FLOTATION OPTIMIZATION AND VARIABILITY TESTING ON COMPOSITES FROM THE MORRISON PROJECT

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1.0 SUMMARY

In this test program, pre-feasibility and variability testing were conducted on various interval individual and master composites which were sorted out from 4 recent drill holes to represent three main mineral types and various horizons. The unused individual samples were archived for variability tests with respect to work index and concentration.

The main constituents of interest were from 0.1g/t to 0.4g/t Au and between 0.3% and 0.6% Cu for the interval composites, as shown in the table below.

Head Assay

Composite		Mineral Type	Hole ID / Comp ID	Intervals, m	Meas. Head Au, g/t	Meas. Head Cu, %
Individual Composites	MH1	1, BFP	MET 01	5.6 –93.8	0.26	0.48
	MH2	1, BFP	MET 02	7.9 –82.0	0.14	0.34
	MH3	1, BFP	MET 03	10.5 – 61.5	0.16	0.52
	MH4	1, BFP	MET 04	3.7 – 92.3	0.13	0.35
	MH5	1, BFP	MET 01	93.8 –194.7	0.21	0.62
	MH6	1, BFP	MET 02+04	115.7 – 181.2	0.22	0.43
	MH7	1, ZS	MET 02+03+04	2.7 – 81.8	0.13	0.35
	MH8	1, ZS	MET 01+04	107.0 –170.0	0.13	0.35
	MH9	2	MET 01+02+03	5.6 –80.0	0.21	0.51
	MH10	2	MET 01+04	92.3 – 128.6	0.39	0.60
	MH11	2	MET 02	101.0 – 252.5	0.19	0.42
	MH12	3	MET 01+02+04	68.6 – 256.0	0.17	0.40
	MH13	3	MET 03	20.2 – 97.5	0.14	0.44
Master Composites	MHM1A	1, BFP	MH 1 to 6	All	0.19	0.45
	MHM1B	1, ZS	MH 7 to 8	All	0.12	0.37
	MHM1C	1	MHM 1A +1B	All	0.18	0.45
	MHM2	2	MH 9 to11	All	0.21	0.43
	MHM3	3	MH 12 + 13	All	0.15	0.44
	MHM4	All	MHM 1C + 2 + 3	All	0.21	0.46

The comminution test results show that the energy consumption of all material types for the comminutions would be moderate.

The flotation flow sheet was mainly developed on the type 1 sample as labeled as Composite MHM1C, which represents major mineralization characteristics. The use of lime, PAX and MIBC at pH 10, recovered approximately 91% Cu and 82% Au by 6-stage rougher flotation. Although finer grinding improved the copper recovery, primary grinding to a 80% passing size (P_{80}) of 150μm was the indicated optimum target with regarding the energy consumption in the comminution processes.

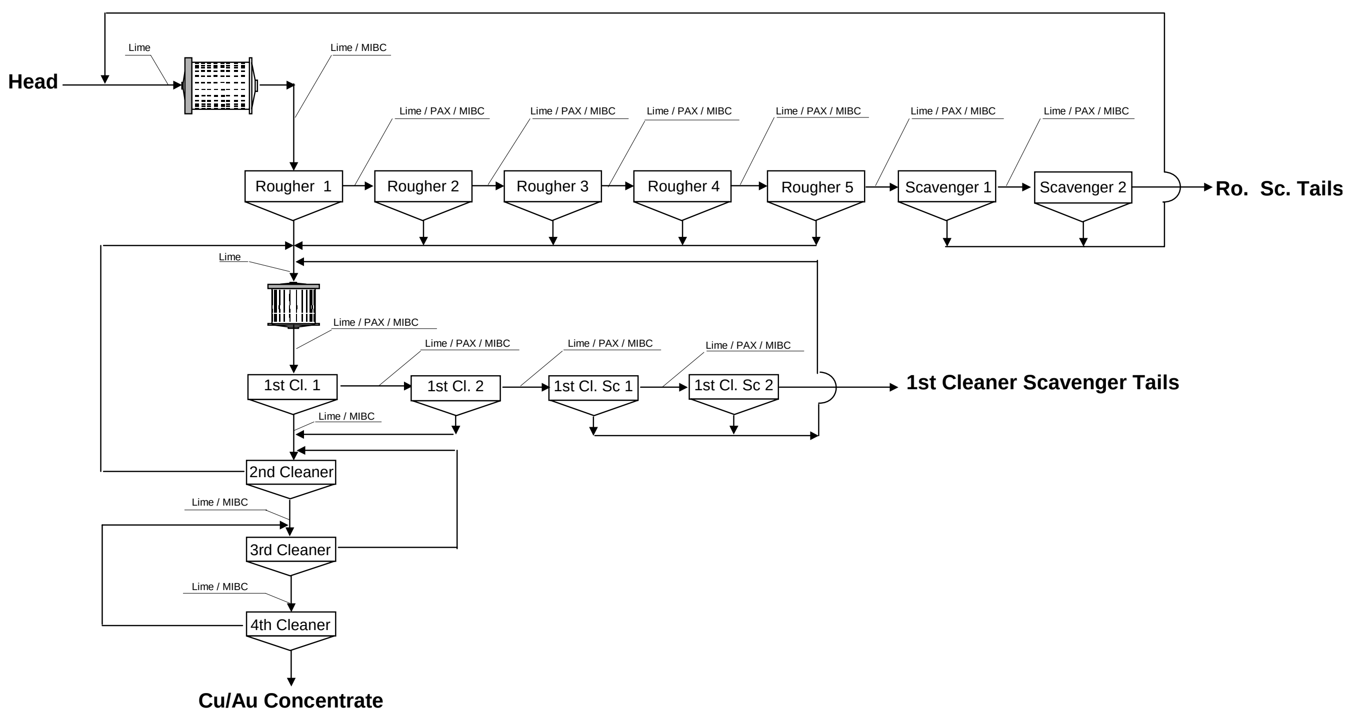
The tests reveal that the mineralization type has substantial influence on the material response to the flotation process, as following order: mineral types 1 > 3 >2. The worst two individual samples, categorized as mineralization type 2 family, yielded only 71% Au and 79% Cu recoveries respectively after 6 stage rougher flotation. The type 2 samples were more sensitive to primary grind size, compared to the other two types of samples.

Four stages of cleaning at pH >11.5 with rougher concentrate regrinding obtained a product grade higher than 25% Cu.

Locked cycle testing using a flowsheet as shown below confirmed that the type 1 sample (MHM1C) had the best performance with recovering 86% Cu and 71% Au, while the type 2 sample showed the lower recoveries at only 81% Cu and 44% Au. The tests on Composite MHM4, which was blended from various types of samples, produced a 26.0% Cu and 6.8g/t Au concentrate with recoveries of 85.7% Cu and 59.7% Au. The some of locked cycle test results based on the last three cycles are summarized in the table below. The results also indicated that the main value recoveries were inversely related to the copper grade of the final concentrate. Further tests should be required to optimize regrind size and establish the relationship between the copper grade of the final concentrate and the recoveries of the main values.

Locked Cycle Test Results

Test ID	Composite ID	Ore Type	Conc. Grade Au, g/t	Conc. Grade Cu, %	Conc. Recovery Au, %	Conc. Recovery Cu, %	Grind Size (Primary/Secondary)
F46	MHM 1C	1	8.16	26.4	71.3	86.2	P_{80}155µm/P_{90} 29µm
F47	MHM 2	2	7.30	26.1	43.7	80.6	P_{80}167µm/P_{87} 25µm
F48	MHM 3	3	5.61	27.5	58.3	85.0	P_{80}145µm/P_{89} 25µm
F51	MHM 4	1+2+3	7.77	27.8	54.7	83.8	P_{80}156µm/P_{89} 25µm
F52	MHM 4	1+2+3	6.80	26.0	59.7	85.7	P_{80}149µm/P_{80} 27µm



Locked Cycle Test Flowsheet

Size analysis and mineralogical examination on rougher flotation tailings indicated that major loss of copper minerals and other sulfides occurred as in locked forms with gangues in coarse particle size fractions.

2.0 INTRODUCTION

In March 2005, Process Research Associates Ltd. (PRA) was engaged by Beacon Hill Consultants (1988) Ltd. on behalf of Pacific Booker Minerals to undertake metallurgical testing, based on Proposal No. P0500802. The work was to form part of the basis for a Pre-Feasibility Study of the Morrison Copper project in Northern B.C. Fresh samples from a limited drill program would be assayed and grouped into three specific types, and various composites would be prepared for metallurgical testing according to detailed client's consultant instructions.

The test program includes:

Sample preparation, sorting, crushing, blending into composites, splitting, assaying, and comminution testing.

Optimization of the flotation conditions, including grind and regrind requirements, pH and reagent regime for the bulk and cleaner flotation of all type composites.

Investigation into the impact of recycling streams on the final concentrate quality and recoveries of interested metals.

Generation of various design and characterization parameters as needed.

Limited mineralogical examination with particular attention to the relationship between main value minerals and gangue minerals.

Preparation of testing samples for other testing programs such as environmental and tailing characteristic testing.

3.0 PROCEDURES

Much of the work was conducted according to specific client's consultant instructions. Detailed procedures were compiled for each task, and a general overview is briefly outlined in this section, with more details provided in individual test reports and in the discussions.

3.1 Sample Preparation

Samples arrived in four lots between March 30 and April 22, 2005, as shown in the Receiving Log Sheets attached in Appendix I. Sorting of the samples by label and interval preceded the collection of a 10-12 cm length of competent core from each 4-meter interval of each mineral type sample, for comminution testing. The remaining core intervals were then individually crushed to –1/4 inch and grouped in 3m to 7m lengths by mineralization type for assaying. The client's geologist also designated about 40 of various intervals as waste material.

All 179 crushed sample lots were stored individually in plastic pails purged with nitrogen after riffling out required test portions to be crushed to –10 mesh and blended into 13 initial composites to represent distinct horizons of three mineralization types. Mineral type, crushed size, hole number, and depth interval identified each sample for ease of reference.

Four Master Composites (labeled as MHM) were first prepared to represent three mineral types (OT1 (OT1A, OT1B), OT2, OT3) according to the detailed lists provided in the Appendix I. Blending all material types into a main Composite MHM4 according to weight ratio of 66.6% OT1, 26.6% OT2 and 6.8% OT3 was also performed according to client's consultant instructions.

3.2 Assay Procedures

Copper was determined by Atomic Absorption (AA) Spectrophotometry or the Inductively Coupled Plasma Atomic Emission Spectroscopy (ICP-AES). after samples were digested in a suite of strong mineral acids The gold was done by standard fire assay procedures, and minor elements were scanned using ICP-AES method. Sulfide sulfur (S^{-2}) was analyzed by wet assay. Total sulfur was determined using Leco method. Blanks and repeat samples were carried with each batch of assays for Quality Control and Quality Assurance (QA/QC) purposes.

3.3 Grinding and Screening

Grinding was performed in a stainless steel laboratory rod mill, by wet grinding 2.0 kg of nominal minus 10 mesh sample, at a 65% by weight solids content. Test grind was conducted on each sample to determine the necessary grind time required to achieve specified target 80% (P_{80}) passing sizes.

Screen analyses were carried out in a Rotap™, equipped with 20 cm (8") diameter test sieves, stacked in ascending mesh sizes. The sample was initially wet screened at 37 microns (400 Tyler® mesh). The +37 micron fraction was then dry screened through stacked of 65 mesh to 400mesh sieves. Each sieved fraction was collected and weighed for calculating the size distribution.

3.4 Flotation

The flotation tests were conducted using a Denver D12 laboratory flotation machine in appropriately sized cells to yield the target test pulp density. The solids were pulped in Vancouver municipal water at an ambient temperature of ~18°C. The impeller speed was set at the required rate according to cell size and the airflow was controlled manually to maintain the froth level.

