CONFIDENTIAL to WDR

Metallurgical Testwork Summary

for

Western Desert Resources

by

Sargon Engineering

Project No. P1124

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Report

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CONTENTS

EXECUTIVE SUMMARY

Testwork was conducted under the direction of Sargon Engineering with the objective of determining the optimum methods for recovery of iron into marketable product grades. The target product requested by WDR is +60% Fe. However this has proven difficult to obtain, especially for the BFO ore types, and hence a lower grade target of 58% Fe has been used for BFO to determine potential recoveries for competing processing methods.

The testwork has focussed on two ore types:

- High Grade Halo ore which surrounds the DSO ore; and
- Beneficiable Ore (BFO) represented in two samples – “Sandy Comp” and “RC Chip”.

HG Halo Ore

For the High Grade Halo ore the testwork has deployed jigs, wet tabling and Wet High Intensity Magnetic Separation (WHIMS). This testwork was performed at Nagrom. A pilot-scale Allmineral Jig was used with 40 to 50kg samples of ore in specified size ranges. Laboratory wet table tests were performed to simulate spiral recovery of ore ground to minus 300 microns. WHIMS was tested for the minus 300 and minus 106 micron fractions.

Jigging: The jig tests were successful in demonstrating that Halo Ore of 52% Fe grade could be upgraded to 58 to 60% Fe grade. However for Halo Ore of 37% Fe, an upgrade to 58% Fe was not attained. Interpolations made on these jig test predict that the cut-off grade for Halo Ore is around 45% Fe, where the jig Fe recovery would be reduce to around 16%.

Wet Tabling: The wet tabling of Halo Ore produced higher recoveries than the jigs, with 70% and 48% Fe recovery for the 52% and 37% Fe grade ores respectively. However in grinding the ores down to the appropriate sizing for wet tables / spirals, only around 45% by mass reported to the optimal range of 106 to 300 microns, with the remainder minus 106 µm. Hence for a 45% Fe Halo ore, the testwork indicates a recovery of 27%. **Grind optimisation has the potential** to double the mass reporting to the desired size fraction and hence double the recovery to over **50%.**

WHIMS: This was unsuccessful in all size ranges of Halo ores tested, however use of improved technology (Pulsed High Gradient Magnetic Separation or PHGMS) could be expected to yield superior results.

Comparison: From this testwork the flowsheet options for processing Halo ores have been compared, and the projected outcomes are shown in Table 1.

Table 1: Predicted Recoveries for 52% Fe Halo Ore for Jig and /or Spiral Flowsheets

Flowsheet	Parameter	Ore Head	-32 +8mm Ore	-24 +6.3mm Ore	-6.3 +1.4mm Ore	-1.4mm +300um	-300 +75um Ore	-75um Ore	Total
			Ore Size Range						
Crush for Jigs Only	Mass Distribution (wt%)	100	**32**	**32**	**22**	**11**	**1.0**	**2.0**	100
	Fe Recovery (%)	-	**50**	**50**	**58**	-	-	-	**44.8**
Crush with Jigs & Spirals	Fe Recovery (%)	-	**50**	**50**	**58**	-	70	-	**45.5**
Crush & Grind -1.4 mm	Mass Distribution (wt%)	100	32	32	22	**0**	**7.3**	6.7	100
with Jigs and Spirals	Fe Recovery (%)	-	**50**	**50**	**58**	-	**70**	-	**50**
Grind All Ore to -300um	Mass Distribution (wt%)	100	0	0	0	0	**52**	48	100
for Spirals	Fe Recovery (%)	**-**	**-**	**-**	**-**	0	70	-	**36**

The results indicate that a flowsheet consisting of jigs on the +1.4 mm fractions, and spirals on the -1.4 mm fraction ground to minus 300 microns would yield the optimal Fe recovery of 50%. Jigs alone produced 44.8% recovery whilst spirals alone gave 36%.

Further grind and gravity separation testwork is recommended for Halo ore in the range 30 to 50% Fe grade to determine the optimal grinding and classification regime and determine the cut-off grade for Halo ore.

Beneficiation of BFO

Flotation: The first tests conducted for BFO where flotation. Eight tests were completed under varying conditions and the final test achieved ~59% Fe with 55 to 60% recovery. However, this was achieved with high reagent usage and at that stage it was expected that other methods would prove to be more cost effective. In the light of disappointing magnetic separation results since then, further work on flotation should be considered.

