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DEPARTMENT OF MINES AND TECHNICAL SURVEYS

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MINES BRANCH INVESTIGATION REPORT IR 64-50

A FLOTATION INVESTIGATION FOR BRITISH COLUMBIA MOLYBDENUM LIMITED, ALICE ARM, B. C.

by

T. F. BERRY

MINERAL PROCESSING DIVISION

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SUMMARY OF RESULTS

The molybdenite ore from Alice Arm, B.C. analysed 0.25% MoS_2.

There was a very fine intergrowth of molybdenite and quartz so that a concentrate grade of 88.80% MoS_2 was the best obtained.

The best overall results gave a final concentrate analysing 86.90% MoS_2 with a recovery of 80.7% of the molybdenite.

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INTRODUCTION

On February 20, 1963, Mr. H.M. Wright of Wright Engineers Limited, 1103 West Pender Street, Vancouver 1, B.C., asked the Mines Branch to conduct a metallurgical investigation on a sample of molybdenite ore. The property, Alice Arm Molybdenite, is owned by Kennco Explorations (Western). Limited, a subsidiary of Kennecott Copper Corporation Limited, and was renamed British Columbia Molybdenum Limited in August 1963 with the head office at 675 West Hastings Street, Vancouver 1, B.C.

Location of Property

The property is a molybdenite prospect located near the head of Alice Arm Inlet on the west coast of British Columbia near the southern extremity of the Alaskan panhandle.

History

A good deal of early interest has been shown in the molybdenite possibilities of the Alice Arm area of the Skeena Mining Division, British Columbia.

In 1916 Mr. J.D. Ross (1) of Seattle, Washington, staked a group of claims about 5 miles from the head of Alice Arm Inlet. These claims were operated by the Molybdenum Mining and Reduction Company (2) who constructed a 200 ton a day mill, and treated 383 tons of about 2% MoS_2 (3) ore before suspending operations in the winter of 1916 because of heavy snow.

In 1929 Mr. D.S. Tait of Victoria, British Columbia (4) took an option on promising molybdenite deposits on the east and west shores of Alice Arm Inlet and incorporated the Tidewater Molybdenite Mines Limited. This property, which had been operated by Molybdenum Mining and Reduction Company in 1916, was optioned to the Dalhousie Mining Company in 1930 (5). Operations continued in the original 200 ton a day mill until suspended in April 23, 1931 (6).

In 1931 a pilot plant investigation (7) was done on a 2700 lb shipment of ore from the Alice Arm property of the Dalhousie Mining Company at the Testing and Research Laboratories of the Mines Branch in Ottawa. The ore analysed 1.67% MoS_2 and a good recovery of 89.9% of the MoS_2 was obtained in a concentrate analysing 85.5% MoS_2. The finely disseminated nature of the molybdenite and its intimate association with quartz presented a difficult problem.

Shipment and Instructions

On March 11, 1963, two boxes of drill core weighing 262 lb were received at the Mines Branch from Wright Engineers Limited, who requested an investigation to determine the grade and recovery of molybdenite that could be obtained from the sample.

Sampling and Analysis

Representative pieces of the ore were selected for a mineralogical investigation. The remainder of the shipment was crushed to -10 mesh and a representative sample was riffled out for a chemical analysis. A small sample of pulverized ore was submitted for a semi-quantitative spectrographic analysis.

TABLE 1

Results of Semi-Quantitative Spectrographic Analysis*

Range, %	Elements - Decreasing Order of Abundance
5	Na
4	Si, Al
2	Ca
1	Mg, Fe
1.0 to 0.1	Ba, Pb, Ti, Mo
0.1 to 0.01	Mn, Cu, Sr, Sn, Ni
0.01 to 0.001	Bi, Cr, V, Ga, Zr
< 0.001	Ag, Co, Be

*From Internal Report MS-AC-63-70.

