

TR6-214-222

R. 386**BLYTHE RIVER IRON ORE BENEFICIATION****Sample**

Two samples of ore from the Bythe River deposits were submitted by Industrial & Mining Investigations Pty. Ltd. for beneficiation tests to produce a concentrate containing over 60% iron suitable for export to Japan.

Each sample weighed approximately nine cwt.

Sample R.386A, marked Bly-N, was stated to be from the Northern Adit. Sample R.368B, marked Bly-S, was stated to be from an ore deposit dump on the left bank of the Blythe River, and is believed to have come out of the Southern Adit.

The ore consists of massive hematite with irregular broken veins of quartz, in places coloured red by contained hematite and limonite.

In thin section, typical specimens show a fine grained white quartz mosaic and black opaque hematite. In places the hematite is covered with a red coating of limonite, and limonite also colours the quartz in small irregular spots. Minute granules of limonite occasionally build up small banded and pisolitic structures in the quartz. The hematite and the quartz mosaic are finely intergrown, and in much of the ore it would be difficult to find an area of more than about 0.2 mm squared which did not contain both hematite and quartz. The hematite exerts its crystal form against the quartz mosaic which consists of interlocking anhedral crystals from 0.1 mm across down to the limits of visibility with the microscope. Some places show microstructures consisting of radiating needles of red opaque limonite, growing out of the hematite.

Sample R.386A assayed 55.9% iron.

Sample R.386B assayed 52.4% iron.

Ores from both samples are similar, with the exception that sample R.386B contained more free quartz (which was liberated at rather coarser sizes) than sample R.386A.

No responsibility is accepted for the results shown in this report, except in so far as they relate to the samples tested.

Sizing Specification

A tentative sizing specification for the upgraded concentrate was supplied by Industrial & Mining Investigations Pty. Ltd. for our guidance, as follows:—

Eighty five percent minus 3 mm.

Less than 15% minus 150 mesh.

Summary

Two samples, R.386A and R.386B, tested from the Blythe River deposits, were comparatively high grade, assaying 55.9 and 52.4% iron respectively.

By gravity concentration, it is possible to obtain concentrates in excess of 60% iron, and containing about 92% and 85% of the iron respectively.

Due to the fine grained nature of the ore, it is not possible to reject significant quantities of clean tailings coarser than about 150 mesh. Regrinding of the tailings from concentration of the coarser sizes allows further recovery of iron in good grade concentrates.

The logical concentration procedure appears to involve—

- (1) initial grinding to approximately minus 5 mesh followed by close sizing of the ground material;
- (2) concentration of plus 20 or 40 mesh material by jigging;
- (3) concentration of minus 20 or 40 mesh plus 150 mesh material by Humphreys Spirals;
- (4) concentration of minus 150 mesh material by tabling.

The concentrate will approximately meet the tentative sizing specification supplied by Industrial & Mining Investigations Pty. Ltd.

The concentrate consists essentially of iron oxides and silica. Common contaminants such as phosphorus, sulphur, titanium, manganese and vanadium are present in very small amounts.

Preliminary Examination of Sample R.386A

A sample of R.386A was stage crushed in the rolls to minus 5 mesh. The crushed material had the following sizing:—

Mesh B.S. Screen	Aperture mm	Percent Weight
Plus 10 Mesh	1.67	55.5
Plus 22 Mesh	0.70	18.7
Plus 44 Mesh	0.35	10.5
Plus 72 Mesh	0.21	2.7
Plus 150 Mesh	0.105	4.1
Minus 150 Mesh "Sands"		2.9
Minus 150 Mesh "Slimes"		5.6
		<u>100.0</u>

The minus 150 mesh material was divided into "sand" and "slime" fractions by decantation, as shown above.

Portion of the minus 5 mesh plus 10 mesh material was tested in a heavy liquid (actylene tetrabromide), with a specific gravity of 2.93.

Product	Percent Weight	Percent Distribution	
		Fe	Fe
Float	2.5	11.2	0.5
Sink	97.5	58.4	99.5
Composite	100.0	57.2	100.0

The very small quantity of quartz freed at the minus 5 mesh plus 10 mesh sizing is shown by the test given above. This test shows that significant quantities of a low grade tailing cannot be rejected by gravity concentration at comparatively coarse sizings.