Magnetic Separation: Most of the BFO ore test program has focussed on WHIMS and PHGMS to generate recoveries similar to that obtained for near optimal flotation – at 50+% Fe recovery to a 58% Fe grade. The results for batch SLon (i.e. the original type of PHGMS) tests and also for pilot scale WHIMS800 (also known as the GZRINM unit) have obtained 57 to 58% Fe grade magnetics products at near 50% Fe recoveries. Further tests are now recommended to optimise the magnetic separation equipment types and flowsheet options which could include and cleaner as well as rougher stage, plus classification and regrind of magnetic middlings.

Filtration: A simple filtration test of milled BFO mag's was completed which showed that vacuum filtration would not be adequate for dewatering finely milled slurry.

1. Introduction

This report provides a summary of testwork complete to date, comprising testwork conducted by:

- Allied Mineral Laboratories (AML) – Batch SLon Magnetic Separation
- Nagrom – Crushing, Grinding, Screening, Wet Tabling, Magnetic Separation(WHIMS)
- Optimet Laboratories (Kwan Wong)– Flotation
- Eriez – Magnetic Separation

These tests are listed in Appendix 1 which provides provides a tabular summary and references to the source data.

2. Results of Testwork on High Grade Halo Ore

The work carried out by Nagrom on High Grade Halo Ore consisted of Jigging, Grinding, Wet Tabling, Magnetic Separation (WHIMS) and assaying of the feed sample together with the treated sample.

2.1 Jigging

There are total of 6 different High Grade Halo samples for the jigging testwork - WDR RBMT 15, 16, 17, 18, 19 and a composite of these five samples ("Feed Composite"). The tests are carried out on 20th of October 2011 using in 3 different size fractions which were obtained by crushing and screening the samples. The size ranges were:

- -32 to +8mm,
- -24 to +6.3mm and
- -6.3 to +1.4mm).

The aim of this jigging testwork was to upgrade the High Grade Halo Ore to achieve 60% Fe grade.

The testing was done on the pilot Allmineral jig at Nagrom

In all cases except for the composite, the best performance was achieved with the particles in the smallest size range, 1.4mm to 6.3mm. The best composite performance was obtained with the middle size fraction, 6.3mm to 24mm. The results are summarised below and shown in Figure 1. Further details are referenced in Appendix 1.

WDR RBMT 15, 16 & 17

These samples had very low head grades (10%, 22% and 38% Fe) and didn't achieve the target grade of 60% Fe for any of the three size ranges. The results are shown in Figure 1.

WDR RBMT 18

This sample had a Fe head grade of 52% and successfully upgraded to the targeted 60% Fe grade from passing the 8 to 32 mm size fraction. The results are shown in Table 1 and the grade versus recovery plot in Figure 1.

Table 2: Jig Results for WDR RBMT18 – Size Range: -6.3 +1.4mm

Stream	Cumlative Grade				Cumulative Distribution (%)				
	Fe	SiO2	Al2O3	LOI (1000)	Total Sample	Fe	SiO2	Al2O3	LOI (1000)
Cut 1	**62.0**	**8.4**	1.1	1.4	18	**21.5**	7	10	11
Cut 2	**60.1**	**10.5**	1.2	1.7	33	**38.6**	17	21	26
Cut 3	58.5	12.4	1.4	2.0	47	53	29	32	42
Cut 4	57.1	14.2	1.4	2.0	59	65	41	42	54
Cut 5	55.6	16.1	1.6	2.1	72	77	57	56	67
Cut 6	54.1	18.1	1.7	2.1	84	87	74	70	80
Cut 7	52.4	20.2	1.9	2.2	94	95	93	88	93
Cut 8	51.8	20.9	2.0	2.2	96	96	98	94	96
Under Hutch	52.0	20.5	2.0	2.2	100	100	100	100	100
Calc Head	52.0	20.5	2.0	2.2					

WDR RBMT 19

This sample had a head grade >62%. Some improvement was achieved but at the cost of yield – refer to Figure 1.

WDR RBMT Feed Composite

This sample failed to achieve the target of 60% Fe grade for all 3 different size fractions refer to Figure 1.

