

TR17-234-241

R.655 Extraction of gold from residue dumps at Beaconsfield.

The past unpublished projects on gold extraction from the tailings dumps left by the Tasmania Gold Mine have been reviewed following interest in these dumps by B.M.I. Mining Pty. Ltd.

The unpublished projects reviewed comprise Investigation R1, R2, R41, R50, R51, R77, R128 and R130 which were carried out between 1936 and 1944. A later work, Investigation R417 was completed in 1962 and published in Technical Reports No. 7.

In the reviews given comments not in the original work have been appended to Investigations R51, R128 and R130 under the heading 'Comment'.

The problems associated with the gold extraction from the tailings have been reviewed and recommendations made.

REVIEW OF PREVIOUS INVESTIGATIONS

Investigation R.1

A sample, 360554, of roasted Beaconsfield concentrate was analysed and subjected to cyanidation tests to recover the gold.

The sample assayed at:

	%		%
Fe	26.5	Al <sub>2</sub> O <sub>3</sub>	3.8
Cu	1.6	Insoluble	28.0
SO <sub>3</sub>	10.6	As	present but not qualitatively determined.
CaO	3.8		
MgO	1.8	Au	44.5 g/t

The following results were obtained from the cyanidation tests:

Test No.	% Pulp Solids	Agitation Time (Hours)	Consumption (kg/t)		% Gold Extraction
			KCN	CaO	
N1	33	24	1.65	2.23	46
N2	33	22	3.13	4.46	66
N3	25	24	4.42	6.43	88

Investigation R.2

The material used was a composite made from Samples 360981 and 360982 from Middle Arm dump, Beaconsfield. Sulphides and a little copper (not assayed) were contained in the head sample which assayed 2.3 g of gold per tonne. The following results were obtained from cyanidation tests:

Test No.	Agitation Time (Hours)	Consumption (kg/t)		% Gold Extraction
		KCN	CaO	
N1	24	1.56	1.79	34.3
N2	22	1.69	2.63	45.7
N3	24	2.55	5.18	60.0

Each test was pulped (2 : 1 Liquid : solid), aerated, filtered and washed.

### Investigation R.41

Cyanidation tests were carried out on a series of samples from the dumps named below. Agitation time was 20 hours and pulp dilution was 2 : 1 in each test.

Dump	Assay (Au) (g/t)	Consumption (kg/t)		% Gold Extraction
		KCN	CaO	
Edward's No. 1	1.84	0.013	3.30	46.5
Edward's No. 2	2.76	0.013	3.30	31.4
Edward's No. 3	1.22	0.013	3.30	23.7
Manion's D	2.45	1.11	4.33	31.2
Manion's S	1.53	0.62	3.97	12.5
Middle Arm	2.45	0.75	3.97	67.5
Fowler's	1.99	1.02	3.97	43.5

### Investigation R.50

Cyanidation tests were carried out on six samples taken from the Middle Arm Dump. The agitation time was 20 hours and in each test the pulp dilution was 2 : 1.

Sample Reg. No.	Assay (Au) (g/t)	Consumption (kg/t)		% Gold Extraction
		KCN	CaO	
410058	3.07	0.58	3.03	32
410059	2.15	0.44	2.59	35
410060	3.07	0.80	2.72	26
410061	2.45	0.58	2.90	53
410062	3.68	0.71	2.94	30
410063	2.14	0.98	3.26	55

### Investigation R.51

This project is an extension of Investigation R.50 in which the work was carried out on a composite sample made from the six samples used in that project. The composite, which assayed 3.37 g/t Au and 0.12% Cu, was sized and a portion was ground to 90% -64  $\mu$ m for Tests N7 and N9. The remaining tests were carried out on the sample in the 'as received' state.

The gold extraction procedure involved first froth floating the sulphides in Tests N7 and N8 then cyaniding the flotation tailings. In Test N9 the ground tailings were cyanided without a flotation stage to compare the extraction thus obtained with that from cyaniding in the 'as received' condition. The average extraction in Investigation R.50 was stated to be 30%. In Test N10 a table concentrate was made from the 'as received' sand.

