

R.690. Further investigation on sediments from Macquarie Harbour.

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This report deals with some further studies on samples obtained by drilling unconsolidated sediments in Macquarie Harbour. Previous work, reported in Investigation R.683, covered analyses and sizings, ceramic tests and an attempt to recover copper concentrate from one of the samples which was comparatively rich in sulphides.

The aim of this investigation was to study:

- (1) The effect of high intensity magnetic separation.
- (2) The possibility of obtaining higher grades of copper concentrate by grinding and selective flotation of the sulphide-rich material.
- (3) The possibility of recovering mica concentrate by flotation from the bulk sulphide flotation tailing.
- (4) The feasibility of obtaining concentrates of other metals known to be present in the sulphide-rich sample, notably tin, zircon and titanium (as rutile), by gravity and magnetic concentration of the flotation tailings.
- (5) The ability of the slime and possible metallurgical products to support plant growth.

The samples utilised in this investigation were:

740477 HOLB321*. Magnetic separation tests and Department of Agriculture tests.

742553 HOLB432*. Said to be similar to HOLB329. Concentration tests for copper, tin, rutile, zircon and mica. Flotation tailings to Department of Agriculture for testing.

Analysis

Item	%	Item	g/t
Cu	0.16	Co	<1
Pb	0.01	Ni	40
Zn	0.03	U ₃ O ₈	<10
Fe	8.1	As	24
S	3.8	Au	nil
Sn	0.009	Ag	nil
Mo	<0.01		

TEST WORK AND RESULTS

TEST N1. High intensity wet magnetic separation of slime sample 740477 HOLB321.

The dilute wet pulp (10% solids) was passed through the Jones high intensity wet magnetic separator using a field current of 6 amperes to produce magnetic and non-magnetic products. Washings were included with the non-magnetics.

The non-magnetics were then reprocessed at a similar dilution using a field current of 40 amperes. The magnetic products resulting from the two *Samples for submission to Department of Agriculture were renumbered, the details of which appear in the text.

passes were assayed for the indicated elements, with the following results:

Product	% Mass	Assay (%)				Assay (g/t)			
		Cu	Pb	Zn*	Mo	Co	Ni	U ₃ O ₈	As
M/S1 M/A 6A	4	0.05	0.04	0.32	0.01	2	105	10	775
M/S2 M/A 40A	3	0.05	0.01	0.24	0.01	3	90	10	245
Head	100	0.021	0.0027	0.016	0.01	17	25	19	40

*Some zinc contamination is suspected from galvanised iron storage drums.

There is some concentration of heavy metal in the magnetic fractions but in view of the low percentage of mass involved the recoveries are not significant.

TEST N2. Concentration of copper on Sample 742553 HOLB432.

Cleaner bulk flotation of sulphide was carried out on 10 kg of sample using the same flotation conditions for a similar test reported in R.683, except for the addition of 200 g/t sodium sulphide. By the use of this reagent it was hoped to improve copper recovery by the sulphidisation of oxidised copper minerals, so making them more responsive to flotation.

The bulk sulphide was then ground for 10 minutes in a steel ball mill (70% solids) in the presence of lime (to pH 11) and sodium cyanide (50 g/t), and an attempt made to produce a copper concentrate by recleaner selective flotation from the ground pulp diluted to 25% solids.

Flotation conditions

Operation	Reagent	Usage g/t
Bulk Sulphide	Sulphuric acid	to pH 4.5
Flotation 1	Sodium sulphide	200
	Copper sulphate	500
	Sodium ethyl xanthate	250
	Potassium amyl xanthate	250
	Teric 401 (frother) approx.	5
	Conditioning: 5 minutes	
	Flotation: 15 minutes	
Bulk Sulphide	Potassium amyl xanthate	100
Flotation 2		
Ball mill grinding	Lime	to pH 11
Bulk F2C	Sodium cyanide	50
Copper flotation 1	Aerofloat 238	50
	Teric 401 approx.	2.5
	Conditioning: 5 minutes	
	Flotation: 10 minutes	
Copper flotation 2	Aerofloat 238	25
	Sodium cyanide	10
Copper flotation 3	No reagent	