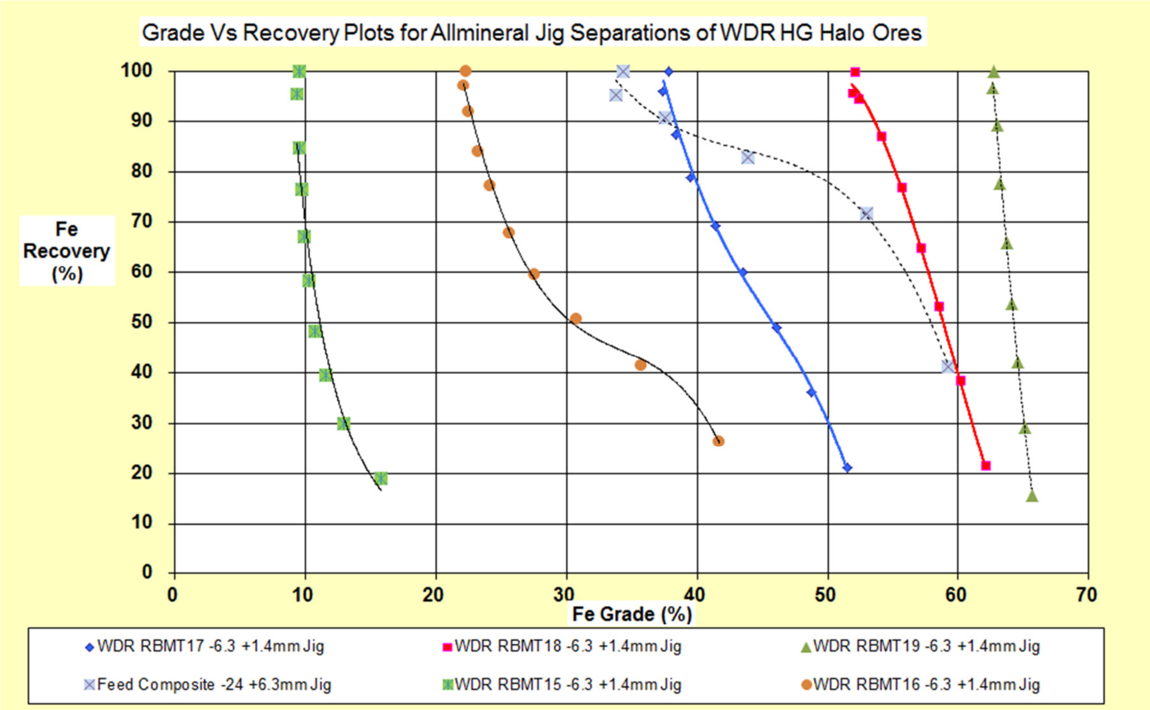


Figure 1: Halo Grade vs Recovery Plots for Allmineral Jig Batch Separations

Collectively, these results showed that Jigging could achieve the target grade of 60% with Fe recovery around 40% and SiO2 concentration around 10%, provided that:

- The head grade is well controlled
- The feed particle size is appropriate. The most effective size range tested was the finest of the three ranges (-6.3mm to +1.4mm).

2.2 Grinding

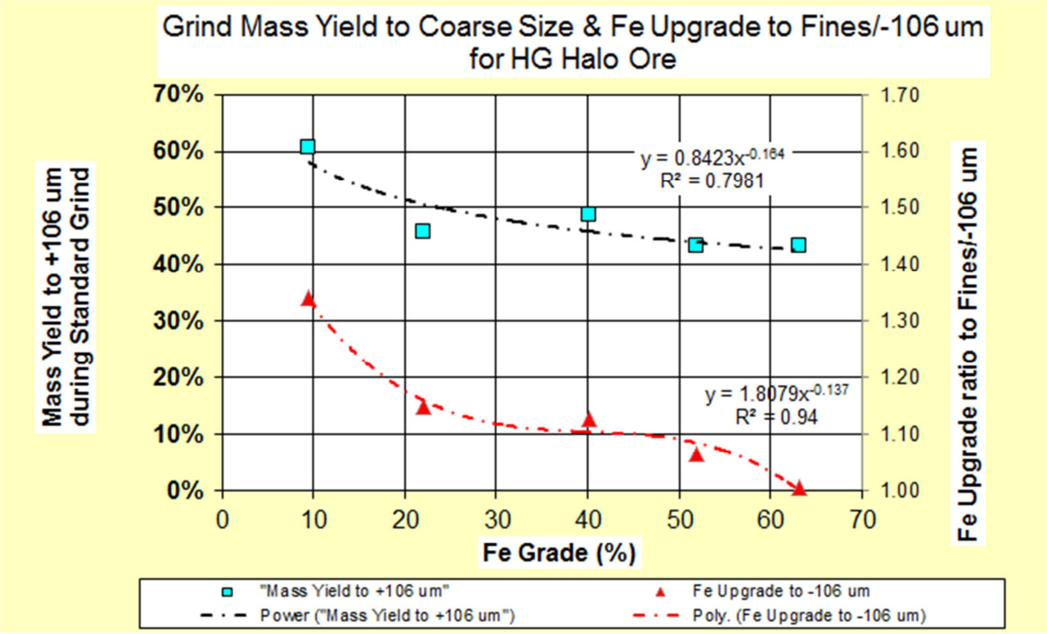
The same samples from the Jigging testwork have been ground up for further testwork. Assays indicated that the iron tends to concentrate in the fines (-106µm). Please refer to Table 3 and Figure 2.