The various sized fractions were concentrated by jigging or tabling, according to the size range of the fraction.

Size Fraction	Method of Concentration	Product	Percent Wght	Percent Fe	Percent Distribution Fe
Minus 5 mesh Plus 10 mesh	Jigging	Concentrate	57.9	60.5	61.2
		Tailing	42.1	52.7	38.8
		Composite	100.0	57.2	100.0
Minus 10 mesh Plus 22 mesh	Jigging	Concentrate	73.5	63.1	78.9
		Tailing	26.5	46.7	21.1
		Composite	100.0	58.8	100.0
Minus 22 mesh Plus 44 mesh	Jigging	Concentrate	65.3	63.3	72.6
		Tailing	34.7	44.9	37.4
		Composite	100.0	56.9	100.0
Minus 44 mesh Plus 72 mesh	Tabling	Concentrate	67.3	62.7	78.6
		Tailing	32.7	35.2	21.4
		Composite	100.0	53.8	100.0
Minus 72 mesh Plus 150 mesh	Tabling	Concentrate	51.5	65.0	66.5
		Tailing	48.5	39.1	33.5
		Composite	100.0	50.4	100.0
Minus 150 mesh "Sands"	Tabling	Concentrate	48.9	66.6	64.7
		Tailing	51.1	34.8	35.3
		Composite	100.0	50.4	100.0
Minus 150 mesh "Slimes"	Not concen- trated			38.5	

Examination of the coarser sized tailings showed that they consisted essentially of middling particles. There was very little free quartz.

The preliminary tests, in conjunction with the heavy liquid test and the mineralogical examination of the ore, clearly shows that it is not practicable to discard any appreciable quantity of tailings of low iron content at comparatively coarse sizes. At the same time, the tests show that it is quite practicable to obtain comparatively coarse concentrates with iron contents in excess of 60%.

Further preliminary tests (not reported) showed that further size reduction of the coarse tailings enabled further production of high grade concentrates.

On the basis of the above information, closed concentration tests were carried out of samples R.386A and R.386B involving successive removal of high grade gravity concentrates at various sizings, with further size reduction of the tailings, followed by further gravity concentration steps.

Concentration Tests: Sample R.386A

Approximately 25 lbs. of sample R.386A was stage crushed in the laboratory rolls to minus 5 mesh.

A closed concentration test was then carried out as follows:—

- (a) The plus 10 mesh fraction was concentrated by jigging.
- (b) The jig tailings were stage crushed in the rolls to minus 10 mesh.
- (c) The plus 22 mesh materials from the original crushed ore, plus that obtained by crushing the first tailings, was then concentrated by jigging.
- (d) The jig tailings were stage roll crushed to minus 22 mesh.
- (e) The combined plus 44 mesh material was concentrated by jigging.
- (f) The jig tailings were stage ground to minus 44 mesh by ball milling.
- (g) The combined plus 72 mesh material was concentrated by tabling.
- (h) The table tailings were stage ground to minus 72 mesh in the ball mill.
- (i) The combined plus 150 mesh material was concentrated by tabling.
- (j) The table tailings were stage ground to minus 150 mesh in the ball mill.
- (k) The minus 150 mesh material was separated into "sand" and "slime" fractions in a hydraulic classifier.
- (l) The minus 150 mesh "sand" fraction was concentrated by tabling. Table tailings were removed as a final tailing.

(m) The minus 150 mesh "slime" fraction was deslimed in a 3-inch hydrocyclone, the cyclone overflow being removed as a final tailing.

(n) The cyclone underflow was concentrated by tabling. Table tailings were removed as a final tailing.

The procedure outlined above would give results similar to what would be obtained commercially by successive regrinding and concentration of middlings.

