.8	19.2
-325 m	12.4	90.7	3.23	11.6	66.3

*From Internal Report MS-AC - 63 - 1357.

These results confirmed the presence of very fine bismuth minerals in the molybdenite concentrate as observed in the mineralogical examination.

CONCLUSIONS

The Utufora ore assayed 0.51% MoS_2, 0.025% Bi and 0.007% Cu. The molybdenite occurs as coarse particles mostly free of impurities with the exception of a small amount of fine bismuthinite inclusions which cannot be liberated from the molybdenite by mechanical means.

A flotation technique consisting of a rougher and a cleaner flotation with kerosene, 1:1 pine oil-Dowfroth 250 and sodium cyanide, and of a recleaner flotation without addition of reagent produced a final concentrate assaying 95.8% MoS_2, 0.36% Bi and 0.04% Cu. A similar test resulted in a concentrate assaying 98.2% MoS_2, 0.38% Bi and 0.02% Cu, when the 1:1 pine oil-Dowfroth 250 was replaced by a 10:1 Butanol High Boiler - Normal Butanol mixture. Molybdenite recoveries in these tests varied from 93.6% to 94.1%.

The bismuth content of the molybdenite concentrates was attributed partly to inclusions of bismuthinite in the molybdenite and partly to unavoidable entrainment during the flotation. It is quite possible that mechanical entrainment will be greater in a plant operation due to the lower dilution than in the bench scale tests. Consequently, a complete removal of the associated and entrained bismuthinite will require an acid leach.

The depressing action of the sodium cyanide on the bismuth minerals present in Utufora ore was minimized by the large proportion of bismuth occuring as bismuthinite. Sodium cyanide has a strong depressing action on the native bismuth and chalcopyrite, but has little effect on bismuthinite. The copper content in the molybdenite concentrate was sufficiently reduced to meet market specifications.

No attempt has been made to determine the cost of milling this ore, but in view of the simplicity of the flowsheet recommended, milling costs should be low.

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GIM/Jg