Table 3: Grinding of HG Halo Ore

Product	Fe		Head % Fe	+106µm Mass Yield	Fe Upgrade Ratio to -106µm
	Grade %	Dist. of Fe			
WDR RBMT 15					
+106µm	7.41	47	9.5	60.8%	1.34
-106µm	12.7	53			
WDR RBMT 16					
+106µm	18.1	38	22.0	45.8%	1.15
-106µm	25.2	62			
WDR RBMT 17					
+106µm	34.7	42	40.1	48.7%	1.13
-106µm	45.2	58			
WDR RBMT 18					
+106µm	47.4	40	51.9	43.2%	1.07
-106µm	55.3	60			
WDR RBMT 19					
+106µm	62.7	43	63.2	43.2%	1.01
-106µm	63.5	57			
WDR RBMT Feed Composite					
+106µm	31.5	38	36.3	43.2%	1.1
-106µm	39.9	62			

Comparison of the Grade data (second column of Table 3) with the Head Grade show that Fe tends to concentrate in the fine fraction.

Figure 2: Grind Mass Yield to Coarse Size & Fe Upgrade to Fines (-106µm) for HG Halo Ore



The upper curve shows approximately 50% of the ground Halo ore reporting to the +106µm fraction; more if the grade is low. The lower curve quantifies the upgrade available by selecting the -106µm stream.

2.3 Wet Tabling

There are total of 4 grinded High Grade Halo Ore samples for wet tabling testwork:

- WDR RMBT 15 -300 +106µm
- WDR RMBT 16 -300 +106µm
- WDR RMBT 17 -300 +106µm
- WDR RMBT 18 -300 +106µm

The aim of this Wet Tabling was to upgrade the Halo ore to 60% Fe. Wet table testing was used as a proxy for spiral performance because it provides a good indication of performance with a small sample.

The size range of 106 to 300µm was used to enable good separation. This method only provides separation for particles within a limited size range. Although the wet table performs well for this feed, overall Fe recovery by this method suffers because the milling fines cannot be processed in this way.

The tests were carried out on 28th of November 2011.

Wet Tabling results which achieved the target are reported below. Further details are referenced in Appendix 1.

WDR RBMT 15 -300 +106µm

This sample didn't achieve the target of 60% Fe grade.

WDR RBMT 16 -300 +106µm

This sample didn't achieve the target of 60% Fe grade but came very close (i.e. 59.6%) on the first cut.

WDR RBMT 17 -300 +106µm

This sample did achieve the target of 60% Fe grade. Please refer to the table below. The figures for Fe recovery in Table 4 ("Distribution of Fe") are based on the indicated size range which is fed to the table. Losses outside the given size range are neglected.

Table 4: Wet Tabling Results for WDR RBMT 17 -300 to +106µm

	Fe		SiO2	
Product	Grade %	**Dist'n of Fe**	Conc'n %	**Dist'n**
Cut 1	**65.5**	8.49	**3.69**	0.39
Cut 2	**61.8**	18.3	**6.93**	1.66
Cut 3	53.6	20.2	16.1	4.89
Cut 4	39.6	19.3	36.1	14.2
Cut 5	25.8	18.9	56.3	33.3
Cut 6	18.0	14.1	67.4	42.6
Slimes	14.2	0.73	72.0	2.97
Calculated Head	**35.0**	100.0	43.4	100.0

The cumulative recovery to a grade of 61.8% Fe is nearly 27%. Given the modest head grade of 35%, this is a promising.

WDR RBMT 18 -300 +106µm

For this sample, the cumulative recovery to a grade of 60.5% Fe is nearly 40% (9.1+14.3+15.8%). As for RBMT 17, these figures for Fe recovery ("Distribution of Fe") are based on the indicated size range which is fed to the table. Losses outside the given size range are neglected.

Table 5: Wet Tabling Results for WDR RBMT 18 -300 +106µm

Product	Fe		SiO2	
	Grade %	**Dist'n of Fe**	Conc'n %	**Dist'n**
Cut 1	**66.3**	**9.08**	**2.79**	0.61
Cut 2	**64.6**	**14.3**	**4.20**	1.49
Cut 3	**60.5**	**15.8**	9.11	3.82
Cut 4	54.5	19.1	17.2	9.69
Cut 5	47.9	17.8	26.5	15.9
Cut 6	31.1	22.2	50.9	58.5
Slimes	18.6	1.69	68.7	10.0
Calculated Head	**46.6**	100.0	29.0	100.0

Overall Wet Table Performance

Figure 3 shows the results of wet tabling testwork after accounting for losses due to particles which do not fall within the limited size range. The particles account for over half of each sample. Performance could be significantly improved by optimising the grinding circuit in a way which minimises the production of fines smaller than ~106µm.