Results

Product	% Mass	Assays %					% Cu Distn
		Cu	Sn	Zr	Ti	S	
Bulk F2C	9.5	0.51				38.0	34.8
F2T	4.1	0.53	0.01	0.03	0.34	2.13	15.6
F1T	86.4	0.08	0.01	0.03	0.20	0.12	49.6
Comp. Head	100.0	0.14	0.009*			3.8	100.0
Copper F3C	1.2	1.90					18.0
F3T	1.0	0.53					4.2
F2T	3.8	0.24					7.2
F1T	3.6	0.19					5.4
Comp. Bulk F2C	9.5	0.46					34.8

*Head assay

Sizing analysis of N2 copper concentrate (copper F3C)

Fraction	% Mass	% Cu	% Cu Distn
+75 μ m	3.0	0.8	1.3
+38 μ m	37.7	0.9	17.9
C/S 1	23.8	0.9	11.3
C/S 2	14.4	1.7	12.9
C/S 3	10.4	2.7	14.8
C/S 4	5.6	4.3	12.7
C/S 5	1.8	6.8	6.4
O/F	3.3	(13.1)	22.7
Comp. F3C	100.0	1.90	100.0

() = derived C/S 13°C

About 95% of the total sulphur was recovered in rougher bulk flotation but only 50.5% of the total copper appeared in this product. This may indicate that only about half of the total copper is present as sulphide. There was thought to be a possibility of the copper not recovered by flotation being present as slag, emanating from Mt Lyell blast furnace operations, but a mineragraphic examination of the flotation tailings did not indicate this. In fact no copper minerals were identified in this product.

The copper recovery in the operation agrees closely with that obtained in a similar test reported in R.683 (Technical Report No. 19, p.172).

Re-grinding of the bulk sulphides ahead of selective copper flotation shows a significant increase in copper recovery over the similar operations in R.683.

Sizing analysis of the recleaner copper concentrates confirms that grinding is necessary to achieve higher grades of concentrate.

This information gives the basis for the design of a further test for copper concentration, which is discussed later in this report.

TEST N2A. Concentration of cassiterite, zircon and rutile from the bulk sulphide rougher tailing (N2 F1T).

About 4 kg of the rougher tailing was concentrated by tabling to a low

grade gravity concentrate. No middling was taken, but a fairly wide band of dark mineral was included in the concentrate. The crude table concentrate was dried and submitted to high intensity magnetic separation on a Rapid laboratory dry magnetic separator. All magnetic products were combined.

Results

Product	% Mass overall	Assay %		
		Sn	Zr	Ti
TC N	0.38	1.62	1.7	1.6
TC M/S	0.87			
TT	85.15			
Comp. FlT	86.40	0.01*	0.03*	0.20*

*Assays

This test has shown that it is possible, by the conventional means outlined above, to produce low grade concentrate of tin, rutile and zircon. The zirconium and titanium contents are equivalent to 2.5% and 2.7% zircon and rutile respectively. The small amount of concentrate involved did not lend itself to further upgrading but little difficulty could be foreseen in achieving this.

The distribution of tin, rutile and zircon was not determined but under the condition of the test it is reasonable to assume that recoveries to this stage would be high. Some relatively coarse cassiterite (about 150 μ m) was observed during tabling.

The magnetics appeared to consist of ilmenite, magnetite and a variety of ferro-magnesian minerals possibly including muscovite and biotite. The latter, if present, are extremely fine.

TEST N2B. Flotation of mica from table tailings

The table tailings from Test N2A were submitted to cleaner cationic flotation in an attempt to produce a mica concentrate. The flotation concentrate was screened on 75 μ m and visually examined for its mica content.

Test conditions

Operation	Reagent	Usage g/t
Rougher flotation	Aeromine 3037 H ₂ SO ₄	800 to pH 3
Cleaner flotation	No further reagent	

Test results

Product	% Mass overall
F2C	2.84
FlT + F2T	82.31
Comp. N2A TT	85.15

The flotation concentrate was screened $\pm 75 \mu$ m. The +75 μ m contained practically no biotite or muscovite, comprising a greenish mineral which is possibly chlorite. The -75 μ m fraction contained too much ultrafine material to assess its composition visually.

TEST N3. Concentration of copper by selective flotation of ground bulk sulphide, and stripping the finest fraction by hydrocycloning.

The data acquired in Test N2 showed a progressively increasing grade of copper with decrease of grain size in the recleaner copper concentrate. In that test, some degree of grinding was performed on the rougher sulphide before selective flotation of copper. The evidence from the sizing analysis of the copper concentrate indicated that much finer grinding would be required before any material increase in grade without loss of recovery could occur. It seemed possible that a relatively high grade fine fraction (-C/S 4) could be stripped from the recleaner copper concentrate by hydrocycloning, the cyclone underflow being reground along with the first and second cleaner tailings and re-entering the rougher flotation stage.

