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SKUKUM CREEK GOLD/SILVER DEPOSIT - RAINBOW ZONE

BIOLEACH AND CYANIDATION GOLD/SILVER RECOVERY

PHASE 1 TEST PROGRAM

By

Melis Engineering Limited

For

Wheaton River Minerals Limited

14-34

Canada

Yukon

This report is available from:
Exploration and Geological Services Division,
Indian and Northern Affairs Canada,
200 Range Road, Whitehorse, Yukon Y1A 3V1

SKUKUM CREEK GOLD/SILVER DEPOSIT - RAINBOW ZONE

BIOLEACH AND CYANIDATION GOLD/SILVER RECOVERY PHASE I TEST PROGRAM

MELIS Project No. 270

October 2, 1993

prepared for

Wheaton River Minerals Limited
25 Adelaide Street East
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by

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ENGINEERING LTD.

October 2, 1993

Wheaton River Minerals Limited
25 Adelaide Street East
Suite 1400
Toronto, Ontario
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MELIS Project No. 270

Attention: Mr. V.V. Jutronich, President

Dear Mr. Jutronich:

re: Skukum Creek Rainbow Zone
Bioleach/Cyanidation Test Program - Phase I

Melis Engineering Ltd. is pleased to enclose fifteen (15) copies of our report on flotation and bioleach/cyanidation testing of a Rainbow zone composite from the Skukum Creek gold/silver deposit in the Yukon. The enclosed report provides all the test results from Phase I of the test program.

We trust you will find the report satisfactory and we look forward to completing the second phase of the work, once appropriate budgets are in place for continuation of the program.

Respectfully submitted,
MELIS ENGINEERING LTD.

L.A. Melis, P. Eng.
President

J. Jarvi
Project Metallurgist

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SKUKUM CREEK GOLD/SILVER DEPOSIT - RAINBOW ZONE

BIOLEACH AND CYANIDATION GOLD/SILVER RECOVERY PHASE I TEST PROGRAM

EXECUTIVE SUMMARY

Introduction

Wheaton River Minerals Limited (WRML) received a Canada/Yukon Mineral Development Agreement (MDA) grant to perform metallurgical testwork on their Skukum Creek Rainbow deposit to see if bioleaching could be used for pre-treatment of flotation concentrate ahead of cyanidation as a means of recovering refractory gold. Melis Engineering Ltd. was contracted to carry out the metallurgical testwork. Flotation testing and bulk concentrate production was completed at Lakefield Research's facilities in Lakefield, Ontario and the bioleaching/cyanidation testing was completed at Triton Development Corporation's facilities in Vancouver, B.C.

The Rainbow zone composite tested assayed 8.6 g Au/tonne (0.251 oz/ton), 948.9 g Ag/tonne (27.68 oz/ton), 2.29% Pb, 2.20% Zn, 0.075% Cu, 1.77% As, 4.50% Fe and 5.00% S.

Flotation Testing

Batch flotation tests showed that a simple xanthate gold float using one cleaning stage would yield acceptable gold and silver recoveries for the Rainbow zone mineralization.

A total of 145 kg of the Rainbow zone composite was then floated as 15 kg batches in a large flotation cell to produce bulk concentrate for bioleach testing. Only one stage cleaning was used. Gold and silver recoveries to the bulk cleaner concentrate, assaying 41.8 g Au/tonne (1.219 oz/ton) and 4,651 g Ag/tonne (135.65 oz/ton), were 89.6% and 94.2% respectively. The first cleaner concentrate weight was 17.2%. This concentrate (total dry weight of 24.9 kg) was used in bioleaching and cyanidation test.

Bioleaching/Cyanidation Testing

The bioleach testwork indicated that a 4-day bioleach retention time provides adequate dissolution of sulphides to render contained refractory gold and silver amenable to cyanide extraction. Extended bioleaching (to

a 6-day retention time) appeared to result in losses of gold and silver to the bioleachate solution which in turn led to poorer cyanide extraction efficiencies.

Regrinding of concentrate prior to bioleaching appear to be a requirement, at least in terms of achieving acceptable silver extractions. The optimum mesh-of-grind for ground concentrate was not established in this phase of the test program.

Conclusions

Flotation testing of the Rainbow zone composite provided for this test program indicates that flotation recoveries of 92% for gold and 88% for silver should be achievable, into a flotation concentrate assaying 40 to 45 g Au/tonne and 4,000 to 5,000 g Ag/tonne, depending on the head grade of the material being processed.

Achievable cyanide extractions on washed bioleach residue appear to be 92% for gold and 88% for silver. These extraction values will need to be confirmed in the second phase of work planned for this test program. Suitable cyanidation conditions appear to be a 36 to 48-hour leach retention time on washed bioleach residue, pH 10 to 10.5, a target cyanide concentration of 1 g NaCN/L, and reagent consumptions of 10 to 15 kg NaCN/tonne and 35 to 45 kg $Ca(OH)_2$/tonne of cyanidation feed.

SKUKUM CREEK GOLD/SILVER DEPOSIT - RAINBOW ZONE

BIOLEACH AND CYANIDATION GOLD/SILVER RECOVERY
PHASE I TEST PROGRAM

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SKUKUM CREEK GOLD/SILVER DEPOSIT - RAINBOW ZONE

BIOLEACH AND CYANIDATION GOLD/SILVER RECOVERY PHASE I TEST PROGRAM

1.0 INTRODUCTION

Wheaton River Minerals Limited (WRML) received a Canada/Yukon Mineral Development Agreement (MDA) grant to perform metallurgical testwork on their Skukum Creek Rainbow deposit to see if bioleaching could be used for pre-treatment of flotation concentrate ahead of cyanidation as a means of recovering refractory gold. Melis Engineering Ltd. was contracted to carry out the metallurgical testwork which included flotation testing and bulk concentrate production at Lakefield Research's facilities in Lakefield, Ontario followed by bioleaching/cyanidation testing at Triton Development Corporation's facilities in Vancouver, B.C. The testwork at Lakefield Research was undertaken in March 1993 and the bioleaching testwork at Triton's laboratory was completed from April to August 1993.

2.0 SAMPLING PROGRAM

WRML contracted Aurum Geological Consultants Inc. of Whitehorse, Yukon to conduct a sampling program of the Skukum Creek Rainbow deposit to provide a bulk sample for testing.

The sampling work commenced on February 5, 1993. The first 75 kg of mineralized sample was collected on February 8, 1993. The remainder of the sampling was completed on February 10. The samples were transported to Wheaton River Bridge by snowmobile and sled on February 11 and delivered to Motorways in Whitehorse on February 12. The shipment was received at Lakefield Research on February 24, 1993.

The location of sampling points is shown in the location map presented in Appendix A. Eight ore blocks were sampled in the preparation of one bulk composite with approximately 50 kg taken from each ore block. Reserve blocks R10, R12, R13 and R15 were sampled from one site in each block and reserve blocks R7, R8, R14 and R11 were sampled from two or more sites in each block. The sample locations for each ore block are listed below:

R7 Sample collected from entire block but concentrated in the area of No. 1 drawpoint,

R8 From the drift face,

R10 6.5 m west of survey plug 30-32 near the south wall,

R11 13 m west of survey plug 30-9 near the north wall,

R12 13 m east of survey plug 30-9 near the south wall,

R13 Sample from under stub raise/brow, south wall 8 m west from 30-950 service, raise,

R14 Sample collected from area between 10 m - 20 m east of No. 1 crosscut, and

R15 Approximately 55 m east of No. 1 crosscut.

3.0 COMPOSITE PREPARATION

A total of 372 kg of ore was received at Lakefield Research and blended into a single bulk sample composite for metallurgical testwork. A 10 kg sample of minus 1/4 inch ore was set aside for possible future Bond work index measurements. The remaining 362 kg was crushed to 100% minus 10 mesh. A 1.0 kg head sample was sent to Triton Development Corporation for preliminary bacterial culture growth. Twenty charges of 2 kg each were packaged for batch flotation tests and 32 charges of 10 kg each were packaged for the production of bulk concentrate. The remaining 1 kg of the composite was kept as a reject.

The head assay of the composite, which is similar to previous assays of the Rainbow deposit, was as follows:

g Au/tonne	g Ag/tonne	% Pb	% Zn	% Cu	% As	% Fe	% S
8.60	948.9	2.29	2.20	0.075	1.77	4.50	5.00

4.0 INITIAL TESTWORK

4.1 INTRODUCTION

Initial testwork was comprised of flotation testwork and baseline cyanidation tests at Lakefield Research. The Lakefield Research test data are detailed in Appendix B.

4.2 BATCH FLOTATION TESTS

The first two flotation tests were designed to determine the flotation kinetics of the Rainbow Zone mineralization at two different grinds. The results of these two tests are summarized in Table 4-1. A simple xanthate float at natural pH was used in these two tests. The primary grind for the first test was 61.0% minus 200 mesh and the primary grind for the second test was 47.7% minus 200 mesh. As shown in Figure 4-1, gold recovery at the coarser grind levelled off after 17 minutes (Test No. 2) but gold recovery at the finer grind was still increasing after 15 minutes (Test No. 1). The gold grade/recovery curve shown in Figure 4-2 illustrates that the finer grind increased the concentrate gold grade and improved recovery. Therefore, a grind of 61.0% minus 200 mesh and a bulk flotation time of 20 minutes were chosen as design parameters for the subsequent flotation tests. Figures 4-3 and 4-3A illustrate the similarity of sulphur grade and recovery with that of gold. This similarity shows that gold can be recovered in a bulk sulphide flotation circuit.

A series of four batch tests were completed to check on bulk concentrate cleaning with and without concentrate regrinding, to check on the use of Aerofloat 208 promoter as gold collector, and to check on the effect of increasing fineness of grind. These results are summarized in Table 4-2 and presented graphically in Figures 4-4, 4-5 and 4-6.

Test No. 4 and Test No. 5 compared the effect of regrinding the rougher concentrate prior to the cleaner flotation stage. Regrinding the concentrate prior to cleaning increases the second cleaner concentrate grade from 39.6 g Au/tonne to 60.2 g Au/tonne and the first cleaner concentrate grade from 38.2 g Au/tonne to 55.1 g Au/tonne. Also, the total concentrate weight as a percentage of the original head weight dropped from 18.4% to 10.8% as shown in Figure 4-6. Unfortunately, the regrinding step had the effect of dropping first cleaner gold recovery from 90.2% to 81.0% (and second cleaner gold recovery from 88.1% to 77.0%). Consequently, regrinding of rougher concentrate ahead of cleaner flotation does not appear to be beneficial.

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TABLE 4-1

SKUKUM CREEK RAINBOW ZONE
KINETIC FLOTATION TESTS

Test No.	Grind	Calc. Head	Cumulative % Au Recovery					g Au/tonne				
	%-200 M	g Au/t	Ro Con 1	Ro Con 1-2	Ro Con 1-3	Ro Con 1-4	Ro Con 1-5	Ro Con 1	Ro Con 1-2	Ro Con 1-3	Ro Con 1-4	Ro Con 1-5
1	61.0	7.74	63.2	75.5	83.0	87.3	92.1	47.6	42.0	38.6	34.9	30.4
2	47.7	7.83	57.4	78.4	87.0	90.7	91.7	46.0	37.5	32.5	29.3	28.3

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TABLE 4-2

SKUKUM CREEK RAINBOW ZONE
BATCH FLOTATION TESTS

Test No.	conditions	Grind	Calc. Head		1st Cln. Con		% Rougher Recovery		% 1st Cln Rec.		No. Talls		1st Cln. Talls	
		%-200 M	g Au/t	g Ag/t	g Au/t	g Ag/t	Au	Ag	Au	Ag	g Au/t	g Ag/t	g Au/t	g Ag/t
4	PAX, $CuSO_4$, regrinding of rougher con to 21 um	61.0	8.35	773	55.1	5820	92.5	94.9	81.0	92.5	0.84	53.3	7.27	139
5	PAX	71.1	8.26	755	38.2	3606	92.0	94.5	90.2	93.2	0.86	54.4	4.00	252
6	PAX, 208, $CuSO_4$, regrinding of rougher con	61.0	8.15	765	49.2	5051	93.7	94.9	85.0	93.0	0.69	53.2	5.89	120
7	PAX, $CuSO_4$, finer primary grind	91.5	8.16	778	41.2	4038	94.2	95.7	90.9	93.4	0.63	44.1	4.17	283

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FIGURE 4-1
SKUKUM CREEK RAINBOW FLOTATION TESTS
% Au Recovery vs Flotation Time

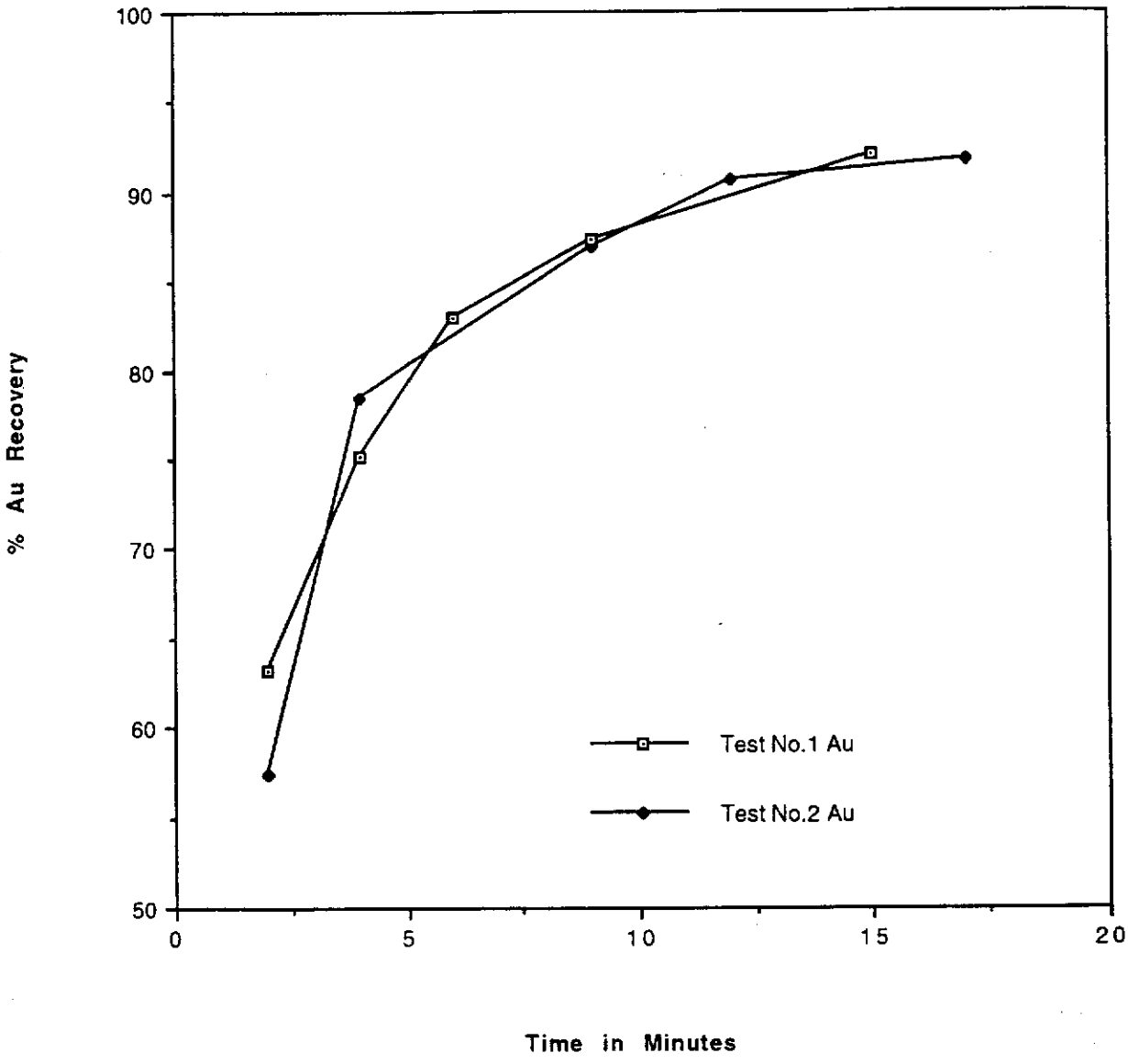

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FIGURE 4-2
SKUKUM CREEK RAINBOW FLOTATION TESTS
% Au Recovery vs g Au/tonne Concentrate

