APPENDIX D
Process Research Associated Report

Metallurgical Study
Doris Deposit
Hope Bay Project

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1.0 SUMMARY

Laboratory studies were performed on a number of mineral samples obtained from the Doris Deposit, at the Hope Bay Gold Project. The samples were obtained from three areas, consisting of the Doris Central - Stringer Zone (CSZ), Doris Central – Lakeshore Vein (CLV), and Doris North.

The use of gravity recovery followed by cyanidation of gravity tailing or cyanidation of flotation concentrate provided for a promising treatment procedure;

- The gravity concentrate typically recovered 25% to 50% of the gold present, depending on the composite sample tested and grind conditions used.
- The primary grind can be relatively coarse (80% passing 149 microns), which will impact the size of the mill as well as the power required. Gold recovery improved at finer grind sizes and this may be justified pending economic evaluation.
- Overall gold recoveries using gravity and cyanidation ranged from 89% to 98.5% depending on the composite sample tested and conditions used.
- The gold recovery to the flotation rougher concentrate is good and only this concentrate needs to be reground prior to cyanidation, rather than the whole ore.
- The overall recovery of the gold by gravity and cyanidation of reground flotation concentrate ranged from 93% to 98%.

The test program indicates that the Doris material responds well to conventional gravity, flotation and cyanidation procedures for recovery of gold.

2.0 INTRODUCTION

Process Research Associates Ltd. (PRA) was commissioned by Miramar Mining Corporation to undertake laboratory metallurgical studies on samples from the Hope Bay deposit located in the Nunavut Territory, Canada. The objective of the test work was to identify a preliminary process flow sheet using gravity, flotation and cyanidation procedures to recover the precious metals from the Doris ore zone.

This report summaries the metallurgical test procedures and results of the program.

3.0 PROCEDURES

3.1 Sample Preparation

The samples for the Doris test program were received in August 2001. The samples came from the mine exploration site for composition and for metallurgical testing. The drill core samples were jaw crushed to –10 mesh before compositing according to client instructions. After compositing, a sub-sample was taken out and pulverized for head assaying. The remainder of the sample was riffled into either 1kg or 2kg batches for metallurgical testing. The sample inventory log sheets, which include the individual sample identification numbers and sample weights are provided in Appendix.

A number of test grinds were performed in a laboratory stainless rod mill on composite samples to establish a suitable time to achieve a desired particle distribution for the test program.

3.2 Analytical Procedures

3.2.1 Fire Assay

The Au and Ag analysis was performed by using a standard fire assay procedure. A weighed sample was mixed with litharge and the required soda ash and borax fluxes to produce a fluid slag at 1000°C. After cooling, the lead button was separated from the glassy slag and re-melted in a cupel, which absorbed the oxidized base metals. The remaining precious metals bead was weighed, dissolved in acid and analyzed by Atomic Absorption (AA) spectrophotometry.

3.2.2 Sulfur Analyses

The total sulphur concentration was determined by a wet chemical technique. The sample was oxidized by digesting it on a hot plate in a mixture of potassium

bromide, bromine and nitric acid, until the excess bromine had been driven off. The solution was evaporated to dryness, re-dissolved in hydrochloric acid and re-evaporated to dryness. This step was repeated before a final dissolution in a 10% HCl solution. The sulphur was precipitated as barium sulphate, filtered, burned to an ash, and weighed.

3.3 Grinding

Test grinds were conducted to determine the grind time required to achieve target size of K80 in a laboratory stainless steel rods mill at 65% w/v solid content.

Screen analyses were carried out in a standard Rotap, with 8" diameter stacked test sieves in ascending mesh sizes. The sample was initially wet screened at 37 microns. The +37 micron fraction is then dry screened through a series of stacked test sieves. Each fraction was collected and weighed for calculating the individual percent retained on the screen.