TABLE 2

Results of Chemical Analysis of Head Sample*

Element	Per cent
Molybdenum disulphide (MoS_2)	0.25
Iron (soluble Fe)	2.22
Sulphur (total S)	1.36
Copper (Cu)	0.12
Lead (Pb)	<0.01
Bismuth (Bi)	0.006
Insoluble	81.80

*From Internal Reports MS-AC-63-360, 63-507.

MINERALOGICAL EXAMINATION*

In summary "the principal metallic minerals in the ore are molybdenite and pyrite and the principal non-metallic mineral is quartz. The molybdenite is intergrown with the quartz and pyrite".

Figure 1. Photomicrograph of a polished section showing an aggregate of molybdenite grains. It also shows a few small molybdenite grains intergrown with pyrite (white) and quartz (black).

*From Investigation Report IR 63-80 by W. Petruk, August 7, 1963.

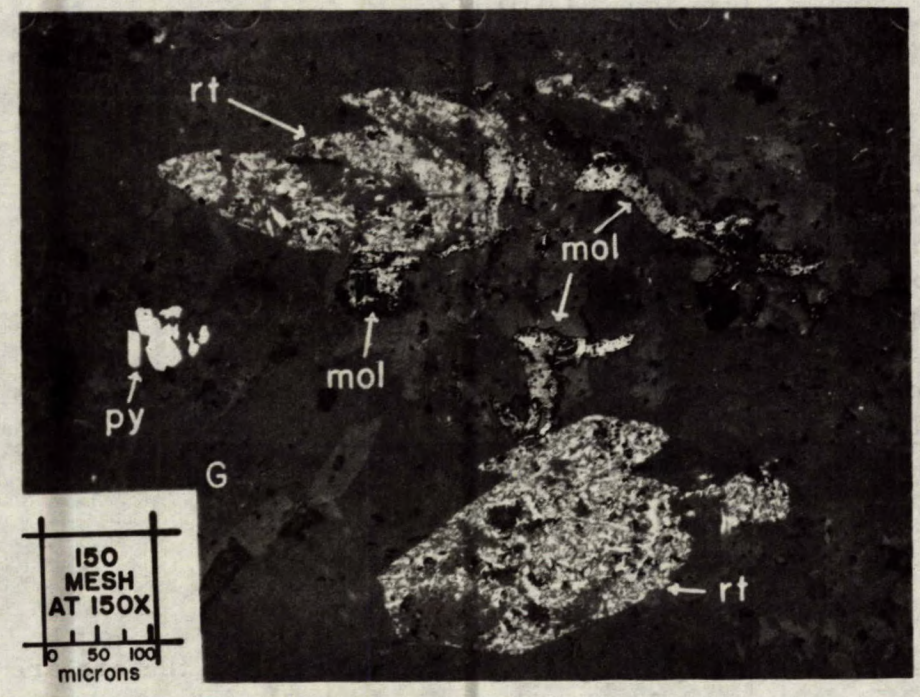

Figure 2. Photomicrograph of a polished section showing three molybdenite flakes (mol) in quartz (G), rutile-quartz masses (rt) and a few grains of pyrite (py).

DETAILS OF INVESTIGATION

Tests 1, 2, 3 and 4

Four preliminary tests were done to determine the rougher flotation recovery at successively finer grinds. In each test kerosene and pine oil were the only reagents used and flotation was continued until no more molybdenite was visible in the froth. The test data and results are shown in Table 3.

TABLE 3

Results of Flotation Tests 1, 2, 3 and 4

Product	Weight %	Analysis* % MoS_2	Distribution % MoS_2	Grind % -200 m	Pulp pH	Reagent lb/ton Ore		Flotation Time min
						Kerosene	Pine Oil	
Conc	0.4	44.40	71.8	-	8.2	0.45	0.04	2
Tail	99.6	0.07	28.2	43.1	-	-	-	-
Head(calcd)	100.0	0.25	100.0	-	-	-	-	-
Conc	0.7	27.84	85.2	-	8.3	0.45	0.04	3
Tail	99.3	0.034	14.8	61.2	-	-	-	-
Head(calcd)	100.0	0.23	100.0	-	-	-	-	-
Conc	2.4	9.60	95.9	-	8.2	0.60	0.06	5
Tail	97.6	0.01	4.1	70.6	-	-	-	-
Head(calcd)	100.0	0.24	100.0	-	-	-	-	-
Conc	5.3	4.42	97.3	-	8.3	0.675	0.08	6
Tail	94.7	0.007	2.7	84.8	-	-	-	-
Head(calcd)	100.0	0.24	100.0	-	-	-	-	-

*From Internal Report MS-AC-63-507.

