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MINES BRANCH INVESTIGATION REPORT IR 64-18

INVESTIGATION OF A GOLD ORE FROM TABLE MOUNTAIN MINES LTD., NEAR CASSIAR, B. C., SUBMITTED BY WILSON MINING CORPORATION LIMITED

by

R. P. BAILEY

MINERAL PROCESSING DIVISION

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SUMMARY OF RESULTS

The vein ore sample, assaying 0.83 oz Au/ton and 0.32 oz Ag/ton, consisted of fractured vein quartz with inclusions and veinlets of gold, pyrite, pyrrhotite and magnetite. The sample of green chloritic wall rock was practically barren of gold, silver and other metallic minerals. For this investigation, four parts of vein ore were diluted with one part of wall rock to make a composite with average gold and silver content of 0.55 and 0.28 oz/ton, respectively.

Although straight cyanidation of the ore gave the highest gold extraction (98.2%), flotation recovered 96.8% of the gold at a concentration ratio of 27:1. In a laboratory test of an experimental flowsheet, 96.0% of the gold was recovered by jigging, amalgamation of the jig concentrate, regrinding and flotation of the combined jig tailing and amalgamation residue, and cyanidation of the flotation concentrate.

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INTRODUCTION

In a letter dated October 3, 1962, Mr. William Dunn, Superintendent of Exploration, Wilson Mining Corporation Limited, 802 Bank of Nova Scotia Bldg., 602 West Hastings St., Vancouver 2, B.C., asked the Mines Branch to do an investigation on samples of gold ore taken from the property of Table Mountain Mines Ltd.

Location of Property*

This property consists of twelve crown-granted claims and six recorded claims, situated about 1 1/2 miles south of McDame Lake and nine miles from Cassiar, B.C., along the ridged and domed crest of Table Mountain between about 5,000 and 6,000 feet elevation.

History*

The claims, essentially the old Vollaug group, were originally staked on the discovery of a gold-bearing quartz vein made by Vollaug and Erickson in the autumn of 1935. In 1936 the group was optioned by the Cassiar Syndicate, composed of B.C. interests. Later that year the syndicate transferred its option to Cominco which, during 1937, did extensive exploratory work on this group and a number of adjoining and contiguous claims. On conclusion of this work at the end of the 1937 season, Cominco relinquished its options.

Work done by the present company included trenching and sampling during the summer of 1962.

Shipment

On December 27, 1962 six sacks of samples were received from Mr. William Dunn, Superintendent of Exploration for Wilson Mining Corporation Limited. Four of the sacks, weighing 312 pounds gross, contained ore described as rejects of samples of the quartz vein. This material was about 90% minus 1/4 inch in size. The other two sacks, weighing 105 pounds, contained lump rock, about 6 inches in size, described as argillite from the hanging wall.

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* From B.C. Minister of Mines Annual Reports, 1937, pp. B24-34 and 1962, p. 6.

Sampling and Analysis

The vein ore, as received, was split into two equal parts. One part was crushed to minus 10 mesh and head samples were riffled out for mineralogical examination, chemical analysis and semi-quantitative spectrographic analysis. The remainder of the minus 10 mesh material was reserved for test work.

While the wall rock was being crushed to about 1/4 in., a few 1 1/2 in. lumps were selected for mineralogical examination. The crushed material was then split into two equal parts, one of which was reduced to minus 10 mesh and sampled similarly to the vein ore.

Chemical analysis* gave the following results:

	Vein Ore	Wall Rock
Gold (Au), oz/ton	0.83	0.0022
Silver (Ag), oz/ton	0.32	0.005
Iron (soluble Fe), %	1.36	2.23
Iron (total Fe), %	1.36	2.23
Sulphur (S), %	0.023	0.019
Insoluble, %	83.90	74.10

Semi-quantitative spectrographic analysis** showed no other elements present in economic concentration. Elements detected are listed below in decreasing order of abundance.