3.4 Gravity Concentration

The ground sample was repulped to 20% solids and subjected to Falcon SB40 concentrator in typically one pass at a centrifugal force of 200G; with the back water pressure set at 1 psi. The Falcon concentrate was panned, the pan concentrate was assayed and the pan tail and Falcon tail combined for either cyanide leaching or flotation.

3.5 Batch Flotation

The batch flotation tests were conducted in a Denver D12 laboratory flotation machine. A 2 kg gravity tailing ore sample was used in each test. The cell size was chosen to make a typical flotation pulp density of 30-35% solids by weight. The impeller speed was set at 1800 RPM and the air flow was controlled

manually to maintain the froth level. Potassium amyl xanthate (PAX) was used as the collector for most of the flotation tests. The flotation was conducted at natural pH with one stage rougher and three stages of scavenger and combined into a bulk concentrate. The detailed procedures and conditions were recorded for each individual flotation test and are attached in the Appendix.

3.6 Cyanidation

The gravity tailing, flotation concentrate and flotation tailing were each cyanide leached at 40% solids, typically for 48 hours. A target pH 10.5, and minimum NaCN concentration of 1 g/L was maintained throughout the test. Intermittent solution samples were taken for kinetic determination of gold extraction. At termination of testing the slurry was filtered and the cake washed with hot NaCN solution, followed with two displacements hot water washes. Mass and material balances were performed for all the tests.

4.0 RESULTS AND DISCUSSION

4.1 Sample Preparation and Characterization

The samples were jaw crushed to –10 mesh and blended into five composites. The composition information and head assay results are tabulated in Table 4.1 and Table 4.2, respectively.

Table 4.1 – Doris Composites

Doris CSZ	Doris CLV	Doris North
TDD129S	TDD129LV	TDM97LV
TDD131S	TDD131LV	TDM98LV
TDD135S	TDD135LV	TDM100LV
TDD138S	TDD368LV	TDM105DH
TDD368S	TDD376LV	
TDD376S	TDD387LV	
TDD387S	TDD388ALV	
TDD388AS	TDD389LV	
TDD389S	TDD390ALV	
TDD390AS		
TDD392S		

Table 4.2 – Doris Composites Head Assays

Sample ID	Au	S_T	As	Cu	Fe
	g/t	%	%	%	%
Doris CSZ	13.4	2.87	<0.0005	0.009	7.2
Doris CLV	9.60	1.36	<0.0005	0.007	2.7
Doris North	7.60	0.46	0.0007	0.008	1.3

4.2 Bond Ball Mill Index

A Bond Ball Mill Work Index (W.I.) was conducted with a Bico Mill using standard procedures with a 149 um sieve size. The results are summarized in Table 4.3, with detailed procedures and results provided in the Appendix.

Table 4.3 – Ball Mill Work Index

Test No.	Zone	W.I., kWh/tonne
BI3	Doris North	17.5
BI4	Doris CSZ	15.7
BI7	Doris CLV	15.3

4.3 Gravity Concentration – Cyanidation

The gold recovery using a combination of gravity procedures and cyanide leaching process was conducted to determine the benefit of gravity concentration on gold recovery prior to cyanide leaching

The composites were tested at three different primary grind sizes, of 80% passing 140 microns, 74 microns and 44 microns respectively. The combination of gravity concentration and cyanidation achieved excellent overall gold recovery exceeding 97% at the finest primary grind size. The gravity (pan concentrate) recovery ranged from 28% at the coarser grind size to 49% at the finer grind size. The cyanide leach circuit extracted over 95% of the Au on the gravity tail at finer grind size after leaching for 48 hours. The detailed procedures and results are provided in the Appendix. The summaries of the test results are tabulated in Table 4.4 and Figures 4.1 to 4.3.