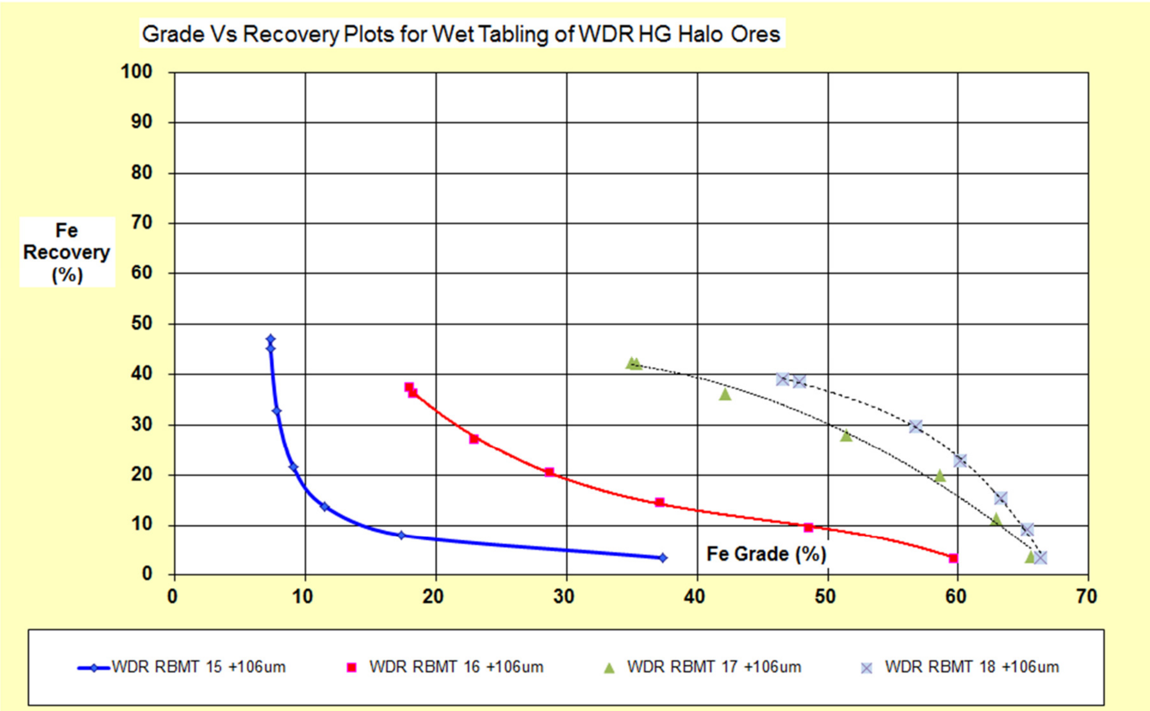


Figure 3: Grade Vs Recovery Plots for Wet Tabling of WDR HG Halo Ores

2.4 Wet High Intensity Magnetic Separation (WHIMS)

There are total of 3 grinded High Grade Halo Ore samples for WHIMS:

- WDR RBMT 15 -106µm;
- WDR RBMT 17 -106µm and
- WDR RBMT 18 -106µm.

These tests were carried out on 28th of November 2011.

If successful, WHIMS could be used to process the fines stream which was too fine for spirals.

None of the samples achieved the target of 60% as shown in Table 6. Improvement from the head grade and the recoveries were disappointing in each case.

Table 6: WHGMS for Fines (-106µm)

Product	Fe		SiO2	
WHIMS	Grade %	Dist'n of Fe	Conc'n %	Dist'n
WDR RBMT 15 -106µm				
Magnetics	**19.2**	**55.0**	53.1	31.2
Middlings	11.6	15.6	68.9	19.0
Non-Magnetics	8.92	29.4	74.0	49.8
Calculated Head	13.3	100.0	65.1	100.0
WDR RBMT 17 -106µm				
Magnetics	**47.7**	**41.3**	22.0	29.0
Middlings	42.2	10.8	32.6	12.7
Non-Magnetics	42.2	47.9	33.8	58.3
Calculated Head	44.3	100.0	29.1	100.0
WDR RBMT 18 -106µm				
Magnetics	**57.5**	**64.5**	12.6	48.0
Middlings	53.1	19.3	19.4	23.9
Non-Magnetics	49.4	16.2	25.3	28.1
Calculated Head	55.1	100.0	16.3	100.0

3. Results of Testwork on Beneficiable Ore ("BFO")

BFO is represented by samples namely, "RC Chip" and "Sandy Comp". Their head analyses are shown in Table 7.