Test 5

A 10,000 g sample of -10 mesh ore was ground and floated as shown in Table 4-A. The summarized results are tabulated in Table 4-B.

A mineralogical examination of the final MoS_2 concentrate showed the fine intergrowth of the molybdenite with quartz (Figures 3 and 4). The fractions shown are heavy liquid fractions floated from the concentrate at a specific gravity of 2.96.

TABLE 4

A. Flotation Procedure in Test 5

Data	Grind (1)	Conditioning		Flotation		Remarks
		Rougher	Cl	Rougher	Cl	
Time, min		2	3	5	6	3 stages rougher flotation, 1 min conditioning for 2nd and 3rd stages.
pH	8.2	8.7	8.3	-	-	
Reagents, lb/ton ore						
NaCN	-	0.10	0.25	-	-	
Kerosene	0.30	-	-	0.30	-	3 stages Cl flotation, 3 min conditioning for 2nd and 3rd stages.
Frother (2)	-	-	-	0.08	-	
Sod. silicate	-	-	-	-	0.3	

(1) 70.6% -200 mesh.
(2) 1:1 mixture of pine oil and Dowfroth 250.

B. Results of Test 5

Product	Weight %	Analysis* % MoS_2	Distribution % MoS_2
Final MoS_2 conc	0.3	64.80	76.8
3rd Cl tail	0.1	18.43	7.2
2nd Cl tail	0.8	2.41	7.6
1st Cl tail	3.5	0.21	1.6
Flotation tail	95.3	0.018	6.8
Head (calcd)	100.0	0.25	100.0

*From Internal Report MS-AC-63-507.

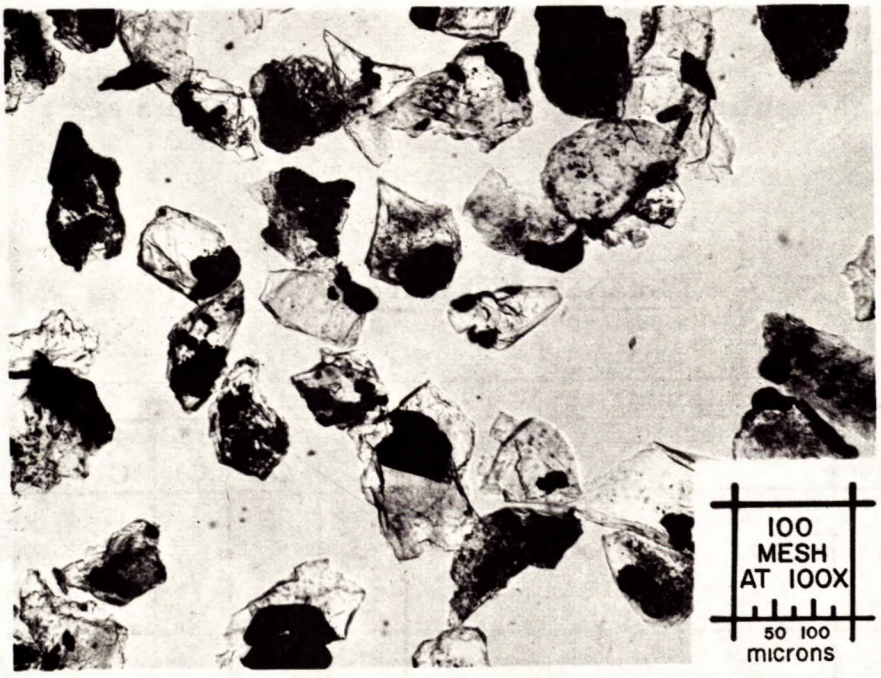

Figure 3. Photomicrograph of an oil immersion mount of a 2.96 float fraction from the final concentrate in Test 5. It shows quartz grains (white) and chlorite grains (diffuse grey areas) containing inclusions of molybdenite (black).