Table 4.4 – Summary of Gravity and Cyanidation Test Results

Test No	Sample ID	Grind P80=um	% Recovery			Reagent Consumption, kg/t	
			Gravity	Cyanide	Total	*NaCN	*Ca $(OH)_2$
C15	Doris CSZ	149	27.5	61.5	89.0	2.63	0.17
C16		69	52.6	44.8	97.4	2.45	0.17
C17		45	45.3	53.0	98.3	2.95	0.17
C24	Doris CLV	140	36.7	58.1	94.9	0.63	0.13
C25		73	45.2	52.1	97.3	0.75	0.14
C26		48	42.6	55.9	98.5	0.77	0.18
C27	Doris North	145	32.5	61.3	93.8	0.60	0.12
C28		99	36.1	59.0	95.1	0.69	0.10
C29		45	35.8	61.9	97.7	0.74	0.16

*the cyanide recovery and reagent consumption was calculated at 48 hours retention time.

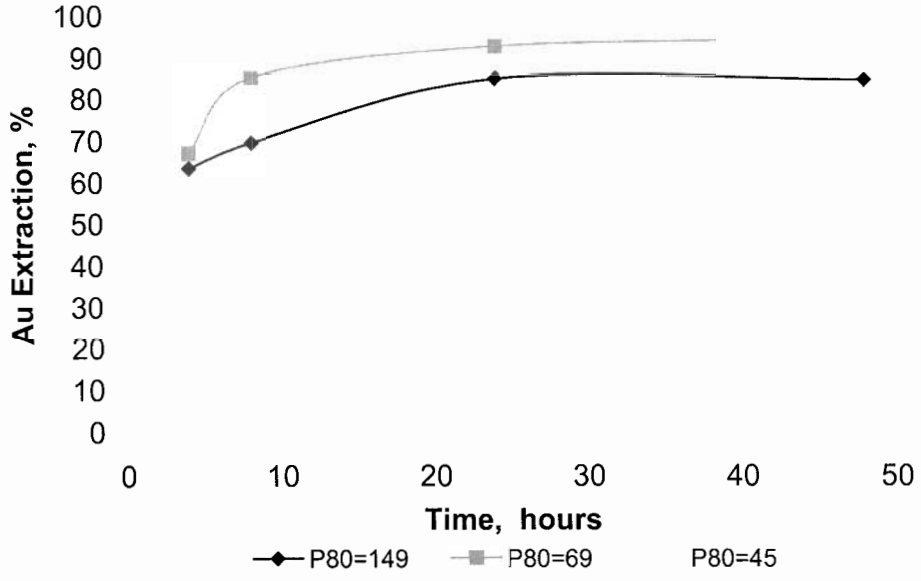

Figure 4.1 – Cyanide Leach Kinetics on Doris CSZ

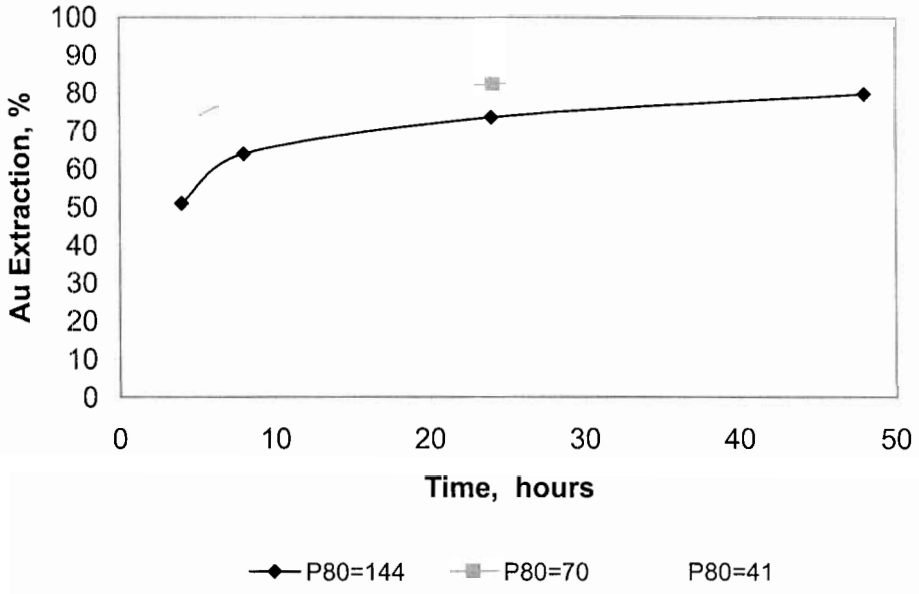

Figure 4.2 – Cyanide Leach Kinetics Doris CLV

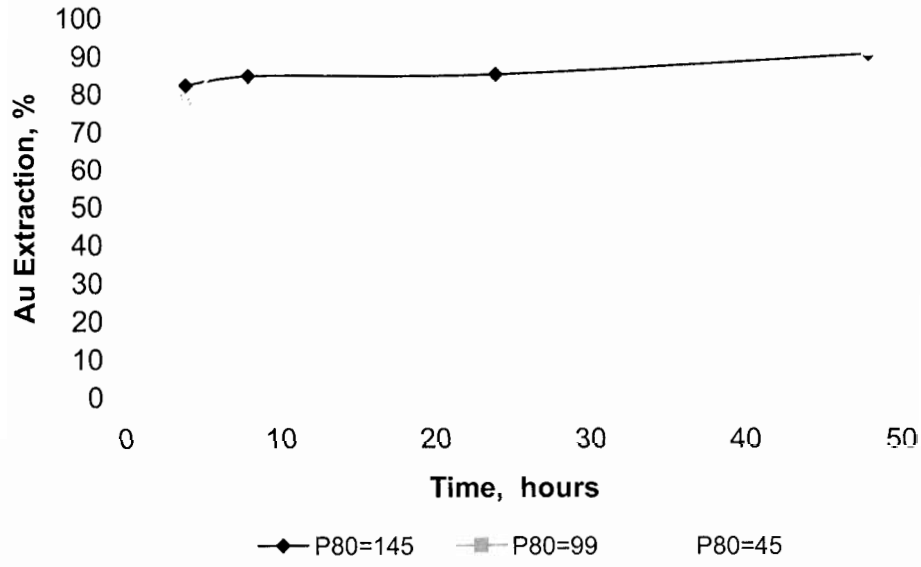

Figure 4.3 – Cyanide Leach Kinetics on Doris North

The data shows that the leaching kinetics increased with a finer grind size, and that optimum gold extraction appeared after approximately 24 hours leach retention time. The NaCN consumption will be lower at 24 hours, as compared to 48 hours of leaching.

4.4 Batch (Open Circuit) Flotation

A series of rougher flotation tests were conducted on the Doris zone composites to determine the amenability of the ore to the flotation process. All the flotation tests were conducted on the gravity tailing using procedures established on earlier studies conducted for other samples obtained from the Hope Bay Project.

The tests (F20 to F25) on the Doris composites used only PAX as collector and were conducted at two different primary grind sizes. Prior to flotation, the ground samples were subjected to gravity concentration using Falcon® SB40 concentrator. The finer primary grind size marginally improved the overall gold recovery. The test results are summarized in Table 4.5 and 4.6. The detailed procedure and results are provided in the Appendix.