Table 7: Head Analysis of RC Chip and Sandy Composite

Sample	%Fe	%SiO2
RC Chip	41.9	31.9
Sandy Composite	46.5	27.5

Improvements in the grade of WDR BFO have proven to be difficult even for a target grade of 58%.

The tests conducted to date are:

- Magnetic separation by AML (Batch SLon), Nagrom (WHGMS) and Eriez (Melbourne).
- Flotation testing by Optimet
- Filtration Testing

Assays of Eriez samples are progressing at Nagrom, but results were not available for this report.

3.1 Batch SLon Magnetic Separation

The batch SLon magnetic separation is conducted in Allied Mineral Laboratories (AML). The purpose of this testing was to assess the viability of magnetic separation for this material and determine the optimum setting to be used in WHGMS and GZRINMs magnetic separation (i.e. Gauss strength (amp), grind size (P80), Pulse Rate and Matrix).

A total of 18 tests were conducted using both RC Chip and Sandy Composite targeting 58% Fe.

For RC Chip the best result was RC Chip Test 9 which gave 54.8% Fe.

For Sandy Comp three tests gave grades over 58% (58.1%, 58.4% and 58.5%) starting with a head grade of 52% - refer to Table 8. The main variables between the three tests are shown at the right. The effect of these on product grade varation between the three tests was small, and the fine test matrix (See Figure 3) produced marginally better performance than the 1mm matrix. However, high field strength and pule rate caused a major reduction in iron recovery.

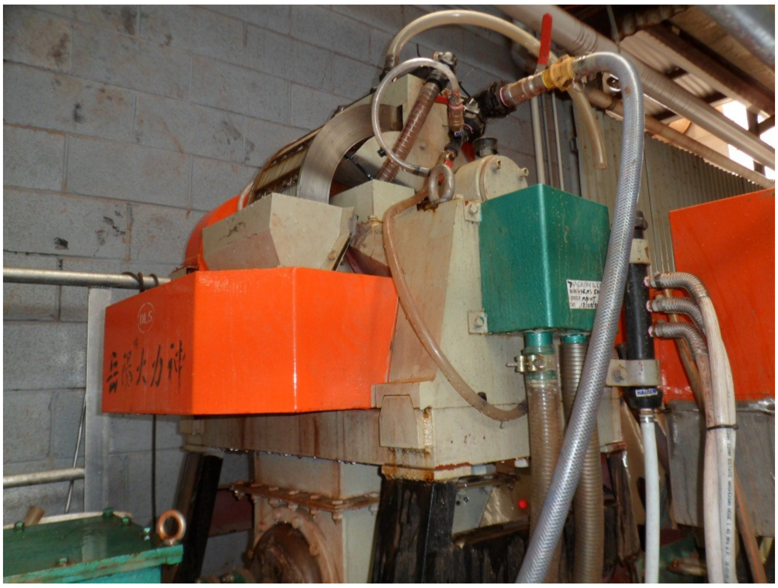
Table 8: Batch SLon Magnetic Separation

Product	Fe		SiO2		Setting		
Batch SLon	Grade %	Dist'n of Fe	Conc'n %	Dist'n %	Gauss (Amp)	Pulse Rate (Hz)	Type of Matrix
Sandy Composite Test 16							
Magnetics	**58.1**	**56.1**	9.48	24.9	780	30	1.0mm
Non-Magnetics	45.4	43.9	28.6	75.1			
Calculated Head	**51.8**	100.0	19.0	100.0			
Sandy Composite Test 17							
Magnetics	**58.4**	**46.3**	9.83	21.2	1040	40	Fine
Non-Magnetics	47.5	53.7	25.6	78.8			
Calculated Head	**52.0**	100.0	19.1	100.0			
Sandy Composite Test 18							
Magnetics	**58.5**	**56.9**	9.08	25.0	780	30	Fine
Non-Magnetics	45.7	43.1	28.0	75.0			
Calculated Head	**52.2**	100.0	18.4	100.0			

Figure 4: Slon Test Matrices - 1mm (LHS) and "Fine" (RHS)

3.2 Wet High Gauss Magnetic Separation (WHGMS 500)

This is the continuous Wet High Gauss Magnetic Separation that we used for beneficiating RC Chip and Sandy Composite. From the optimum setting that we get from the batch SLon magnetic separation in AML, we are trying to replicate the results for Sandy Composite in a continuous magnetic separation. Below is a photo of WHGMS 500 (smaller unit).