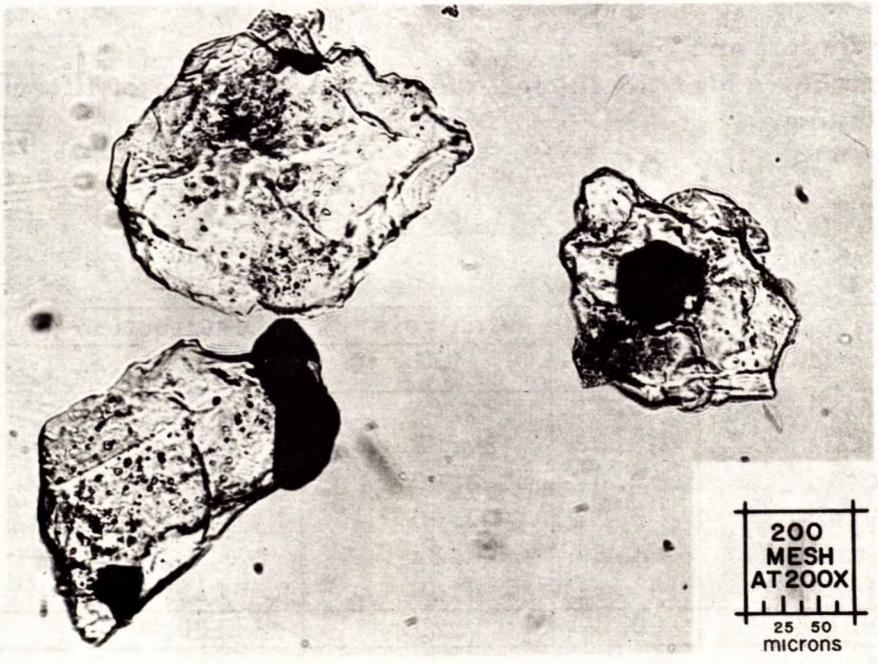

Figure 4. Photomicrograph of three grains from the oil immersion mount of the 2.96 float fraction from the final concentrate in Test 5.

Test 6

A 6000 g sample of -10 mesh ore was ground and floated according to the outline shown in Table 5-A. The results are shown in Table 5-B.

TABLE 5

A. Flotation Procedure in Test 6

Data	Grind(1)	Conditioning		Flotation					Remarks
		Rougher	Cl	Rougher	1st Cl	2nd Cl	3rd Cl	4th Cl	
Time, min	-	3	3	-	3	2	1	1	kerosene and frother stage added to rougher cell.
pH	8.3	-	9.7	-	-	-	-	-	
Reagents, lb/ton ore									
NaCN	-	-	0.1	-	-	-	-	-	Ro. conc reground 10 min in pebble mill.
Kerosene	0.25	0.15	0.15(3)	0.30	-	-	-	-	
Frother(2)	-	0.04	0.02	0.04	-	-	-	-	
Sod. silicate	-	-	0.5	-	-	0.5	0.5	0.5	

(1) 70.6% -200 m.
(2) 1:1 mixture of pine oil and Dowfroth 250.
(3) Kerosene and frother added to cleaner conditioning because of filtering prior to regrinding.

B. Results of Test 6

Product	Weight %	Analysis* % MoS_2	Distribution % MoS_2
Final MoS_2 conc	0.24	84.66	74.1
4th Cl tail	0.02	24.08	1.7
3rd Cl tail	0.07	8.90	2.2
2nd Cl tail	0.57	0.60	1.2
1st Cl tail	4.39	0.22	3.5
Flotation tail	94.71	0.05	17.3
Head(calcd)	100.0	0.27	100.0

*From Internal Report MS-AC-63-875.