Table 4.5 – Rougher Flotation Test Summary

Test No	Sample ID	Grind Size P80=um	Weight Rec. %	Flotation Concentrate Grade		Flotation Recovery	
				Au, g/t	S_T, %	Au, %	S_T, %
F20	Doris	135	14.2	46.8	21.6	89.8	98.4
F21	CSZ	67	12.7	51.0	23.0	91.0	98.2
F22	Doris CLV	144	6.7	88.2	20.2	94.0	98.7
F23		74	7.6	101	18.2	96.5	99.3
F24	Doris	143	6.1	83.4	8.22	97.1	98.1
F25	North	80	6.7	74.2	6.81	97.8	98.0

Table 4.6 – Overall Test Summary

Test No	Sample ID	Grind Size P80=um	Final Tail Au Grade G/t	% Au Distribution		
				Gravity	Flotation	Total
F20	Doris CSZ	135	0.88	29.2	63.6	92.8
F21		67	0.73	38.5	56.0	94.5
F22	Doris CLV	144	0.41	32.3	63.6	95.9
F23		74	0.30	40.5	57.5	97.9
F24	Doris North	143	0.16	29.0	69.0	97.9
F25		80	0.12	25.8	72.5	98.4

The test results show that all the samples tested were amenable to gravity-flotation procedure. The overall gold recovery ranged from 93% to 98%.

4.5 Gravity-Flotation-Cyanidation

The Doris composite samples were subjected to gravity-flotation-cyanidation procedures to determine the total gold (Au) extraction at a target primary grind size of 80% passing 149 microns. The test procedure is presented schematically in Figure 4.4. The detailed procedure is in the Appendix.

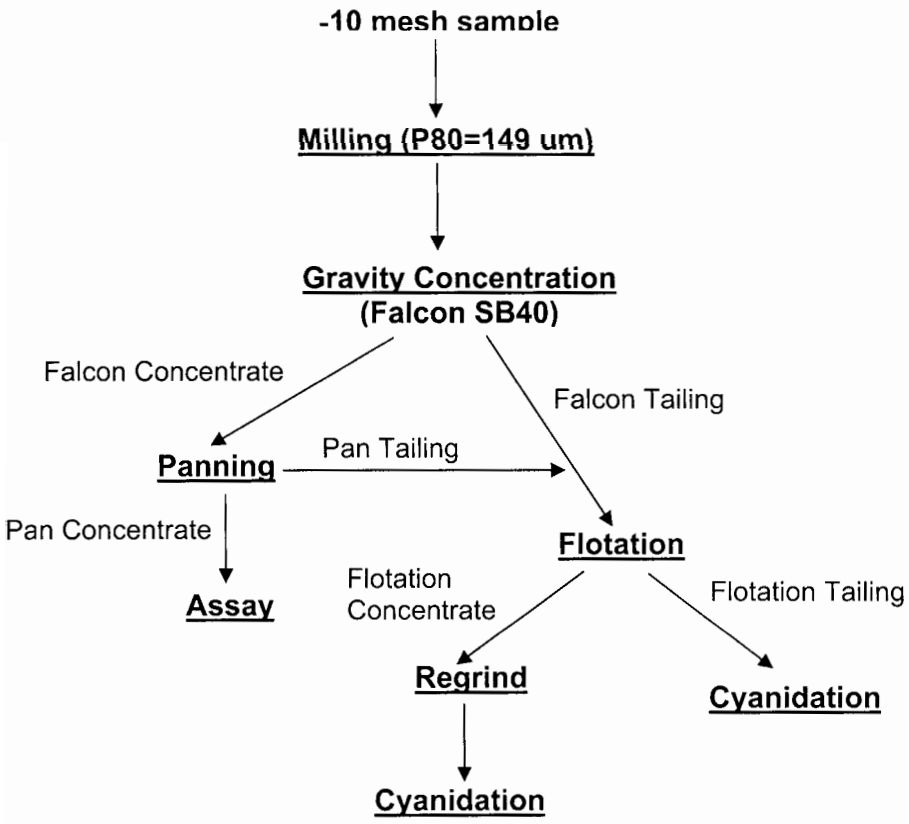

Figure 4.4 – Gravity-Flotation-Cyanidation Test Procedure

The combined gravity and cyanidation performed on the whole ore achieved greater than 97% gold recoveries for composites Doris North, CSZ, and CLV. The combination of gravity-flotation-cyanidation procedure achieved excellent results as summarized in Table 4.7. The cyanide leach kinetics is presented graphically in Figure 4.5 and 4.6. The detailed procedures and results are provided in the Appendix.