Vein ore:	I	Si	(principal constituent)
	II	Al, Fe	(5 - 1%)
	III	Ca, Mg	(1 - 0.1%)
	IV	Cu, Ni, Mn, Ti, Cr, Ba	(0.1 - 0.01%)
	V	V, Sn, Pb, Ag, Be, Zr, Co, Mo, Na	(0.01% - trace)
Wall rock:	I	Si	(principal constituent)
	II	Ca, Al, Fe, Mg	(6 - 1%)
	III	Ti, Mn	(1 - 0.1%)
	IV	Ba, Sr, Zr, B, Ni, Cu, Cr	(0.1 - 0.01%)
	V	V, Ga, Ag, Co, Be, Na, Sn, Pb	(0.01% - trace)

* From Mineral Sciences Division Internal Report MS-AC-63-239, February 7, 1963.

** From Mineral Sciences Division Internal Report MS-AC-63-15, by Miss E.M. Kranck, January 25, 1963.

MINERALOGICAL EXAMINATION*

Representative specimens of vein ore (about 1/4 in. size) and wall rock (about 1 1/4 in.), along with portions of each head sample crushed to minus 10 mesh, were submitted to the Mineralogy Section of the Mineral Sciences Division for microscopic examination.

The vein ore sample was found to consist of fractured vein quartz and a small amount of wall rock. The quartz contains inclusions and veinlets of gold, pyrite, pyrrhotite and magnetite. In places the pyrite and pyrrhotite have been altered to goethite. The gold is partially bordered by goethite.

The wall rock sample consists of green chloritic rock containing a few minute grains of goethite but no other metallic minerals were observed.

DETAILS OF INVESTIGATION

As requested in Mr. Dunn's letter of December 19, 1962 all test work was done on mixtures of the vein ore and wall rock in the ratio of 4:1, representing the dilution expected in mining the ore body. Calculations, based on head assays of each, indicated a gold content of 0.66 oz/ton in the mixed ore, with silver content of 0.25 oz/ton. However, averages of calculated head assays from all tests gave gold and silver values of 0.55 and 0.28 oz/ton, respectively.

Test work included amalgamation, jigging, straight cyanidation of the ore, flotation of the ore and cyanidation of the flotation concentrate.

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* From Mineral Sciences Division Internal Report MS-63-15 by W. Petruk, March 26, 1963.

Tests 1 and 2, Amalgamation

In Test 1, a 1000 g sample of the mixed ore at minus 10 mesh size (12.5% minus 200 mesh) was amalgamated for one hour with 10 ml of clean mercury and lime equivalent to 2.0 lb per ton of ore.

For Test 2, similar conditions were maintained, except that the ore sample was ground for 20 minutes (to 58.7% minus 200 mesh) before amalgamation.

In each case amalgam and residue were assayed, with results as shown in Table 1.

TABLE 1

Results of Amalgamation Tests

Test No.	Fineness of Grind % - 200 m	Product	Assays* oz/ton of feed		Distribution %	
			Au	Ag	Au	Ag
1	12.5	Amalgam	0.234	--	42.2	--
		Tailing	0.320	--	57.8	--
		Feed (calcd)	0.554	--	100.0	--
2	58.7	Amalgam	0.497	--	84.0	50.0**
		Tailing	0.095	0.125	16.0	50.0
		Feed (calcd)	0.592	--	100.0	100.0

* From Internal Report MS-AC-63-202.

** The amalgam was not assayed for silver. Distribution has been obtained by difference from calculated feed assay (0.25 oz/ton).

Tests 3 to 6, Straight Cyanidation

Four straight cyanidation tests were done at 2:1 dilution on 1000-gram lots of the mixed ore, two of which were ground for 20 minutes to about 56% minus 200 mesh, and two for 30 minutes to about 76% minus 200 mesh. Agitation times were 24 and 48 hours for each grind at cyanide and lime solution strengths of 1.0 lb/ton and 0.5 lb/ton, respectively. Because of the relatively low silver value of the ore, cyanide residues were assayed for gold only. Results are summarized in Table 2.