Product	Weight	Percent Fe	Percent Distribution Fe
Minus 5 mesh, plus 10 mesh jig concentrate	30.4	63.3	34.0
Minus 10 mesh, plus 22 mesh jig concentrate	22.4	62.3	24.7
Minus 22 mesh, plus 44 mesh jig concentrate	14.5	60.1	15.4
Minus 44 mesh, plus 72 mesh table concentrate	5.5	62.1	6.0
Minus 72 mesh, plus 150 mesh table concentrate	7.0	57.2	7.1
Minus 150 mesh "sands" table concentrate	2.1	63.9	2.4
Cyclone underflow table concentrate	2.5	63.3	2.8
Combined gravity concentrates	84.4	61.9	92.4
Minus 150 mesh "sand" table tailing	1.4	23.6	0.6
Cyclone underflow table tailing	2.6	19.3	0.9
Cyclone overflow	11.6	30.0	6.1
Combined tailings	15.6	27.6	7.6
Composite ore	100.0	56.6	100.0

The test indicates that 92.4% of the iron can be recovered in a concentrate assaying 61.9% of iron. The sizing of the combined gravity concentrate was—

	Mesh B.S. Screen	Aperture mm	Percent Weight
Plus	10 mesh	1.67	31.9
Plus	22 mesh	0.70	28.0
Plus	44 mesh	0.35	16.1
Plus	72 mesh	0.211	7.4
Plus	150 mesh	0.105	7.8
Plus	200 mesh	0.067	2.1
Minus	200 mesh	6.7
			100.0

The concentrate is all minus 5 mesh (3.34 mm aperture).

Concentration Tests: Sample R.386B

Sample R.386B is similar to sample R.386A, but has a lower iron content and contains more relatively coarse free silica. However, the quantity of silica freed at coarse sizes is not sufficient to make rejection of coarse sized final tailings practicable.

A 50 lb. sample of R.386B was given similar treatment to R.386A outlined above, with the following exceptions:—

- (a) The minus 72 mesh plus 150 mesh table tailing was a final tailing.
- (b) The "slimes" from hydraulic classification were not cycloned, but were taken as a final tailing.

Product	Weight	Percent Fe	Percent Distribution Fe
Minus 5 mesh, plus 10 mesh jig concentrate	34.3	59.1	37.7
Minus 10 mesh, plus 22 mesh jig concentrate	16.4	60.3	18.4
Minus 22 mesh, plus 44 mesh jig concentrate	2.7	64.5	3.2
Minus 44 mesh, plus 72 mesh table concentrate	6.9	57.3	7.4
Minus 72 mesh, plus 150 mesh table concentrate	5.3	61.5	6.1
Minus 150 mesh "sand" table concentrate	9.2	68.1	11.7
Combined gravity concentrates	74.8	60.7	84.5

Product	Percent Weight	Fe	Percent Distribution Fe
Minus 72 mesh, plus 150 mesh table tail- ing	8.2	18.3	2.8
Minus 150 mesh "sand" table tail- ing	5.0	28.1	2.6
Minus 150 mesh "slimes"	12.0	45.0	10.1
Combined tailings	25.2	32.9	15.5
Composite ore	100.0	53.7	100.0

The test indicates that 84.5% of the iron can be recovered in a gravity concentrate assaying 60.7% iron. The sizing of the combined gravity concentrate was—

Mesh B.S. Screen	Aperture mm	Percent Weight
Plus 10 mesh	1.67	41.0
Plus 22 mesh	0.70	24.6
Plus 44 mesh	0.35	6.0
Plus 72 mesh	0.211	8.1
Plus 150 mesh	0.105	6.6
Plus 200 mesh	0.067	1.7
Minus 200 mesh	12.0
		100.0

In testing sample R.386B, the minus 150 mesh "slimes" were not cycloned, and hence the underflow was not concentrated. Such procedure could be expected to increase the overall recovery of iron by about 2%, as was the case with sample R.386A.

Discussion of Above Tests

These two tests show that high recoveries of the iron in gravity concentrates, with iron contents in excess of 60%, are readily attainable. The tests throughout were conducted on pilot scale models of commercial equipment, and the laboratory results should be duplicated in a commercial plant using similar processes. In a commercial plant, it is unlikely that concentration tables would be used for the finer sizes if Humphreys Spirals could be used to concentrate these fractions with similar efficiencies. However, it is not practicable to undertake Humphreys Spiral concentration tests with small quantities of solids, and it was primarily for this reason that tabling was used for concentrating the finer fractions in the above tests.

Concentration Tests on Humphreys Spiral

Provided satisfactory grade and recovery are attainable, the cheapest method of iron ore concentration is by hydraulic classification and concentration on Humphreys Spirals. Accordingly tests were carried out to determine the feasibility of concentration of the Blythe River sample R.386B on the Humphreys Spiral.