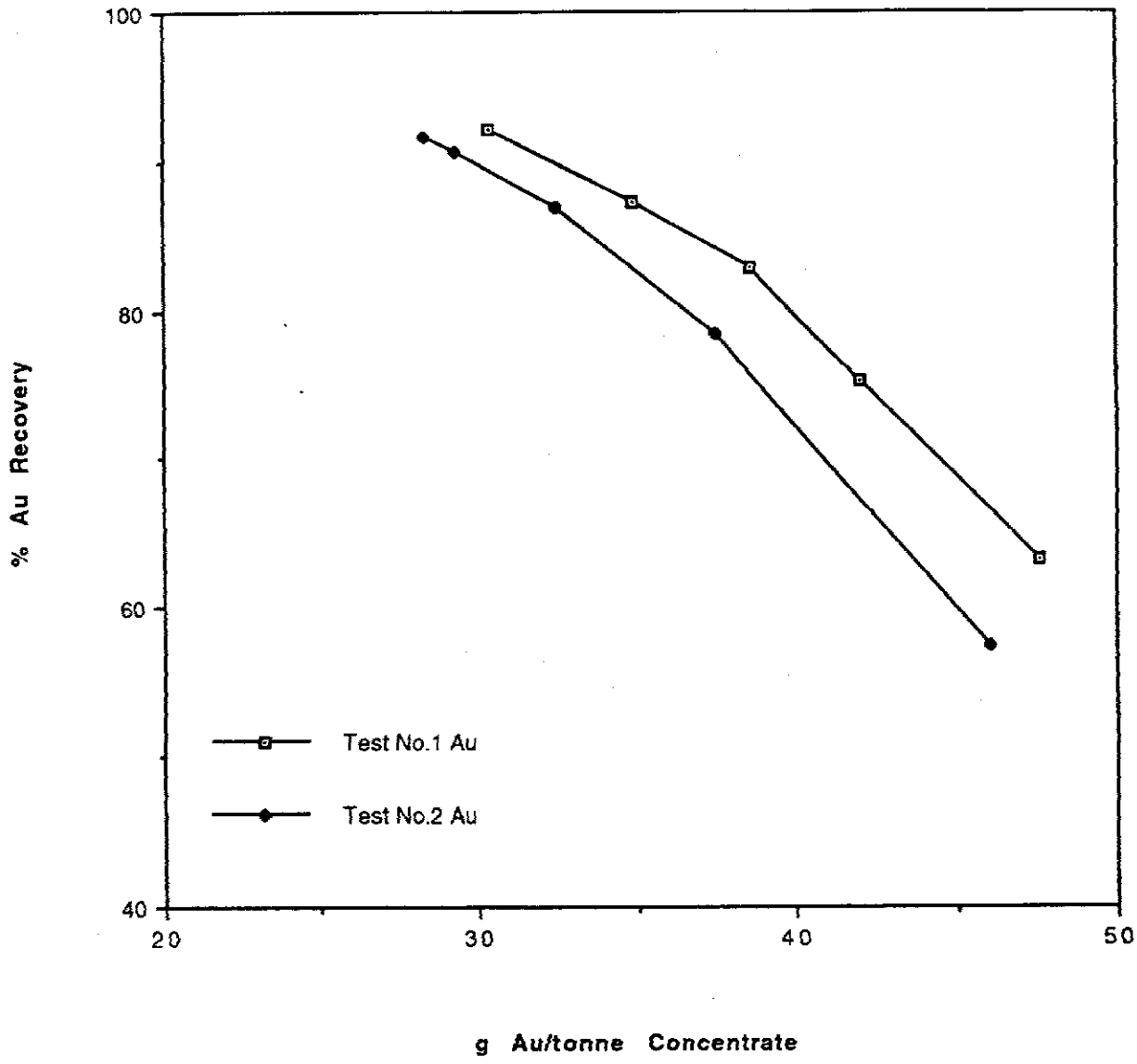

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FIGURE 4-3

SKUKUM CREEK RAINBOW FLOTATION TESTS

% Au Recovery vs % S Recovery

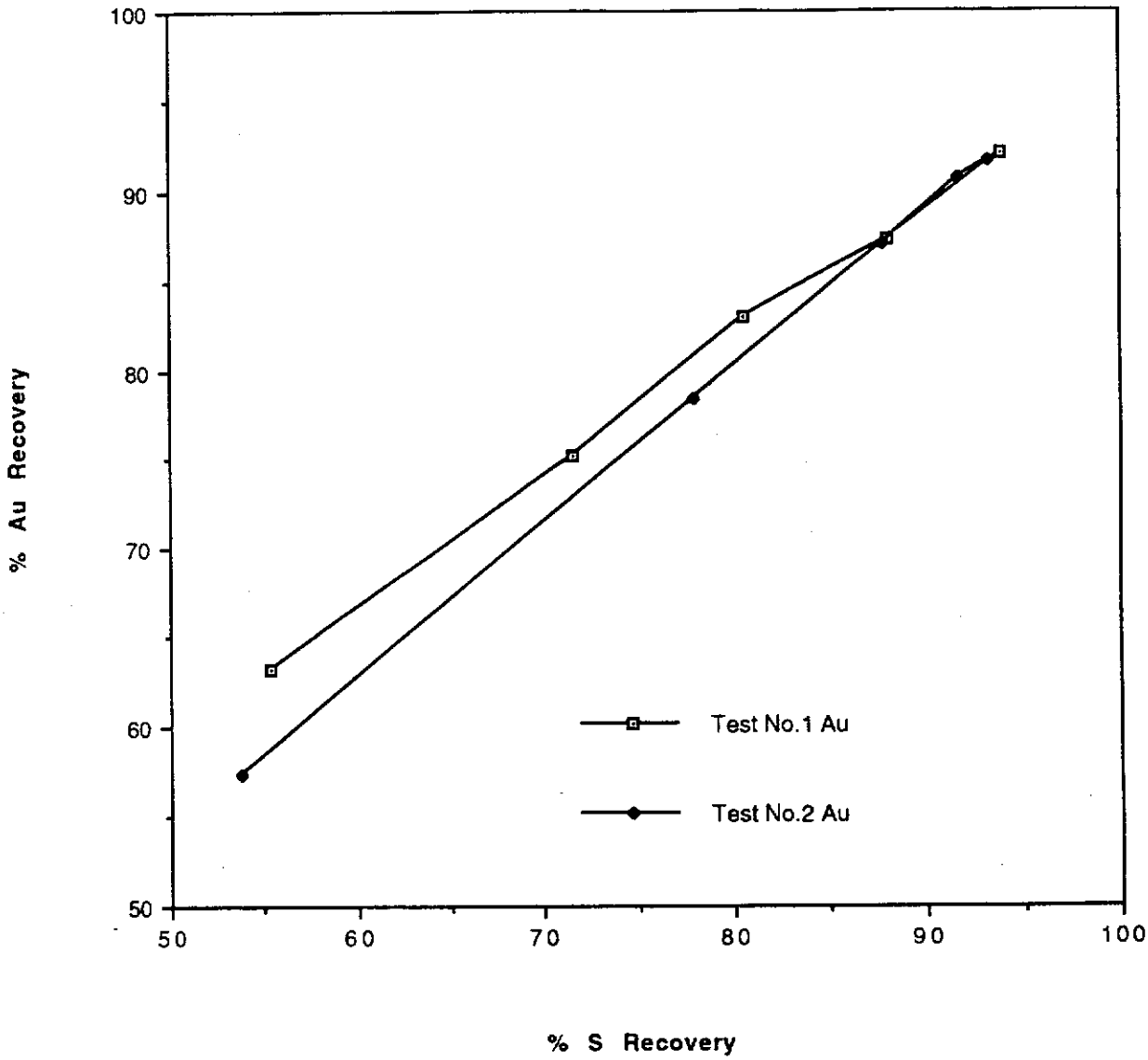

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FIGURE 4-3A
SKUKUM CREEK RAINBOW FLOTATION TESTS
% Au Recovery vs % S in Concentrate

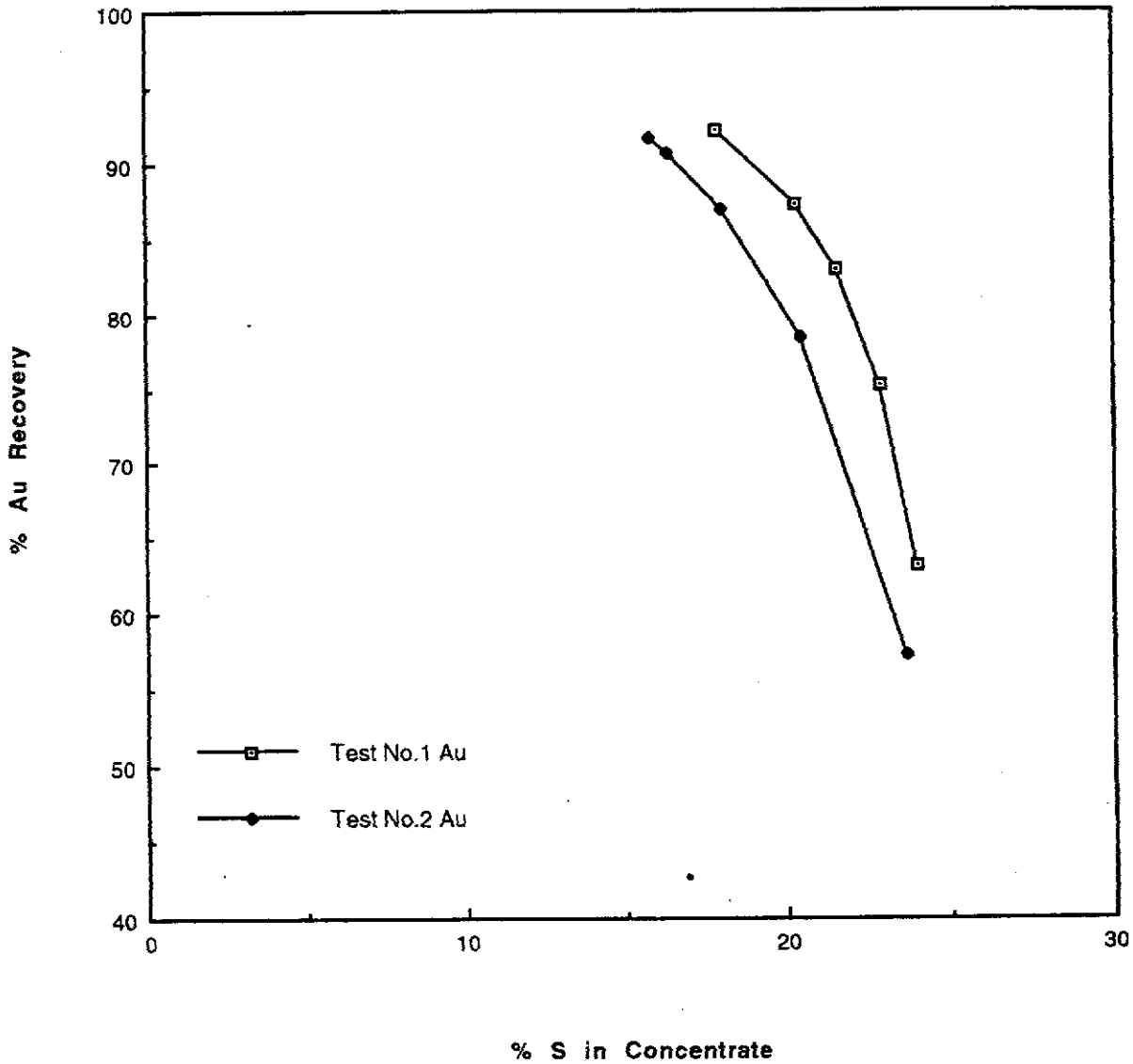

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FIGURE 4-4
SKUKUM CREEK RAINBOW FLOTATION TESTS
% Au Recovery vs g Au/tonne Concentrate

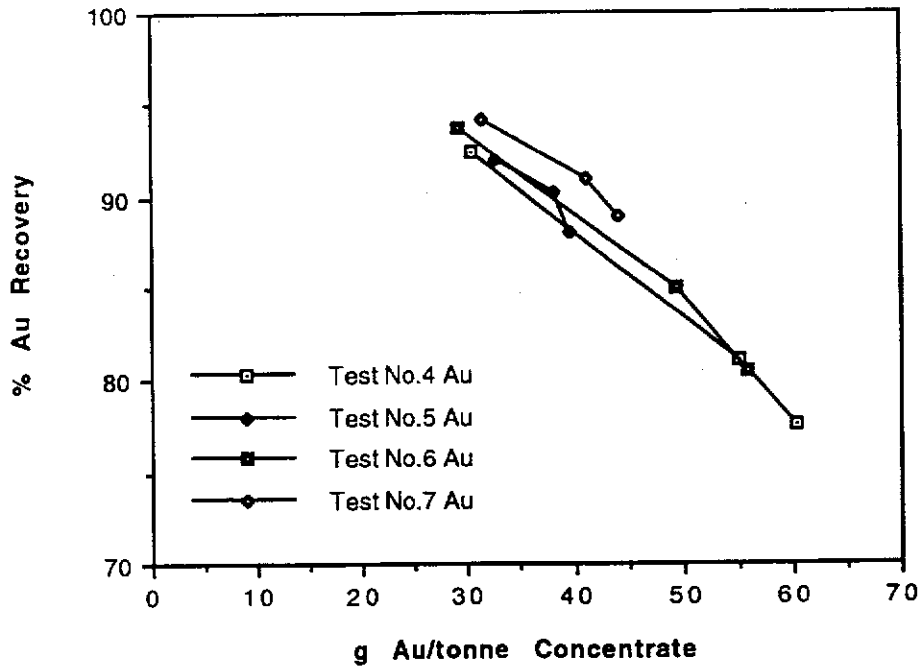

FIGURE 4-5
SKUKUM CREEK RAINBOW FLOTATION TESTS
% Ag Recovery vs g Au/tonne Concentrate

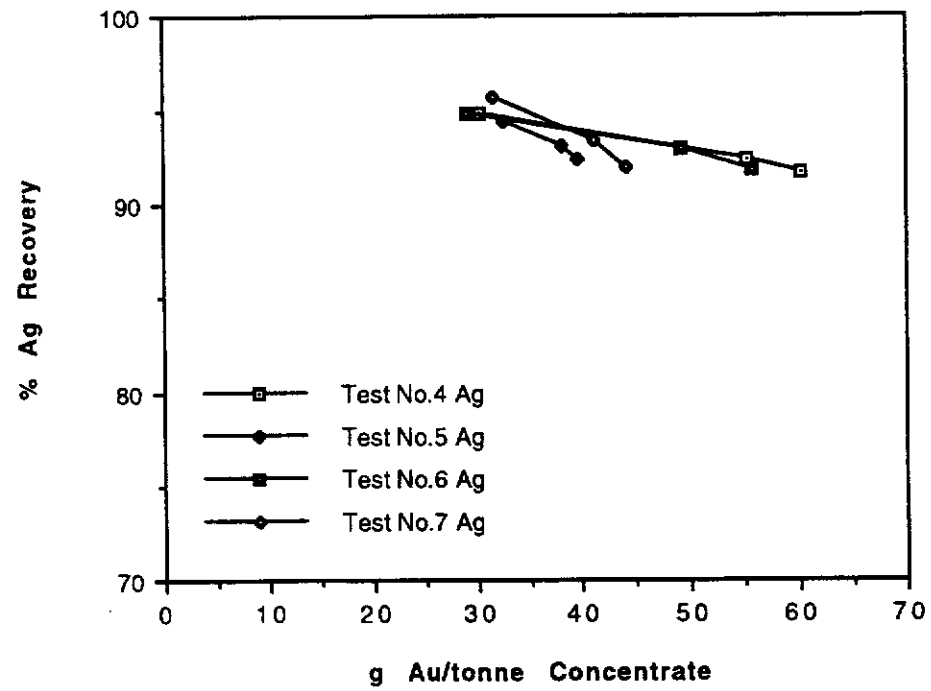

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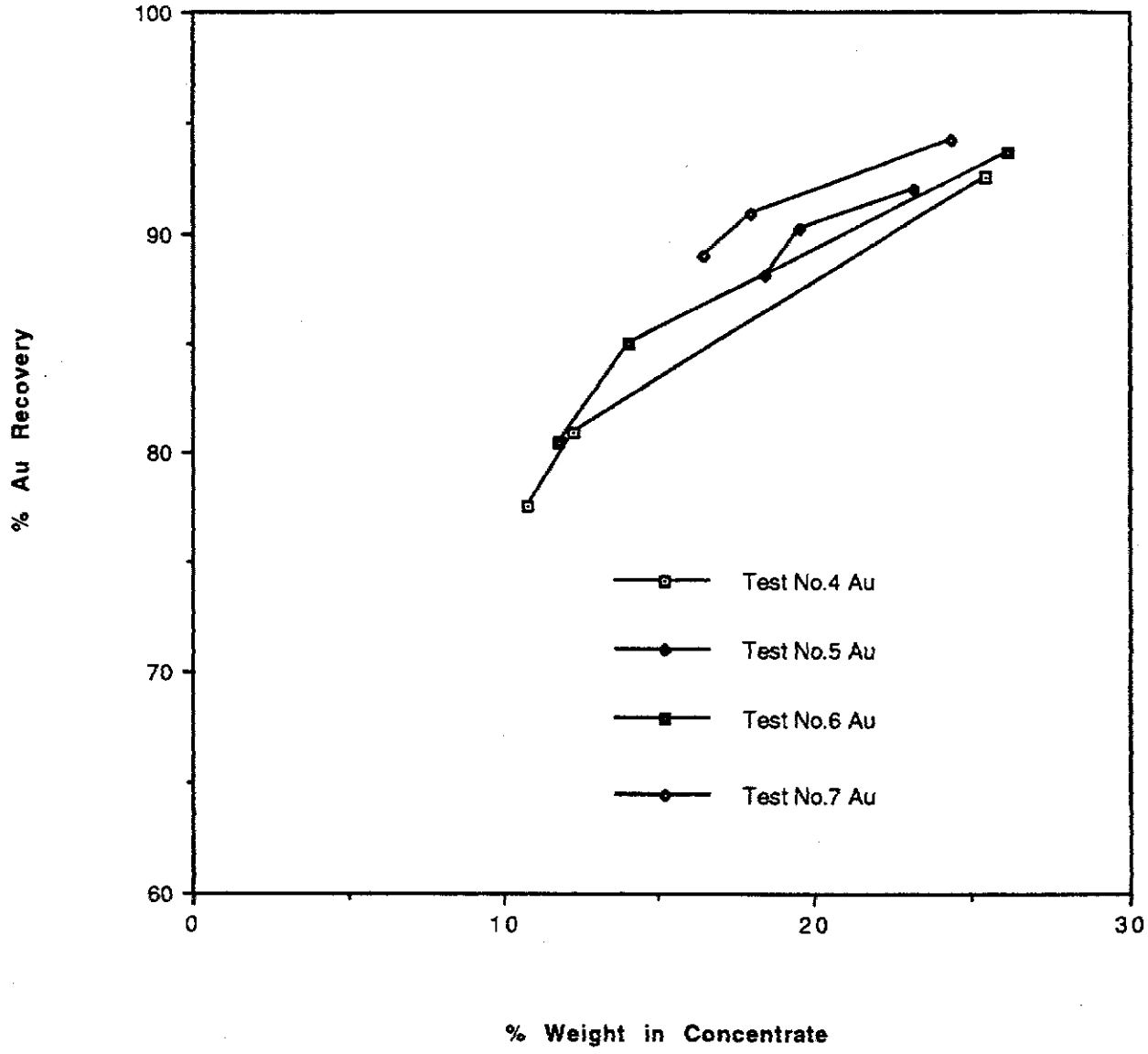
FIGURE 4-6
SKUKUM CREEK RAINBOW FLOTATION TESTS
% Au Recovery vs % Weight in Concentrate



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Test No. 4 and Test No. 6 compared the effect of adding Aerofloat 208 promoter to enhance gold recovery. With this collector gold recovery in the rougher stage increased from 92.5% to 93.7%.

Test No. 7 was done to check the effect of an ultra-fine grind (91.5% minus 200 mesh) on gold recovery. This test achieved the best rougher gold recovery (94.2%) and the best first cleaner gold recovery (90.9%) without regrinding.

With respect to silver recovery, Table 4-2 and Figure 4-5 show that silver recoveries of 95% in rougher flotation will be achievable. This high recovery is partially due to the very high silver content of the Skukum Creek Rainbow deposit.

From these test results it appears that xanthate (potassium amyl xanthate) and Aerofloat 208 promoter with Oreprep F557 frother are the required reagent conditions for flotation of a gold/silver sulphide concentrate. A total rougher flotation time of 20 minutes appears adequate under the batch testing conditions used. A primary grind of some 80% minus 200 mesh appears satisfactory to optimize rougher recoveries. One cleaning stage reduces the concentrate weight by some 5% and increases the grade to 40+ g Au/tonne (4000+ g Ag/tonne), but this is accompanied with some loss of gold and silver (approximately 2% to 3%).

A final batch flotation test (Test No. 8) was completed to confirm the selected flotation parameters for the Skukum Creek Rainbow zone composite. The results of this test are summarized in Table 4-3. The first cleaner gold and silver recoveries were 90.7% and 93.7% respectively into a first cleaner concentrate assaying 43.0 g Au/tonne (1.254 oz/ton), 4,229 g Ag/tonne (123.35 oz/ton), 0.41% Cu, 9.54% Pb, 10.4% Zn, 10.9% As, 18.5% Fe and 21.8% S.