TABLE 2

Results of Straight Cyanidation

Test No.	Fineness of Grind % - 200 m	Agitation Time hrs	Concentration lb/ton soln		Consumption lb/ton ore		Residue Assays* oz/ton Au	Gold Extraction** %
			NaCN	CaO	NaCN	CaO		
3	55.3	24	1.0	0.5	0.72	2.52	0.0125	97.5
4	58.5	48	1.0	0.5	0.84	2.84	0.0125	97.5
5	75.9	24	1.0	0.5	0.96	2.52	0.01	98.2
6	76.8	48	1.0	0.5	0.92	2.92	0.01	98.2

*From Internal Report MS-AC-63-202.

**Calculated by difference from a head of 0.55 oz Au/ton.

Test 7, Jigging, Amalgamation and Cyanidation

Although the results of previous tests demonstrated the effectiveness of straight cyanidation, the extent of the free milling gold indicated by amalgamation tests (42.2 % from minus 10 mesh ore) prompted a trial of jigging, amalgamation of the jig concentrate and flotation of the jig tailing.

A 2000 g sample of mixed ore at minus 10 mesh was thoroughly blended and jigged in a Denver Laboratory Mineral Jig, Model 1-M, using a 10 mesh screen, with a bed of 3/16 in. shot plus some 10 mesh ore screened from the feed. The jig was operated at 425 rpm with 1/8 in. stroke. Jig concentrate and jig bed were combined, ground for 30 minutes (to 89.8% minus 200 mesh) and amalgamated for one hour with 10 ml of new mercury, 1 g lime and 1000 ml water. Amalgam was assayed for gold only, the amalgamation residue for gold and silver.

The jig tailing was ground and floated under the following conditions:

Operation	Reagents, lb/ton of feed		Time min	pH
Grinding (63% -200 m)			30	8.2
Conditioning	Soda ash	0.75	5	8.9
	Aero Promoter 404	0.1		
	Aerofloat 242	0.04		
Flotation	1:1 Dow 250/Pine oil	0.05	15	

Results of this test are summarized in Tables 3 and 3a.

TABLE 3

Results of Test 7 (Jigging, Amalgamation and Flotation)

Operation	Product	Weight %	Assays*, oz/ton		Distribution %	
			Au	Ag	Au	Ag
Jigging + amalgamation of jig concentrate	Amalgam	--	0.154**	0.02**	27.1	7.5
	Amalgamation res.	16.1	0.147	0.17	4.2	10.2
	Jig conc + bed (calcd)	16.1	1.10	0.29	31.3	17.7
	Jig tailing (= flot. feed)	83.9	0.465	0.26	68.7	82.3
	Jig feed (calcd)	100.0	0.57	0.26	100.0	100.0
Flotation of jig tailing	Flot. conc	7.1	6.05	2.93	93.2	80.3
	Flot. tailing	92.9	0.034	0.055	6.8	19.7
	Flot. feed (calcd)	100.0	0.465	0.26	100.0	100.0

* From Internal Report MS-AC-63-202.

** Amalgam assay expressed in oz/ton of original feed.

TABLE 3a

Summary of Test 7

Product	Weight %	Assays, oz/ton		Distribution %	
		Au	Ag	Au	Ag
Amalgam	--	0.154	0.02	27.1	7.5
Amalgamation residue	16.1	0.147	0.17	4.2	10.2
Flot. conc	6.0	6.05	2.93	64.0	66.2
Flot. tailing	77.9	0.034	0.055	4.7	16.1
Feed (calcd)	100.0	0.57	0.26	100.0	100.0

Test 8, Jigging, Amalgamation and Flotation

Because of the large quantity of jig concentrate produced in the previous test (16.1% by weight containing only 31.3% of the gold), the test was repeated on somewhat finer feed.