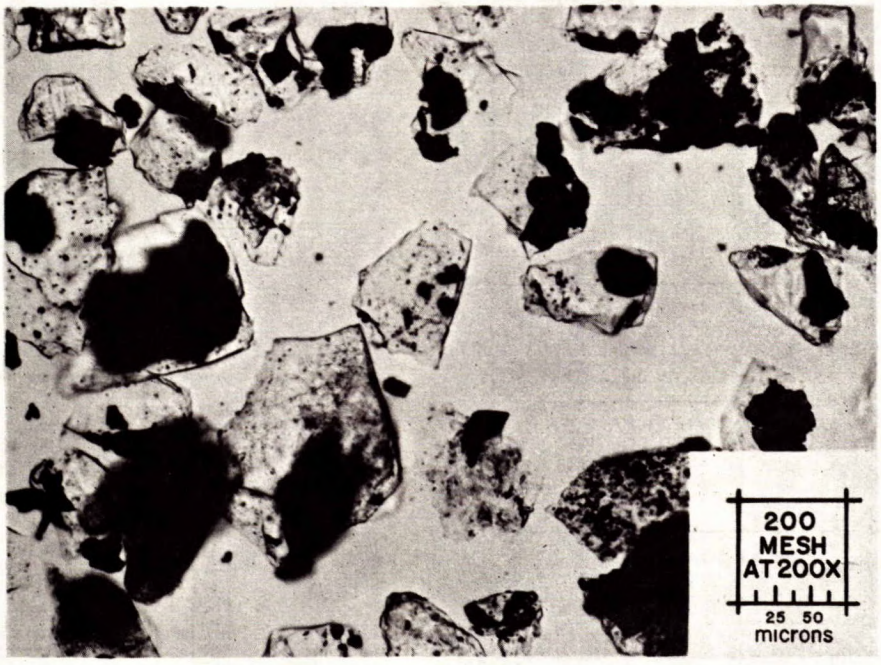

Figure 5. Photomicrograph of an oil immersion mount of the 2.96 heavy liquid float fraction of the final concentrate from Test 6. It shows quartz grains (white) and chlorite grains (diffuse grey areas) containing inclusions of molybdenite (black).

Test 7

This test was done in an attempt to increase the recovery in the rougher flotation and to increase the grade of the final MoS_2 conc. Table 6-A shows the method which was followed and Table 6-B shows the results obtained.

TABLE 6

A. Flotation Procedure in Test 7

Data	Grind(1)	Regrind Cl conc	Conditioning		Flotation						Remarks
			Rougher	Cl	Rougher	Cl	Regrind(3)				
							1st Cl	2nd Cl	3rd Cl	4th Cl	
Time, min	-	20(3)	-	-	7	4	3	1.5	1	1	kerosene and frother added to rougher cell.
pH	8.2	-	-	-	-	-	-	-	-	-	
Reagents, lb/ton ore											
NaCN	-	-	-	-	-	0.2	-	-	-	0.03	
Kerosene	0.30	-	-	-	0.45	-	-	-	-	-	
Frother(2)	-	-	-	-	0.08	-	-	-	-	-	
Sod. silicate	-	-	-	-	-	-	0.5	0.5	0.5	0.25	

(1) Grind 70.6% -200 m.

(2) 1:1 mixture of pine oil and Dowfroth 250.

(3) 20 min regrind of Cl conc in Abbé mill. No screen test.

B. Results of Test 7

Product	Weight %	Analysis* %	Distribution %
		MoS_2	MoS_2
Final MoS_2 conc	0.18	88.80	65.5
4th regrind Cl tail	0.01	64.26	2.6
3rd regrind Cl tail	0.02	37.37	3.1
2nd regrind Cl tail	0.18	20.80	15.3
1st regrind Cl tail	0.60	1.48	3.6
Cleaner tail	5.46	0.15	3.4
Flotation tail	93.55	0.017	6.5
Head(calcd)	100.00	0.25	100.0

*From Internal Report MS-AC-63-1077.

The final concentrate from Test 7 was examined under a microscope and was seen to contain attached particles of gangue as shown in Figure 6.