4.0 RESULTS AND DISCUSSION

Core samples from 4 drill holes, as identified as MET01 to MET04, arrived in short succession between March 30th and April 22nd, 2005. The core samples were logged in as listed in Appendix I, and the procedures for material preparation as outlined in the previous section were followed. Based on the interval assignments made by the geologist and apart from the overburden, the main material categories of interest were as followed:

- Mineral Type 1 (OT1), BFP (Biotite Feldspar Porphyry) – igneous porphyry
- Mineral Type 1 (OT1), ZS (Siltstone) – sedimentary silts
- Mineral Type 2 (OT2)
- Mineral Type 3 (OT3)
- Waste – off-grade materials of various types

4.1 Sample Preparation and Head Assays

Before preparing composites for metallurgical testing, core sections were removed, including waste samples, for comminution testing. The overburden sections were archived.

The various lengths of drill cores were split into 3 to 7m intervals according to mineralization type and alteration, and a total of 179 intervals were assayed for Au and Cu, as shown in the Appendix II. A total of 18 Composites were then prepared (Table 4.1) to represent different horizons for each mineral type, and aliquots from these blends were assayed for Au, Cu and ICP. The master composite MHM4 was prepared from 66.6% MHM1C, 26.6% MHM2 and 6.8% MHM3 towards the end of the program and used for locked-cycle testing. The head assay results show that gold assay grades fluctuate from 0.1g/t to 0.4g/t and copper between 0.3% and 0.6% for the interval composites, as shown in

Table 4.1. Calculated head assays from all the flotation tests are also listed in Table 4.1.

The unused individual sample splits were collected and stored under nitrogen for further testing. In addition, waste samples were prepared for environmental testing according to client's consultant instructions. The external laboratory results, however, were sent to the client's consultant directly and will not be discussed in this report.

Table 4.1 Composites Head Assays

Composite		Mineral Type	Hole ID / Comp ID	Intervals m	Meas. Head		Calc. Head*	
					Au, g/t	Cu, %	Au, g/t	Cu, %
Individual Composites	MH1	1, BFP	MET 01	5.6 –93.8	0.26	0.48	0.28	0.47
	MH2	1, BFP	MET 02	7.9 –82.0	0.14	0.34	0.15	0.34
	MH3	1, BFP	MET 03	10.5 – 61.5	0.16	0.52	0.18	0.52
	MH4	1, BFP	MET 04	3.7 – 92.3	0.13	0.35	0.13	0.35
	MH5	1, BFP	MET 01	93.8 –194.7	0.21	0.62	0.22	0.62
	MH6	1, BFP	MET 02+04	115.7 – 181.2	0.22	0.43	0.17	0.43
	MH7	1, ZS	MET 02+03+04	2.7 – 81.8	0.13	0.35	0.11	0.36
	MH8	1, ZS	MET 01+04	107.0 –170.0	0.13	0.35	0.15	0.37
	MH9	2	MET 01+02+03	5.6 –80.0	0.21	0.51	0.25	0.52
	MH10	2	MET 01+04	92.3 – 128.6	0.39	0.60	0.40	0.61
	MH11	2	MET 02	101.0 – 252.5	0.19	0.42	0.24	0.43
	MH12	3	MET 01+02+04	68.6 – 256.0	0.17	0.40	0.20	0.41
	MH13	3	MET 03	20.2 – 97.5	0.14	0.44	0.16	0.47
Master Composites	MHM1A	1, BFP	MH 1 to 6	All	0.19	0.45	0.20	0.50
	MHM1B	1, ZS	MH 7 to 8	All	0.12	0.37	0.14	0.39
	MHM1C	1	MHM 1A +1B	All	0.18	0.45	0.18	0.46
	MHM2	2	MH 9 to11	All	0.21	0.43	0.26	0.50
	MHM3	3	MH 12 + 13	All	0.15	0.44	0.16	0.47
	MHM4	All	MHM 1C + 2 + 3	All	0.21	0.46	0.20	0.49

* Averaged calculated head from all the tests

4.2 Bond Work Index Results

A 10-12 cm length of core was collected from each 4-meter interval of each mineralization, for comminution testing, including Bond low-energy Impact, Bond rod-mill work index, Bond ball-mill work index and Bond abrasion tests. The detailed test reports are provided in Appendix III. Since the waste material was needed for environmental testing, the determination of grinding work index was avoided. Table 4.2 summarizes the results of the testing that simulated primary crushing, rod mill grinding to 14 mesh and ball mill grinding to 100 mesh. Comparison with the available databases indicated that the energy consumption for crushing and rod mill grinding for all of the samples tested were of medium hardness. The sample abrasiveness ranged from mildly abrasive to medium.

Table 4.2 Bond Work Indices

Sample ID	Mineral Type	Abrasion Index (g)	Impact Index (kWh/t)	Rod Mill Index (kWh/t)	Bond Mill Index (kWh/t)
OT1	1	0.3804	8.5	15.9	15.4
OT2	2	0.1262	6.7	12.6	17.0
OT3	3	0.2078	8.5	15.5	17.4
Waste	Waste	-	6.8	-	-
MHM1C	1	-	-	-	15.4
MHM2	2	-	-	-	15.9

Bond ball-mill work indices on the randomly picked core samples were between 15.4 and 17.4 kWh/tonne. Further tests were conducted on the master composites, MHM1C and MHM2. The results obtained were 15.4 and 15.9 kWh/t respetctively.

4.3 Primary Flotation Results

Exploratory primary flotation was conducted with 6 stages of roughing and 5g/t of Potassium Amyl Xanthate (PAX) collector added to all but the 1st stage. The duration of each flotation stage was about 5 minutes. Lime was added to the grind mill and in all rougher stages to maintain pH at 10, and Methyl Iso-Butyl Carbinol (MIBC) was used as frother to obtain a stable froth. Systematic testing was conducted on various main composites only.

Selected tailing samples were submitted for mineralogy as a diagnostic tool, and these findings will be discussed in a separate subsection.

4.3.1 Effect of Grind Size

4.3.1.1 Composite MHM1C

Tests F1 to F3 on Composite MHM1C, showed that the coarsest primary grind size of P80 of 203μm affected the final rougher concentrate grades and recoveries to some extent, as summarized in Table 4.3. At the coarsest grind, the final flotation tailing graded 0.04g/t Au and 0.06g/t Cu with recoveries of 80% Au and 88% Cu. Recoveries at the two finer grinds were comparable at 84.6% Au and around 90.5% Cu, with primary tailings grades of 0.03g/t Au and 0.05% Cu in both cases. The mass pull decreased with finer grinding.

Table 4.3 Rougher Concentrates at pH 10

Test ID	P_{80} μm	1st Ro. Grade Au, g/t	Cu, %	Total Ro. Grade Au, g/t	Cu, %	Total Ro. Recovery, % mass	Au	Cu
F1	203	4.8	20.4	1.60	4.36	9.3	80.5	88.2
F2	153	4.6	22.5	1.87	5.29	8.1	84.6	90.3
F3	105	4.5	22.5	1.92	5.64	7.9	84.6	90.7

The 1st rougher concentrate grades obtained without collector were high at >20% Cu with a recovery of more than 60% Cu. Although the grade-recovery curves indicate that finer grinding is beneficial, further tests were conducted at the intermediate size for the rougher-scavenger circuit with concerning grinding energy consumption.

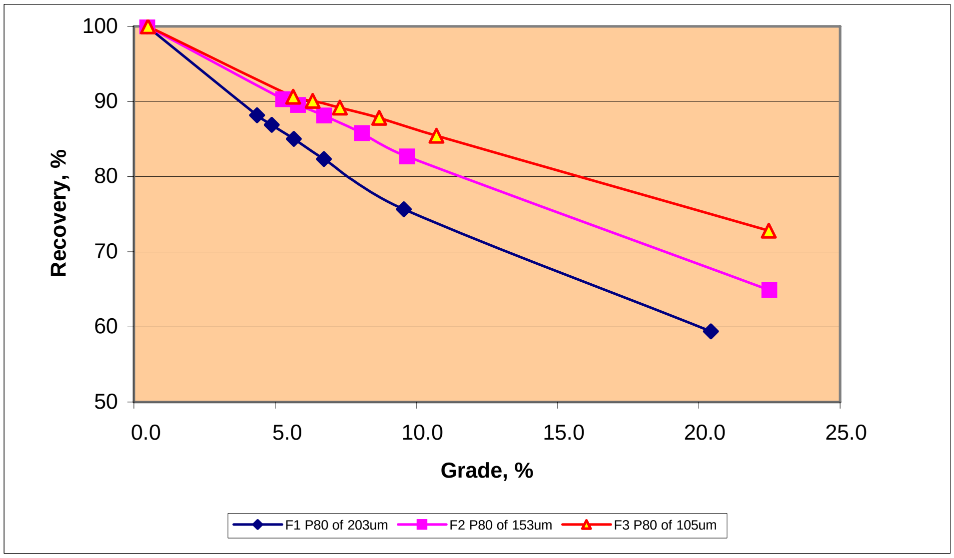


Figure 4.1 Effect of Grind on Copper Flotation for MHM1C

4.3.1.2 Composite MHM1A and MHM1B

Two different grind sizes were tested on Composites MHM1A and MHM1B to evaluate the effect of the lithological characteristic on the flotation. Table 4.4 indicates that gold and copper recoveries and grades improved slightly at the finer grind size. The difference in response was likely due to varying degrees of liberation, as the mass pulls dropped with finer grinding. The gold recovery dropped slightly even for the higher-grade MHM1A sample, compared to the MHM1C blend.

Table 4.4 Rougher Concentrates at pH 10 and various P_{80}

Test ID	Comp. ID	Grind Size P_{80}, µm	Head Grade Au g/t	Head Grade Cu %	Total Ro. Grade Au g/t	Total Ro. Grade Cu %	Ro. Recovery mass %	Ro. Recovery Au %	Ro. Recovery Cu %
F6	MHM1A	~150	0.19	0.50	1.53	4.37	10.3	81.5	91.0
F41	MHM1A	~100	0.21	0.50	2.29	6.24	7.5	82.3	93.6
F7	MHM1B	~150	0.13	0.38	1.18	3.73	9.0	79.7	88.1
F42	MHM1B	~100	0.14	0.39	1.40	4.51	7.9	79.9	90.6

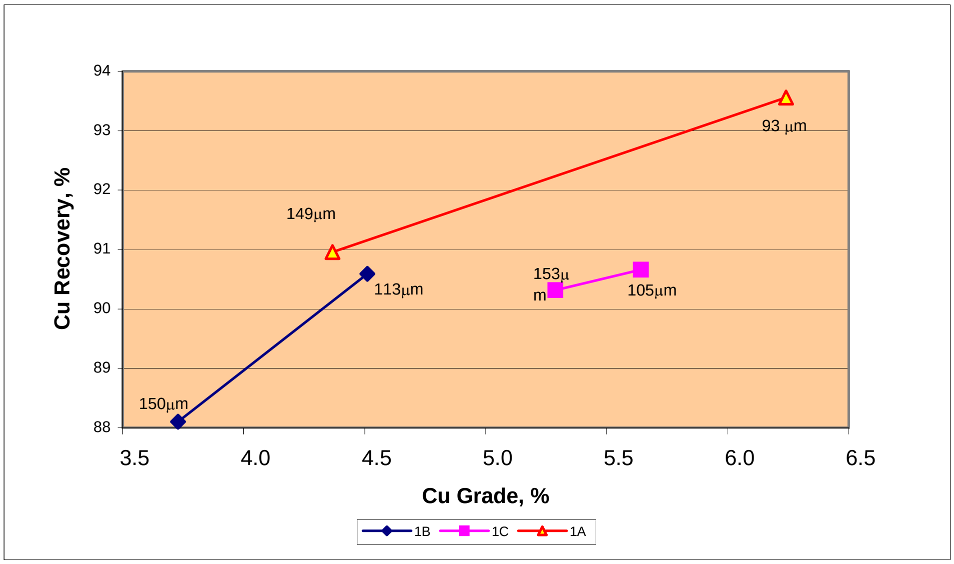


Figure 4.2 Copper Response vs. Grind, MHM1A, B and C

As shown in Figure 4.2, the copper recovery from these composites seem sensitive to the primary grind size. Both the rougher concentrate grades and recoveries increased with increasing grind fineness. Also, the copper recovery was positively related to head grade, as shown in Figure 4.3.