From a 2000-gram sample of ore feed, some coarse material (about 115 grams) was screened out for a jig bed. The remainder was wet ground for 10 minutes (to about 30% minus 200 mesh) and dried for feeding to the laboratory jig. For jigging, a 14 mesh screen was used, with one layer of 3/16 in. shot plus a 1 1/4 in. bed of minus 6 plus 14 mesh ore. Jig stroke was increased to 3/16 in. After jigging, the plus 14 mesh fraction of the jig bed was retained for analysis. The jig concentrate and the minus 14 mesh fraction of the bed were ground for 20 minutes (to about 80% minus 200 mesh) and amalgamated for one hour with 10 ml of fresh mercury and 0.5 gram lime in 300 ml water. Amalgam and residue were assayed for gold only.

The jig tailing was ground and floated with two-stage addition of reagents as follows:

Operation	Reagents, lb/ton		Time, min	pH
Grinding (60% -200 m)			10	8.3
1st conditioning	Soda ash	0.5	5	9.4
	Aero Promoter 404	0.1		
	Aerofloat 242	0.04		
Flotation			10	
2nd conditioning	Aero Promoter 404	0.025	3	
	Aerofloat 242	0.02		
Flotation			5	

Results of this test are shown in Table 4.

TABLE 4

Results of Test 8 (Jigging, Amalgamation and Flotation)

Product	Weight %	Assay*, oz/ton	Distribution %
Amalgam	--	0.286**	49.8
Amalgamation residue	3.4	0.355	2.1
Jig bed (+14 m fraction)	5.9	0.310	3.2
Flot. conc	1.9	12.33	40.8
Flot. tailing	88.8	0.027	4.1
Feed (calcd)	100.0	0.57	100.0

* From Internal Report MS-AC-63-307.
** Amalgam assay expressed in oz/ton of original feed.

Tests 9, 10 and 11, Flotation

Because of the relatively high gold recoveries (93% and 91%) obtained by flotation of the jig tailing in Tests 7 and 8, three bulk flotation tests were made on 2000-gram samples of mixed ore ground for 20, 30 and 45 minutes, respectively. Reagents used and flotation conditions were as in Test 8. Results are summarized in Table 5.

TABLE 5

Results of Flotation Tests

Test No.	% - 200 m	Product	Weight %	Assays*, oz/ton		Distribution %	
				Au	Ag	Au	Ag
9	55.1	Flot. conc	3.1	18.55	--	96.2	--
		Flot. tailing	96.9	0.023	--	3.8	--
		Feed (calcd)	100.0	0.59	--	100.0	--
10	72.1	Flot. conc	3.4	14.46	6.4	96.2	85.0
		Flot. tailing	96.6	0.02	0.04	3.8	15.0
		Feed (calcd)	100.0	0.51	0.26	100.0	100.0
11	84.9	Flot. conc	3.7	14.44	6.0	96.8	82.2
		Flot. tailing	96.3	0.018	0.05	3.2	17.8
		Feed (calcd)	100.0	0.55	0.27	100.0	100.0

*From Internal Reports MS-AC-63-261 and 263.

Test 12, Jigging, Amalgamation, Flotation and Cyanidation

In this final test, the best procedures indicated by previous work were incorporated in a flowsheet suitable for mill practice as illustrated in Figure 1.