Table 4.7 – Gravity-Flotation-Cyanidation Total Au Recovery

Test No	Sample ID	% Au Recovery			
		Gravity	Cyanide C	Cyanide T	Total
F27	Doris North	32.9	63.8	2.4	99.1
F30	Doris CSZ	32.3	59.2	6.0	97.5
F31	Doris CLV	51.0	45.9	2.3	99.2

Cyanide C=Flotation Concentrate, Cyanide T=Flotation Tailing

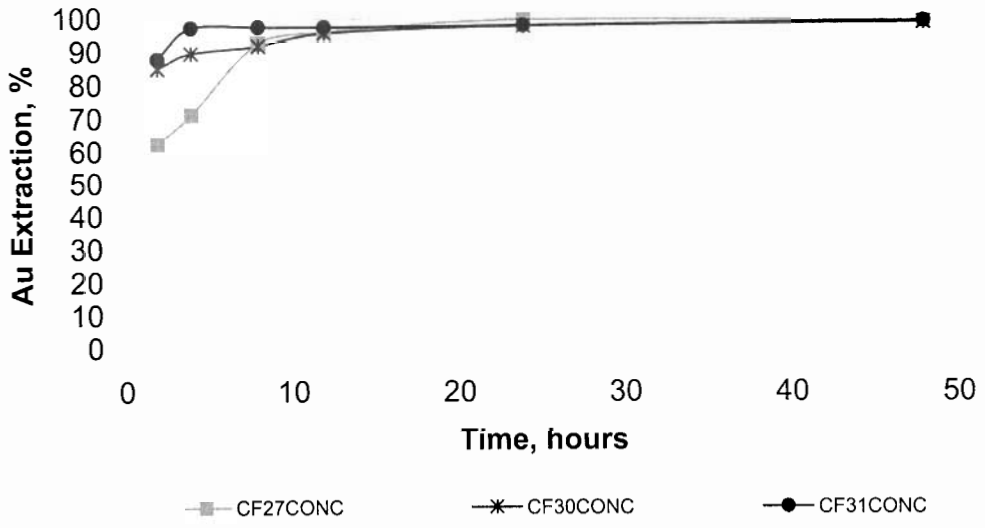

Figure 4.5 – Flotation Concentrate Cyanidation Kinetic

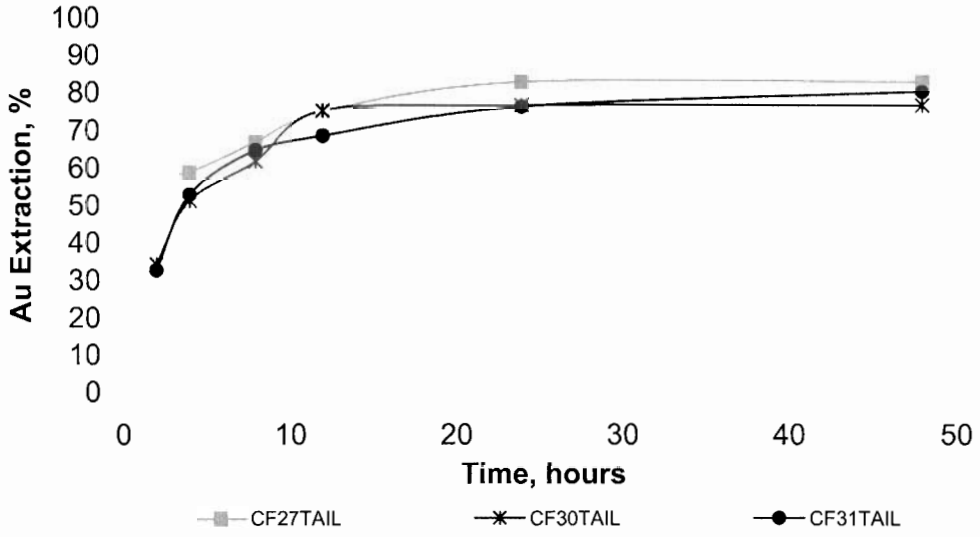

Figure 4.6 – Flotation Tail Cyanidation Kinetic

The leach kinetic data indicates that the Au extraction appeared to be complete within 24 hours cyanidation time, for both flotation tailing and flotation concentrate. The un-leached gold remaining in the cyanided tailing may be due to finely disseminated gold in sulfide minerals, or gold associated within silicates. The total NaCN consumption per tonne of original ore to gravity feed is summarized in Table 4.8.

Table 4.8 – NaCN Consumption at 24h Leaching Time

Composite ID	NaCN Consumption, kg/t of Ore at 24 hours
Doris North	0.99
Doris CSZ	1.68
Doris CLV	1.05

4.6 Flotation Optimization Suggested by Bateman Engineering