Preliminary tests on minus five mesh ore indicated that material coarser than about 10 mesh was very slow to move on the surface of the spiral, and difficulty was experienced in removing the comparatively large proportion of concentrate. Concentrate discharge parts tended to choke quickly on the coarse material.

A large sample, approximately 140 lbs., was stage roll crushed to minus 20 mesh, and sized hydraulically in a three spigot hydrosizer. The first spigot product was concentrated on the spiral to give a concentrate and tailing. The concentrate was cleaned once on the spiral. Combined tailings were reground, reclassified hydraulically and added to the original second spigot product. This product was treated in a similar manner to the first spigot product. The third spigot product was similarly treated. The hydrosizer overflow was concentrated by tabling, after desliming.

Overall results of the spiral concentration were—

Product	Weight	Percent Fe
First spigot spiral concentrate	22.1	60.6
Second spigot spiral concentrate	19.7	58.4
Third spigot spiral concentrate	9.3	60.5
Combined spiral concentrates	51.1	59.7

The above results indicate that hydraulic classification and Humphreys Spiral concentration can be used to concentrate the ore in the minus 20 mesh sizes to approximately 60% iron concentrates.

The major problem encountered in the spiral concentration was the removal of the large quantity of concentrate produced, due to the relatively high hematite content of the feed. This difficulty was most apparent in the two coarser sizes treated.

The third spigot product contained a high proportion of minus 150 mesh material, and much of this sized material appeared in the tailing. It appears that the practical size limit for spiral concentration is about 150 mesh. This fine material was readily concentrated by tabling into a concentrate containing 63.5% iron.

Results for spiral concentration in the size range 20 mesh to about 150 mesh sizes were encouraging, and it would appear that Humphreys Spirals could be used in this range to concentrate the Blythe River ore.

During crushing, &c., considerable slimes were produced, and these appeared in the hydrosizer overflow. The quantity of slimes produced in this test was much higher than that produced in the jigging and tabling tests recorded earlier. This was basically because the ore was ground through 20 mesh in the present test, while it was ground through five mesh previously. This overflow was deslimed in a 3-inch hydraulic cyclone, the cyclone overflow being regarded as portion of the final tailing. The cyclone underflow was concentrated by tabling to give a concentrate assaying 66.0% iron, and amounting to 16.6% of the original sample.

Overall recovery of the iron was 86.7% in a concentrate assaying 60.6% iron. This includes several small middling fractions, which in a continuous plant could be further ground and concentrated.

Discussion of Above Tests

This test showed that concentrates containing approximately 60% iron could be produced on the Humphreys Spiral in the size range minus 20 mesh plus 150 mesh approximately. Jigs have been previously shown to be satisfactory in the minus five mesh plus 44 mesh fractions, and table concentration is satisfactory in the minus 150 mesh size range.

At this stage, the logical concentration procedure appears to be—

- (1) reduce the whole sample to minus five mesh;
- (2) concentrate the plus 20 or 40 mesh fractions by jiggling;
- (3) concentrate the minus 20 or 40 mesh plus 150 mesh fractions on Humphreys Spirals;
- (4) concentrate the minus 150 mesh fractions by tabling after desliming by cycloning.

This procedure will allow concentrates of over 60% iron to be produced at all sizes.

The test work has shown that it is not possible to reject any significant quantity of low iron tailing above about 150 mesh. Concentrates of approximately 60% iron can be produced after regrinding tailings from coarser size concentration steps and re-concentrating.

Impurities in Iron Concentrates

Composite samples were made from the concentrates from the jiggling and tabling tests on Samples R.386A and R.386B. These concentrates had the following compositions:—

	R.386A	Percent R.386B
Phosphorus (P)	0.04	0.01
Sulphur (S)	0.02	0.02
Silica (SiO ₂)	10.8	13.5
Titania (TiO ₂)	0.02	0.01
Manganese (Mn)	0.10	0.02
Vanadium (V)	Trace	Trace

These concentrates are particularly free of the common contaminants of iron ores.

Note:—

- (1) All screens used were of the British Standard Screen series.
- (2) All iron assays reported are acid soluble iron.