Figure 4-7 shows that the flotation parameters used in Test No. 8, which included Aerofloat 208 promoter to enhance gold recovery, improved the gold grade/gold recovery curve compared to Test No. 6 using regrinding, and marginally improved recovery compared to Test No. 7 with no regrinding. The gold grade/silver recovery curves illustrated in Figure 4-8 show a marginal improvement in silver recovery for Test No. 8 compared to Tests No. 6 and 7. Figure 4-9 shows that Test No. 8 also achieved the best recovery at the lowest concentrate weight. Figure 4-10 compares the recoveries of gold, silver, lead, zinc and sulphur against gold grade. A similar metallurgical comparison for copper, arsenic and iron was not possible because of some assays being unavailable. In cleaner flotation there is a significant drop in lead, zinc and sulphur distributions while

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TABLE 4-3

SKUKUM CREEK RAINBOW ZONE
FLOTATION TEST NO. 8 RESULTS

Product	Weight		Assays								% Distribution							
	g	%	g Au/t	g Ag/t	% Cu	% Pb	% Zn	% As	% Fe	% S	Au	Ag	Cu	Pb	Zn	As	Fe	S
2nd Cl. Con.	323.2	16.2	45.2	4495	0.43	10.1	10.9	11.4	19.3	22.9	88.8	92.7	93	72	80	>95	70	83
2nd Cl. Tails	24.1	1.2	13.3	662	0.11	2.09	3.66	4.15	8.11	7.50	1.9	1.0	<1	1	2	<5	<1	2
1st Cl. Scav Con.	5.2	0.3	13.0	782	N/A	N/A	N/A	N/A	N/A	N/A	0.4	0.3	<1	21	9	<5	<1	5
1st Cl. Scav Tail	99.3	5.0	4.43	264	0.034	0.95	0.97	2.22	4.92	2.99	2.7	1.7	<1	2	2	<5	<1	3
Ro. Tails	1540.5	77.3	0.66	44.1	0.007	0.13	0.17	0.27	1.36	0.38	6.2	4.3	7	4	6	<5	23	7
Head (calc.)	1992.3	100.0	8.26	787	0.075	2.29	2.20	1.77	4.50	4.46	100.0	100.0	-	-	-	-	-	-
Combined Products																		
1st Cl. Conc.		17.4	43.0	4229	0.41	9.54	10.4	10.9	18.5	21.8	90.7	93.7		73	82			85
1st Cl. Tails		5.2	4.86	-	-	-	-	-	-	-	3.1	2.0		23	11			8
1st Cl. + 1st Cl Sc Conc.		17.7	42.5	-	-	-	-	-	-	-	91.1	94.0		94	91			90
Ro. Conc.		22.7	34.2	-	-	-	-	-	-	-	93.8	95.7		96	94			93

* silver balance completed using average assay for first cleaner concentrate from Tests No. 5 and 7.

N/A Not available.

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FIGURE 4-7
SKUKUM CREEK RAINBOW FLOTATION TESTS
% Au Recovery vs g Au/tonne Concentrate

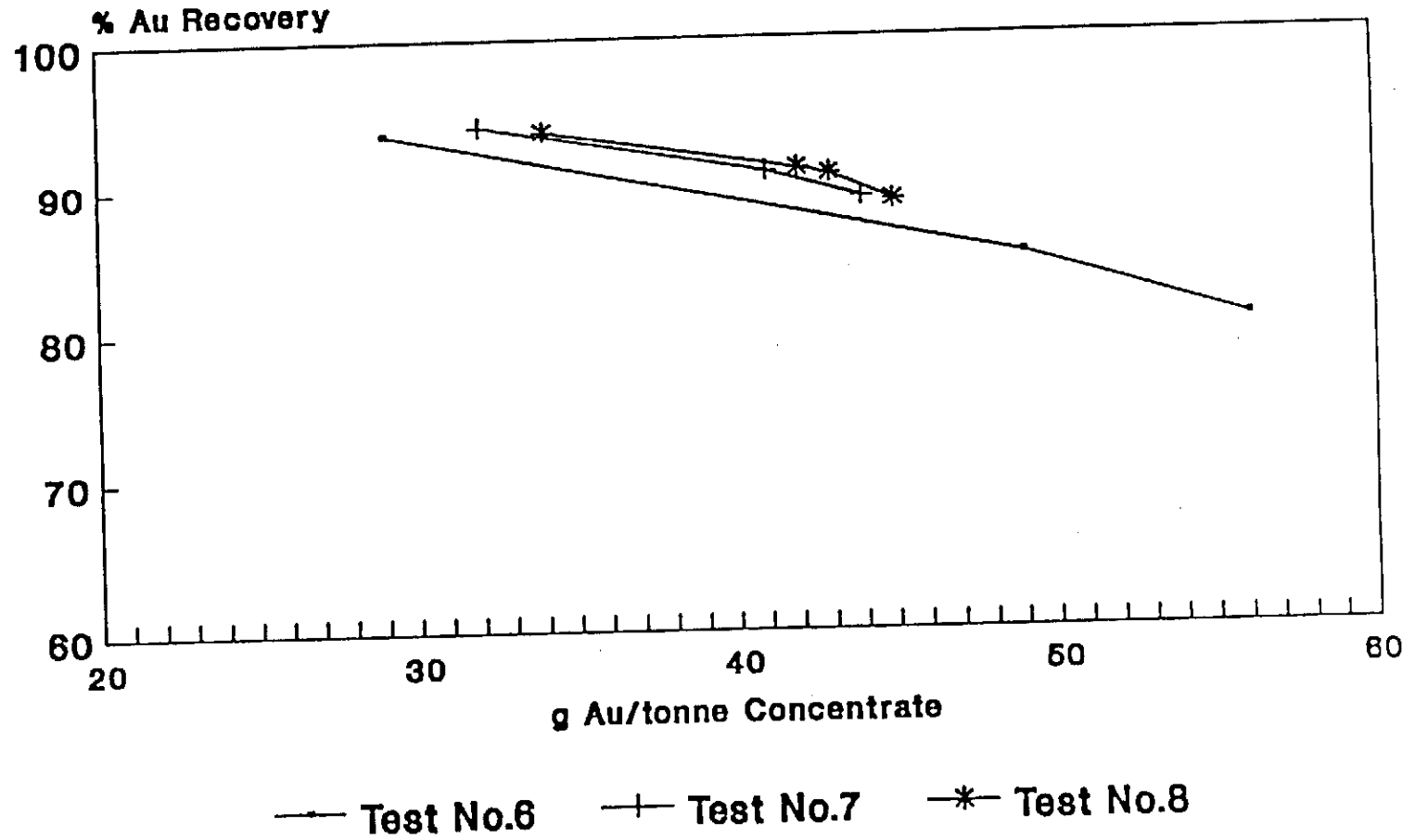

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FIGURE 4-8
SKUKUM CREEK RAINBOW FLOTATION TESTS
% Ag Recovery vs g Au/tonne Concentrate

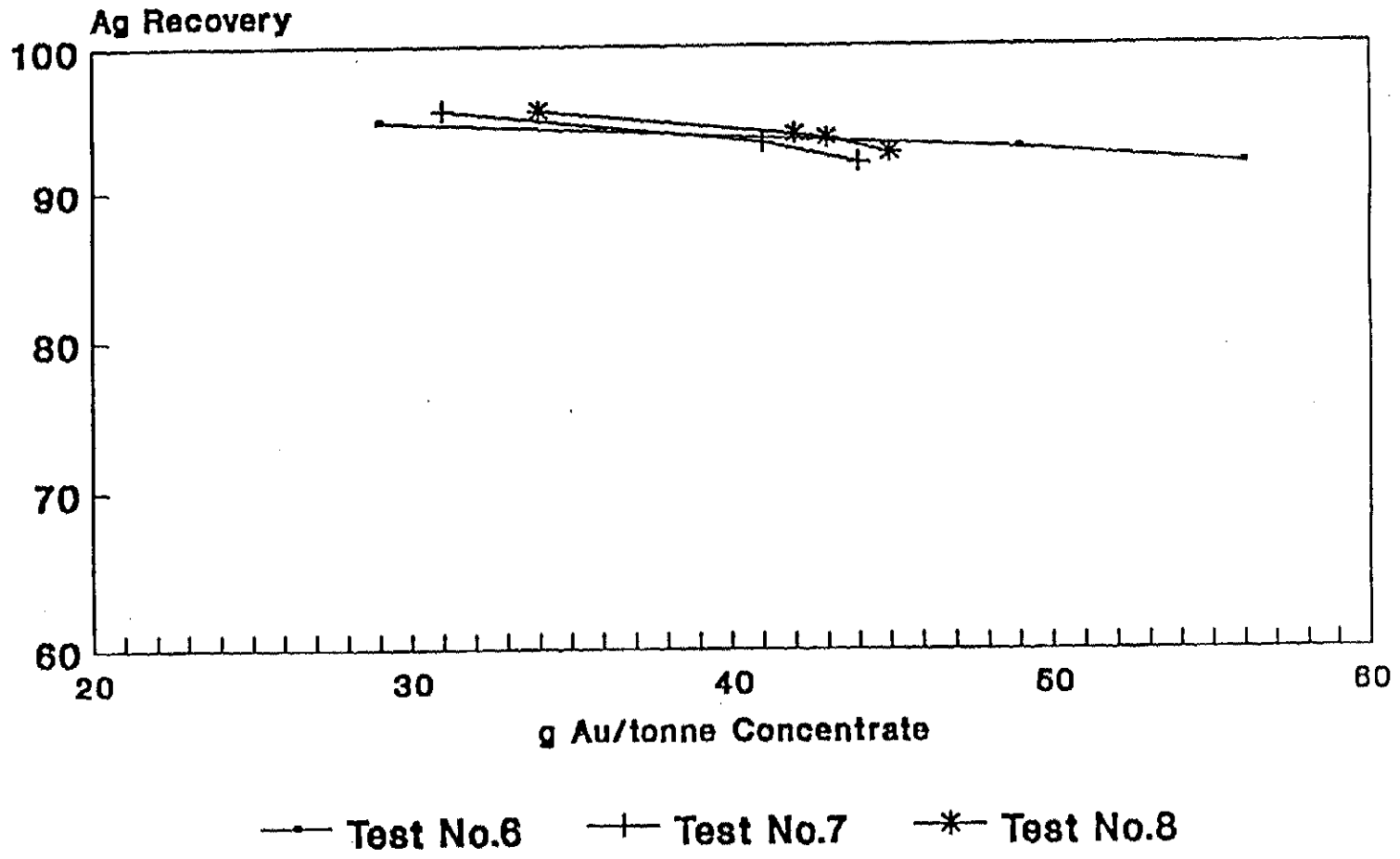

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FIGURE 4-9

SKUKUM CREEK RAINBOW FLOTATION TESTS
% Au Recovery vs % Weight in Concentrate

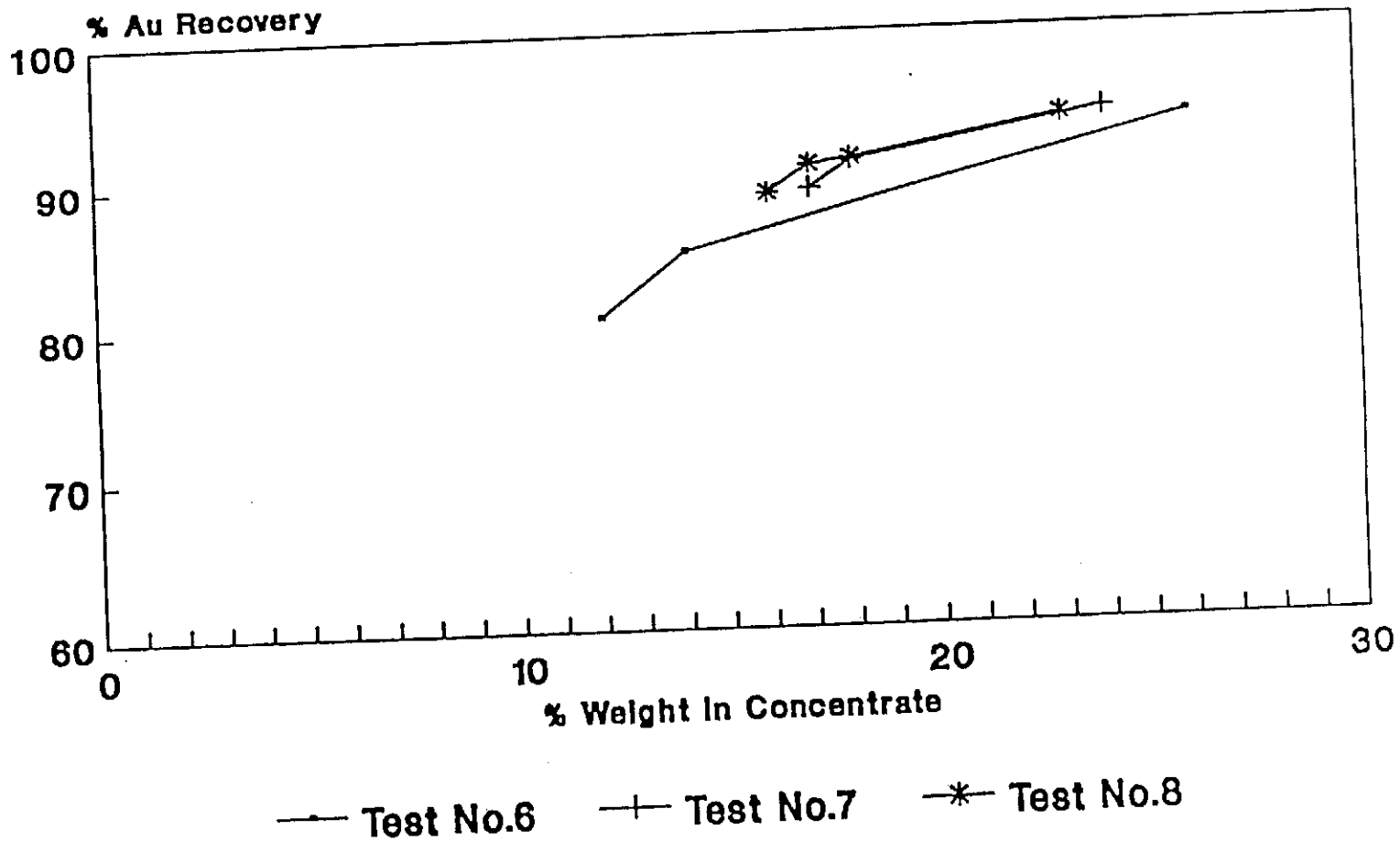

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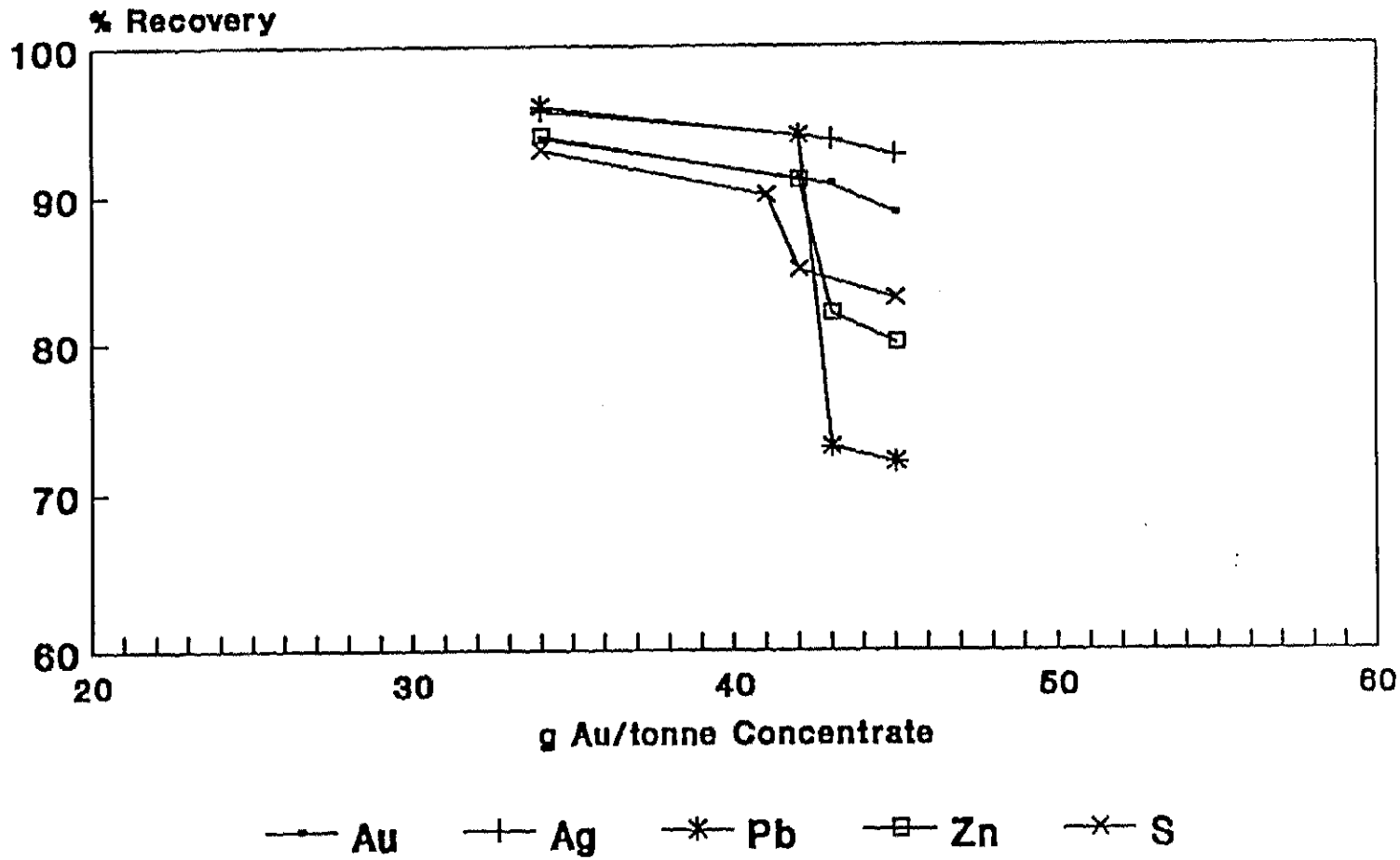
FIGURE 4-10

SKUKUM CREEK RAINBOW FLOTATION TESTS
Test No.8 - % Recovery vs g Au/tonne



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gold and silver recoveries are maintained.

Allowing for some recovery of recycle streams in a continuous operation, achievable gold and silver recoveries for the Skukum Creek Rainbow zone composite tested appear to be approximately 92% and 95% respectively.

4.3 BULK CONCENTRATE FLOTATION

The production of bulk concentrate for the purpose of bioleach testing was completed by floating a total of 145 kg of the Rainbow zone composite as 15 kg batches in a large flotation cell. Grinding to 82% minus 200 mesh was accomplished in 30 kg batches. Only one stage cleaning was used. The results of bulk flotation are summarized in Table 4-4.

A total of 24.9 kg of concentrate was produced or 17.2% of the feed weight. Gold and silver recoveries to the bulk cleaner concentrate, assaying 41.8 g Au/tonne (1.219 oz/ton) and 4,651 g Ag/tonne (135.65 oz/ton) were 89.6% and 94.2% respectively. Detailed analyses of the concentrate and the Rainbow zone composite, provided by Triton Development Corporation, are listed in Table 4-5.