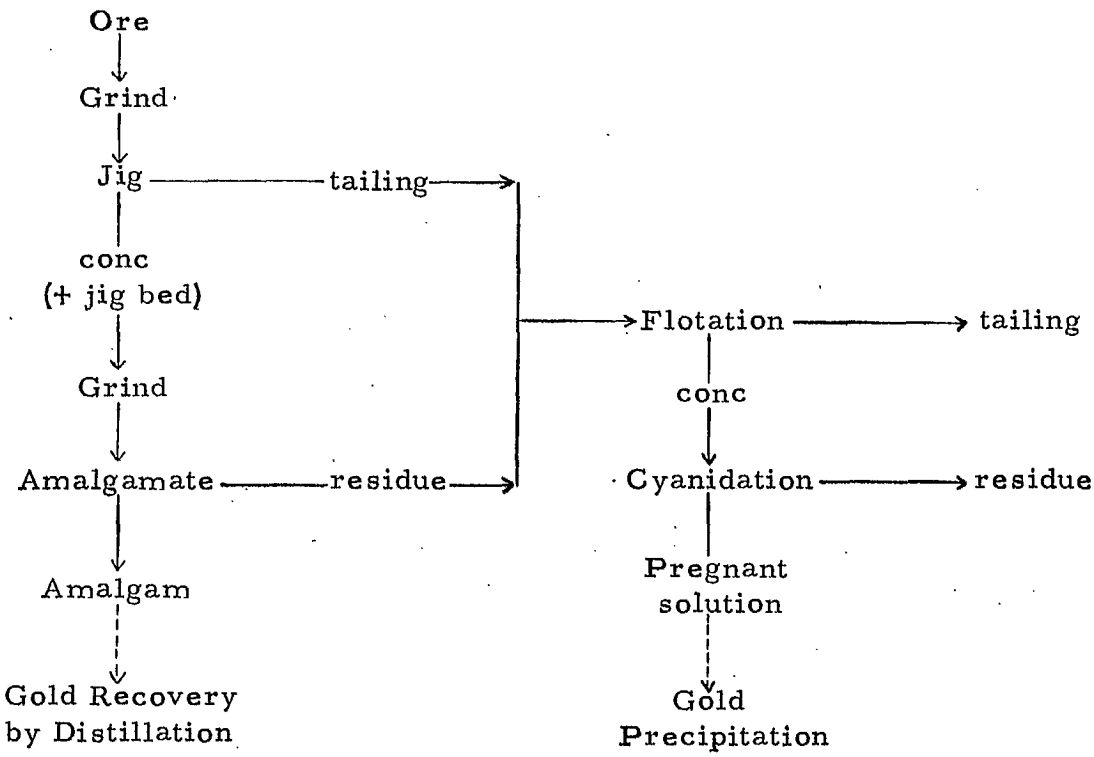

Figure 1. Flowsheet for Test 12

A 4000-gram lot of minus 10 mesh feed (4:1 composite of vein ore and wall rock) was ground for 10 minutes (to 31.9% minus 200 mesh) and jigged as in Test 8. The jig concentrate and jig bed were ground for 20 minutes (to about 75% minus 200 mesh) and amalgamated with fresh mercury as in Test 8. The amalgam was distilled and the metal residue assayed for gold and silver.

The amalgamation residue and the jig tailing were combined, split into two approximately equal portions and ground for 20 minutes (to 81.8% minus 200 mesh). Each portion was floated separately under the following conditions:

Operation	Reagents, lb/ton		Time, min	pH
Grinding (81.8% - 200 m)			20	8.2
1st conditioning	Soda ash	0.5	5	9.3
	Aero Promoter 404	0.1		
	Aerofloat 242	0.04		
Flotation			10	
2nd conditioning	Soda ash	0.3	3	9.2
	Aero Promoter 404	0.025		
	Aerofloat 242	0.02		
Flotation			5	

Part of the flotation concentrate (about 40%) was retained for assay for gold and silver; the remainder, without regrinding, was cyanided for 48 hours at 5:1 dilution while maintaining NaCN concentration at 1.0 lb/ton and CaO at 0.5 lb/ton of solution. Cyanidation residue was assayed for gold and silver. Flotation tailings were combined and sampled for assay.

Results of the test are summarized in Tables 6 and 6a.

TABLE 6

Results of Test 12 (Amalgamation of Jig Concentrate, Flotation and Cyanidation)

Operation	Product	Weight %	Assays*, oz/ton		Distribution %	
			Au	Ag	Au	Ag
Amalgamation of jig concentrate	Amalgam	--	0.224**	0.08**	45.4	26.6
Flotation of jig tailing	Flot. conc	4.3	5.92	4.03	94.3	78.3
	Flot. tailing	95.7	0.016	0.05	5.7	21.7
	Flot. feed (calcd)	100.0	0.27	0.22	100.0	100.0
Cyanidation of flot. conc	Flot. conc (feed)	4.3	5.92	4.03	100.0	100.0
	Cyanidation res.	4.3	0.105	1.21	1.8	30.0
	Pregnant soln (by diff.)	--	--	--	98.2	70.0

* From Internal Report MS-AC-63-948.