Fine grinding of the bulk sulphides would also be necessary to minimise copper losses in the rougher copper flotation stage.

Ideally the experiment should be set up so that the only products leaving the system should be the rougher copper tailing and the overflow from cycloning the recleaner copper concentrate, according to the following flow diagram.

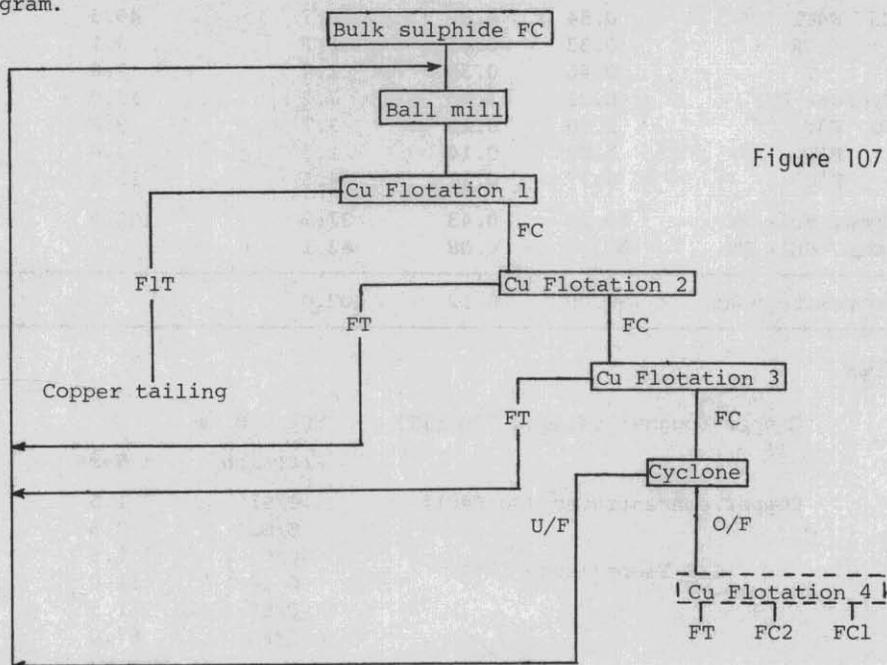


Figure 107.

Procedure

- (1) Approximately 22.4 kg of the sediment (sample 742553) was subjected to rougher bulk sulphide flotation under the same conditions as Test N2. This resulted in the production of approximately 2.3 kg of flotation concentrate.
- (2) The concentrate was then divided into two portions; one portion was ball mill ground for 20 minutes in the presence of lime and sodium cyanide. The ground pulp was then subjected to recleaner copper flotation using the same reagents as in Test N2.
- (3) The recleaner copper concentrate was then hydraulically cycloned.

The first copper flotation tailing and the cyclone overflow were put aside as finished products.

- (4) The copper cleaner tailings and cyclone underflow were added to half the remaining bulk sulphides and the grinding, flotation and cycloning operation repeated.
- (5) The operations were repeated once more. At this stage all the bulk sulphide concentrate had been used. The cyclic process was halted and the products, F1T, F2T, F3T, cyclone U/F and O/F retained separately for examination.
- (6) The cyclone O/F was found to be of much lower grade than expected (due in part to some ultrafine material which did not respond to selective flotation). This product was again cleaned by flotation, the FCl from this operation being the final copper concentrate. This section is shown dotted in the flow diagram.

Results

Product	% Mass		% Cu Distribution	
	overall	% Cu	Overall	In copper circuit
Cu F4Cl	0.54	4.0	18.7	49.3
C2	0.33	0.41	1.2	3.1
T	0.46	0.35	1.4	3.6
Cyclone U/F	0.21	3.90	7.2	19.0
Cu F3T	2.80	0.15	3.7	9.8
F2T	1.09	0.14	1.3	3.4
F1T	4.77	0.11	4.5	11.8
Comp. Bulk FC	10.20	0.43	37.9	100.0
Comp. Bulk FT	89.80	0.08	62.1	
Composite Head	100.00	0.12	100.0	