### Sizing Analyses

Screen aperture ( $\mu$ m)	Dump material as received		Ground to 90% -64 $\mu$ m	
	% Wt	% Cum. Wt	% Wt	% Cum. Wt
+635	0.4	0.4	-	-
+320	37.8	38.2	-	-
+210	28.9	67.1	-	-
+160	15.7	82.8	-	-
+125	7.1	89.9	0.2	0.2
+85	4.9	94.8	1.3	1.5
+64	2.6	97.4	8.4	9.9
-64	2.6	100.0	90.1	100.0

Flotation Conditions

Investigation R.41

In both tests reagents used were as follows:

Reagent	Consumption (kg/t)
Soda ash	0.44
Pot. amyl xanthate	0.089
Pine Oil	As required for froth
<b>Flotation data</b>	
Conditioning time (N7)	5 minutes
(N8)	30 minutes
Flotation time (both tests)	5 minutes
pH	8 to 8.5

Cyaniding Data

Test No.	Product	Consumption (kg/t)	
		KCN	CaO
N7	FLT	0.49	1.87
N8	FLT	0.84	2.14
N9	H	0.98	2.01

In each test the dilution was 2 : 1 (33% solids), lime was added at 2.23 kg/t initially and a 0.1% KCN cyanide solution was used. Agitation times were 48 hours in tests N7 and N8 and 20 hours in N9. The results of the tests are given below.

Test No.	Product	% Wt	Assay Au (g/t)	% Gold Extraction	Remarks
N7	FLC.LLS/N	4.2	62.49	76	sulphide conc.
	FLT.LLS/N			17	cyanided from tailing.
				—	total gold recovered
N8	FLC	2.5	55.88	41	sulphide conc.
	FLT.LLS/N			16	cyanided from tailing.
				—	total gold recovered
N9	LLS/N			48	cyanided from ground sand.
R50				30	average result from cyaniding 'as received' sand.
N10	TLC		56.19	17	sulphide gravity conc.

Comment: From the work in this Investigation the sulphides appear to carry about 55.84 g/t Au hence the gold recovery is dependent on sulphide recovery. Gravity concentration has probably failed to recover the fine sulphides hence gold recovery is very low in Test N10. Fine grinding has released sulphides from composite grains thus yielding more sulphide concentrate and hence a larger gold recovery in this product.

The procedure of adding the gold recovered in a sulphide concentrate

to that in a cyanide solution to achieve the total recovery must be questioned. A 55.84 g/t gold-pyrite concentrate is unlikely to yield all the gold in bullion as the results in Investigation R1 show.

In Test N10 cyanidation of the table tailing to bring it into line with the other tests would probably recover a further 16% of gold thus giving an overall recovery of 33%.

#### Investigation R.77

A sample, Reg. No. 420689, of tailings from the Middle Arm Dump was obtained by drilling several holes to a depth of one metre.

The sample was hydraulically classified to yield the following.

Product	% Wt	% Assays			% Distribution		
		Au*	Cu	S	Au	Cu	S
S	71.0	2.76	0.09	0.59	58.0	41.1	53.3
O/F	28.4	4.91	0.31	1.28	41.4	56.5	46.3
Colloidal†	0.6	3.53	0.58	0.52	0.6	2.3	0.4
Head	100.0	3.41	0.15	0.78	100.0	100.0	100.0

Note \* g/t, † unsettled after 12 hours.

The sizing of spigot (S) and overflow (O/F) products was:

Screen aperture (µm)	S		O/F	
	% Wt	% Cum. Wt	% Wt	% Cum. Wt
+635	1.0	1.0		
+320	35.1	36.1		
+210	30.7	66.8		
+160	19.3	86.1	1.0	1.0
+125	9.8	95.9	3.4	4.4
+85			13.8	18.2
+64			21.0	39.2
U/S	4.1	100.0	60.8	100.0

Sulphide flotation tests were carried out on the O/F fraction. These tests gave similar results that may be summarized thus:

Product	% Wt	% Assays			% Distribution		
		Au*	Cu	S	Au	Cu	S
F1C	5	61.41	2.0	φ	50	30	50
F1T	95	2.30	0.2	1	50	70	50

Note \* g/t, φ quite variable, viz. 8, 12, 18 and 27 % S.

Poor flotation of the sulphides was attributed to the oxidation of the grain surface, since none of the grains had been ground.