** Assay expressed in oz/ton of original feed.

TABLE 6a

Summary of Test 12

Product	Distribution %	
	Au	Ag
Amalgam	45.4	26.6
Cyanide soln	50.6	40.2
Overall recovery	96.0	66.8
Cyanidation residue	0.9	17.3
Flot. tailing	3.1	15.9
	100.0	100.0

DISCUSSION AND CONCLUSIONS

This investigation was done on a composite of four parts of vein ore and one part of wall rock, representing the dilution expected in mining the ore body.

The vein ore sample, which assayed 0.83 oz Au/ton and 0.32 oz Ag/ton, consisted of fractured vein quartz, with inclusions and veinlets of gold, pyrite, pyrrhotite and magnetite; the wall rock, which contained only traces of gold and silver, was green chloritic rock. For the diluted ore, gold and silver values were 0.55 and 0.28 oz/ton respectively, based on the average calculated head assays for all tests.

The occurrence of considerable free gold was indicated by amalgamation of the composite ore (Tests 1 and 2). On minus 10 mesh ore (12.5% minus 200 mesh) gold extraction was 42.2%; on ore ground to 58.7% minus 200 mesh, gold recovery in the amalgam was 84.0%, and silver 50%.

Straight cyanidation of the ore was very effective, giving high gold extraction even at moderate grind and short agitation time, with relatively low reagent consumption. In Test 3, at 55.3% minus 200 mesh, 97.5% of the gold was extracted in 24 hours with cyanide and lime consumptions

of 0.72 lb/ton and 2.52 lb/ton, respectively. By extending the agitation time to 48 hours (Test 4), no additional gold was extracted, but cyanide and lime consumptions were increased by about 15%. By finer grinding (to about 76% minus 200 mesh) extraction was increased only slightly, to 98.2% (Tests 5 and 6).

By jigging the ore at minus 10 mesh (in Test 7), gold and silver recoveries were only 32.8% and 18.1%, respectively, in a jig concentrate (including jig bed) comprising 16.1%, by weight, of the feed. However, in Test 8, with finer feed (about 30% minus 200 mesh) gold recovery in the jig concentrate and bed was increased to 55.1% in 9.3% of the original feed weight.

By flotation of the jig tailing, 91 - 93% of the remaining gold and 80% of the silver were recovered. The low concentration ratio in Test 7 (about 14:1), due to unnecessary addition of a frother, was increased to about 45:1 in Test 8.

Bulk flotation of the composite ore at 55.1% minus 200 mesh (Test 9) gave a gold recovery of 96.2% at a concentration ratio of 32:1. Finer grinding (to 84.9% minus 200 mesh) in Test 11 increased recovery only slightly to 96.8% at a 27:1 concentration ratio. Silver recoveries were 82 - 85%.

No coarse gold was indicated by mineralogical examination, and none was observed either in the jig concentrates or even in the plus 14 mesh fraction of the jig bed in Test 8. Numerous, very fine grains were seen at low magnification under microscopic examination of the flotation concentrate in Test 9. However, the presence of some relatively coarse-grained gold may be inferred from the fact that about 42% of the gold was recovered by amalgamating minus 10 mesh ore. Therefore, jigging (with amalgamation of the jig concentrate) was included in Test 12 simulating a flotation-cyanidation flowsheet suitable for mill practice. The effectiveness of such a flowsheet is indicated by the overall gold recovery of 96%.

Although straight cyanidation gave the highest gold recovery, the flowsheet outlined by Test 12 is more practical for a small tonnage operation than an all-cyanidation plant because of its lower capital cost.

Because of the low silver value in the ore, no attempt was made to improve on the 66.8% recovery obtained in Test 12. However, 17.3% of the original silver at a grade of 1.2 oz/ton appears in the cyanidation residue, comprising only 4.3% of the ore feed. Part of this silver, and perhaps some of the residual gold, might be scavenged economically by

tabling this material. However, the small scale of the laboratory cyanidation prevented accumulation of sufficient residue for such a test.

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