4.4 BASELINE CYANIDATION TESTS

4.4.1 Composite Sample

A whole ore cyanidation test (pH 10.5, 1 g NaCN/L, 48 hours) was completed by Lakefield Research at a 60% minus 200 mesh grind to provide a reference value for the bioleach/ cyanidation testwork. The gold extraction achieved in this test, Test No. 3, was 49.8% and silver extraction was 54.2%. These low extraction values are an indication of the refractory nature of the Skukum Creek Rainbow deposit. Cyanide consumption was 2.72 kg NaCN/tonne and lime consumption was 0.29 kg $Ca(OH)_2$/tonne.

4.4.2 Concentrate

Three baseline bottle roll cyanidation tests were completed by Triton Development Corporation on 400 g test charges of the Rainbow zone concentrate to check on gold and silver extractions without bioleach pre-treatment. One test was completed on the concentrate as-received, one test was done on the concentrate ground to 100% passing 325 mesh, and one carbon-in-leach test was done to check on any preg-robbing species. Target reagent conditions in these tests were pH 11 adjusted with lime and 2 g NaCN/L free cyanide. The pulp density was 33% solids(w/w) and the total leach time was 72 hours with a three hour pre-aeration time prior to

TABLE 4-4

SKUKUM CREEK RAINBOW ZONE
BULK FLOTATION RESULTS (TEST NO. 9)

Product	Weight		Assays		% Distribution	
	g	%	g Au/t	g Ag/t	Au	Ag
Cl. Con.	24921	17.2	41.8	4651	89.6	94.2
Cl. Tails	9660	6.7	2.21	240	1.8	1.9
Ro. Tails	110597	76.2	0.90*	44.1	8.6	4.0
Head (calc.)	145178	100.0	8.01	848	100.0	100.0

* average gold assay of nine Ro. Tail samples was 0.90 g Au/tonne.

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TABLE 4-5

SKUKUM CREEK RAINBOW ZONE
HEAD AND CONCENTRATE ANALYSES

Element	Composite	Concentrate
g Au/tonne	10.2	42.9
g Ag/tonne	998	4,664
Pb, %	2.29	9.08
Zn, %	2.20	10.31
Cu, %	0.075	0.40
As, %	1.91	6.50
Fe, %	5.30	18.66
S, %	4.33	20.66
S as SO_4, %	< 0.01	< 0.01
SiO_2, %	73.7	23.8
Al, %	0.61	0.30
Ba, ppm	120	8
Bi, ppm	47	< 3
Ca, ppm	0.76	0.32
Cd, ppm	216.2	> 1,000
Co, ppm	10	13
Cr, ppm	80	31
K, %	< 0.01	< 0.01
Mg, %	0.26	0.13
Mn, ppm	1302	937
Mo, ppm	66	186
Na, %	2.42	4.80
Ni, ppm	36	78
P, ppm	0.03	0.02
Sb, ppm	378	1,711
Sn, ppm	28	74
Sr, ppm	55	20
U, ppm	< 5	< 5
W, ppm	449	< 3

cyanidation.

Test results are summarized in Table 4-6. Gold extractions were 58.1% on the concentrate as-received and 67.2% on the concentrate ground to 325 mesh. Comparative silver extractions were 39.0% and 44.9% respectively. The carbon-in-leach test did not improve extractions.

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TABLE 4-6

SKUKUM CREEK RAINBOW ZONE
RESULTS OF BASELINE CONCENTRATE CYANIDATION TESTS

Test No.	Conditions	Calc. Head		% Extraction		kg/tonne	
		g Au/t	g Ag/t	Au	Ag	NaCN	$Ca(OH)_2$
1	As-Received	43.7	5,023	58.1	39.0	6.07	1.43
2	Minus 325 Mesh	44.0	4,564	64.2	44.9	8.80	1.63
3	Carbon-in-Leach	38.5	4,559	53.3	34.8	6.22	1.33

5.0 BIOLEACHING TESTWORK

5.1 INTRODUCTION

Bioleaching testwork along with cyanidation tests on bioleach residues were completed at Triton Development Corporation's laboratory in Vancouver, B.C. using bulk concentrate produced at Lakefield Research. Triton Development Corporation's report on this work is presented in Appendix C.

Bacterial cultures were developed on samples of the Rainbow zone composite using two different TDC cultures to inoculate the pulp slurry. These developed cultures were then used to inoculate two separate samples of concentrate in shake flash tests. A very rapid increase in redox potential (emf) was observed (over 500 mV after six days) indicating that the Rainbow zone concentrate was very amenable to bacterial oxidation.

5.2 BATCH TEST

Based on the initial shake flash test results a batch tank bioleach test was initiated on 561 g of concentrate in a total pulp volume of 5.2 L. The tests was run for 25 days. The reactor was aerated with CO_2-supplemented compressed air and the pulp temperature was maintained at 35°C. Evaporative losses were compensated with additions of fresh water.

In the first 18 days of this test, the emf gradually increased to 478 mV after 9 days and then started dropping. Further inoculation was found to be necessary since an insufficient amount of inoculum was added at the start of the test which led to insufficient biomass being available to maintain the iron in the ferric state. The emf of the slurry after 18 days was 568 mV which indicate the presence of excellent oxidizing/bioleaching conditions. Iron extractions gradually increased to 32.2% after 18 days. Arsenic extractions gradually increased to 7% up to Day 7 and increased to 81% after 18 days.

Redox (emf) and pH measurements during the bioleach test are depicted graphically in Figure 5-1. The rise in pH, and drop in emf, after nine days was due to an insufficient addition of inoculating mass at the start of the bioleach. Two 1 L solution exchanges and further inoculation provided the proper bioleach conditions as noted by the increasing emf values after Day 14.

Samples of bioleach pulp after 10 days, 18 days, and on Day 25 (the end of the batch bioleach test) were submitted to bottle roll cyanidation tests

to check on gold and silver extraction efficiencies against the extent of sulphur oxidation. Sulphur assays were done on the residue after cyanidation to measure the amount of sulphur oxidation in each test.

Extraction efficiencies for various elements are summarized in Table 5-1 along with gold and silver recoveries achieved from cyanidation of the 10, 18 and 25-day bioleach pulp samples, Tests No. P1, P2 and P3 respectively. The cyanidation test results are summarized in Table 5-2. The extraction efficiencies are shown graphically on a time-dependent basis in Figures 5-2 to 5-4. Gold extraction versus arsenic and sulphur extraction is depicted in Figures 5-5 and 5-6 respectively. Silver extraction versus arsenic and sulphur extraction is depicted in Figures 5-7 and 5-8 respectively. Arsenic extraction versus sulphur destruction is shown in Figure 5-9.

These batch test results indicated that the Skukum Creek Rainbow zone gold/silver arsenopyrite concentrate was amenable to bioleach oxidation to enhance gold/silver extraction. The gold and silver extraction after 25 days was 82.0% and 68.2% respectively. It appeared that sulphur oxidation beyond 68% would be required to achieve the target gold extraction of 90% or better.

5.3 CONTINUOUS TEST

Based on the results of the batch test a laboratory scale continuous bioleach circuit was run on the remaining 21 kg of Skukum Creek Rainbow zone flotation concentrate. Pulp samples from this circuit were submitted to bottle-roll cyanidation tests. The main objectives of this final component of the Phase I test program were to:

- establish the relationship between retention time, sulphur oxidation and gold recovery,
- define conditions for optimum gold extraction,
- determine the effect of grind on gold extraction,
- confirm nutrient requirements, and
- determine the appropriate cyanidation conditions for the bioleach residue.

The laboratory scale continuous bioleach test was operated for a total of 59 days. Temperature, pH and redox measurements monitored during the test are summarized in Table 5-3.

To start the test, concentrate was added in small increments to two agitated reactors in series (volumes of 5.0 L and 2.2 L respectively) to increase the pulp density to 15% solids(w/w). Biomass inoculant was added

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TABLE 5-1

SKUKUM CREEK RAINBOW ZONE CONCENTRATE
BIOLEACH/CYANIDATION EXTRACTION EFFICIENCIES

Test No.	Day	% Weight Loss	% Extraction						
			Au	Ag	As	Fe	Cu	Zn	S^{2-}
P1	10	19.3	45.1	40.7	36.2	36.1	60.0	24.4	21.6
P2	18	25.9	68.8	44.1	72.0	45.1	69.8	31.4	23.6
P3	25	48.2	82.0	68.2	96.4	82.0	87.5	64.0	67.6

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TABLE 5-2

SKUKUM CREEK RAINBOW ZONE CONCENTRATE
RESULTS OF CYANIDATION TESTS ON BIOLEACH RESIDUE

Test No.	Day	Calc. Head*		% Extraction		kg/tonne**	
		g Au/t	g Ag/t	Au	Ag	NaCN	$Ca(OH)_2$
P1	10	44.0	4,600	45.1	40.7	4.54	25.3
P2	18	47.4	5,080	68.8	44.1	5.38	28.4
P3	25	66.8	6,566	82.0	68.2	7.87	26.5

* calculated head of bio-leach residue feed to cyanidation. Increasing head grade is due to increasing weight loss from Day 10 to Day 25, namely 19.3%, 25.9%, 48.2%.

** reagent consumptions in kg/tonne of concentrate.

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TABLE 5-3

SKUKUM CREEK RAINBOW ZONE CONCENTRATE
CONTINUOUS BIOLEACH TEST CONDITIONS

Date	Day	Reactor No. 1 (5.0 L)						Reactor No. 2 (2.2 L)						% Solids (w/w)
		Temp(°C)	pH	emf (mV)	$Ca(OH)_2$(g)	g Fe/L	g As/L	Temp (°C)	pH	emf (mV)	$Ca(OR)_2$(g)	g Fe/L	g As/L	
May														
11		32.1	2.06					30.0	2.11					5.0
12	0	34.7	1.82					32.2	1.88					5.0
13	1	34.2	2.00	331				34.7	1.88	338				5.0
14	2	34.7	1.81	358				34.5	1.75	344				5.0
15	3	34.6	1.67	422				34.8	1.63	409				5.0
17	5	34.3	1.63	632				34.3	1.71	573				5.0
18	6	34.9	1.52	642				34.5	1.56	642				5.0
19	7	35.0	1.37	670				34.9	1.47	662				5.0
20	8	35.1	1.31	680				34.7	1.41	673				5.0
21	9	35.3	1.28	684				34.4	1.39	676				6.0
23	11	35.4	1.20	694				34.9	1.27	684				8.0
25	13	35.3	1.09	683				34.3	1.28	686				10.0
26	14	35.5	1.06	673				34.4	1.28	659				12.0
27	15	35.9	1.09	688				34.2	1.23	675				12.0
28	16	35.9	1.07	667				34.8	1.20	640				15.0
30	18	36.4	1.40	614				34.3	1.20	656				15.0
31	19	36.3	1.40	590		19.26	10.27	33.6	0.98	650		23.22	12.66	15.0
June														
1	20	36.5	1.41	592				33.7	0.96	651				15.0
2	21	37.0	1.33	570		18.51	11.10	33.4	0.95	653		25.35	14.10	15.0
3	22	36.1	1.24	584				33.9	0.93	648				15.0
4	23	36.0	1.13	584				33.2	0.90	644				15.0
7	26	36.1	1.15	535		12.80	7.30	33.9	0.89	593		19.20	8.80	15.0
8	27	36.6	1.19	560				33.7	0.91	613				15.0
9	28	26.0	1.23	536				33.5	0.96	608				15.0
10	29	34.5	1.40	511		11.90	7.70	33.4	1.11	600		18.00	8.70	15.0
11	30	34.4	1.35	513	40			34.2	0.97	604	40			15.0
12	31	33.3	1.79	520				34.6	1.65	590				15.0
13	32	33.6	1.67	571				34.8	1.56	613				15.0
14	33	33.5	1.40	558		10.80	7.00	34.3	1.23	609		20.70	9.40	15.0
15	34	33.6	1.33	582	30			34.9	1.10	629	32			15.0
16	35	34.0	1.63	587				34.9	1.66	610				15.0
17	36	34.1	1.42	600	20	16.30	11.40	34.2	1.37	633	20	21.40	14.10	15.0
18	37	34.0	1.34	600	20			34.0	1.45	626	10			15.0
20	39	35.0	1.15	609	30			34.6	1.15	638	20			15.0
21	40	34.5	1.25	612		20.80	14.30	34.5	1.33	635		23.70	14.50	15.0
22	41	34.2	1.50	554	30			34.2	1.70	500	10			15.0
23	42	36.2	1.53	531	40			34.7	1.16	613	20			15.0
24	43	30.2	0.89	650				34.9	1.39	610				15.0
25	44	34.4	1.50	526				34.4	1.37	641				15.0
27	46	35.6	1.31	550				-	-	-				15.0
28	47	35.9	1.20	580	30	18.30	11.70	34.5	1.15	681	20	25.40	12.60	15.0
29	48	35.7	1.01	617	40			34.5	1.27	666				15.0
30	49	35.6	1.33	607				34.3	1.31	651				15.0

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TABLE 5-3 (continued)

SKUKUM CREEK RAINBOW ZONE CONCENTRATE
CONTINUOUS BIOLEACH TEST CONDITIONS

Date	Day	Reactor No. 1 (5.0 L)						Reactor No. 2 (2.2 L)						% Solids (w/w)
		Temp (°C)	pH	emf (mV)	$Ca(OH)_2$(g)	g Fe/L	g As/L	Temp (°C)	pH	emf (mV)	$Ca(OH)_2$(g)	g Fe/L	g As/L	
July														
2	52	35.8	0.89	643	50	22.10	8.80	34.1	0.91	673	30	23.30	12.40	15.0
5	54	35.8	1.37	632				34.9	1.53	661				15.0
6	55	35.9	1.26	646		21.10	11.30	33.5	1.38	666		23.40	13.10	15.0
7	56	36.0	1.22	621	30			34.0	1.32	633				15.0
8	57	35.9	1.40	624				33.5	1.38	661				15.0
9	58	36.0	1.34	627		33.80	15.40	33.5	1.40	660		37.40	17.00	15.0
10	59	36.2	1.14	625		29.20	13.20	34.2	1.11	627		34.70	14.80	15.0

Notes:
1. 18.4 g conc. H_2SO_4 added to Reactor No. 1 at start of test and 9.2 g conc. H_2SO_4 added to Reactor No. 2.
2. Half of pulp in each reactor replaced with ground concentrate feed pulp on Day 41 after samples of unground concentrate bio-leach residue were removed from each reactor for cyanidation testing.

FIGURE 5-1
CONCENTRATE BATCH BIOLEACH TEST
pH and Redox vs Time

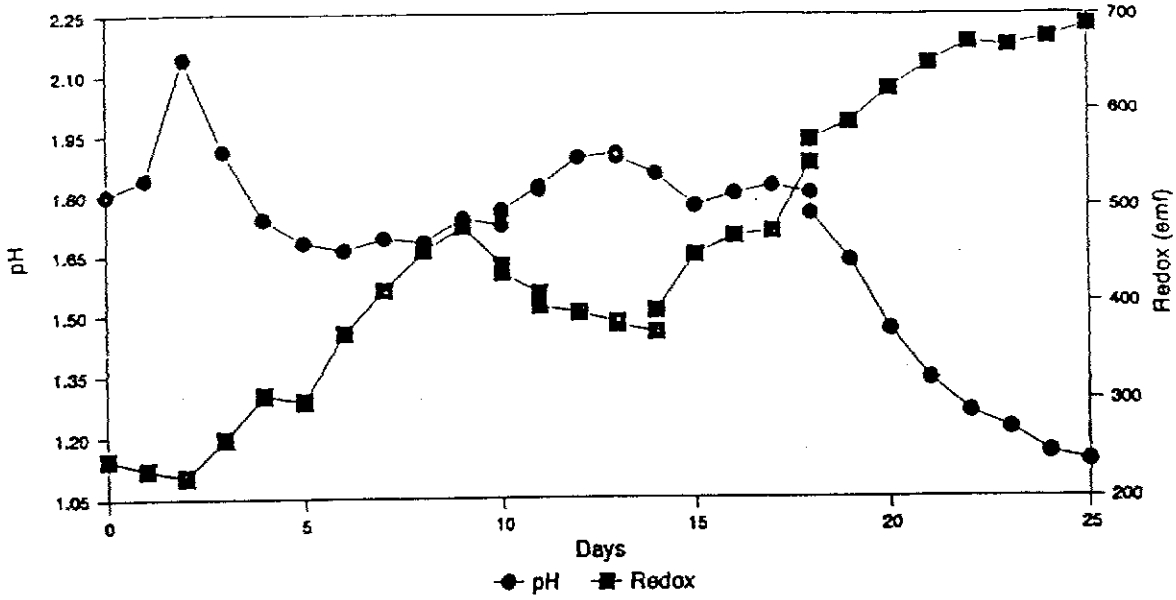

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FIGURE 5-2
CONCETRATE BATCH BIOLEACH TEST
S and As Extraction vs Time

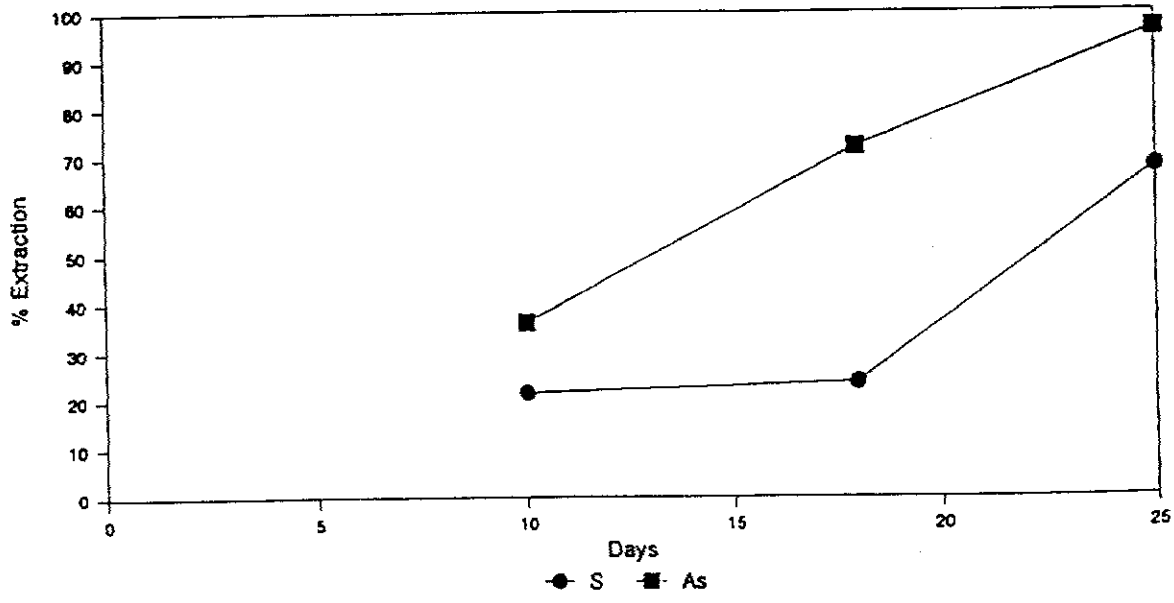

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FIGURE 5-3
CONCENTRATE BATCH BIOLEACH TEST
S, Fe, Zn and Cu Extraction vs Time