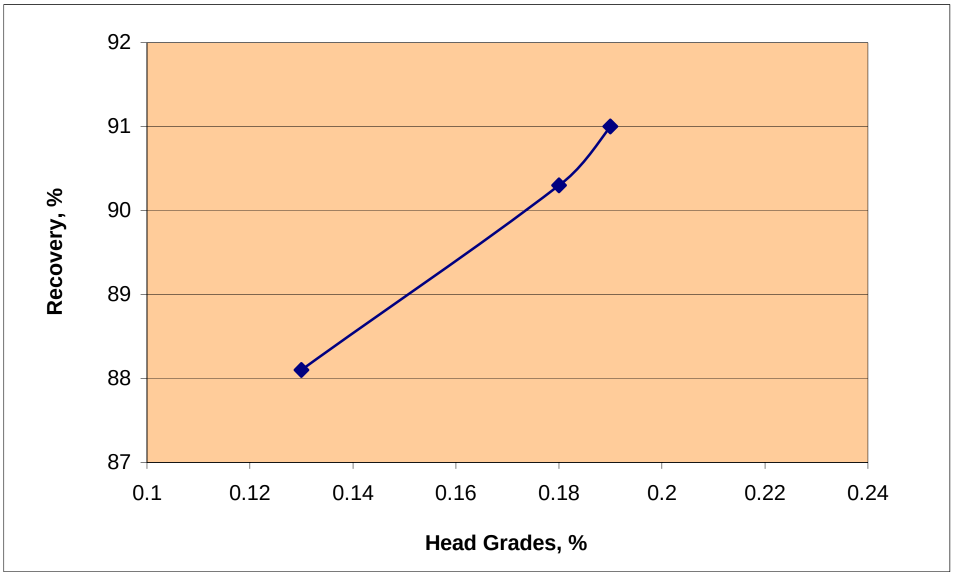


Figure 4.3 Copper Response vs. Head Grade, MHM1A, B and C

4.3.1.3 Composite MHM2 and MHM3

A similar series of tests was conducted on Composites MHM2 and MHM3 to confirm the response of different mineralization materials to the grind size. The results are shown in Table 4.5 and Figure 4.4. Composite MHM2 appears to be more grind-sensitive than Composite MHM1C. The copper recovery dropped from 90.3% to 83.3%. while the gold recovery from 84.6% to 71.7% with increasing particle size from P80 of 92μm to 148μm. The losses of Composite MHM2 were considerable with tailing grades of 0.07g/t Au and 0.09% Cu at the grind size of P80 of 148μm. The response of Composite MHM3 to the flotation regime was between Composites MHM1 and MHM2, and appeared to be less sensitive to the grind size change from around P80 of 100μm to 150μm.

Table 4.5 The Effect of Grind Sizes on Composite MHM2 and MHM3

Test ID	Grind Size, µm	Total Ro. Grade Au, g/t	Cu, %	Total Ro. Recovery, % mass	Au	Cu
F8-MHM2	148	1.10	2.79	13.9	71.7	83.3
F23-MHM2	113	1.70	3.48	12.1	70.0	88.1
F24-MHM2	92	1.67	3.61	13.1	80.8	91.6
F9-MHM3	150	1.16	4.28	9.3	79.9	86.2
F26-MHM3	102	1.56	5.64	7.7	72.4	85.5

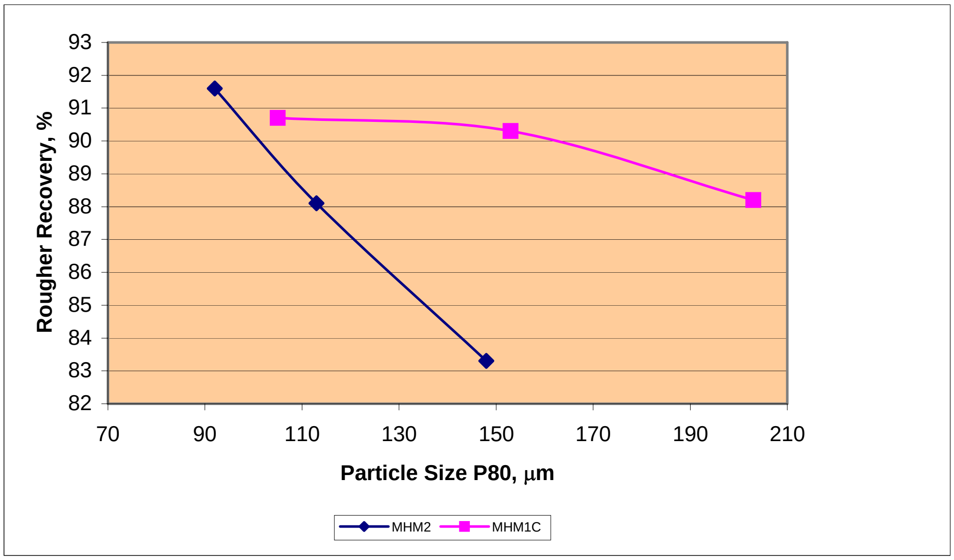


Figure 4.4 Copper Recovery vs. Grind Size, Composites MHM2 and 1C

4.3.2 Effect of Pulp pH

4.3.2.1 Effect of pH on Composite MHM1C

Lime addition was varied in one series of tests on Composite MHM1C to assess its impact on the rougher flotation. The test conditions were similar to Test F2 with only minor variations in stage retention or grind size. While slightly lower tailing grades of 0.04% Cu resulted in Tests F13 and F4, the tests did not show a significant effect of the pH on the flotation of the main value minerals, as shown in Table 4.6. The low mass pulls at higher pHs would indicate that the addition of lime benefited for the rejection of gangues, whereas the Au flotation was not depressed at pH10. Figures 4.5 and 4.6 show the effect of pH on the flotation kinetic curves.

Table 4.6 Rougher Concentrates at P_{80} ~150μm

Test ID	pH	Total Ro. Grade Au, g/t	Total Ro. Grade Cu, %	Total Ro. Recovery, % Mass	Total Ro. Recovery, % Au	Total Ro. Recovery, % Cu
F13	10.5	1.55	4.97	9.0	79.4	92.5
F2	10.0	1.87	5.29	8.1	84.6	90.3
F5	9.5	1.58	4.23	9.7	80.9	88.3
F4	8.7	1.33	3.89	10.9	80.3	92.3

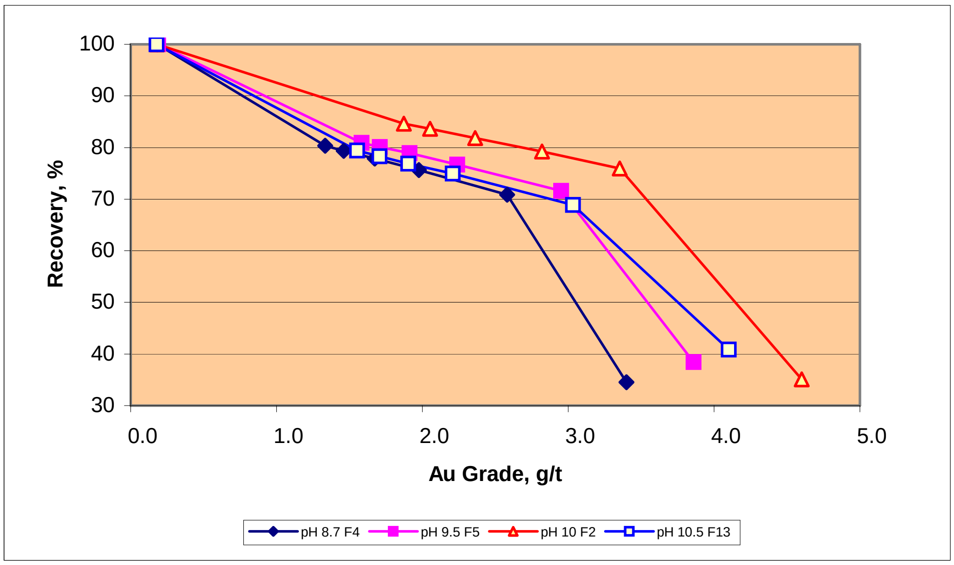


Figure 4.5 Effect of pH on Au Flotation for MHM1C

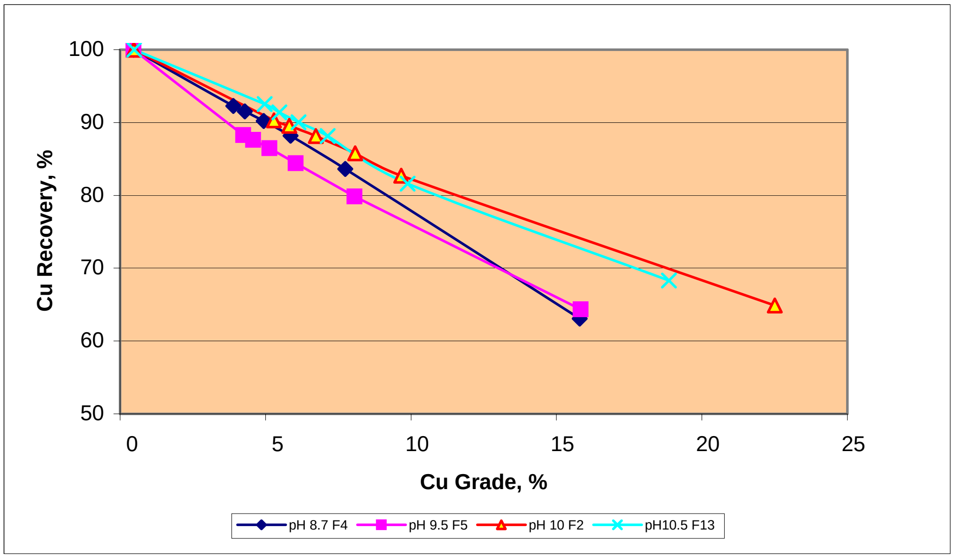


Figure 4.6 Effect of pH on Cu Flotation for MHM1C

4.3.2.2 Composite MHM2

Similar tests on Composite MHM2 were conducted at the natural pH and pH 10, but at a finer grind size of P_{80} approximately 115μm, to investigate the effect of pH on the flotation behavior of the copper minerals and gold bearing minerals. The test results, as given in the Appendix III and summarized in Table 4.7, indicated that the copper recovery dropped with the pH decreasing from 10 to 8.1. However, the copper grade of the total rougher concentrate increased from 3.48% to 4.11% Cu. Also, a significant increase in the gold recovery was noticed with reducing the pulp pH.

Table 4.7 Rougher Concentrates at Different pHs

Test ID	pH	Total Ro. Grade		Total Ro. Recovery, %		
		Au, g/t	Cu, %	Mass	Au	Cu
F23	10	1.70	3.48	12.1	70.0	88.1
F25	Natural pH, 8.1	2.41	4.11	10.9	80.8	84.8

4.3.3 Effect of Collectors

4.3.3.1 Composite MHM1C

The substitutions for PAX were made to investigate the selectivity for gold and copper recovery, using Sodium Ethyl Xanthate (SEX) and A3418 as promoter. The overall results, together with averaged results obtained by using PAX as collector from Tests F2 and F14 to F18, are summarized in Table 4.8 and Figure 4.7. The data indicate that these reagents are quite comparable for rougher flotation, but indications of higher selectivity of SEX for gold and copper minerals might bear further consideration for fine-tuning the cleaner performance. Also, the addition of A3418 promoter appears to slightly benefit for the copper flotation.