Sizings

Copper rougher tailing (Cu F1T)	90% -38 μ m	
	Fraction	% Mass
Copper concentrates (Cu F4Cl)	C/S1	1.5
	C/S2	2.5
	C/S3	6.5
	C/S4	11.0
	C/S5	11.5
	O/F	67.0
C/S Temperature 10°C	Total	100.0

Other determinations on copper concentrates

	Au (g/t)	Ag (g/t)	Se (g/t)
Cu F4Cl	<5	25	66
Cyclone U/F	<5	19	68

The copper recovery in the bulk sulphide flotation stage was rather disappointing, as was the final copper concentrate grade. However, out of the copper entering the copper circuit, 49.3% was recovered in the concentrate, 18.5% was lost as tailing (F4C2, F4T and F1T) and the remaining 32.2% remained within the system when treatment was stopped.

It is reasonable to expect that in a continuous process, about half of the circulating copper could be recovered in a similar grade of concentrate. The total would then amount to about 60% recovery in the copper circuit or about 25% overall at about 4% copper.

Because of the low recovery of copper in the bulk flotation stage it was decided to test the response of the tailings (FlT) to high intensity wet magnetic separation (test N3A). The results of this were negative with no selectivity for copper being shown by any product.

The end results of Test N3A were:

Product	% Mass	% Cu	% Cu Distr
M/S1 M/A 5 A	8.3	0.09	9.4
M/S2 M/A 40 A	12.0	0.10	15.1
M/S2 W	18.6	0.06	14.1
M/S2 N	61.1	0.08	61.4
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Comp. FlT	100.0	0.08	100.0

TEST N4. (Department of Agriculture tests)

If commercial exploitation of the sediments becomes possible, it would be necessary for some metallurgical waste products to be disposed of, probably on the foreshore of Macquarie Harbour.

Accordingly typical samples were prepared and submitted to the Department of Agriculture for an investigation as to whether plant growth could be established on them.

The samples submitted were as follows:

- 742544 'As received' slime made up from equal parts of HOLB321 and HOLB324.
- 747515 Slime as above but washed by decantation and settling. Considerable loss of 'ultrafine' material occurred.
- 742546 'Slime/sand' mixture. This was obtained by filtering the 'as received' slime in a Buchner funnel on a bed of Macquarie Harbour foreshore sand.
- 742547 Flotation tailing. This was a sample of N2 Bulk FlT.

The report of Mr. K. Stackhouse, Department of Agriculture Senior Agronomist is as follows:

'R.690 slimes ex Macquarie Harbour

Subterranean clover and Wimmera ryegrass have grown satisfactorily in Samples 742515 (washed slime) and 742547 (tailings). 742544 was too saline (salts greater than 1%) for plant growth.

The physical characteristics of the washed slime would make it extremely difficult to establish plants in it.

At this stage, it appears to me that if the tailings are to be processed and the waste deposited on the shore, the best procedure would be to excavate sand, deposit the slurry, allow to dry and backfill with sand. It may then be possible to re-establish native plants on the areas.'

Mr. Stackhouse further reported verbally that the characteristics of the 'slime/sand' mixture would be similar to the washed slime and tailings. He suggested also that other problems could occur if plants, which are to be grazed by animals, absorb traces of harmful elements which may be contained in the waste products.

SUMMARY

The tests described have not given any indication that beneficiation of valuable metals in the slime materials is economically possible.

However, some encouraging results have been obtained by selective flotation of copper from the sulphide 'rich' samples. Extremely fine grinding of bulk sulphide concentrate is necessary to achieve even moderate grades of copper concentrate, indicating that most of the copper recoverable by flotation is intimately associated with other sulphides.

The reason for the comparatively low recoveries in bulk sulphide work remains obscure. The possibility that the un-recovered copper is present as slag appears to have been eliminated as such material would be rich in FeO, and should therefore respond to magnetic separation. Moreover, mineragraphic examination has failed to observe slag particles.

A significant amount of tin (as cassiterite) was present in the sulphide-rich sample. The tests have shown that this can be concentrated by conventional gravity means after removal of sulphides. Relatively high recoveries could be expected as the grain size, visually estimated, appears to be relatively coarse.

The zircon and rutile contents of the same sample, although small in amount were mostly recovered in the gravity concentrate.

Department of Agriculture tests have indicated that waste products, suitably processed, could possibly be disposed of on the harbour foreshore.

[13 May 1975]