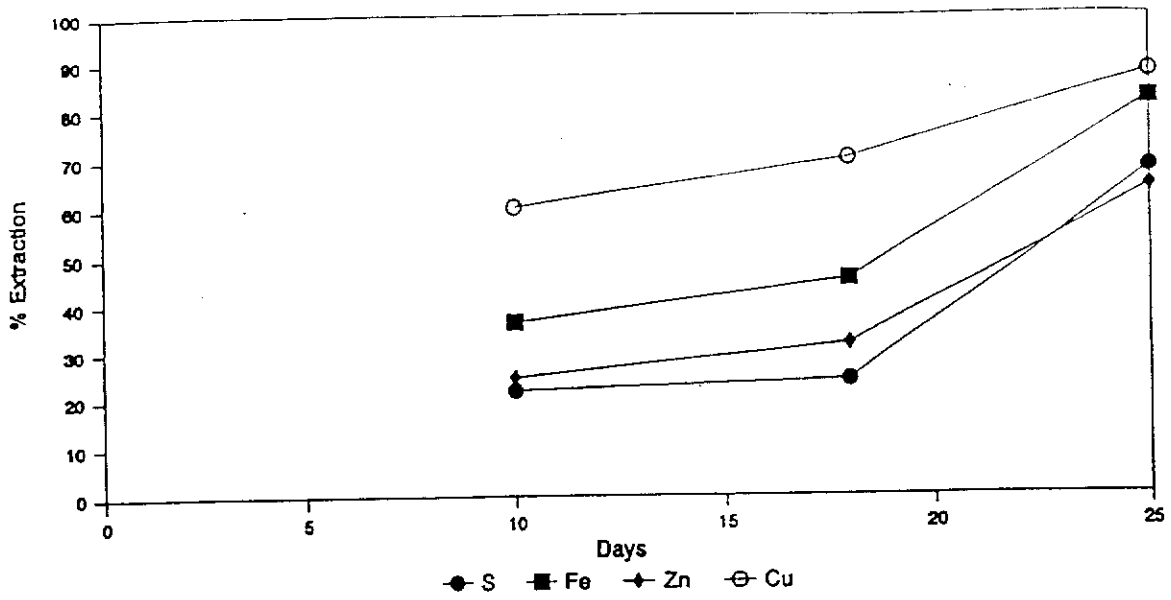

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FIGURE 5-4
CONCENTRATE BATCHS BIOLEACH TEST
Au and Ag Extraction vs Time

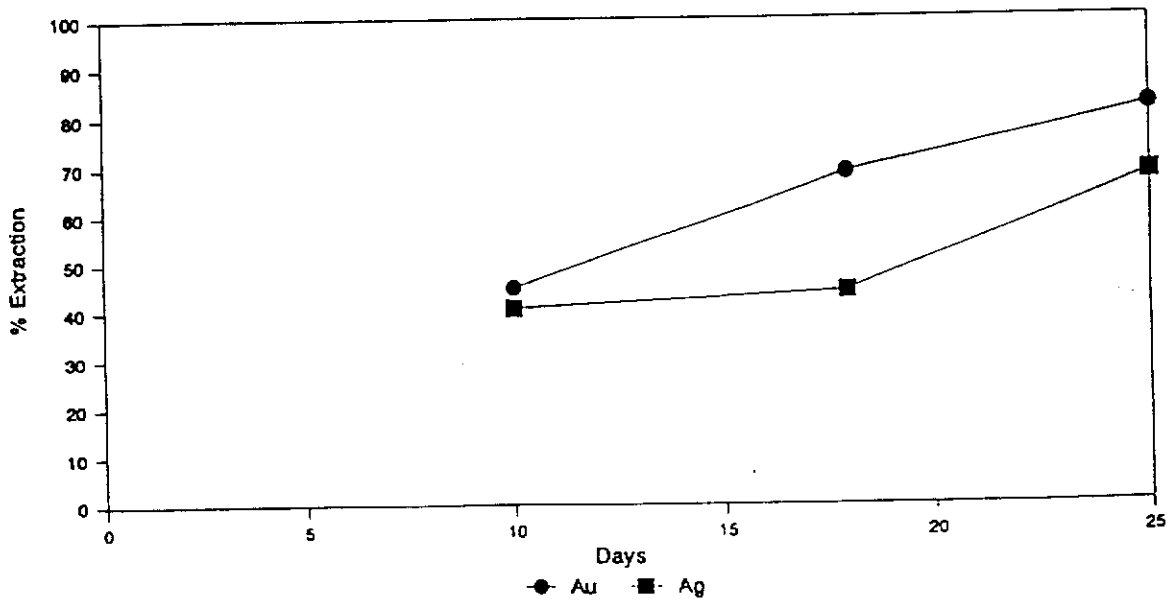

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FIGURE 5-5

CONCENTRATE BATCH BIOLEACH TEST
Au Extraction vs As Extraction

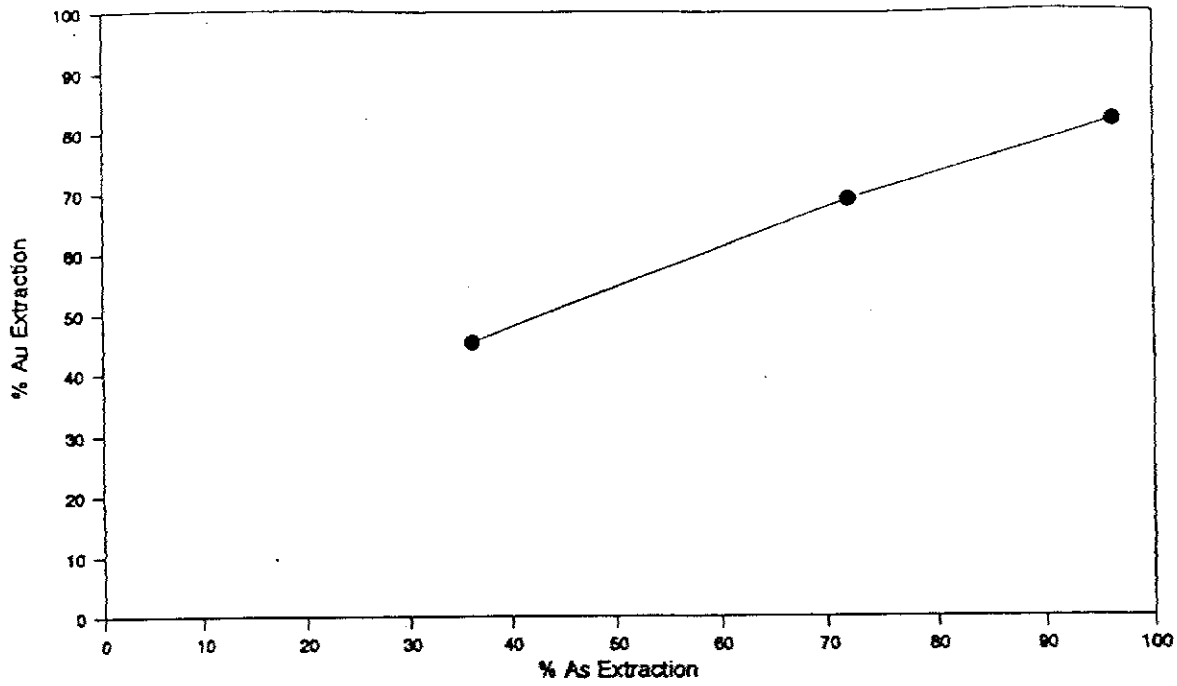

FIGURE 5-6

CONCENTRATE BATCH BIOLEACH TEST
Au Extraction vs S Destruction

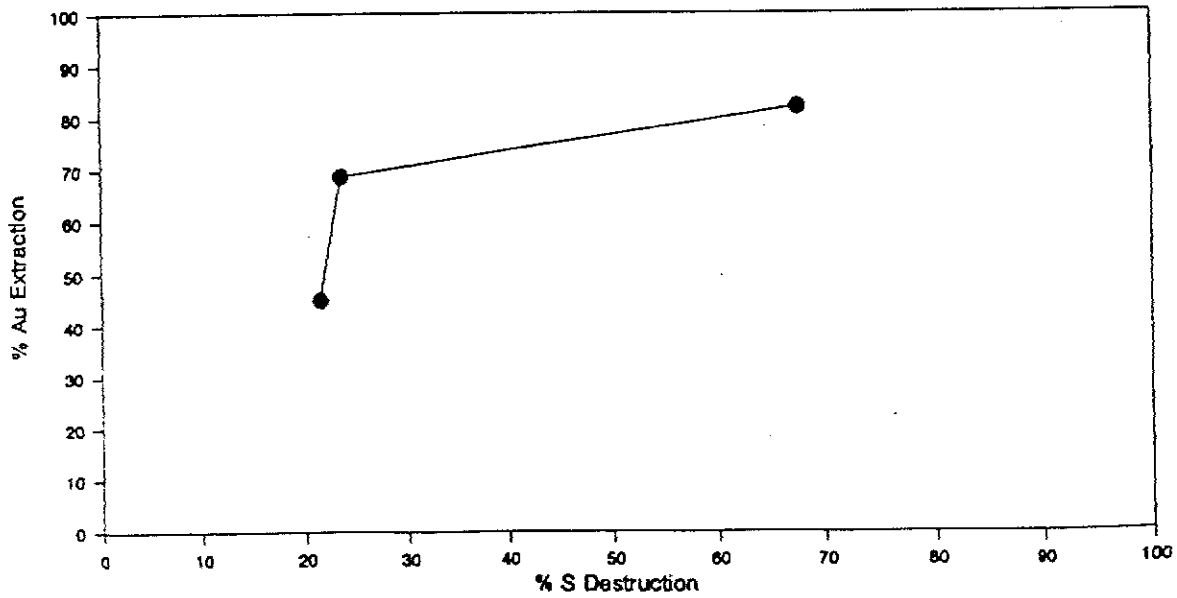

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FIGURE 5-7

CONCENTRATE BATCH BIOLEACH TEST
Ag Extraction vs As Extraction

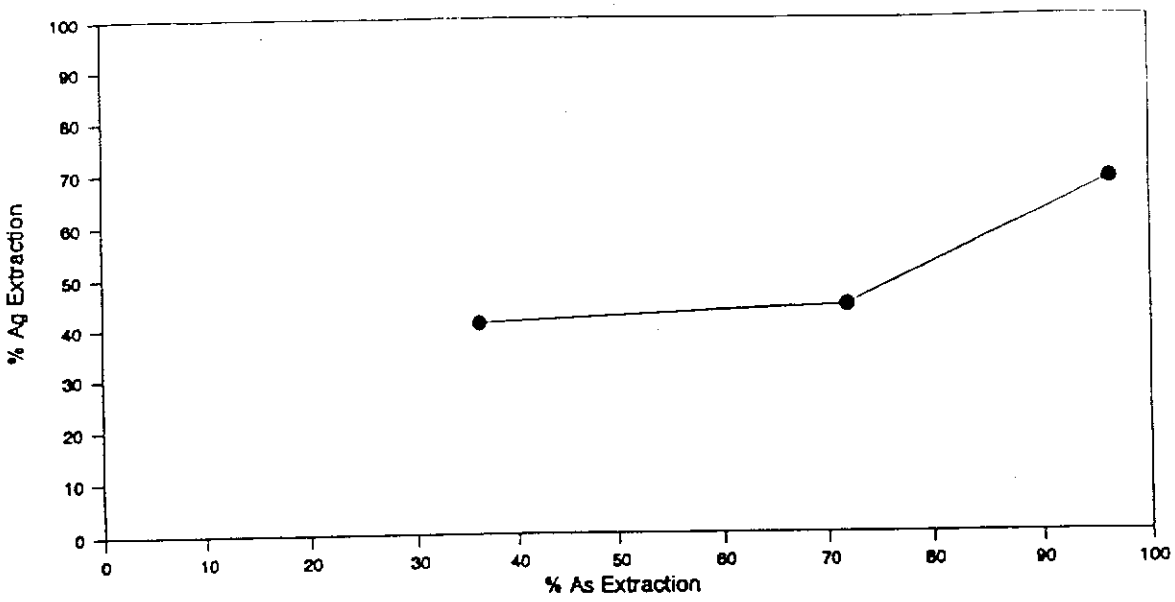

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FIGURE 5-8

CONCENTRATE BATCH BIOLEACH TEST
Ag Extraction vs S Destruction

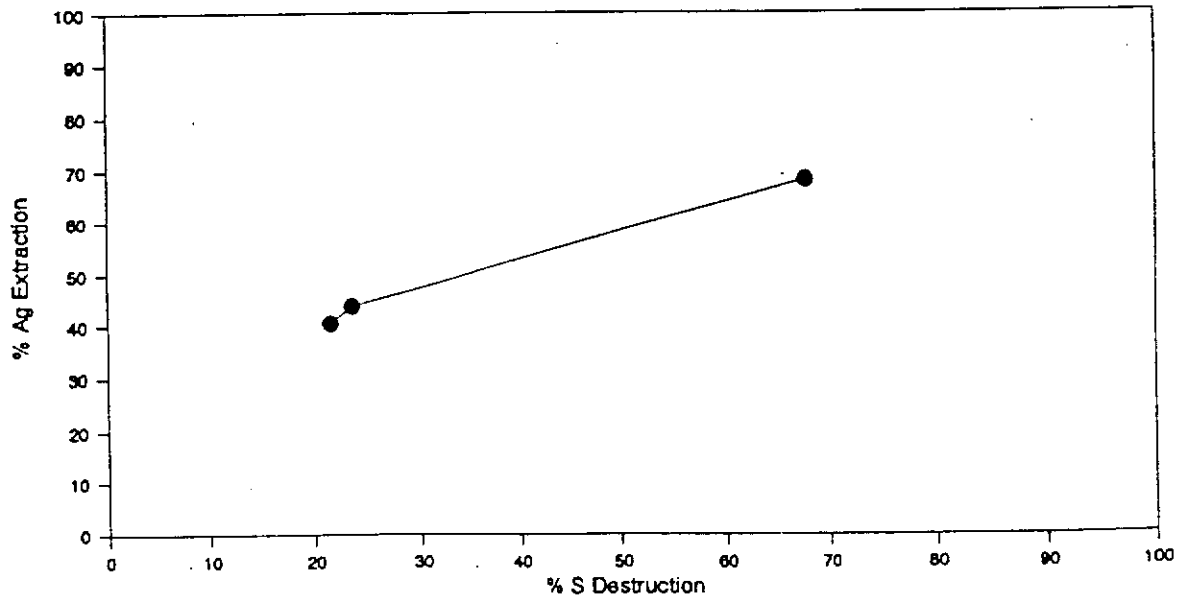

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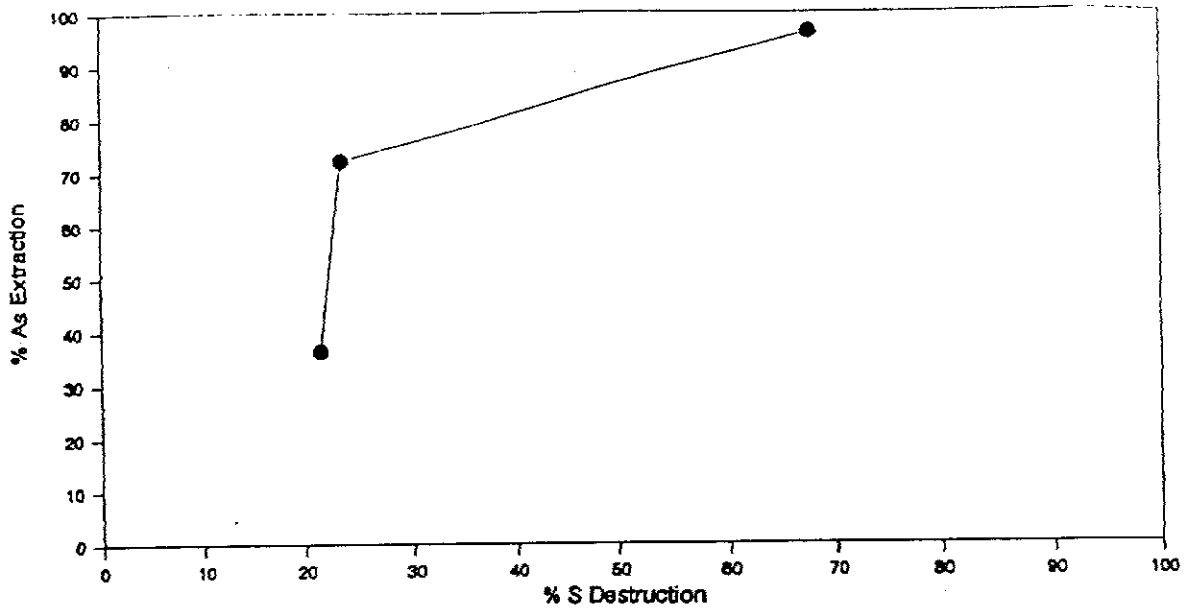
FIGURE 5-9

CONCENTRATE BATCH BIOLEACH TEST

S Destruction vs As Extraction



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at the start of the test. Over 14 days this allowed the biomass to develop and prepare the pulp for continuous feeding of concentrate slurry through the two reactors. Excellent bio-oxidation conditions developed as noted in the measurements listed in Table 5-3 (low pH and high redox values). The pH was maintained at greater than pH 1.2 for optimum thiobacillous ferroxidan activity, the sulphur oxidizing bacteria.

Continuous feeding of concentrate slurry was initiated on Day 15. The concentrate was added to the feed tank on an as-received basis, diluted to 15% solids(w/w) pulp density. A 5-day total retention time in the two reactors (7.2 L total volume) was equal to 15 seconds of slurry flow every two hours. This initial flowrate was changed to provide a 6-day total retention time in the two reactors in order to ensure maximum sulphur oxidation.

Based on the requirement of a 3-fold pulp exchange in the reactors, the bio-oxidation circuit was fed on a continuous basis for 18 days (3 times 6 days). After 18 days (Day 41) the first reactor, representing a 4-day bioleach retention time, was sampled to provide a 1 L pulp sample (approximately 100 g of concentrate residue with weight loss taken into account) for cyanidation testing. The second reactor, representing a 6-day bioleach retention time, was also sampled in the same way.

Bioleaching of ground concentrate was tested after Day 41. Once the above pulp sampling was completed, the feed concentrate was ground to >99% passing 325 mesh before adding to the 15% solids(w/w) slurry feed tank. The bio-oxidation circuit was run on a continuous basis for an additional 18 days (3 times 6 days) to provide three pulp exchanges by Day 59 (41 + 18). Stable conditions of low pH and high redox potentials were maintained in both reactors. Lime was added to both reactors periodically to control pH. Weekly dissolved oxygen measurements from Day 30 onwards indicated consistent oxygen levels of 5 to 7 ppm in both reactors. On Day 59 the slurry in the first and second reactors was sampled to provide 4-day and 6-day ground residues for cyanidation testing.

Analytical monitoring (As, Fe) was done twice per week with arsenic assays done by atomic absorption. The arsenic and iron analyses are listed in Table 5-3. Monitoring of emf and pH was done on a regular basis as listed in Table 5-3. Sulphur assays were done on cyanidation residues to quantify sulphur oxidation.