Table 4.8 Rougher Concentrates at P_{80} ~150μm and pH 10

Test ID	Reagent ID	1st Ro. Grade		Total Ro. Grade		Total Ro. Recovery, %		
		Au, g/t	Cu, %	Au, g/t	Cu, %	mass	Au	Cu
Ave.*	PAX			1.51	4.57	9.3	82.1	91.2
F10	SEX	4.25	18.4	2.23	5.90	6.6	79.7	87.4
F11	PAX+A3418	4.30	17.3	1.49	4.06	10.2	80.9	92.0
F12	SEX+A3418	3.90	16.7	1.84	4.77	8.6	85.2	91.8

* averaged datas obtained from Tests F2 and F14 to F18

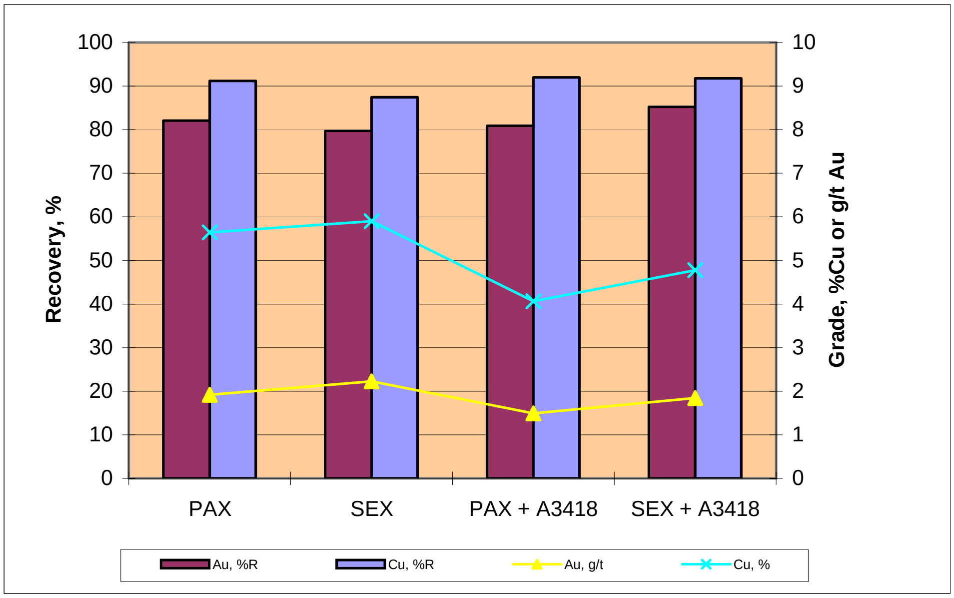


Figure 4.7 Effect of Collector Types on MHM1C

4.3.4 Composite MHM 2 and MHM 3

A similar series of tests was conducted on Composites MHM2 and MHM3 to confirm the similarity in response to the reagent combinations tested. The results, as listed in Table 4.9 and displayed in Figure 4.8, show an overall summary of the copper rougher flotation recovery for the three composites tested. PAX collector may performe slightly better than SEX collector. No matter which collector was used, the copper recoveries of Composite MHM2 were lower than the other two composites at P80 around 150μm. It should be noted (see Table 4.1), based on the calculated head from the test program, that the head grades of Composite MHM2 were slightly higher than Composites MHM1C and MHM3.

Table 4.9 Rougher Concentrates at various P_{80} and pH

Test ID	Reagent ID	Total Ro. Grade Au, g/t	Total Ro. Grade Cu, %	Total, % mass	Recovery Au	Recovery Cu
F8-MHM2	PAX	1.10	2.79	13.9	71.7	83.3
F19-MHM2	SEX	1.47	3.21	12.6	75.2	82.2
F20-MHM2	PAX+A3418	1.29	3.06	14.0	72.4	83.2
F9-MHM3	PAX	1.16	4.28	9.3	79.9	86.2
F21-MHM3	SEX	1.56	5.65	6.8	74.0	83.8
F22-MHM3	PAX+A3418	1.27	4.42	9.0	75.8	88.0

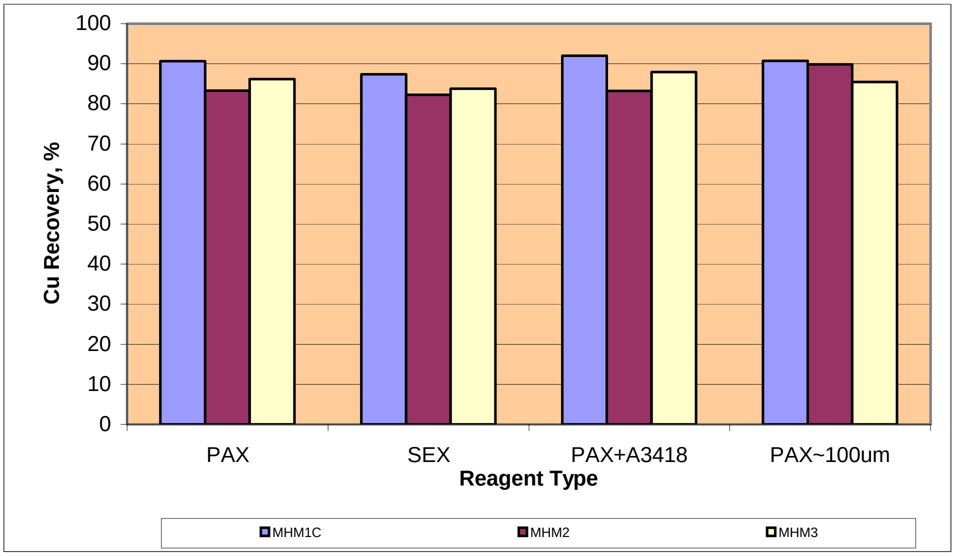


Figure 4.8 Summary of Collector Effect on Cu-Recovery

The results in Table 4.9 may suggest that the PAX + A3418 combination offers a slight advantage for copper-recovery over PAX or SEX alone.

4.3.5 Rougher Flotation Tailing Mineralogy

Differences in metallurgical behavior were investigated by optical microscopy on the tailings of Tests F2, F8 and F9, which were conducted with PAX alone on the three Master Composites MHM1C, MHM2 and MHM3, all at a primary grind of P_{80} ~150μm, respectively. The main conclusions were that despite a similar make up of gangue components, a noticeable difference degree of liberation confirmed the significantly increased Cu losses for the higher grade Composite MHM2 mainly. Sulfides (chalcopyrite and pyrite) are entirely in locked form as particles 5 – 150μm in size in the Composite MHM2 tailings, or 2 – 70 μm in the Composite MHM3 tailings. The sulfides are incorporated within larger silicate and/or carbonate fragments.

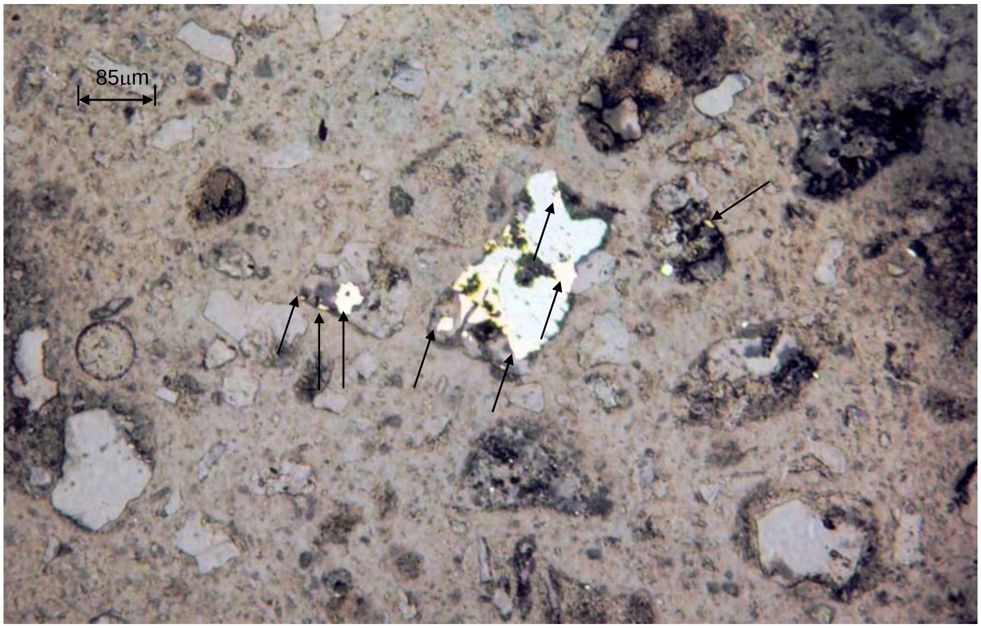


Figure 4.9 Unliberated Chalcopyrite and Pyrite in F8 Tailings

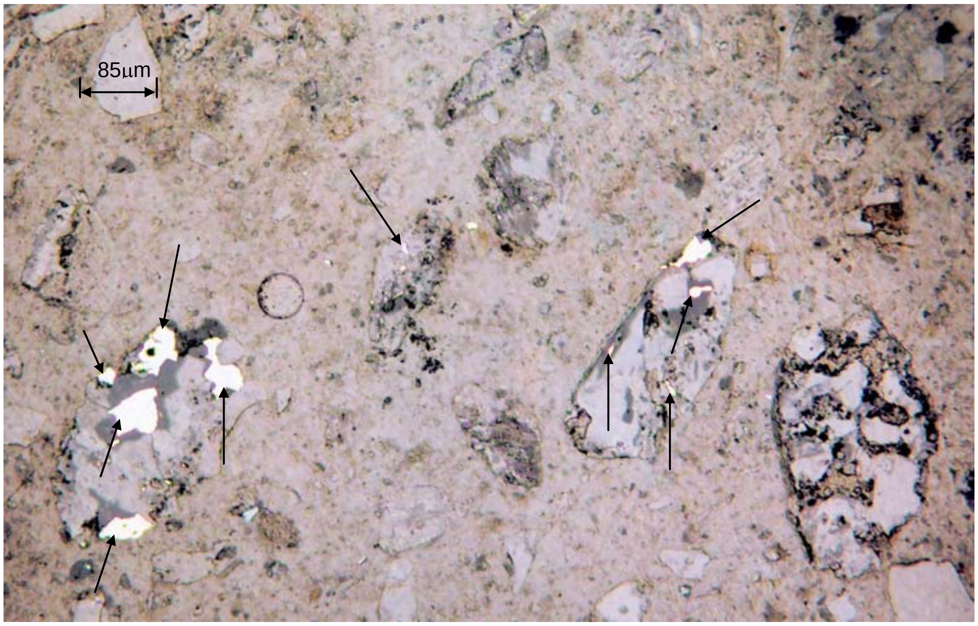


Figure 4.10 Unliberated Chalcopyrite and Pyrite in F8 Tailings

The micrograph of Test F8 tailing (Figures 4.9 and 4.10, Composite MHM2, 1cm = 85μm) shows the occasional locked chalcopyrite that could be further recovered with finer primary grinding. Further details and micrographs are provided in the Appendix V.

4.3.6 Variability Testing

Baseline flotation conditions of pH 10, PAX alone and at a target P_{80} of 150μm were applied on various interval composites, and the results are shown in Table 4.10 to yield average primary recoveries of 76.8% Au and 86.6% Cu. Figures 4.11 and 4.12 suggest that the copper response would be not related to the sample head grade, but to the mineralization type and also to grind size. The type 1 samples showed the best response to the flotation regime, while the type 2 samples had the worst performance. Also, The relationship between recovery and head grade, as displayed in Figure 4.13, shows that the gold recovery appears to be less sensitive to the head fluctuation.