An eight kilogram Doris North composite was ground to target 80% passing 147 microns and subjected to two-pass Falcon gravity recovery procedure. The two gravity concentrates were combined and cyanide leached. The extraction was excellent at 97.9% Au and 98.5% Ag. The gravity tailing was split into 4 equal portions for the subsequent flotation tests.

The first flotation test F41, was similar to PRA procedure using PAX as the collector and floated at natural pH of 8.6. A kinetic flotation study was conducted and the test results are presented in Figure 4.7. The flotation recovery was 94.4% Au, 78.2% Ag and 97.1% total sulphur. The flotation kinetic data indicates that these metals were floated in 15 minutes.

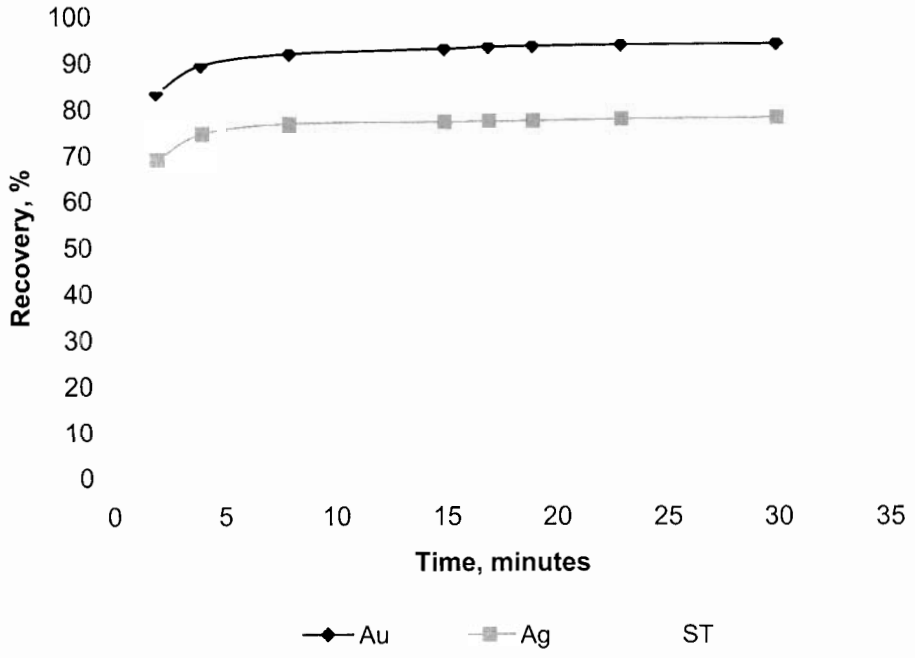

Figure 4.7 – Doris North Flotation Kinetics

A second flotation test F42 was conducted to study the response of copper sulfate addition. The results indicate that the copper sulfate did not have a significant effect on the gold recovery, as summarized in Table 4.9, below. The Au and Ag extraction from the flotation concentrate by cyanidation was 87.1% and 73.5%, respectively.