We did a few runs for both RC Chip and Sandy Comp, but were unable to replicate the results that were achieved in the batch SLon magnetic separation in AML. Please refer to the table below.

Table 9: Sandy Comp WHGMS500 Test 4

Product	**Fe**		**SiO2**	
WHGMS 500	Grade %	Dist'n of Fe	Conc'n %	Dist'n %
Magnetics	48.2	54.9	24.8	46.3
Non-Magnetics	43.4	45.1	31.5	53.7
Calculated Head	45.9	100	28.0	100

3.3 GZRINM's WHIMS (WHGMS800)

GZRINM's WHIMS is Chinese technology developed to enhance magnetic separation performance. It is larger to WHGMS 500 and the supplier claims that its performance is optimised by the following innovations.

- Dual jigging mechanism to increase recovery and grade
- Air assisted water flushing mechanism to reduce water usage and still prevent clogging over the long term.
- Advanced design to eliminate ring step motion and so improve reliability.
- Optimised yoke design to prevent concentrate drop off and enhance Fe recovery
- Optimised matrix design to evenly distribute the magnetics in the matrix, which increases capacity and separation efficiency

We did 3 tests on GZRINM's WHIMS by changing the intensity in order to give us a better separation.

Sandy Comp sample was passed over the GZRINM's WHIMS at Nagrom with Test 3 mags sieved at 38 microns as per the test flowsheet below. The objective is to improve the Fe grade by reprocessing poorly liberated particles (+38µm) after regrinding. Better liberation of the minerals in this relatively coarse stream should allow non-Fe minerals to be diverted to the tailings stream on the next GZRNM pass.

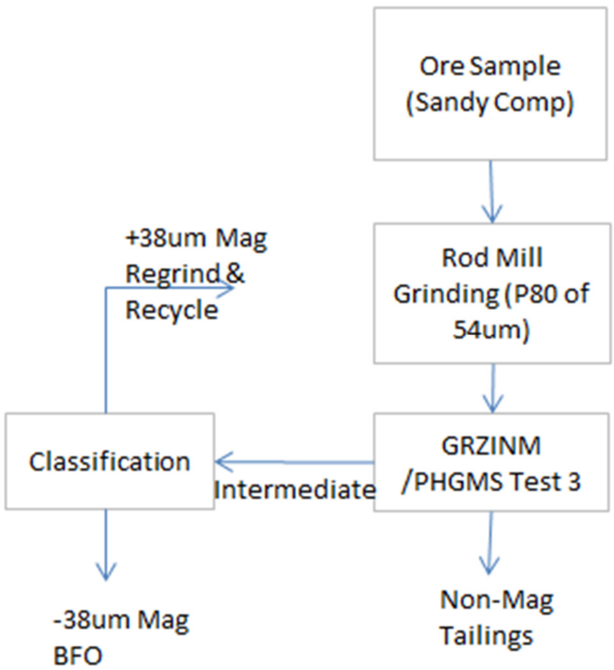


Figure 5: Flowsheet for Enhanced Product by Regrinding +38µm Mags

Figure 5 shows the samples which were tested. The +38 µm stream was analysed but has not yet been reprocessed.

The results are summarised by the table below. The classification stage upgrades the first-pass 'Intermediate' stream from 57.1%, to 57.9% Fe in the -38 µm product stream, with 37.2% Fe recovery. The +38µm mag's still contain a 54% Fe and 15.6% of the total Fe and reprocessing this steam is expected to increase grade above 58% and Fe recovery towards 50%.

Product silica is over 10% and may improve slightly after re-processing of the +38µm stream.

Given the head grade of 47.8%, additional investigation of this option is justified, starting with reprocessing of the +38µm stream.

Table 10: Sandy Comp WHGMS800 Test 3

Stream		Fe		SiO2	
		Grade %	Dist'n of Fe	Conc'n %	Dist'n
Intermediate	Magnetics	57.1	53.0	12.3	21.2
Products	Mags +38µm Regrind & Recycle	**54.2**	**15.6**	16.7	9.9
	Mags -38µm Product	**57.9**	**37.2**	**11.5**	16.3
	Non-Magnetics	40.6	47.0	36.6	78.8
Input	Calculated Head	47.8	100.0	26.2	100.0

3.4 Flotation

Flotation tests were conducted on the Sandy Composite sample by Optimet, using reverse flotation to float off Silica leaving Fe minerals concentrated in the tails.