Table 4.10 Rougher Concentrates at pH 10

Test ID	Mineral Type	P_{80} μm	Head Grade		Total Ro. Grade		Total Ro. Recovery, %		
			Au, g/t	Cu, %	Au, g/t	Cu, %	mass	Au	Cu
MH1	1, BFP	141	0.28	0.47	2.79	5.70	7.5	75.1	90.2
MH2	1, BFP	134	0.15	0.34	1.80	4.81	6.4	75.5	89.1
MH3	1, BFP	146	0.18	0.52	1.74	5.84	7.9	75.0	89.3
MH4	1, BFP	152	0.13	0.35	1.37	4.66	6.8	71.4	89.4
MH5	1, BFP	151	0.22	0.62	2.02	5.88	9.6	87.7	91.2
MH6	1, BFP	140	0.17	0.43	1.91	5.36	7.2	83.6	89.3
MH7	1, ZS	137	0.11	0.36	1.43	5.03	6.2	82.4	86.8
MH8	1, ZS	138	0.15	0.37	1.54	4.80	6.8	69.4	89.8
MH9	2	169	0.25	0.52	1.54	3.86	9.5	59.6	70.5
MH10	2	137	0.40	0.61	2.17	3.49	16.3	87.6	93.2
MH11	2	146	0.24	0.43	1.90	4.04	8.4	65.9	78.7
MH12	3	154	0.20	0.41	1.88	4.95	6.8	63.0	81.8
MH13	3	152	0.16	0.47	1.04	3.70	11.0	71.8	85.9
Avg.		**146**	**0.20**	**0.45**	**1.82**	**4.78**	**8.5**	**76.8**	**86.6**

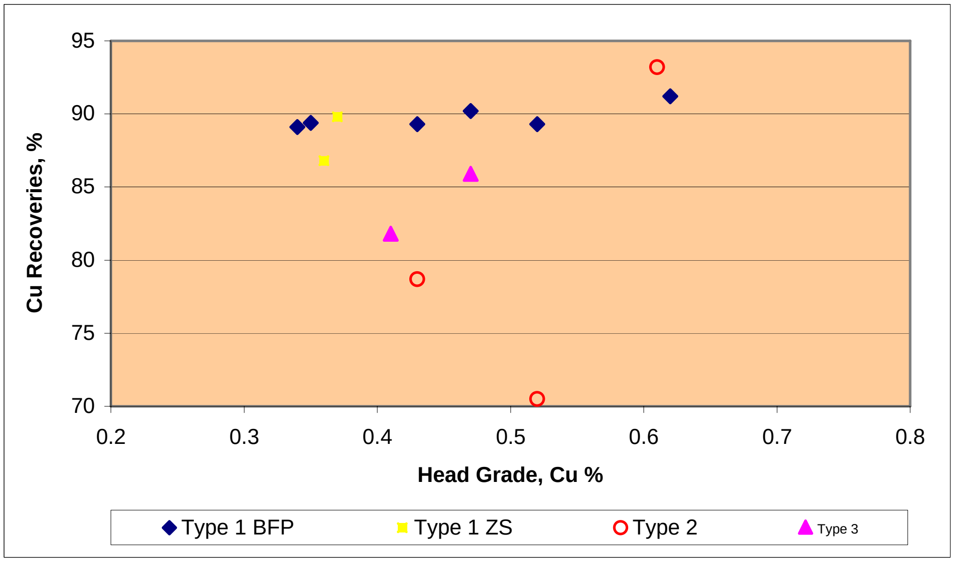


Figure 4.11 Copper Recovery vs Head Grade

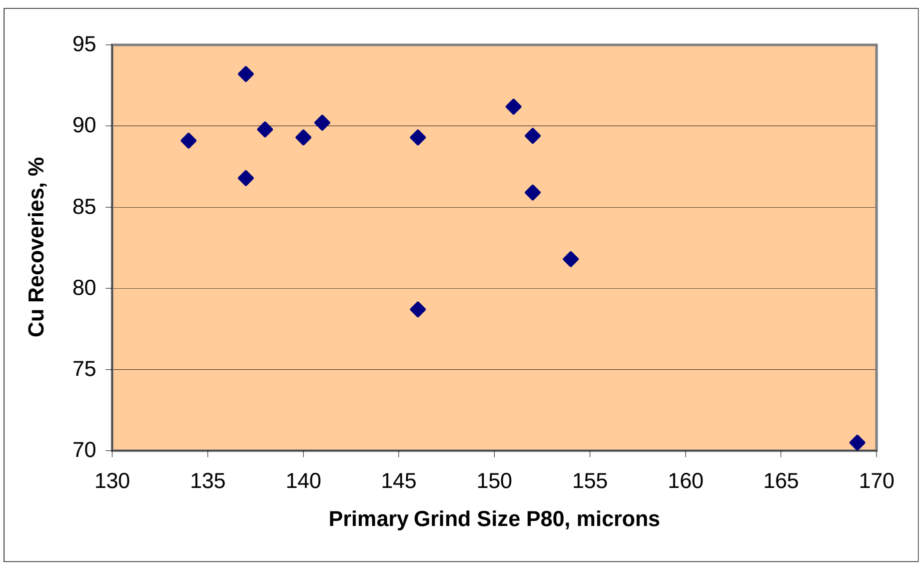


Figure 4.12 Copper Recovery vs Grind size

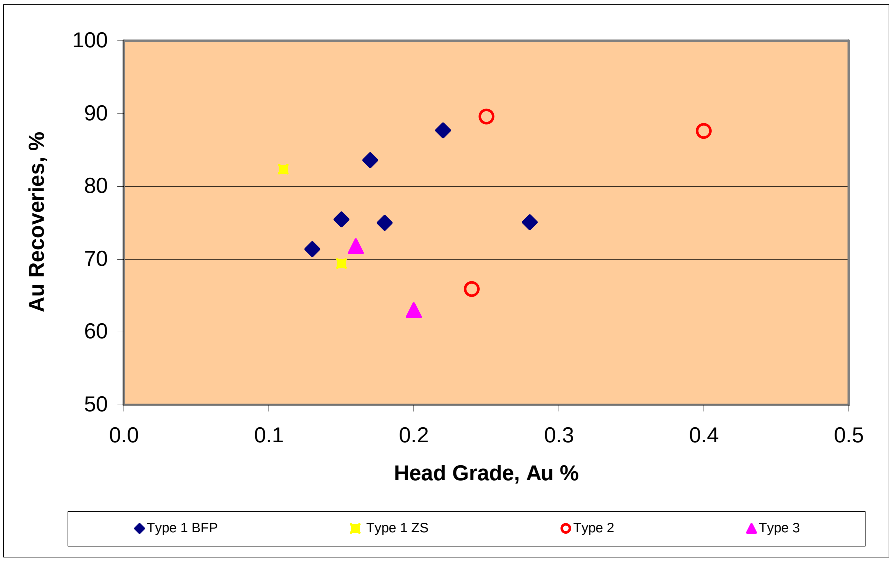


Figure 4.13 Gold Recovery vs Head Grade

4.4 Cleaner Flotation Tests

The effect of regrind time and pH were studied first on the MHM1C composite, using the baseline primary flotation conditions with PAX alone. In one subsequent test, the flotation with a combination of SEX and A3418 was studied as well. The results of these cleaner tests are summarized in Table 4.11 and Figure 4.14 below.

Table 4.11 Baseline Cleaner Tests on Composite MHM1C

Test ID	Regrind minutes	Cl. pH	Ro. Recovery		4th Cl. Grade		4th Cleaner Recovery		
			Au, %	Cu, %	Au, g/t	Cu, %	Mass, %	Au, %	Cu, %
F14	4	11	77.8	90.2	5.80	21.9	1.6	57.8	77.3
F15	10	11	78.8	92.2	6.80	26.1	1.4	56.0	79.5
F16	17	11	74.8	91.6	7.94	32.8	1.2	51.9	79.9
F17	10	11.5	94.4	91.9	8.15	26.6	1.4	69.3	81.6
F18	10	12.0	80.8	91.8	8.32	29.7	1.2	52.7	79.9
F27*	10	11.5	72.0	87.8	7.58	27.1	1.3	50.7	79.0

*Test 27 with SEX + A3418 as collectors, to be compared to Test F17 with PAX as collector

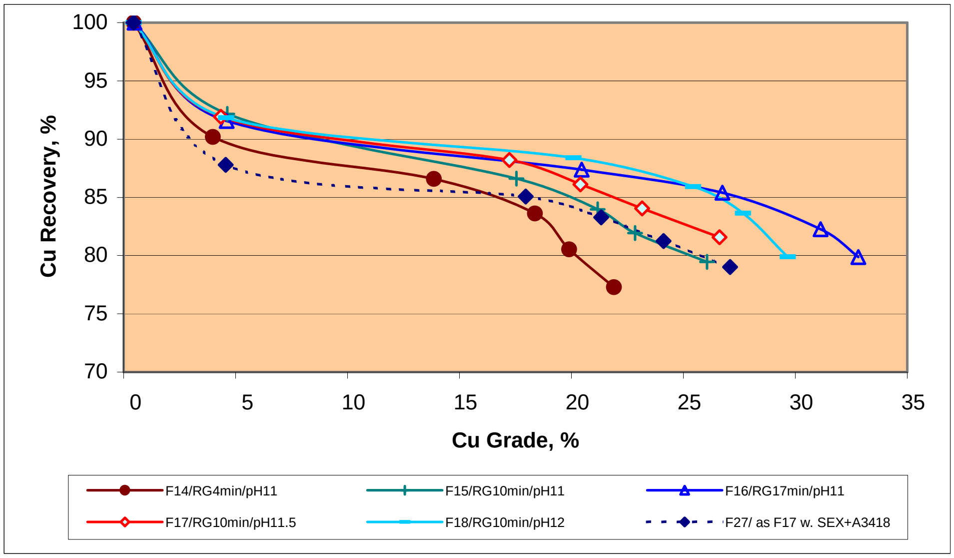


Figure 4.14 Summary of Cleaner Tests on MHM1C

It seems that the copper content of the final concentrate increased with an increase in the regrind time. A moderate regrinding is needed to yield a concentrate grading 26% Cu at pH 11. Copper recovery also increased slightly at finer regrinds. This might reflect mineralogical characteristics that the copper minerals associate closely with pyrite as shown in Figure 4.9. The copper grade of the 4th cleaner concentrate improved when the cleaner flotation was performed at a higher pH. It seems to be pointed out from the results that the gold recovery decreased with improving copper quality. This might imply that some of the gold is closely associated with pyrite.

Substituting SEX and A3418 for PAX did slightly improve the copper grade of the cleaner concentrate. However, a decrease in copper and gold recoveries are also noticed. This could be caused by poor performance in the rougher flotation due to operation, or assay inconsistency because of the tailings grades close to assay limits. The 0.06g/t Au and 0.06% Cu contents of the rougher flotation tailings in Test F27, however, were higher than the corresponding primary flotation (Test F12).

Table 4.12 Regrind Cleaner Tests on Composites MHM2 and MHM3

Test ID	Comp. ID	Cl. pH	Ro. Recovery		5th Cl. Grade		5th Cleaner Recovery, %		
			Au, %	Cu, %	Au, g/t	Cu, %	mass, %	Au, %	Cu, %
F44	MHM2	12	70.2	80.1	7.20	31.8	0.9	27.7	59.3
F45	MHM3	12	74.2	88.1	6.40	32.5	0.9	32.2	62.8

Comparative cleaner tests on Composites MHM2 and MHM3 at P_{80} ~150μm, ran with an extended (14 minute) regrind and at pH 12. The results shown in Table 4.12 confirm that the 4th cleaner concentrate may reach ~31% Cu for the two type materials, Further cleaning resulted in a slight improvement in the copper grades of the 5th cleaner product to ~32% Cu. Compared with Composite MHM1C, the cleaner efficiencies of the two composites were lower for both copper and gold. It could be concluded that a fine regrind and high cleaner pH appear beneficial for the grade.

4.5 Locked Cycle Testing

Three different closed-flowsheets were tested on the master composites to evaluate the impact of middling streams on the concentrate grades and recoveries of the main values, copper and gold. The results are summarized and discussed as followed based on the composites and the averaged last three cycle balance, and the detailed data are attached in the Appendix IV.