The bioleach oxidation results are summarized in Table 5-4. The weight loss during bioleach oxidation was determined by the increase in silica measured in the bioleach residue. For the unground concentrate feed the

TABLE 5-4

SKUKUM CREEK RAINBOW ZONE CONCENTRATE
SUMMARY OF CONTINUOUS BIOLEACHING RESULTS

Concentrate Feed	Reactor No.	Bio-Leach Retention (days)	Residue % SiO_2	% Weight Loss In Bio-Leach	% Extraction As	Cu	Fe	Pb	Zn	S^{-2}
Unground	1	4	38.44	38.09	91.9	59.8	61.5	35.9	46.6	46.8
	2	6	56.04	57.53	98.8	80.9	86.3	61.6	73.6	78.4
Ground	1	4	32.30	26.32	86.4	87.1	82.9	-	88.4	90.3
	2	6	32.84	27.53	89.3	85.5	88.7	19.4	87.9	93.7

weight loss in bioleaching was 38.1% in Reactor No. 1 (4-day retention time) and 57.5% in Reactor No. 2 (6-day retention time). The levels appear anomalously high when compared to the ground concentrate weight loss of 26.32% for Reactor No. 1 (4-day retention time) and 27.53% for Reactor No. 2 (6-day retention time).

Sulphide extraction was greatly improved when using ground concentrate as feed to the bioleach circuit. Extractions of 90.3% for Reactor No. 1 and 93.7% for Reactor No. 2 were achieved using ground concentrate feed versus extractions of 46.8% for Reactor No. 1 and 78.4% for Reactor No. 2 when feeding unground concentrate to the bioleach circuit.

Arsenic extraction for ground concentrate (86.4%) was lower than the arsenic extraction for unground concentrate (91.9%) for the 4-day retention time. In the case of the 6-day retention time (Reactor No. 2) the arsenic extraction was 89.3% for the ground concentrate and 98.8% for the unground concentrate.

Metal extractions of copper, iron and zinc for the ground concentrate (82.9% to 88.4%) were higher than those for the unground concentrate (46.6% to 86.3%). Lead extraction for the unground concentrate was higher than the extraction for the ground concentrate.

5.4 CYANIDATION OF BIOLEACH RESIDUE FROM CONTINUOUS TEST

5.4.1 Introduction

Gold and silver cyanide extraction tests were carried out on 4-day retention time bioleach residue (Reactor No. 1) and 6-day retention time bioleach residue (Reactor No. 2) from unground concentrate feed and ground concentrate feed. Leaching conditions and results are summarized in Table 5-5.

Standard bottle-roll cyanidation tests were done on the 4-day and 6-day unground bioleach residue and on the 4-day and 6-day pre-ground bioleach residue. The bioleach residue was washed 3 times with water by vacuum filtration and then pre-aerated at 33% solids(w/w) at pH 10.5-11 for eight hours. Cyanidation was done for a total of 72 hours on the unground residue and 48 hours on the ground residue. A small pulp sample (pregnant solution) was taken from each test to provide an indication of gold extraction kinetics.

Gold and silver metallurgical accounting was completed on these cyanidation tests, along with assaying of sulphate sulphur, sulphide

MELIS ENGINEERING LTD.
Project No. 270
October 2, 1993

TABLE 5-5

SKUKUM CREEK RAINBOW ZONE CONCENTRATE
SUMMARY OF BIOLEACH RESIDUE CYANIDATION TESTS

Test No.	Reactor	Bio-Leach Retention Time (days)	Reactor Solids Assay g Au/t	Reactor Solids Assay g Ag/t	Reactor Solids Calculated (4) g Au/t	Reactor Solids Calculated (4) g Ag/t	Bio-Leachate(5) mg Au/L	Bio-Leachate(5) mg Ag/L	% Loss to Bioleachate (5) Au	% Loss to Bioleachate (5) Ag	Cyanide Residue g Au/t	Cyanide Residue g Ag/t	% Cyanide Extraction(6) Au	% Cyanide Extraction(6) Ag	Cyanidation Time (hours)	pH
As-Received Unground Concentrate																
CP1-1	Reactor No. 1	4	69.23(1)	7534(1)	60.18	6034	0.29	43	4.4	6.5	8.61	2680	92.5(7)	61.7 (7)	45	11.0
CP1-2	Reactor No. 2	6	51.01(2)	9180(2)	48.59	5334	1.20	51	33.0	12.8	3.78	1670	70.9(7)	70.4 (7)	45	11.0
Concentrate Ground to 99% -325 mesh (45 um)																
CP2-1	Reactor No. 1	4	58.17(1)	6330(1)	43.02	4411	0	49	0	8.6	4.80	690	92.4	88.0 (8)	48	10.0
CP2-2	Reactor No. 2	6	33.76(3)	2969(3)	43.44	5397	1.00	88	18.0	12.7	7.03	2080	69.9(9)	52.2 (9)	48	10.2
CP2-3	Reactor No. 2	6	33.76(3)	2969(3)	32.75	3283	1.00	88	23.9	21.0	4.96	713	61.0(10)	57.3 (10)	48	10.5
CP2-4	Reactor No. 2	6	33.76(3)	2969(3)	43.72	4739	1.00	88	18.0	14.6	3.60	610	73.8	82.8 (11)	48	10.6

Test No.	Cyanide Feed	Target Free Cyanide g NaCN/L	Reagent Consumption (12) kg NaCN/t	Reagent Consumption (12) kg $Ca(OH)_2$/t
As-Received Unground Concentrate				
CP1-1	Reactor No. 1	2	27.9	15.1
CP1-2	Reactor No. 2	2	25.3	14.8
Concentrate Ground to 99% -325 mesh (45 um)				
CP2-1	Reactor No. 1	0.94	13.7	45.9
CP2-2	Reactor No. 2	0.19	6.0	32.8
CP2-3	Reactor No. 2	0.38	7.3	32.0
CP2-4	Reactor No. 2	0.94	12.5	31.2

Notes:

1. Reactor No. 1 solids assay head at the end of bio-leach for Test No. CP1-1 determined from concentrate head assay and weight loss during bio-leach (includes gold and silver lost to bioleachate solution).
2. Reactor No. 2 solids assay head at end of bio-leach for Test No. CP1-2 determined from Reactor No. 1 residue assay (35 g Au/t and 8,500 g Ag/t) and adding gold and silver lost to bioleachate solution.
3. Reactor No. 2 solids assay at end of bio-leach for Tests No. CP2-2 to CP2-4 determined from Reactor No. 1 residue assay (33.2 g Au/t and 2,920 g Ag/t) and incremental weight loss during bio-leach in second reactor (includes gold and silver lost to bioleachate solution).
4. Calculated head for reactor solids at end of bio-leach calculated from total gold and silver extracted (including losses to bioleachate solution and gold/silver in cyanide solution) and gold and silver remaining in cyanidation residue.
5. From analysis of bio-leachate solution. Some of the apparent soluble gold and silver losses could be in the form of ultrafine suspended solids.
6. Cyanide extraction values also include solution losses to sampling and assaying. Represents total gold and silver recovered to cyanide solution.
7. Re-precipitation of gold and silver occurred at the end of the 72-hour cyanide leach with gold and silver cyanide extraction dropping to 81.3% and 49.1% respectively for Test No. CP1-1 (from 92.5% cyanide extraction for gold and 61.7% cyanide extraction for silver after 45 hours) and to 59.2% and 55.9% respectively for Test No. CP1-2 (from 70.9% cyanide extraction for gold and 70.4% cyanide extraction for silver after 45 hours).
8. Silver cyanide extraction after 24 hours was 88.0%, decreasing to 75.8% after 48 hours.
9. Silver cyanide extraction after 8 hours was 52.2%, decreasing to 50.3% and 48.7% after 24 hours and 48 hours respectively. Gold cyanide extraction after 24 hours was 69.9%, decreasing to 65.8% after 48 hours.
10. Test No. CP2-3 was a carbon-in-leach test using 20 g/L activated carbon. Recovery to carbon was 54.9% for gold and 44.4% for silver.
11. Silver cyanide extraction after 24 hours was 82.8%, decreasing to 72.5% after 48 hours.
12. Reagent consumptions given as kg per metric tonne of cyanidation feed.

sulphur, and total sulphur on the residue.

5.4.2 Unground Concentrate Bioleach Residue

Leaching of the bioleach residue produced from unground concentrate was carried out for a total of 72 hours with a target cyanide concentration of 2 g NaCN/L (Tests No. CP1-1 and CP1-2 listed in Table 5-5). Cyanide consumptions were high at 27.9 kg/tonne of cyanidation feed for Reactor No. 1 bioleach residue and 25.3 kg/tonne of cyanidation feed for Reactor No. 2 bioleach residue.

After 45 hours of cyanidation leach time some reprecipitation of silver and gold was observed by the drop in extraction efficiencies observed for the 72-hour samples. The gold and silver extraction efficiencies after 45 hours of cyanidation time were 92.5% and 61.7% respectively for a 4-day bioleach retention time and 70.9% and 70.4% respectively for a 6-day bioleach retention time. Gold and silver losses to the bioleach solution resulted from the extended 6-day bioleach retention time.

5.4.3 Ground Concentrate Bioleach Residue

A 48-hour cyanide leach was used on the ground concentrate bioleach residue (Tests No. CP2-1, CP2-2, CP2-3 and CP2-4 listed in Table 5-5). The decrease in free cyanide concentration to 0.5 g CN^-/L (0.94 g NaCN/L) in the ground concentrate tests reduced cyanide consumption. A cyanide consumption of some 10 to 15 kg NaCN/tonne of cyanidation feed is indicated from these results. Lime consumption increased for the ground concentrate to 46 kg $Ca(OH)_2$/tonne of cyanidation feed for the Reactor No 1 residue test and 32 kg $Ca(OH)_2$/tonne of cyanidation feed for the Reactor No. 2 residue tests.

With a 4-day bioleach on ground concentrate gold and silver extractions from bioleach residue were 92.4% and 88.0% respectively. With a 6-day bioleach on ground concentrate gold and silver extractions were 73.8% and 82.8% respectively. Gold and silver losses to the bioleach solution resulted from the extended 6-day retention time. A fire assay of Reactor No. 2 supernatant (bioleach solution) revealed gold and silver concentrations of 0.60 ppm and 88 ppm respectively in the bioleach solution.

6.0 CONCLUSIONS

For the Skukum Creek Rainbow zone composite tested achievable flotation recoveries appear to be 92% for gold and 95% for silver. Depending on ore head grades flotation concentrate grades will be approximately 40 to 45 g Au/tonne and 4,000 to 5,000 g Ag/tonne.

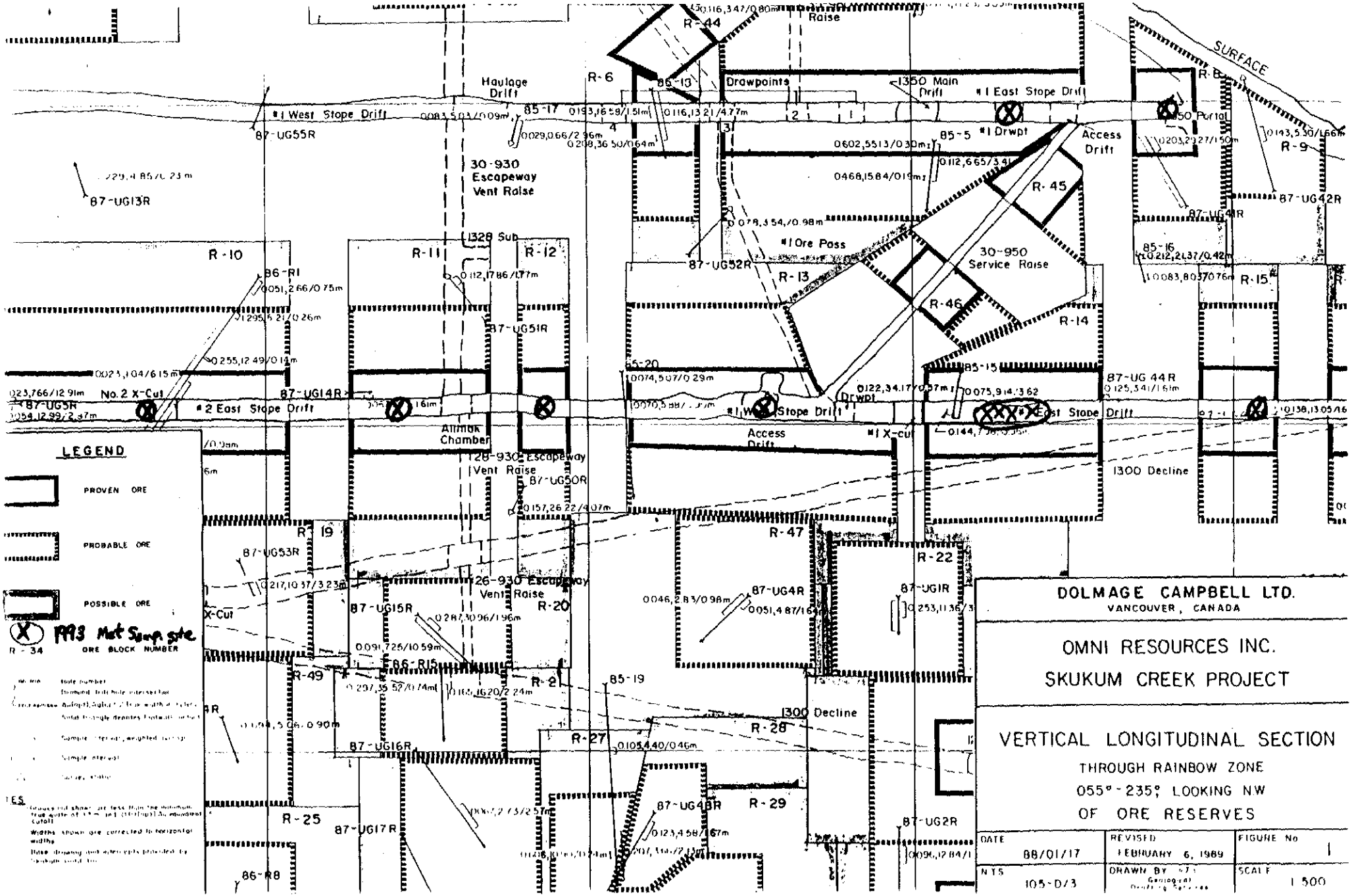
From the results presented in Section 5.0 it appears that a 4-day bioleach retention time on Skukum Creek Rainbow zone flotation concentrate provides adequate dissolution of sulphides to render contained refractory gold and silver amenable to cyanide extraction. Extended bioleaching (6-day retention time) appears to result in losses of gold and silver to the bioleachate solution which in turn leads to poorer cyanide extraction efficiencies.

Regrinding of concentrate to 99% minus 45 micrometers (325 mesh) appears to be a requirement, at least in terms of achieving acceptable silver extractions. The optimum mesh-of-grind for ground concentrate was not established in this phase of the test program.

Achievable cyanide extractions on washed bioleach residue appear to be 92% for gold and 88% for silver. These extraction values will need to be confirmed in the second phase of work planned for this test program. Suitable cyanidation conditions appear to be a 36 to 48-hour leach retention time on washed bioleach residue, pH 10 to 10.5, a target cyanide concentration of 1 g NaCN/L, and reagent consumptions of 10 to 15 kg NaCN/tonne of cyanidation feed and 35 to 45 kg $Ca(OH)_2$/tonne of cyanidation feed.

APPENDIX A

Skukum Creek Rainbow Zone Composite - Sample Location Map



LEGEND

PROVEN ORE

PROBABLE ORE

POSSIBLE ORE

R-34 ORE BLOCK NUMBER

DOLMAGE CAMPBELL LTD.
VANCOUVER, CANADA

OMNI RESOURCES INC.
SKUKUM CREEK PROJECT

VERTICAL LONGITUDINAL SECTION
THROUGH RAINBOW ZONE
055° - 235°, LOOKING N.W
OF ORE RESERVES

DATE	REVISED	FIGURE No
88/01/17	FEBRUARY 6, 1989	1
NTS 105-D/3	DRAWN BY [illegible] Geological	SCALE 1:500

APPENDIX B

Lakefield Research Test Data

Test No. 1 Project : 4432 Date : March 2/93
Operator: Jim

Purpose: To perform a kinetic test on Skukum Creek Rainbow Composite.

Conditions: As outlined below.

Feed: 2 kilograms minus 10 mesh Skukum Creek Rainbow Composite.

Primary Grind: 30 minutes per 2 kilograms at 65% solids in the yellow lab ball mill.

Conditions:

Stage	Reagents, g/t				Time, minutes			pH
	PAX	$CuSO_4$	MIBC	F557	Grind	Cond	Froth	
Grind	-	-	-	-	30			
Rougher 1	25	-	20	7		1	2	7.3
Rougher 2	-	-	-	-		-	2	
Rougher 3	10	-	-	-		1	2	
Condition	-	250	-	-		2	-	6.8
Rougher 4	10	-	-	1		1	3	
Rougher 5 + 6	10	-	-	1		1	3	7.6
	10	-	-	-		1	3	

Stage	Roughers
Flotation Cell	1000 g D-1
Speed RPM	1800
% Solids	

Metallurgical Balance

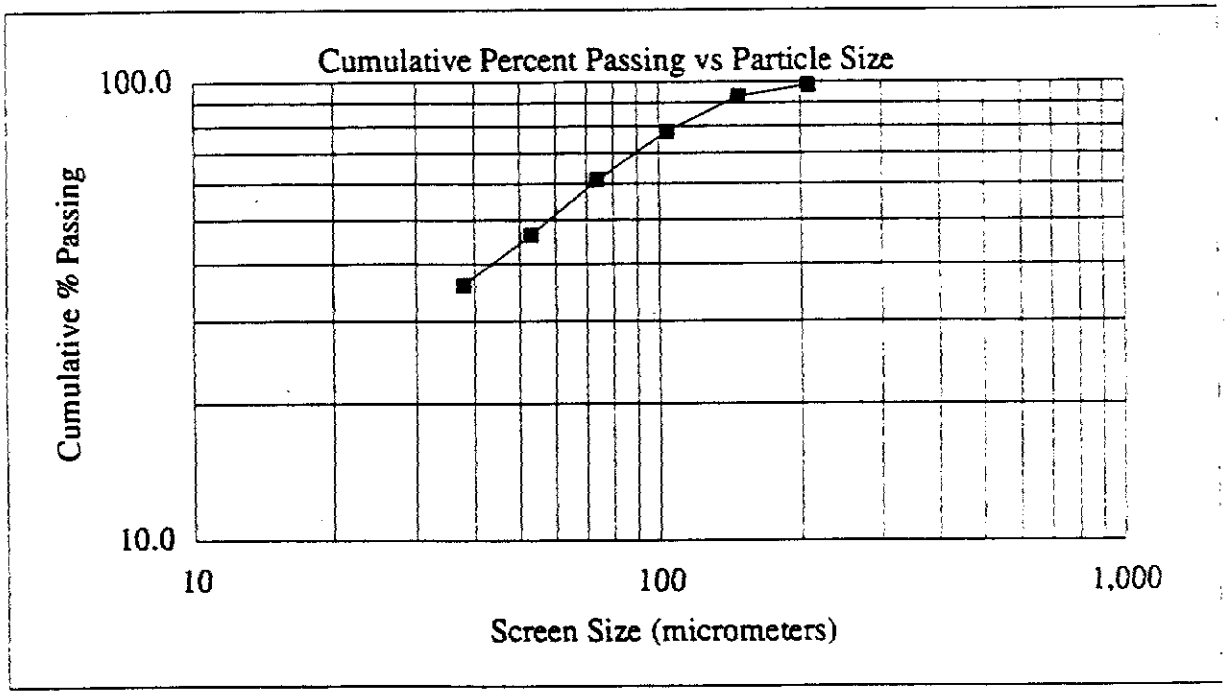
Product	Weight		Assays, %, g/t		% Distribution	
	g	%	Au	S	Au	S
1 Ro Conc 1	203.8	10.3	47.6	24.0	63.2	55.3
2 Ro Conc 2	72.5	3.7	26.1	19.9	12.3	16.3
3 Ro Conc 3	53.6	2.7	21.5	14.8	7.5	9.0
4 Ro Conc 4	54.3	2.7	12.3	12.1	4.3	7.4
5 Ro Conc 5+6	81.6	4.1	9.00	6.28	4.8	5.8
6 Ro Tails	1519.0	76.5	0.80	0.36	7.9	6.2
Head(calc)	1984.8	100.0	7.74	4.46	100.0	100.0
Combined Products						
Ro Conc 1+2		13.9	42.0	22.9	75.5	71.6
Ro Conc 1-3		16.6	38.6	21.6	83.0	80.6
Ro Conc 1-4		19.4	34.9	20.3	87.3	88.0
Ro Conc 1-5		23.5	30.4	17.8	92.1	93.8

Company **Lakefield Research** LR-4432

Size Distribution Analysis

Sample: Rougher Tail **Test No.:** 1

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
65	208	2.2	1.6	1.6	98.4
100	147	7.7	5.6	7.1	92.9
150	104	20.9	15.1	22.2	77.8
200	74	23.3	16.8	39.0	61.0
270	53	20.5	14.8	53.8	46.2
400	38	14.3	10.3	64.1	35.9
Pan	-38	49.8	35.9	100.0	0.0
Total	-	**138.7**	**100.0**	-	-
K80	**110**				



Test No. 2 Project : 4432 Date : March 2/93
Operator: Jim

Purpose: To perform a test similar to test 1 but at a coarser grind.