A series of tests were conducted using a variety of conditions. These failed to achieve the targeted Fe concentration of 58% until Test 8, reported below. These results were achieved for the size fractions indicated. That is, the Fe grade of 58.3% was achieved in the -45µm fraction of the tails stream, which contained 55.0% of the feed iron; and increasing the product size range up to 53µm, increased the recovery to 60.5%, but reduced the grade to 57.6%

Table 11: Flotation Test 8

Product	Fe		SiO2	
Flotation	Grade %	**Dist'n of Fe**	Conc'n %	**Dist'n**
Silica Rougher Tail -45µm	**58.3**	**55.0**	**8.0**	12.8
Silica Rougher Tail -53µm	**57.6**	**60.5**	**9.1**	16.2

Further investigation of floatation was deferred after obtaining these results because it was expected that other methods of beneficiation would be more cost effective, owing to the high consumption rates and cost of flotation chemicals. However, subsequent test work to evaluate the alternative methods has produced disappointing results. Therefore, further work to optimise flotation performance is now considered appropriate.

3.5 Filtration

Simple filtration tests were conducted on some SLon mag's product from ground ore with P_{80} of 54 µm. The objective was to see if the cake could be dried to a transportable moisture limit by vacuum filtration (without resorting to high filtration pressures), and to get a crude indication of filtration time.

The testing was done by Nagrom using laboratory filter funnel. The results are shown in Figure 6.

This testing indicated that adequate moisture removal could not be achieved under these conditions. So high pressure filtration would be necessary if WDR is to use a process which produces a fine slurry by wet milling.

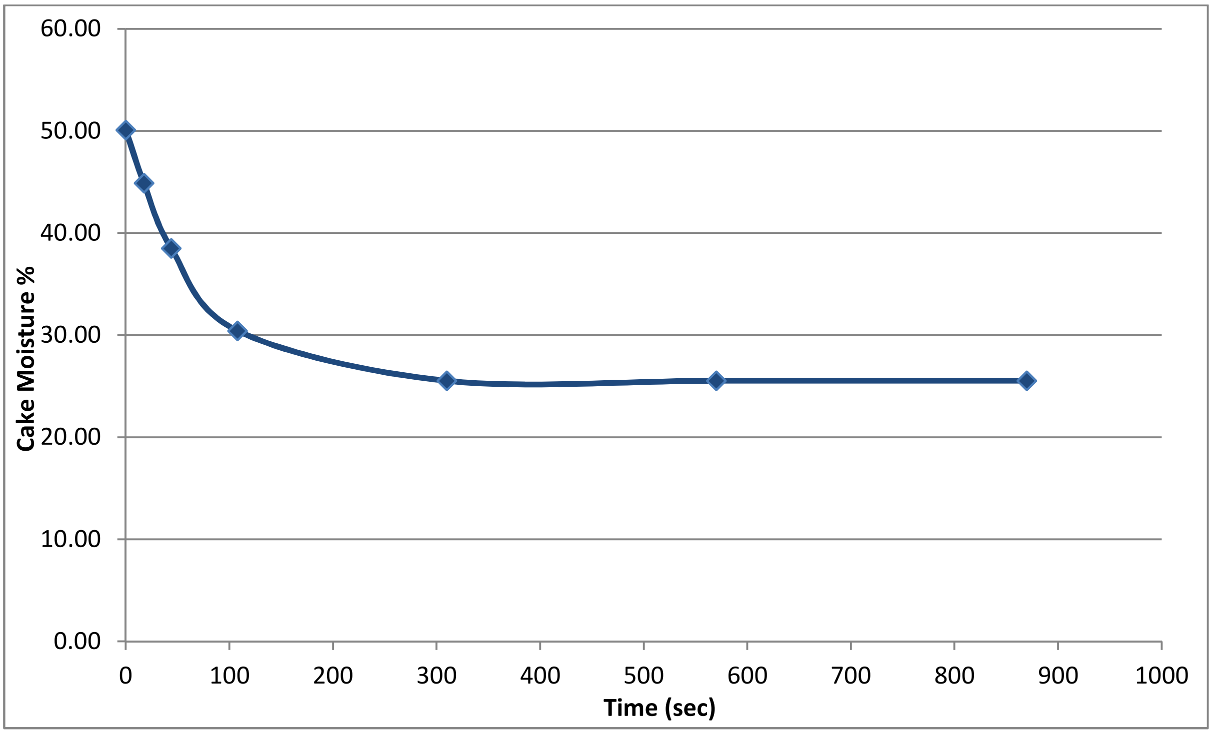


Figure 6: Filtration curve

APPENDIX 1: SUMMARY LIST OF METALLURICAL TESTS