4.5.1 Locked Cycle Flotation on Composite MHM1C

The first locked-cycle flotation, Test F43, was conducted at P_{80} ~150μm as a baseline on the Composite MHM1C. Lime, PAX and MIBC were used throughout and after 5 stages of roughing at pH 10, the two scavenger concentrates were combined with the feed for the primary grind in the next cycle. The combined rougher concentrates were reground for 17 minutes using mild steel balls, and cleaning started with a first stage at pH 11.5 and recycling the 1st cleaner scavenger tailings to the next primary grind as well. Then two further stages of cleaning at pH 12 were followed. The one-tailing procedure, as showed in Figure

4.15, produced a 3rd Cleaner Concentrate grading 6.9g/t Au and 23.6% Cu, based on the average over the last 3 cycles. The corresponding gold and copper recoveries were 67.2% and 89.5%, respectively, with primary tailings at 0.06g/t Au and 0.05% Cu. Gold had a much higher recycling load at 113% in the recycling streams, compared to copper at 41%.

As noted in Test F43, the copper grade of the 3rd cleaner concentrate was low at 23.6% Cu and the pyrite might recycle as the middlings, which might reflect from a high mass recycling burden at the first cleaner stage.

A further test, Test F46, was conducted based on the Test F43 flowsheet, but with a 14 minute regrind time, the discharge of the 1st cleaner scavenger tailings and 4 stages of cleaning. The two-tailings flowsheet is displayed in Figure 4.16. As a result, the product grade increased to 8.2g/t Au and 26.4% Cu in 1.4% of

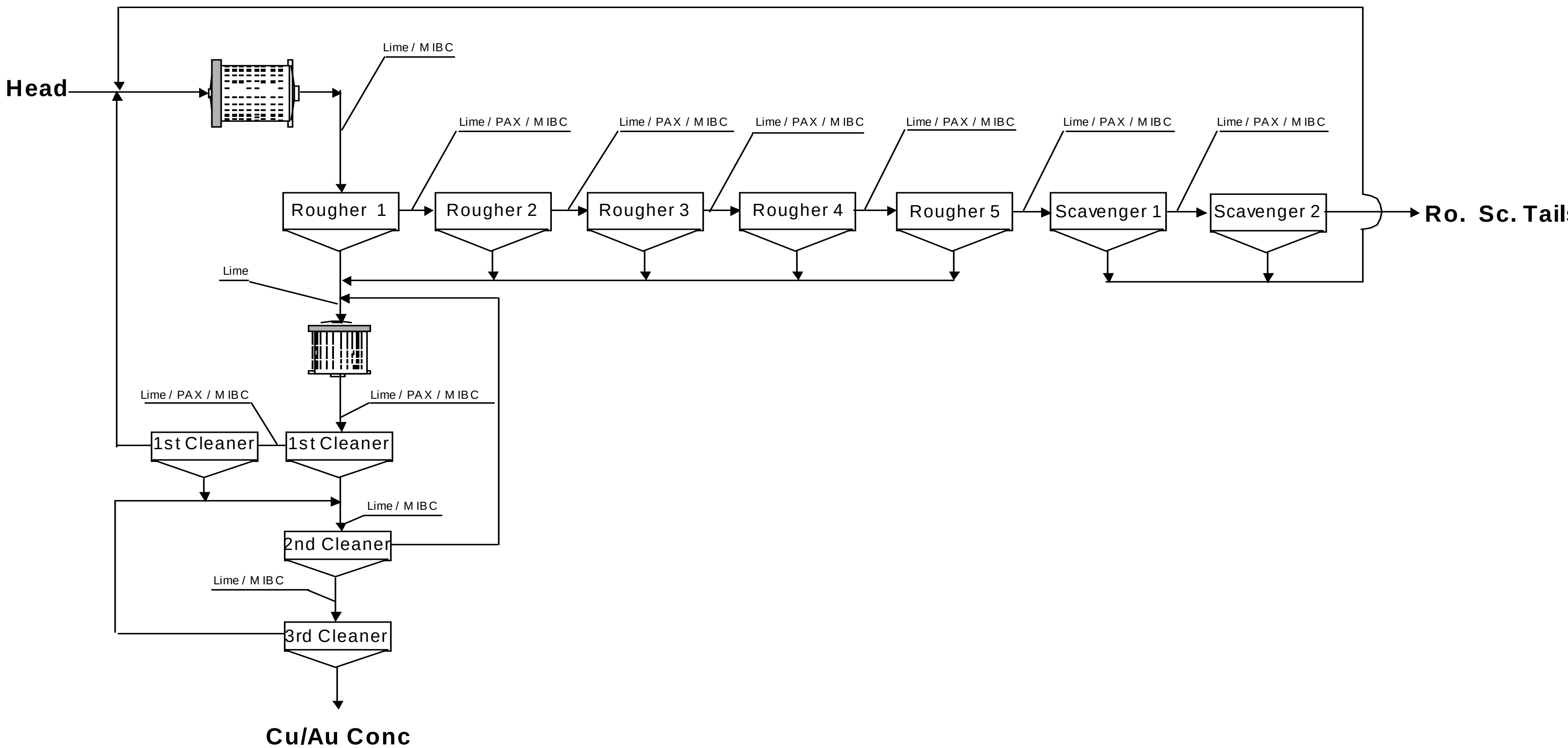


Figure 4.15 One Tailings Rejection Flowsheet

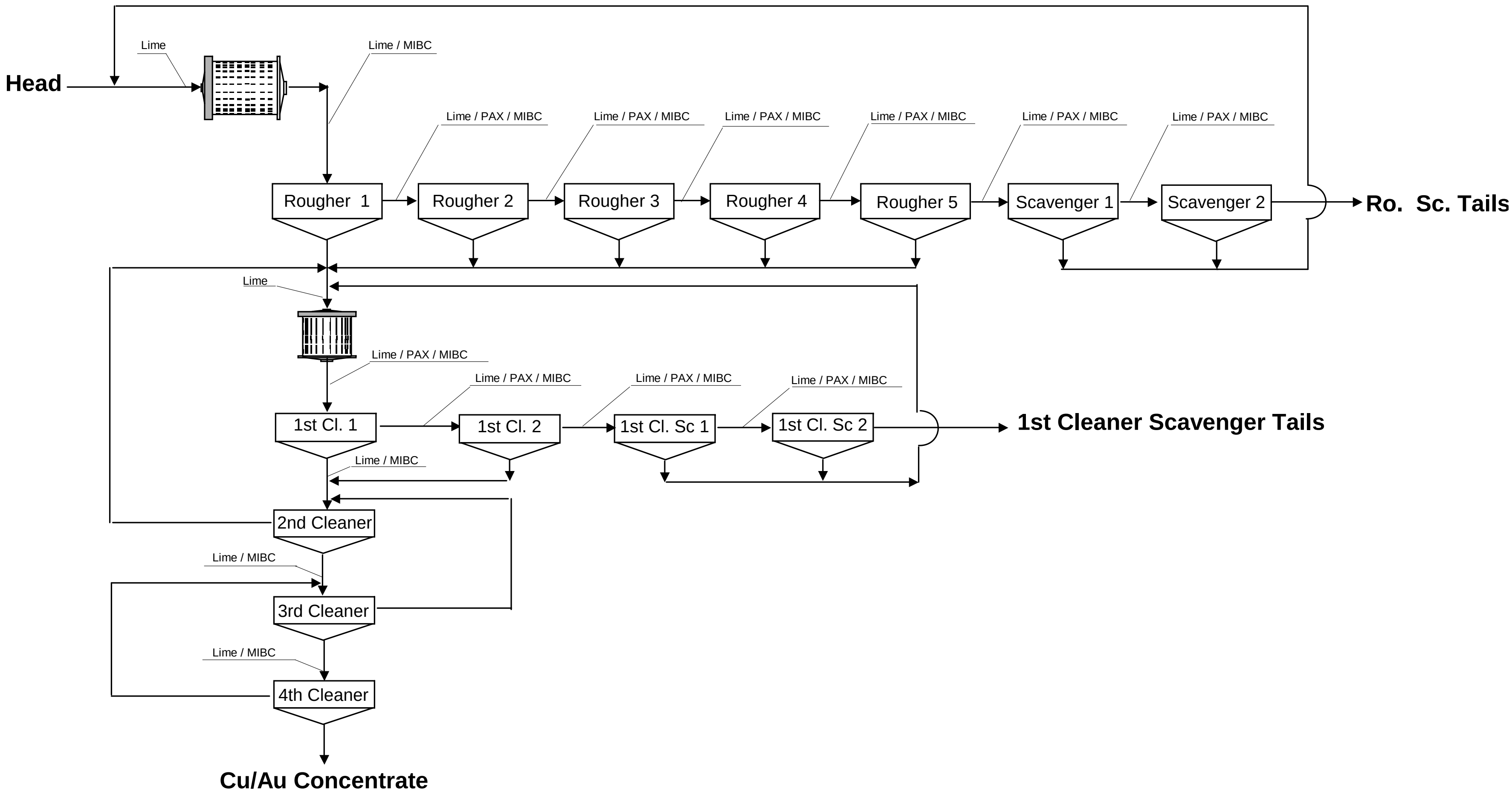


Figure 4.16 Two Tailings Rejection Flowsheet

the mass pull, with recoveries of 71.3% Au and 86.2% Cu on the average of the last three cycles. Table 4.13 gives a brief comparison of the two tests on Composite MHM1C, with further details in the Appendix V.

Table 4.13 Locked Cycle Tests on Composite MHM1C

Product	Test F43					Test F46				
	Grades		Recoveries, %			Grades		F46 Recoveries, %		
	Au, g/t	Cu, %	mass	Au	Cu	Au, g/t	Cu, %	mass	Au	Cu
Cl. Conc.	6.86	23.6	1.7	67.2	89.5	8.16	26.4	1.4	71.3	86.2
1st Cl. Sc. Tails	-	-	-	-	-	0.16	0.15	12.6	12.5	4.4
Ro.Sc.Tails	0.06	0.05	98.3	32.8	10.5	0.03	0.05	86.0	16.2	9.4
Calc.Head	0.17	0.44	100.0	100.0	100.0	0.18	0.43	100.0	100.0	100.0
Recycle Σ	0.49	0.45	39.7	113.0	40.7	1.61	1.8	9.4	95.4	41.6
Grind Size	Primary Grind: P_{80} 150µm; Regrind: P_{90} 28µm					Primary Grind: P_{80} 155µm; Regrind: P_{90} 29µm				

The revised procedure clearly reduced the total recycle burden, as judged from the last three cycles, from 39.7% of the mass in Test F43 to 9.4 % of the mass in Test F46. 11.2% of the mass was discharged at the 1st cleaner stage, into 1st cleaner scavenger tailings. Together with the fourth cleaner, the process improved the copper concentrate grade, but reduced the Cu recovery by 3.3% to 86.2% Cu. A slight increase in gold recovery might be caused by assay fluctuation due to the gold levels in the tailings were very close to the assay limits.

4.5.2 Locked Cycle Flotation on Composite MHM2

Test F47 was conducted on the Composite MHM2, using a procedure similar to Test F46 as shown in Figure 4.16. Table 4.14 shows the results for this more challenging material.

Table 4.14 Locked Cycle Tests on Composite MHM2

Product	Test F47					Test F49				
	Grades		Recoveries, %			Grades		Recoveries, %		
	Au, g/t	Cu, %	mass	Au	Cu	Au, g/t	Cu, %	mass	Au	Cu
Cl. Conc.	7.30	26.1	1.5	43.7	80.6	6.78	22.3	1.7	49.7	81.7
1st Cl. Sc. Tails	0.52	0.11	17.5	35.3	3.7	0.39	0.11	16.9	27.4	4.1
Ro. S. Tails	0.07	0.10	81.0	21.0	15.6	0.07	0.08	81.4	22.9	14.3
Calc. Head	0.26	0.50	100.0	100.0	100.0	0.24	0.47	100.0	100.0	100.0
Recycle Σ	1.42	2.04	11.4	62.7	46.3	1.30	1.27	14.9	81.5	39.9
Grind Size	Primary Grind: P_{80} 167μm; Regrind: P_{85} 25μm					Primary Grind: P_{80} 117μm; Regrind: P_{87} 25μm				

The test confirms that the composite did not respond well to the flotation procedure as noted in the open cycle tests. The copper and gold recoveries were low at 80.6% and 43.7% respectively, based on the average over the last 3 cycles. The copper of 15.6% reported to the primary tailings grading at 0.1% Cu. As shown by size-assay anaylysis which will be discussed in the subsequent section, some of copper would be locked within the host gangue minerals. For gold, the main loss occurred in the 1st cleaner scavenger tailings, which reflects that the gold in the type sample has much closer relationship with pyrite in comparison with the type 1 sample. Also, it is noticed that the mass distribution of the 1st cleaner scavenger tailings increased substantially to 17.5%, as compared to 11.2% for Composite MHM1C.