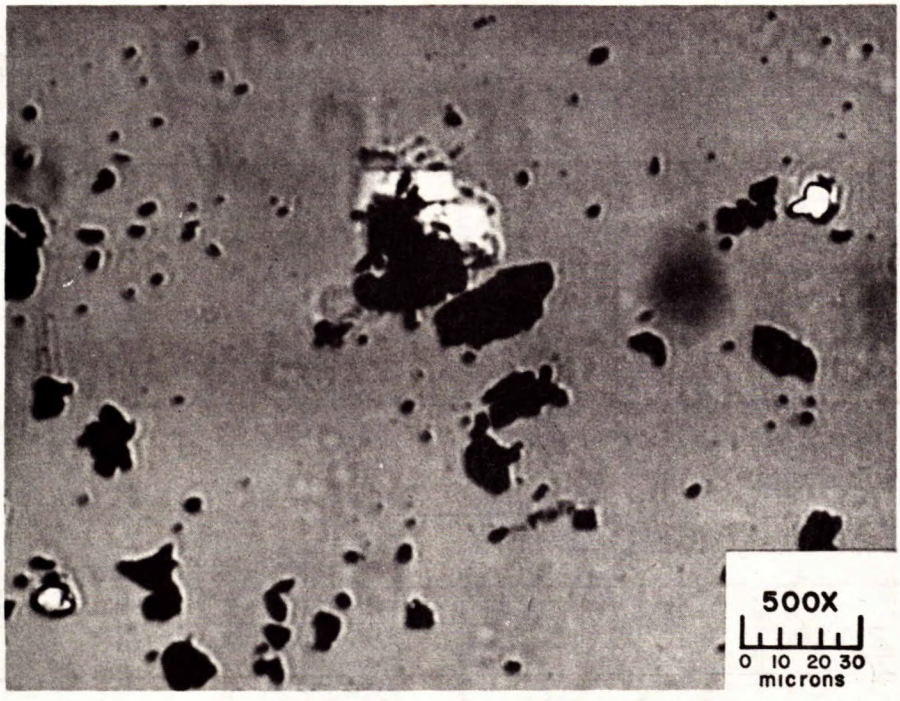

Figure 6. Photomicrograph of an oil immersion mount of molybdenite concentrate, Test 7. It shows the molybdenite (black) with some grains having attached particles of gangue (white). The largest particle shown is approximately 500 mesh.

Test 8

In an attempt to increase the recovery of the MoS_2 in the final concentrate while maintaining a high grade, a 10,000 g sample of -10 mesh ore was ground and a rougher flotation concentrate was obtained using the procedure outlined in Test 7. This concentrate was reground for 20 min and was cleaned 6 times as shown in Table 7-A. The results of this test are shown in Table 7-B.

TABLE 7

A. Regrind Cleaner Flotation Procedure in Test 8

Stage	Reagents and Amounts			Conditioning Time min	Flotation Time min
		lb/ton in test	lb/ton rougher float feed		
1	NaCN	1.0	0.2	1	5
2	Sod. silicate	2.5	0.5	1	4
3	" "	1.75	0.25	1	3
4	" "	1.75	0.25	1	2
5	" "	1.75	0.25	1	2
6	" "	1.75	0.25	1	1

B. Results of Test 8

Product	Weight %	Analysis* %	Distribution %
		MoS_2	MoS_2
Final MoS_2 conc	0.25	77.22	78.3
6th regrind Cl tail	0.05	31.86	6.4
5th regrind Cl tail	0.04	25.92	4.2
4th regrind Cl tail	0.13	3.13	1.7
3rd regrind Cl tail	0.46	0.54	1.0
2nd regrind Cl tail	1.79	0.27	1.9
1st regrind Cl tail	5.61	0.075	1.7
Flotation tail	91.67	0.013	4.8
Head (calcd)	100.00	0.25	100.0

*From Internal Report MS-AC-63-1236.