Conditions: As outlined below.

Feed: 2 kilograms minus 10 mesh Skukum Creek Rainbow Composite.

Primary Grind: 20 minutes per 2 kilograms at 65% solids in the yellow lab ball mill.

Conditions:

Stage	Reagents, g/t				Time, minutes			pH
	PAX	CuSO4	MIBC	F557	Grind	Cond	Froth	
Grind	-	-	-	-	20			
Rougher 1	25	-	-	10		1	2	7.4
Rougher 2	10	-	-	10		1	2	7.3
Condition	-	-	-	-		2		7.6
Rougher 3	20	-	-	-		1	5	
Rougher 4	20	-	-	7		1	3	7.7
Rougher 5	20	150	-	-		1	5	7.1

Stage	Roughers
Flotation Cell	1000 g D-1
Speed RPM	1800
% Solids	

Metallurgical Balance 4432 - 2

Product	Weight		Assays, %, g/t		% Distribution	
	g	%	Au	S	Au	S
1 Ro Conc 1	194.3	9.8	46.0	23.7	57.4	53.8
2 Ro Conc 2	131.0	6.6	24.9	15.8	21.0	24.2
3 Ro Conc 3	91.1	4.6	14.7	9.14	8.6	9.7
4 Ro Conc 4	66.2	3.3	8.81	5.13	3.7	4.0
5 Ro Conc 5	21.9	1.1	7.16	6.10	1.0	1.6
6 Ro Tails	1484.4	74.6	0.87	0.39	8.3	6.8
Head(calc)	1988.9	100.0	7.83	4.30	100.0	100.0
Combined Products						
Ro Conc 1+2		16.4	37.5	20.5	78.4	78.0
Ro Conc 1-3		20.9	32.5	18.0	87.0	87.7
Ro Conc 1-4		24.3	29.3	16.3	90.7	91.7
Ro Conc 1-5		25.4	28.3	15.8	91.7	93.2

Company

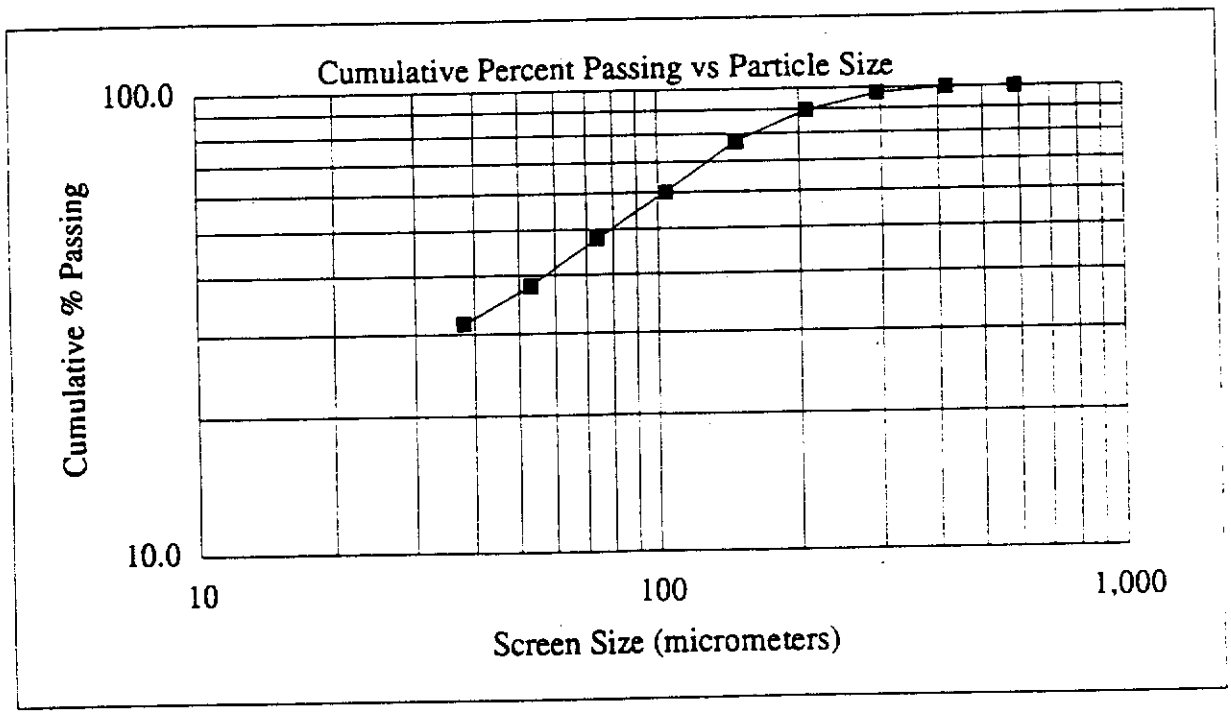
Lakefield Research

LR-4432

Size Distribution Analysis

Sample: Rougher Tail **Test No.:** 2

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
28	589	0.0	0.0	0.0	100.0
35	417	0.0	0.0	0.0	100.0
48	295	5.7	3.0	3.0	97.0
65	208	14.4	7.7	10.7	89.3
100	147	23.3	12.4	23.1	76.9
150	104	31.3	16.7	39.8	60.2
200	74	23.3	12.4	52.3	47.7
270	53	18.6	9.9	62.2	37.8
400	38	11.8	6.3	68.5	31.5
Pan	-38	59.1	31.5	100.0	0.0
Total	-	**187.5**	**100.0**	-	-
K80	**164**				



Test No. 3 Project No. 4432 Operator: Jim M Date: March 3/93

Purpose: To investigate the extraction of gold from Skukum Creek Rainbow Composite by cyanidation.

Procedure : The sample was pulped with water in a 2.5L bottle and agitated on mechanical rolls. Lime and NaCN were added and the cyanidation was carried out in one 48 hour stage. The pulp was then filtered and the residue was washed 3 times with water. All the products were submitted for analysis.

Feed: 500g of -10 mesh Skukum Creek Rainbow Composite.

Solution Volume: 1000 mL Pulp Density: 33 % Solids

Solution Composition: 1.0g/L

pH Range: 10.5 with Ca(OH)2

Grind: 30 minutes/kg at 50% solids in the yellow lab ball mill.

Reagent Consumption (kg/t of cyanide feed) NaCN: 2.72
Ca(OH)2 0.29

Time	Added, Grams				Residual		Consumed		pH
	Actual		Equivalent		Grams		Grams		
Hours	NaCN	Ca(OH)2	NaCN	CaO	NaCN	CaO	NaCN	CaO	
0 - 2	1.05	0.28	1.00	0.21	0.25	-	0.75	-	10.7 - 11.1
2 - 4	0.79	0.00	0.75	0.00	0.90	-	0.10	-	11.1 - 11.0
4 - 10	0.11	0.00	0.10	0.00	0.90	-	0.10	-	11.0 - 11.0
10 - 21	0.11	0.00	0.10	0.00	0.85	-	0.15	-	11.0 - 10.8
21 - 28	0.16	0.00	0.15	0.00	0.95	-	0.05	-	10.8 - 10.8
28 - 48	0.05	0.00	0.05	0.00	0.80	0.07	0.20		10.8 - 10.4
Total	2.27	0.28	2.15	0.21	0.80	0.07	1.35	0.143	

Metallurgical Balance

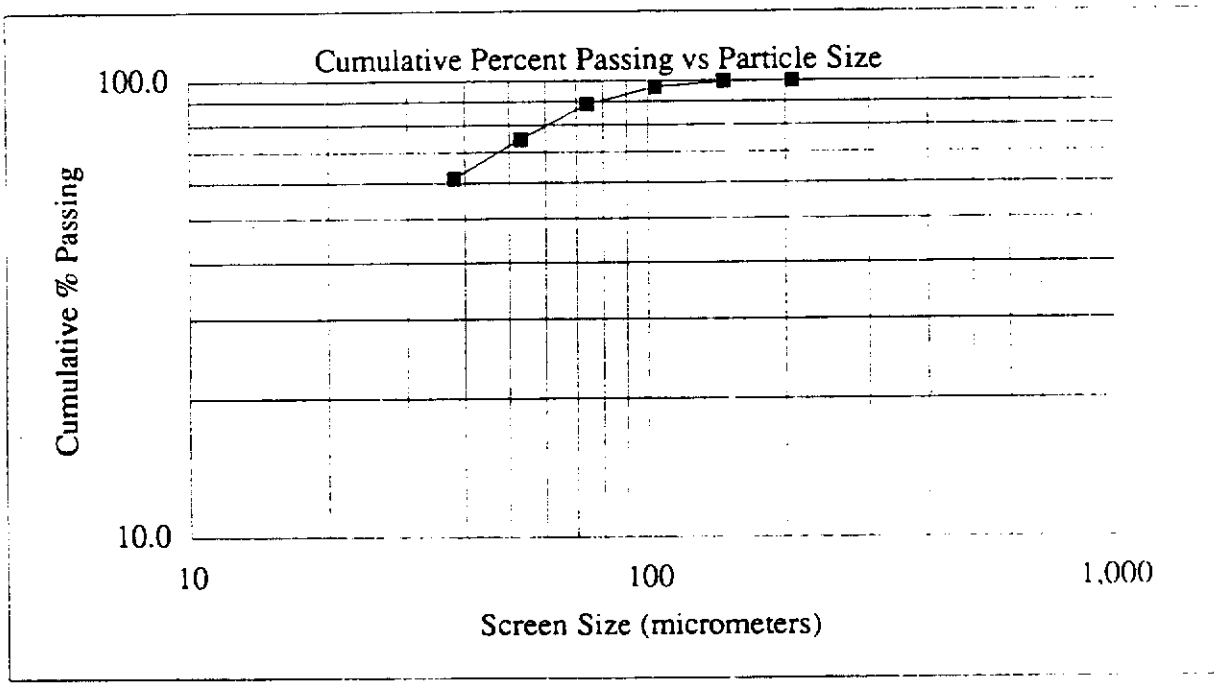
Product	Amount	Assays g/t,mg/L		% Distribution	
	g,ml	Au	Ag	Au	Ag
1 48 hr. Preg &Wash sol'n	1820	1.17	118	49.8	54.2
2 48 hr. Residue	496.7	4.32	365	50.2	45.8
Head (calc.)	496.7	8.61	797	100.0	100.0

Company **Lakefield Research** LR-4432

Size Distribution Analysis

Sample: Ball Mill Grind 30 Min. /KG **Test No.:** 3A

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
65	208	0.2	0.1	0.1	99.9
100	147	0.6	0.4	0.5	99.5
150	104	4.5	2.8	3.4	96.6
200	74	12.5	7.9	11.3	88.7
270	53	22.3	14.1	25.4	74.6
400	38	20.7	13.1	38.5	61.5
Pan	-38	97.3	61.5	100.0	0.0
Total	-	**158.1**	**100.0**	-	-
K80	**60**				



Test No. 4 Project : 4432 Date : March 4/93
Operator: Jim

Purpose: To conduct a series of tests to investigate the effect of fineness of grind on Skukum Creek Rainbow Composite.

Conditions: As outlined below.

Feed: 2 kilograms minus 10 mesh Skukum Creek Rainbow Composite.

Primary Grind: 30 minutes per 2 kilograms at 65% solids in the yellow lab ball mill.

Conditions:

Stage	Reagents, g/t			Time, minutes			
	PAX	CuSO4	F557	Grind	Cond	Froth	pH
Grind				30			
Rougher 1	25	-	14		1	3	7.6
Rougher 2	10	-	10		1	2	7.8
Condition	-	250	-		2		6.7
Rougher 3	20	-	3.5		1	5	
Rougher 4	20	-	-		1	5	7.6
Rougher 5	20	-	-		1	5	7.8
Regrind (S.S. Rod Mill)				20			
Cleaner 1	-	-	3.5		1	7	7.6
	10	-	3.5		1	4	
Scavenger	10	-	-		1	5	
Cleaner 2	-	-	-		1	6	7.7

Stage	Roughers	Cl 1 + Scav	Cleaner 2
Flotation Cell	1000 g D-1	500 g D-1	250 g D-1
Speed RPM	1800	1500	1200
% Solids			

Metallurgical Balance 4432-4

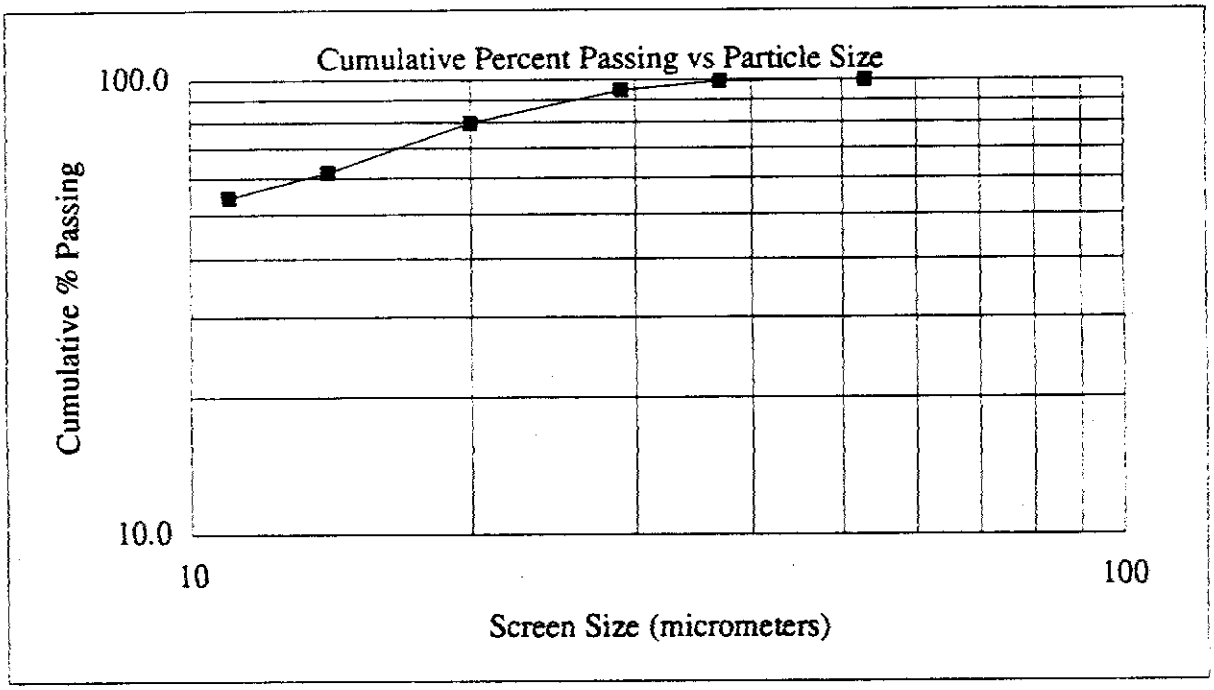
Product	Weight		Assays, %, g/t			% Distribution		
	g	%	Au	Ag	S	Au	Ag	S
1 2nd Cl Conc	214.2	10.8	60.2	6576	30.0	77.6	91.7	72.6
2 2nd Cl Tails	30.0	1.5	18.7	422	14.1	3.4	0.8	4.8
3 1st Cl Scav Conc	37.7	1.9	20.4	453	19.6	4.6	1.1	8.3
4 1st Cl Scav Tails	224.6	11.3	5.07	86.7	3.46	6.9	1.3	8.8
5 Ro Tails	1482.5	74.5	0.84	53.3	0.33	7.5	5.1	5.5
Head(calc)	1989.0	100.0	8.35	773	4.45	100.0	100.0	100.0
Combined Products								
1st Cl Conc		12.3	55.1	5820	28.0	81.0	92.5	77.4
1st Cl Tails		13.2	7.27	139	5.78	11.5	2.4	17.1
Ro Conc (1-4)		25.5	30.3	2878	16.5	92.5	94.9	94.5

Company **Lakefield Research** LR-4432

Size Distribution Analysis

Sample: Regrind Product **Test No.:** 4

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
270	53	0.00	0.0	0.0	100.0
	37	0.60	1.2	1.2	98.8
	29	2.17	4.3	5.5	94.5
	20	7.29	14.6	20.1	79.9
	14	9.07	18.1	38.3	61.7
	11	3.73	7.5	45.7	54.3
	-11	27.14	54.3	100.0	0.0
Total	-	**50.00**	**100.0**	-	-
K80	**21**			**S.G.=**	**3.67**



Test No.5 Project : 4432 Date : March 4/93
Operator: Jim

Purpose: To repeat test 4 but with no conditioning or regrind stages.

Conditions: As outlined below.

Feed: 2 kilograms minus 10 mesh Skukum Creek Rainbow Composite.

Primary Grind: 30 minutes per 2 kilograms at 65% solids in the yellow lab ball mill.