#### Investigation R.128

A sample, Reg. No. 440468, from the Middle Arm Dump was subjected to cyanidation tests similar to those described in earlier projects.

The sample was first sized on a 250  $\mu$ m screen with the following results:

Product	% Wt	% Assays		
		Au*	Cu	S
+250 $\mu$ m	76.4	2.76	Nil	0.48
-250 $\mu$ m	23.6	3.68	0.2	1.5
Head	100.0	2.91		

Note \* g/t

Each size fraction was separately cyanided with two tests being done on the -250  $\mu$ m fraction, the difference being the length of the agitation.

Fraction ( $\mu$ m)	Agitation Time (Hours)	Consumption (kg/t)		% Gold Extraction
		KCN	CaO	
+250	20	0.02	1.21	22
-250	8	0.62	1.11	33
-250	20	0.71	1.16	33

Comment: The agitation time has not affected recovery which is low in all tests.

#### Investigation R.130

A sample, Reg. No. 440565, from Middle Arm Dump was submitted for table concentration tests with regrinding of the coarser material.

The sample was sized on a 250  $\mu$ m screen with the following result (A):

Fraction ( $\mu$ m)	% Wt	Assay Au (g/t)	% Gold distribution
+250	72.5	3.22	67.3
-250*	27.5	4.14	32.7
Head	100.0	3.37	100.0

Note \* of this, 0.34% by weight was - 75  $\mu$ m.

Tabling of part of the +250  $\mu$ m fraction (F) yielded the following result (B):

Product	% Wt	Assay Au (g/t)	% Gold distribution
T2C	3.2	20.42	20.3
T2M	5.1	6.60	10.5
T2T	13.7	3.83	16.5
T1T	78.0	2.15	52.7
+250 $\mu$ m F	100.0	3.22	100.0

A further part of the +250  $\mu$ m fraction was ball mill ground and produced the following (C):

Fraction (µm)	% Wt	% Cum. Wt
+180	0.4	0.4
+150	3.7	4.1
+125	12.4	16.5
+106	6.5	23.0
+75	29.2	52.2
U/S	47.8	100.0

This part was then tabled and yielded the following results (D):

Product	% Wt	Assay Au	% Gold
		(g/t)	distribution
T2C	2.5	80.14	62.3
T2M	2.0	5.98	3.6
T2T	4.2	3.99	5.1
T1T	91.3	1.07	30.0
+250 µm F	100.0	3.22	100.0

The -250 µm fraction was also tabled and produced the following (E):

Product	% Wt	Assays %		% Distribution	
		Au*	S	Au	S
T2C	1.2	70.47	34.4	21.4	19.0
T2M	2.0	33.47		15.8	
C + M	3.2	47.4		37.2	
T2T	12.1	8.44		24.9	
T1T	84.7	1.84		37.9	
-250 µm F	100.0	4.14	2.2	100.0	100.0

Note \* g/t

Comment: The overall picture is not clear from the results as presented. By combining these results, the yield from two methods of treatment can be derived as follows.

- (1) treatment of the material without further grinding by tabling the two fractions +250 µm and -250 µm,
- (2) treatment by ball milling the +250 µm fraction before tabling and then tabling the original -250 µm fraction.

By using the combined concentrate and middling products from tabling (C + M in result (E)) for the recovered gold in the -250 µm fraction we can calculate the following overall recoveries:

Size Fraction (µm)	% Gold distribution*	% Gold recovery	
		Without grinding	After grinding
+250	67.3	20.3**	61.3***
-250	32.7	37.2 †	37.2 †
Head	100.0	25.9	53.4

- Note \* See result (A)  
 \*\* See result (B)  
 \*\*\* See result (C)  
 † See result (E) (C + M) fraction

A sample not representative of, but from, the Middle Arm Dump was submitted for gold recovery tests. It sized 65% +250  $\mu$ m and assayed 6.14 g/t Au.

Cyanidation tests were carried out on the 'as received' sand, N1, and after ball mill grinding to 100% - 75  $\mu$ m in Test N2, a test, N3, to concentrate the sulphide by flotation was made on the ground feed.