Test F49 repeated the same procedure at a finer primary grind size of P_{80} ~120μm followed by a shorter regrind of 11.5 minutes. The finer primary grind in Test F49 improved the overall recoveries to 49.7% Au and 81.7% Cu. The copper content of the rougher scavenger tailings significantly decreased from 0.1% at a primary grind of P80 167μm to 0.08% at the fine primary grind. However, the copper grade of the concentrate decreased to a much lower level at 22.3% Cu, as compared to 26.1% Cu in Test F44.

4.5.3 Locked Cycle Flotation on Composite MHM3

Test F48 on Composite MHM3 at P_{80} ~145μm confirmed that this mineralization type material is intermediate in behavior between Composites MHM1C and

MHM2. Thus, the flotation procedure of Tests F46 and F47 yielded a 4th Cleaner Concentrate grade of 5.6g/t Au and 27.5% Cu in 1.4% of the mass, with recoveries of 58.3% Au and 85.0% Cu.

Table 4.15 Cleaner Flotation Tests on Composite MHM3

Product	Grades		Recoveries, %		
	Au, g/t	Cu, %	mass	Au	Cu
Cl. Conc.	5.61	27.5	1.4	58.3	85.0
1st Cl.Sc. Tails	0.18	0.16	12.4	16.4	4.4
Ro.Sc.Tails	0.04	0.06	86.2	25.3	10.7
Calc. Head	0.14	0.46	100.0	100.0	100.0
Recycle Σ	1.35	2.26	10.7	106.6	53.0
Grind Size	Primary Grind: P_{80} 145μm; Regrind: P_{89} 25μm				

4.5.4 Locked Cycle Flotation on Composite MHM4

A combined composite MHM4 was blended from 66.6% type 1 sample, 26.6% type 2 sample and 6.8% type 3 sample, as per client's consultant instructions for further investigations. The procedure for Tests F51 was essentially identical to the two-tailing one used in Tests F46 to F48, as shown in Figure 4.16. Table 4.16, shows that approximately 84% of the copper and 55% of the gold were recovered into the 4th cleaner concentrate grading at 27.8% Cu and 7.8g/t Au. 11.6% of the copper reported to the primary tailings, while 28% of the gold lost into the 1st cleaner scavenger tailings. The results obtained from the blended sample matched very well to the data calculated Tests F46 to F48 based on the blending ratio.

Table 4.16 Cleaner Flotation Tests on Composite MHM4 - Test F51

Product	Grades		Recoveries, %		
	Au, g/t	Cu, %	mass	Au	Cu
Cl. Conc.	7.77	27.8	1.4	54.7	83.8
1st Cl. Sc. Tails	0.41	0.16	13.5	28.0	4.6
Ro. Sc. Tails	0.04	0.06	85.1	17.2	11.6
Calc. Head	0.20	0.46	100.0	100.0	100.0
Recycle Σ	1.35	2.26	10.5	58.1	51.5
Grind Size	Primary Grind: P_{80} 156μm; Regrind: P_{89} 25μm				

In Test F52, the procedure used was similar to Test F51, but the regrind time was shorten from 14.5 to 7.5 minutes to investigate the sample response to a coarser regrind. The test generated encouraging results as summarized in Table 4. 17. Based on the last three cycles, the improved procedure yielded recoveries of approximately 86% Cu and 60% Au. Although decreasing about 1.8%, the copper grade of the concentrate still stayed at a high level of 26% Cu. The substantial improvement in the gold recovery might result from the procedure collecting more gold bearing pyrite into the copper concentrate, A significant increase in gold recycling in the middling streams could support the implication. The optimum concentrate grade should be evaluated based on the economical point of view.

Table 4.17 Cleaner Flotation Tests on Composite MHM4 - Test F52

Product	Grades		Recoveries, %		
	Au, g/t	Cu, %	mass	Au	Cu
Cl. Conc.	6.80	26.0	1.6	59.7	85.7
1st Cl. Sc. Tails	0.27	0.16	13.5	21.1	4.7
Ro. Sc. Tails	0.04	0.05	84.9	19.2	9.6
Calc. Head	0.18	0.47	100.0	100.0	100.0
Recycle Σ	1.89	2.43	11.0	118.0	56.7
Grind Size	Primary Grind: P_{80} 149μm; Regrind: P_{80} 27μm				

Test F50 was run at P_{80} ~145μm with a 7-minute regrind, but the 1st rougher concentrate was directed to the 2nd cleaner stage as produced. The flowsheet, as shown in Figure 4.17, was tested in an attempt to simulate a potential application

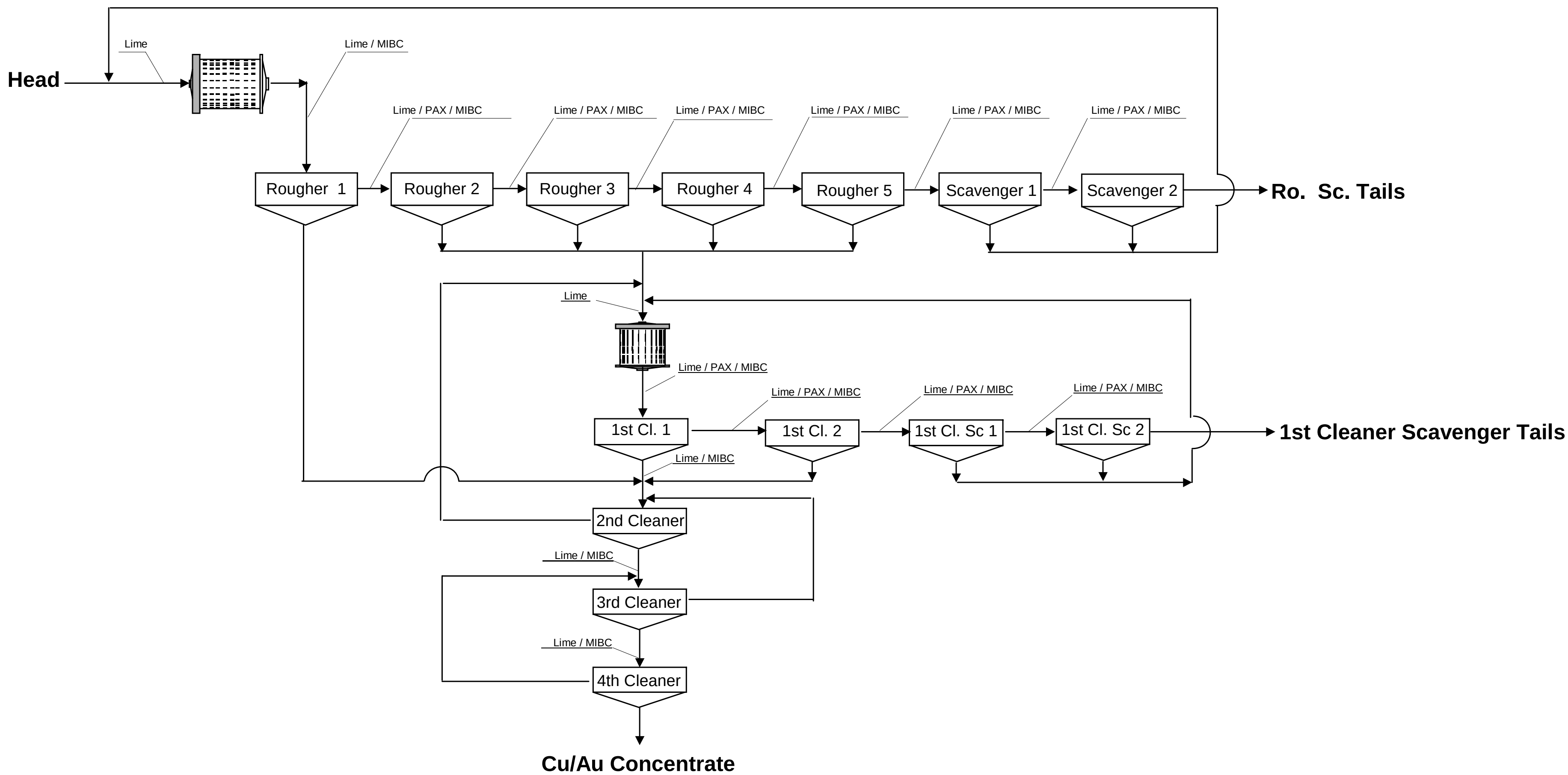


Figure 4.17 Two Tailings Flowsheet with Directing Rougher Concentrate 1 to 2nd Cleaner Flotation

of flash flotation by which overgrinding the liberated copper minerals could be avoided. The test results indicated, as summarized in Table 4.18 that the copper and gold recoveries yielded from the procedure were 84.3% and 58.1% respectively, higher than Test F51, but slightly lower than Test F52. The copper content of the 4th cleaner concentrate was low, only at 21.2%. This might suggest that further optimization should be addressed if the flowsheet should be applied to potential industrial operations.

Table 4.18 Cleaner Flotation Tests on Composite MHM4 - Test F50

Product	Grades		Recoveries, %		
	Au, g/t	Cu, %	mass	Au	Cu
Cl. Conc.	6.70	21.2	1.7	58.1	84.3
1st Cl. Sc. Tails	0.30	0.11	17.6	25.9	4.6
Ro. Sc. Tails	0.04	0.06	80.6	16.0	11.0
Calc. Head	0.20	0.44	100.0	100.0	100.0
Recycle Σ	1.55	2.14	12.7	98.4	62.3
Grind Size	Primary Grind: P_{80} 151μm; Regrind: P_{80} 25μm				

4.5.5 Product Assay and Discussion

4.5.5.1 Flotation Concentrates

The flotation concentrates generated from the locked cycle tests were subjected to multi-elements assay. The results, as summarized in Table 4.19 and detailed in the Appendix V, show that the levels of main penalty elements are low. Apart from copper and gold, the other value in the concentrates was silver. For the MHM4 composite, the grade was approximately 100g/t Ag.

Table 4.19 Chemical Assay on Flotation Concentrates

Test ID	Au g/t	Ag g/t	Pt g/t	Pd g/t	As ppm	Hg ppm	Mo ppm	Sb ppm	Pb ppm	Zn ppm
F46	7.60	66.3	0.02	0.02	<5	<3	1197	<5	66	3493
F47	6.32	248.2	<0.01	<0.01	296	<3	279	302	7444	26042
F48	5.60	100.9	0.01	0.03	143	<3	1345	<5	305	8231
F51	7.76	107.5	<0.01	<0.01	49	<3	828	65	2208	10144
F52	7.29	95.0	<0.01	0.08	118	<3	1233	61	1676	7505

4.5.5.2 Rougher Scavenger Tailings and 1st Cleaner Scavenger Tailings

The chemical analyses, ICP, Hg, S(T) and S(-2), and ABA analysis were conducted on the two flotation tailings: rougher flotation tailings and 1st cleaner flotation tailings. The sulfur and Hg assay results are summarized in Table 4.20 and the other assays are attached in the Appendix V.

Table 4.20 Sulfur Assay on Flotation Tailings

Test ID	Rougher Tailings			1st Cleaner Tailings		
	S(-2), %	S(T), %	Hg, ppm	S(-2), %	S(T), %	Hg, ppm
F46	0.06	0.10	<0.3	0.84	0.95	<0.3
F47	0.28	0.33	<0.3	8.29	8.42	<0.3
F48	0.13	0.16	<0.3	1.46	1.56	<0.3
F51	0.10	0.14	<0.3	5.07	5.20	<0.3
F52	0.05	0.09	<0.3	2.87	2.97	<0.3

In this test program, the bulk rougher scavenger tailings were also subjected to size-assay analysis to determine the main value distribution in various size fractions. The results as shown in Tables 4.21 to 4.24, indicate that major gold and copper losses occur in coarse fractions, especially in the coarser than 100 mesh fractions. For the type 2 sample, about 52% of the copper reports to the coarse sizes. This could suggest that a finer grind would benefit further improvement for copper and gold recovery. Once again, the assay data confirm the refractory properties of the type 2 material because the copper contents in various size fractions are higher than in the other types of the materials.