Test 9

This test was a further attempt to increase the grade of the final MoS_2 concentrate with a high recovery. A 6000 g sample of -10 mesh ore was used. The flotation procedure and the results of the test are shown in Table 8 and 9 respectively.

TABLE 8

Flotation Procedure in Test 9

Data	Grind(1)	Regrind 2nd Cl conc	Conditioning		Flotation						Remarks
			Feed	Rougher conc	Rougher	1st Cl	2nd Cl	Regrind (3)			
								1st Cl	2nd Cl	3rd Cl	
Time, min	-	20(3)	3	3	9	3	3	2	1 1/2	1	rougher flotation 50% solids.
pH	8.4	9.0	-	-	8.2	at end 9.5	9.3	-	-	-	
Reagents, lb/ton ore											
NaCN	-	0.2	-	0.1	-	-	-	-	-	-	
Kerosene	0.30	-	0.05	-	0.10	-	-	0.10	0.05	0.05	
Pine oil	-	-	0.02	-	0.04	-	-	-	-	-	
Dowfroth 250	-	-	0.02	-	-	-	-	-	-	-	
Na_2CO_3	-	-	-	1.0	-	-	-	-	-	-	dispersant.
Sod. silicate	-	-	-	1.0	-	1.0	1.0	1.0	1.0	1.0	
BHB(2)	-	-	-	-	-	-	0.005	0.01	0.005	0.005	

(1) 70.6% -200 mesh

(2) 80% butanol high boiler. The reagent appeared to give a more manageable froth.

(3) 20 min regrind of 2nd Cl conc in Abbé mill. No screen test.

TABLE 9

Results of Test 9

Product	Weight %	Analysis* % MoS_2	Distribution % MoS_2
Final MoS_2 conc	0.24	86.90	80.7
3rd regrind Cl tail	0.01	46.42	1.8
2nd regrind Cl tail	0.02	12.69	1.0
1st regrind Cl tail	0.25	2.43	2.4
2nd Cl tail	1.20	1.13	5.3
1st Cl tail	8.55	0.06	2.0
Flotation tail	89.73	0.02	6.8
Head (calcd)	100.00	0.26	100.0

*From Internal Report MS-AC-63-1436.

TABLE 10

Analysis* of Impurities in Final MoS_2 Concentrate (Test 9)

Element		Per cent
Bismuth	(Bi)	0.18
Copper	(Cu)	0.91
Lead	(Pb)	2.80
Zinc	(Zn)	0.88
Iron	(Sol Fe)	1.87
Silica	(SiO_2)	1.30

*From Internal Reports MS-AC-64-365 and 430.

CONCLUSIONS

The molybdenite in this ore occurs as relatively fine grains disseminated in the gangue and intimately intergrown with pyrite and quartz and requires very fine grinding for liberation (Figures 1 and 2).

The results of the investigation show that it was not possible to make a molybdenite concentrate analysing 90% MoS_2 with a good recovery, even after extremely fine regrinding of a rougher flotation concentrate followed by several stages of cleaning.

The reason for the poor recovery and grade of molybdenite concentrate is the occurrence of molybdenite, finely intergrown with gangue, which resulted in a large amount of true middling particles from the coarse to the very fine sizes (Figures 3, 4 and 5). When attempting to make a high grade concentrate, the recovery dropped as in Test 7 in which a final concentrate analysed 88.80% MoS_2 and contained only 65.5% of the molybdenite. Conversely a high recovery resulted in the retention of fine middlings in the final concentrate which lowered the grade.

The best grade-recovery combination was obtained in Test 9 in which the concentrate analysed 86.90% MoS_2 with a recovery of 80.7%. In spite of regrinding and repeated cleaning, this concentrate contained appreciable amounts of impurities as shown in Table 10.

ACKNOWLEDGEMENTS

The chemical analyses in this investigation were done by R. McAdam, H. Lauder, and R. W. Buckmaster, and the spectrographic analysis was done by E. Kranck of the Analytical Chemistry Subdivision, Mineral Sciences Division. The mineralogy was done by Dr. W. Petruk of the Mineral Sciences Division, Mines Branch.

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