The results of the tests were:

Test No.	Agitation Time (Hours)	Solid/Soln Ratio	Consumption (kg/t)		% Gold Extraction
			NaCN*	CaO	
N1	48	1 : 7.64	3.35	9.85	61.5
N2	48	1 : 7.38	2.82	0.58	71.7

Note \* For comparison with earlier work 3.35 kg/t NaCN is equivalent to 4.46 kg/t of KCN.

In Test N3 a flotation concentrate was made containing 12.4% of the sample weight, assaying 24.79 g/t Au and containing 52% of the gold.

#### REVIEW OF PAST WORK

The problem of recovering gold from the tailings has been approached in three ways, namely:

- (1) by cyanidation of the tailings in their present conditions,
- (2) by cyanidation after further grinding, and
- (3) by concentration of the sulphides by either gravity or froth flotation.

*Gravity Concentration* in Investigation R.130 yielded a gold recovery in the concentrate of 26% without grinding and with grinding, double this amount. The low recovery without grinding is supported by the results from Investigation R51, Test N10.

*Flotation Concentration* in Investigation R.51, Test N8 gave a 41% gold recovery in the sulphide concentrate without grinding and a 76% recovery with further grinding (Investigation R.51, Test N7). These recoveries were made with concentrates assaying about 55.84 g/t Au. In later testing (Investigation R.417, Test N3) 52% of the gold was recovered in a concentrate assaying less than an 28 g/t of gold. This lower recovery from a much richer sample may be a measure of the sulphide oxidation that has taken place in the intervening 20 years between Investigation R.51 and R.417.

*Sulphides*, whether produced by gravity or flotation appear to carry about 55.84 g/t of gold. The gold recovery from such sulphides has not been determined in a laboratory test although the work in Investigation R.1 on a calcine may be indicative of what to expect.

*Cyanidation* tests in Investigation R.41 showed the Middle Arm Dump to be the most promising hence further testing in Investigation R.50 where a range of recoveries of 26-55%, was found. This variability also occurred in Investigation R.2 which used a sample from the same dump.

In Investigation R.51, Test N9, the recovery by cyaniding a ground pulp was 48%, which is an improvement on the average result of 30% in Investigation R.50, which was the same material without grinding.

In Investigation R.417 the recovery was enhanced from 61% to 71% by further grinding, but because this sample was about twice as rich as the dump average, a higher recovery is to be expected from this sample.

#### CONCLUSION

In the tests reviewed, finer grinding of the dump residues has led to a better recovery of gold whatever the method. Therefore a grinding stage seems inevitable in any extraction flowsheet.

However even with a grinding stage the gold recoveries have not been high, about half of the gold being recovered by cyanidation and a similar amount by gravity concentration. Although the recovery of gold in a sulphide concentrate produced by flotation may be higher, there is evidence from the 1941 and 1962 results to suggest the yield may have fallen, hence with another ten years of weathering having occurred the recovery now may be still lower by this method.

The gold must be recovered from the concentrates produced but no tests have established what recovery can be achieved and therefore this aspect needs to be investigated.

Arsenic can be expected. Diamond drill cores from Department of Mines drilling at Beaconsfield in 1966 and 1967 showed arsenic contents ranging from 0.05% As in Sample 671015 to 1.5% As in Sample 660984. In addition arsenic was detected in the calcine Sample 360554, used in Investigation R.1. Therefore with presence of arsenic, recovery of gold by cyanidation can be expected to be incomplete. Arsenic may be removed by roasting but it is unlikely that this could be applied to other than a concentrate. This therefore requires a high recovery of gold in such a concentrate. The variable gold recoveries may be associated with the arsenic distribution in the dumps, hence thorough sampling is necessary.

As the present state of knowledge concerning this material does not offer a certain method for high gold extraction, processes outside the conventional cyanidation and roasting procedures may be worthy of investigation.

However, because of the limited size of the dumps and the low gold content any flowsheet would need to be simple. This probably means in conventional terms grinding in a cyanide solution, flotation of the filter residue after repulping, roasting of the flotation concentrate and the return of the calcine to the cyanide circuit.

#### RECOMMENDATIONS

It is recommended that test work aimed to test the flowsheet outlined above be attempted. In addition sulphide concentration on ground dump material should be examined, together with gold extraction from such a concentrate.

If the above does not yield sufficiently high gold recovery other methods of extraction should be examined.