Table 4.21 Size-Assay Analysis on Rougher Scavenger Tailings –Test F46, MHM1C

Size Fraction		Weight	Assay				Distribution			
Mesh	**Microns**	**%**	**Au, g/t**	**Cu, %**	**Fe, %**	**S(-2), %**	**Au, %**	**Cu, %**	**Fe, %**	**S(-2), %**
+ 65	+210	6.5	0.20	0.09	2.34	0.11	26.0	12.9	5.5	13.3
- 65 + 100	-210+149	14.8	0.05	0.08	2.08	0.08	14.8	26.0	11.0	22.0
- 100 + 150	-149+105	15.9	0.05	0.06	2.10	0.07	16.0	21.1	12.0	20.8
- 150 + 200	-105+74	10.2	0.04	0.04	2.23	0.06	8.1	9.0	8.1	11.3
-200 + 400	-74+37	17.0	0.04	0.02	2.79	0.04	13.7	7.5	17.1	12.7
-400	-37	35.6	0.03	0.03	3.61	0.03	21.4	23.6	46.3	19.9
Calculated		**100.0**	**0.05**	**0.05**	**2.78**	**0.05**	**100.0**	**100.0**	**100.0**	**100.0**
Measured			0.03	0.05	3.19	0.06				

Table 4.22 Size-Assay Analysis on Rougher Scavenger Tailings –Test F47, MHM2

Size Fraction		Weight	Assay				Distribution			
Mesh	**Microns**	**%**	**Au, g/t**	**Cu, %**	**Fe, %**	**S(-2), %**	**Au, %**	**Cu, %**	**Fe, %**	**S(-2), %**
+ 65	+210	9.4	0.20	0.23	4.70	0.69	27.9	23.4	9.2	22.8
- 65 + 100	-210+149	16.2	0.11	0.16	4.40	0.52	26.5	28.2	14.9	29.6
- 100 + 150	-149+105	15.4	0.07	0.10	4.23	0.35	16.1	16.8	13.6	19.0
- 150 + 200	-105+74	9.3	0.04	0.06	4.57	0.22	5.5	6.1	8.9	7.2
-200 + 400	-74+37	13.3	0.04	0.04	4.85	0.13	7.9	5.8	13.5	6.1
-400	-37	36.3	0.03	0.05	5.29	0.12	16.2	19.7	40.0	15.3
Calculated		**100.0**	**0.07**	**0.09**	**4.80**	**0.28**	**100.0**	**100.0**	**100.0**	**100.0**
Measured			0.07	0.10	5.43	0.28				

Table 4.23 Size-Assay Analysis on Rougher Scavenger Tailings –Test F48, MHM3

Size Fraction		Weight	Assay				Distribution			
Mesh	**Microns**	**%**	**Au, g/t**	**Cu, %**	**Fe, %**	**S(-2), %**	**Au, %**	**Cu, %**	**Fe, %**	**S(-2), %**
+ 65	+210	5.4	0.06	0.14	2.51	0.29	7.4	11.8	4.8	11.3
- 65 + 100	-210+149	13.5	0.08	0.11	2.39	0.23	24.3	22.9	11.2	22.2
- 100 + 150	-149+105	15.9	0.05	0.08	2.24	0.17	18.0	19.7	12.4	19.4
- 150 + 200	-105+74	11.6	0.04	0.05	2.19	0.12	10.5	9.0	8.8	10.0
-200 + 400	-74+37	16.1	0.04	0.03	2.33	0.09	14.5	7.5	13.0	10.4
-400	-37	37.5	0.03	0.05	3.81	0.10	25.4	29.1	49.8	26.8
Calculated		**100.0**	**0.04**	**0.06**	**2.87**	**0.14**	**100.0**	**100.0**	**100.0**	**100.0**
Measured			0.04	0.06	3.44	0.13				

Table 4.24 Size-Assay Analysis on Rougher Scavenger Tailings –Test F51, MHM4

Size Fraction		Weight	Assay				Distribution			
Mesh	Microns	%	Au, g/t	Cu, %	Fe, %	S(-2), %	Au, %	Cu, %	Fe, %	S(-2), %
+ 65	+210	6.0	0.08	0.10	2.82	0.18	9.0	11.3	5.2	11.7
- 65 + 100	-210+149	14.2	0.06	0.08	2.58	0.14	16.0	21.4	11.2	21.5
- 100 + 150	-149+105	15.2	0.05	0.07	2.54	0.12	14.3	20.0	11.9	19.8
- 150 + 200	-105+74	9.5	0.05	0.05	2.67	0.11	9.0	9.0	7.8	11.3
-200 + 400	-74+37	15.6	0.05	0.03	2.99	0.06	14.7	8.8	14.3	10.1
-400	-37	39.4	0.05	0.04	4.12	0.06	37.0	29.6	49.7	25.6
Calculated		**100.0**	**0.05**	**0.05**	**3.27**	**0.09**	**100.0**	**100.0**	**100.0**	**100.0**
Measured			0.04	0.06	3.85	0.10				

The ABA test results on the rougher scavenger tailings and 1st cleaner scavenger tailings from the various locked cycle tests are summarized in Table 4.25. The ICP assay results on the supernatants from the locked cycle flotation tailings, rougher scavenger tailings and 1st cleaner scavenger tailings, are attached in Appendix V.

Table 4.25 ABA Test Results

Item	Sample ID	$S_{(-2)}$ %	Paste pH	Acid Potential	Neutralization Potential (NP) Actual	Ratio	Net
1	F46 Bulk Ro.Sc.Tails Cyc 3+4+5	0.06	7.6	1.9	40.08	21.38	38.2
2	F47 Bulk Ro.Sc.Tails Cyc 3+4+5	0.13	8.0	4.1	60.39	14.87	56.3
3	F48 Bulk Ro.Sc.Tails Cyc 3+4+5	0.28	8.0	8.8	25.20	2.88	16.5
4	F51 Bulk Ro.Sc.Tails Cyc 3+4+5	0.10	8.2	3.1	44.24	14.16	41.1
5	F52 Bulk Ro.Sc.Tails Cyc 3+4+5	0.05	7.5	1.6	43.39	27.77	41.8
6	F46 1st Cl.ScTails Cyc 3+4+5	0.84	8.2	26.3	56.32	2.15	30.1
7	F47 1st Cl.ScTails Cyc 3+4+5	8.29	7.6	259.1	54.04	0.21	-205.0
8	F48 1st Cl.ScTails Cyc 3+4+5	1.46	7.9	45.6	38.24	0.84	- 7.4
9	F51 1st Cl.ScTails Cyc 3+4+5	5.07	7.7	158.4	56.14	0.35	-102.3
10	F52 1st Cl.ScTails Cyc 3+4+5	2.87	7.7	89.7	56.24	0.63	-33.4
DUP	F48 Bulk Ro.Sc.Tails Cyc 3+4+5	0.28	8.0	8.8	25.07	2.87	16.3
DUP	F51 Bulk Ro.Sc.Tails Cyc 3+4+5	0.10	8.2	3.1	44.62	14.28	41.5

4.5.5.3 Settling Tests

Settling tests were conducted on the rougher scavenger tailings from the locked cycle test, Test F52, Composite MHM4. The tests included flocculant screening and dosage optimization. The detailed results are attached in the Appendix V and settling curves with and without flocculant are displayed in Figure 4.18. With the addition of 25g/t Percol 156, the initial settling rate was much faster than without flocculant. However, with prolonged settling time, the flocculant free test seems to generate a more compact solid layer than with the flocculant test.

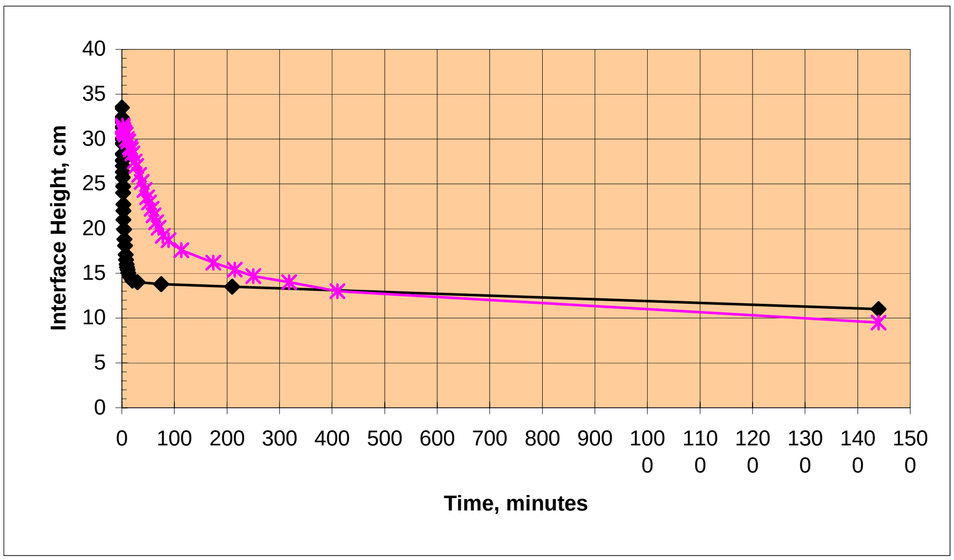


Figure 4.18 Rougher Scavenger Tailings Settling Curves

5.0 CONCLUSIONS AND RECOMMENDATIONS

Test results show that energy consumptions for the communition of the samples are intermediate or mildly intermediate. Low energy impact work indexes range from 6.7 to 8.5 kWh/t, Bond rod mill work indexes from 12.6 to 15.5 kWh/t at a discharge particle size of 14 mesh, and Bond ball mill indexes from 15.4 to 17.4kWh/t at a closing screen size of 100 mesh.

The flotation test results indicate that the various mineralization samples respond significantly differently to the procedure developed for the main composite MHM1C, indicating a substantial impact of the mineralization on the flotation. The type 1 samples show the best performance, while the type 2 samples register the poorest behavior .

Baseline viability rougher flotation on the individual composites at P_{80} ~150μm yields recoveries between 63% and 90% for gold, and from 70% to 93% for copper, on the samples with head grades of 0.1 to 0.4g/t Au and 0.3 to 0.6% Cu.

The main value recovery from the samples seems to be sensitive to primary grind size, especially for Composite MHM2.

It appears that the pulp pH does not play a key role on the rougher flotation for copper, but pH over 10 should be avoided.

Reagent screening tests show that the samples respond well to the reagent regime of PAX alone.

Regrind on bulk rougher concentrates is necessary for improving concentrate quality.

The locked cycle tests have demonstrated that the major material, Composite MHMIC, responds well to flotation to produce a high quality concentrate at a coarse primary grind size of P80 approximately 100 mesh. However, Type 2 sample, Composite MHM2, shows refractory characteristics to the flotation conditions at a similar grind size. The locked cycle tests on Composite MHM4, which is generated from various sample types to represent whole deposit mineralization, produce a 26% Cu and 6.8g/t Au concentrate at recoveries of 85.7% Cu and 59.7% Au.

The testwork has indicated that the following aspect should be investigated:

- The test results appear to show that some of the gold is closely associated with pyrite. Detailed mineralogical examination should be conducted to determine the gold deportment. The recovery and concentration of gold-bearing pyrite and gold recovery by gravity, leaching in cyanide and non-cyanide lixiviants, should be investigated.

- Further locked cycle tests are recommended to further optimize the flotation performance, including primary grind and regrind sizes and reagent regime.

- A pilot plant scale test and more tests are recommended to collect more data for design and feasibility studies, and generate needed materials for smelter acceptance tests.