The third flotation test F43 using sodium isopropyl xanthate as a collector and with copper sulfate resulted in slightly decreased Au and Ag flotation recovery. The flotation tailing losses was higher at 0.23g/t Au and 0.20g/t Ag. The Au and Ag extraction by cyanidation of the concentrate was 93.6% and 79.6%, respectively.

A slime depressant CMC was tested in test F44 to evaluate if mass yield to the concentrate could be achieved. A marginal reduction of concentrate weight was achieved. The cyanide extraction from the flotation concentrate was 85.3% Au and 60.9% Ag. The results summarizing the optimization are presented in Table 4.9.

Table 4.9 – Flotation Optimization Tests F41 to F44 on Doris North

Test	Flot Con	Au %Recovery			Flotation Tail	Cyan Ext'n	
No	Weight, %	Gravity	Flotation	Total	Grade, g/t	Au,%	Ag,%
F41	8.9	69.9	28.4	98.3	0.12	-	-
F42	9.9	69.7	28.0	97.8	0.16	87.1	73.5
F43	8.0	71.1	25.6	96.7	0.23	93.6	79.6
F44	7.5	68.7	29.1	97.8	0.16	85.3	60.9

4.7 Filtration and Settling

A settling test STF41 was conducted on Doris North (test F41) flotation tail. An initial scoping tests show that flocculant alone did not achieve good supernatant clearity. The supernatant became clear when lime was added. Test STF41 achieved 66% solids in the thickener under flow after 24 hours settling. The procedure and detailed results are provided in the Appendix.

Filtration test FTF41 was performed on the STF41 thickener under flow using a 200 cm^2 Buchner funnel. The filtration time was 50 seconds to form a cake thickness of 1.5 cm. The cake moisture was determined to be 11.0%. According to Bateman Engineering instruction, a filtration test was also performed on three cyanide final slurries CF42, CF43 and CF44 produced from cyanidation of the flotation concentrate. The % moisture in each cake (after repulping and filtering) was 32.8%, 8.7% and 27.7%, respectively. The procedure and detailed results are provided in the Appendix.

4.8 Environmental

4.8.1 Acid Base Accounting

Acid base accounting (ABA) was conducted on the Doris North (test F41) flotation tail to determine the neutralization potential (NP). The test was performed according to the Sobek standard procedure. The net NP was determined to be –24.3 kg CaCO3 equivalent per tonne of sample. This indicates that the flotation tailing should be subjected to kinetic tests to better determine if there is acid producing potential.

4.8.2 Cyanide Destruction

The cyanide destruction tests CFH2O2-15 and CFH202-30 were conducted on solutions originating from Doris North material. The solutions originated from tests CF42, CF43 and CF44 filtrate, which contained 2.60g/L NaCN. A 50% H2O2 (hydrogen peroxide) solution was added to two filtrate samples at a rate of 15g/L and 30g/L and agitated for 24 hours. The resulting solutions were then analyzed for weak acid soluble (wad) cyanide, total cyanide, Cu and Fe. The test results are summarized in Table 4.10.

Table 4.10 – Doris North Cyanide Destruction Results

Test No	H2O2 dosage 50%, g/L	CN_{wad} mg/L	CN_{total} mg/L	Cu mg/L	Fe mg/L
CFH2O2-15	15	172	176	31.8	17.7
CFH2O2-30	30	1.85	40	8.79	16.0

The results indicate hydrogen peroxide was effective at reducing some cyanide complexes.

5.0 RECOMMENDATIONS

Based on a finalized process flow sheet, additional metallurgical work is recommended to allow the treatment circuit to be developed to a feasibility level of accuracy. Further environmental studies also appear to be warranted, depending on regulatory permitting requirements.