Conditions:

Stage	Reagents, g/t		Time, minutes			
	PAX	F557	Grind	Cond	Froth	pH
Grind			30			
Rougher 1	25	14		1	3	7.8
Rougher 2	10	10		1	2	7.8
Rougher 3	20	-		1	5	7.8
Rougher 4	20	7		1	5	7.8
Rougher 5	20	-		1	5	8.0
Cleaner 1	-	-		1	7	7.4
	10	3.5		1	4	7.9
Scavenger	10	-		1	2	
Cleaner 2	-	-		1	7	7.8

Stage	Roughers	Cl 1 + Scav	Cleaner 2
Flotation Cell	1000 g D-1	500 g D-1	250 g D-1
Speed RPM	1800	1500	1200
% Solids			

Metallurgical Balance 4432-5

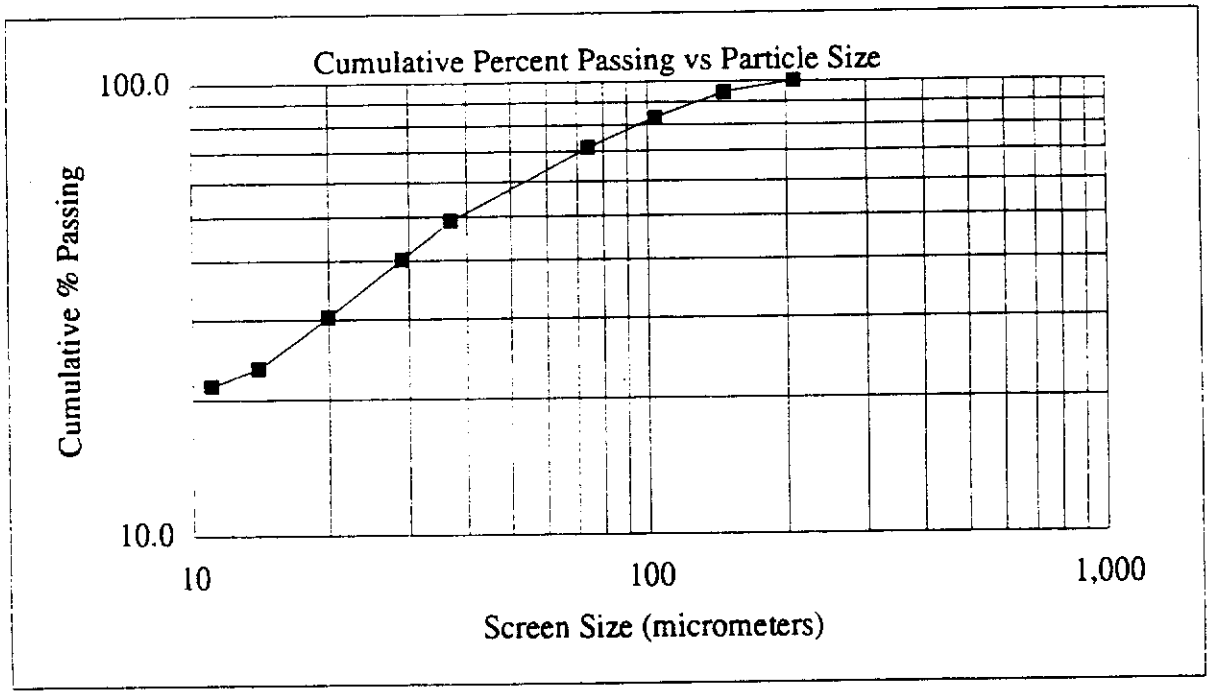
Product	Weight		Assays, %, g/t			% Distribution		
	g	%	Au	Ag	S	Au	Ag	S
1 2nd Cl Conc	365.1	18.4	39.6	3798	22.2	88.1	92.4	89.2
2 2nd Cl Tails	22.8	1.1	15.5	528	5.49	2.2	0.8	1.4
3 1st Cl Scav Conc	6.6	0.3	11.0	769	6.54	0.4	0.3	0.5
4 1st Cl Scav Tails	67.2	3.4	3.29	201	2.16	1.3	0.9	1.6
5 Ro Tails	1526.6	76.8	0.86	54.4	0.44	8.0	5.5	7.4
Head(calc)	1988.3	100.0	8.26	755	4.57	100.0	100.0	100.0
Combined Products								
1st Cl Conc		19.5	38.2	3606	21.2	90.2	93.2	90.5
1st Cl Tails		3.7	4.0	252	2.55	1.8	1.2	2.1
Ro Conc (1-4)		23.2	32.7	3070	18.2	92.0	94.5	92.6

Company Lakefield Research **LR-4432**

Size Distribution Analysis

Sample: Combined Product **Test No.:** 5

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
65	208	0.00	0.0	0.0	100.0
100	147	2.73	5.5	5.5	94.5
150	104	5.75	11.5	17.0	83.0
200	74	5.99	12.0	28.9	71.1
	37	11.05	22.1	51.0	49.0
	29	4.41	8.8	59.9	40.1
	20	4.93	9.9	69.7	30.3
	14	3.44	6.9	76.6	23.4
	11	0.98	2.0	78.6	21.4
	-11	10.72	21.4	100.0	0.0
Total	-	**50.00**	**100.0**	-	-
K80	**96**			**S.G. =**	**3.72**



Test No.6 Project : 4432 Date : March 4/93
Operator: Jim

Purpose: To repeat test 4 but with the addition of R208.

Conditions: As outlined below.

Feed: 2 kilograms minus 10 mesh Skukum Creek Rainbow Composite.

Primary Grind: 30 minutes per 2 kilograms at 65% solids in the yellow lab ball mill.

Conditions:

Stage	Reagents, g/t				Time, minutes			
	PAX	R208	CuSO4	F557	Grind	Cond	Froth	pH
Grind					30			
Rougher 1	25	10	-	14		1	3	
Rougher 2	10	5	-	10		1	2	8.0
Condition	-	-	250			2		6.7
Rougher 3	20	5	-	-		1	5	7.3
Rougher 4	20	-	-	7		1	5	7.8
Rougher 5	20	-	-	-		1	5	7.8
Regrind (S.S. Rod Mill)					20			
Cleaner 1	-			-		1	7	7.7
	10			3.5		1	4	7.9
Scavenger	10			3.5		1	4	8.0
Cleaner 2	-			-		1	7	7.8

Stage	Roughers	Cleaner 1 + Scavenger	Cleaner 2
Flotation Cell	1000 g D-1	500 g D-1	250 g D-1
Speed RPM	1800	1500	1200
% Solids			

Metallurgical Balance 4432-6

Product	Weight		Assays, %, g/t			% Distribution		
	g	%	Au	Ag	S	Au	Ag	S
1 2nd Cl Conc	231.9	11.8	55.8	5978	29.2	80.5	91.9	74.7
2 2nd Cl Tails	45.8	2.3	15.8	358	13.4	4.5	1.1	6.8
3 1st Cl Scav Conc	31.9	1.6	14.7	334	14.7	2.9	0.7	5.2
4 1st Cl Scav Tails	206.7	10.5	4.53	87.3	3.34	5.8	1.2	7.6
5 Ro Tails	1456.5	73.8	0.69	53.2	0.36	6.3	5.1	5.8
Head(calc)	1972.8	100.0	8.15	765	4.60	100.0	100.0	100.0
Combined Products								
1st Cl Conc		14.1	49.2	5051	26.6	85.0	93.0	81.4
1st Cl Tails		12.1	5.89	120	4.86	8.7	1.9	12.8
Ro Conc (1-4)		26.2	29.2	2772	16.5	93.7	94.9	94.2

Test No.7 Project : 4432 Date : March 4/93
Operator: Jim

Purpose: To perform a test similar to 4 but at a finer grind, with no regrind.

Conditions: As outlined below.

Feed: 2 kilograms minus 10 mesh Skukum Creek Rainbow Composite.

Primary Grind: 50 minutes per 2 kilograms at 65% solids in the yellow lab ball mill.

Conditions:

Stage	Reagents, g/t			Time, minutes			
	PAX	CuSO4	F557	Grind	Cond	Froth	pH
Grind				50			
Rougher 1	25	-	14		1	3	7.9
Rougher 2	10	-	10		1	2	7.9
Condition	-	250	-		2		
Rougher 3	20	-	3.5		1	5	7.2
Rougher 4	20	-	7		1	5	7.8
Rougher 5	20	-	3.5		1	5	7.8
Cleaner 1	-	-	-		1	7	7.6
	10	-	-		1	4	7.8
Scavenger	10	-	-		1	2	
Cleaner 2	-	-	-		1	4	7.7

Stage	Roughers	Cl 1 + Scav	Cleaner 2
Flotation Cell	1000 g D-1	500 g D-1	250 g D-1
Speed RPM	1800	1500	1200
% Solids			

Metallurgical Balance 4432-7

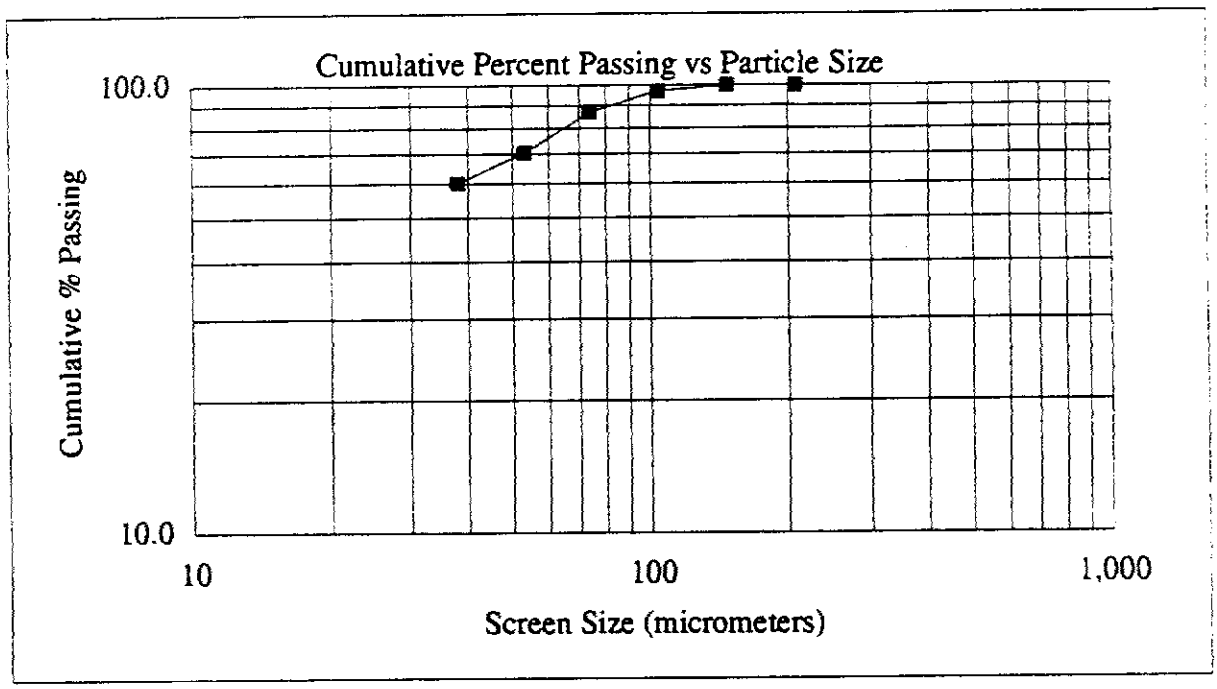
Product		Assays, %, g/t			% Distribution		
	%	Au	Ag	S	Au	Ag	S
1 2nd Cl Conc	329.0	16.5	44.1	4343	23.5	89.0	92.0	88.0
2 2nd Cl Tails	30.1	1.5	9.97	708	7.17	1.8	1.4	2.5
3 1st Cl Scav Conc	6.7	0.3	14.0	788	9.20	0.6	0.3	0.7
4 1st Cl Scav Tails	121.6	6.1	3.63	255	2.45	2.7	2.0	3.4
5 Ro Tails	1508.5	75.6	0.63	44.1	0.32	5.8	4.3	5.5
Head(calc)	1995.9	100.0	8.16	778.08	4.40	100.0	100.0	100.0
Combined Products								
1st Cl Conc		18.0	41.2	4038	22.1	90.9	93.4	90.4
1st Cl Tails		6.4	4.17	283	2.80	3.3	2.3	4.1
Ro Conc (1-4)		24.4	31.5	3050	17.0	94.2	95.7	94.5

Company **Lakefield Research** LR-4432

Size Distribution Analysis

Sample: Rougher Tail **Test No.:** 7

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
65	208	0.1	0.1	0.1	99.9
100	147	0.6	0.3	0.4	99.6
150	104	5.9	3.0	3.4	96.6
200	74	18.9	9.6	13.0	87.0
270	53	32.8	16.7	29.7	70.3
400	38	20.0	10.2	39.9	60.1
Pan	-38	118.1	60.1	100.0	0.0
Total	-	**196.4**	**100.0**	-	-
K80	**66**				

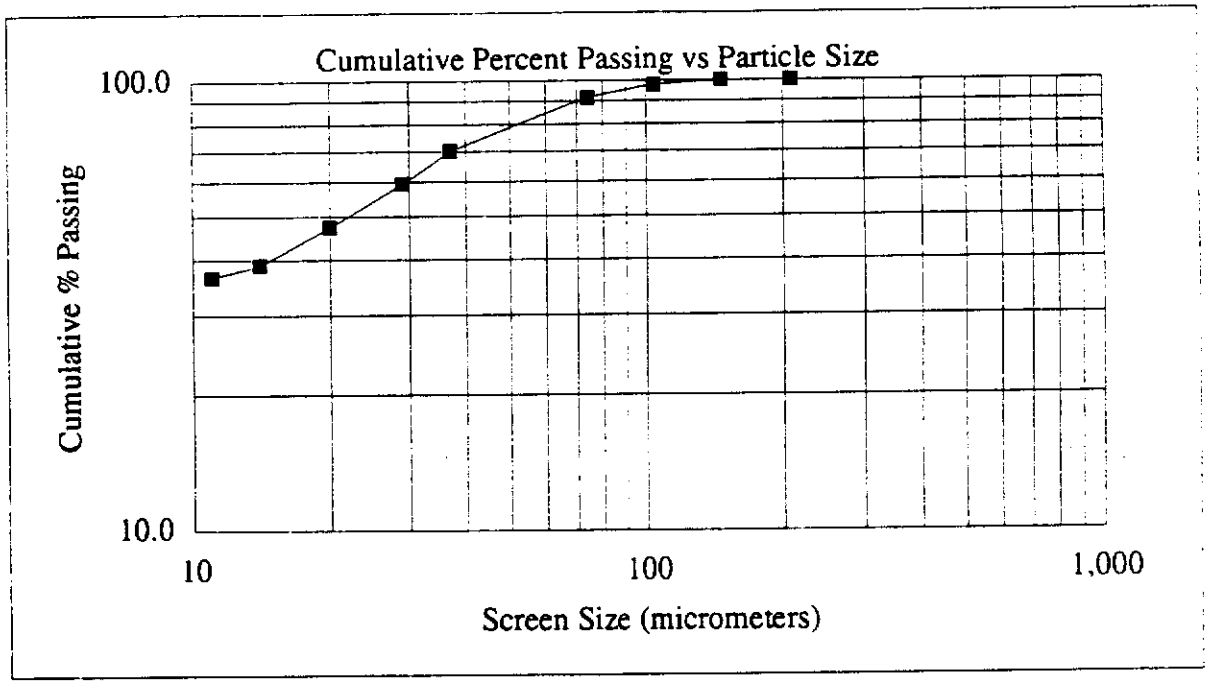


Company Lakefield Research LR-4432

Size Distribution Analysis

Sample: Combined Product **Test No.:** 7

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
65	208	0.00	0.0	0.0	100.0
100	147	0.00	0.0	0.0	100.0
150	104	1.23	2.5	2.5	97.5
200	74	3.02	6.0	8.5	91.5
	37	10.75	21.5	30.0	70.0
	29	5.46	10.9	40.9	59.1
	20	5.93	11.9	52.8	47.2
	14	4.17	8.3	61.1	38.9
	11	1.19	2.4	63.5	36.5
	-11	18.25	36.5	100.0	0.0
Total	-	**50.00**	**100.0**	-	-
K80	**51**			**S.G. =**	**3.70**



Test No.8 Project : 4432 Date : March 9/93
Operator: Jim

Purpose: To perform a test similar to test 5 except R208 was added, and the sample was ground for 45 minutes.

Conditions: As outlined below.

Feed: 2 kilograms minus 10 mesh Skukum Creek Rainbow Composite.

Grind: 45 minutes per 2 kilograms at 65% solids in the yellow lab ball mill.

Conditions:

	Reagents, g/t			Time, minutes			
Stage	A350	R208	F557	Grind	Cond	Froth	pH
Grind				45			
Rougher 1	25	10	14		1	3	7.6
Rougher 2	10	5	10		1	2	7.6
Rougher 3	20	5	-		1	5	7.7
Rougher 4	20	-	7		1	5	7.8
Rougher 5	20	-	-		1	5	7.8
Cleaner 1	-	-	-		1	7	7.5
	10	-	3.5		1	4	7.7
Scavenger	10		-		1	2	7.6
Cleaner 2	-	-	-		1	7	7.6

Stage	Roughers	Cl 1 + Scav	Cleaner 2
Flotation Cell	1000 g D-1	500 g D-1	250 g D-1
Speed RPM	1800	1500	1200
% Solids			

Metallurgical Balance

Product	Weight		Assays, g/t,%								% Distribution							
	g	%	Au	Ag	Cu	Pb	Zn	As	Fe	S	Au	Ag	Cu	Pb	Zn	As	Fe	S
1 2nd Cl Conc	323.2	16.2	45.2	4495	0.43	10.1	10.9	11.4	19.3	22.9	88.8	95	93	72	80	>95	70	83
2 2nd Cl Tails	24.1	1.2	13.3	662	0.11	2.09	3.66	4.15	8.11	7.50	1.9	<1	<1	1	2	<5	<1	2
3 1st Cl Scav Conc	5.2	0.3	13.0	NA	NA	NA	NA	NA	NA	NA	0.4	<1	<1	21	9	<5	<1	5
4 1st Cl Scav Tails	99.3	5.0	4.43	264	0.034	0.95	0.97	2.22	4.92	2.99	2.7	2	<1	2	2	<5	<1	3
5 Ro Tails	1540.5	77.3	0.66	44.1	0.007	0.13	0.17	0.27	1.36	0.38	6.2	4	7	4	6	<5	23	7
Head(calc)	1992.3	100.0	8.26	768*	0.075	2.29	2.20	1.77	4.50	4.46*	100.0	-	-	-	-	-	-	-
Combined Products																		
1st Cl Conc		17.4	43.0	4229	0.41	9.54	10.4	10.9	18.5	21.8	90.7							
1st Cl Tails		5.2	4.86	-	-	-	-	-	-	-	3.1							
1st Cl + 1st Cl Sc Conc		17.7	42.5	-	-	-	-	-	-	-	91.1							
Ro Conc (1-4)		22.7	34.2	-	-	-	-	-	-	-	93.8							

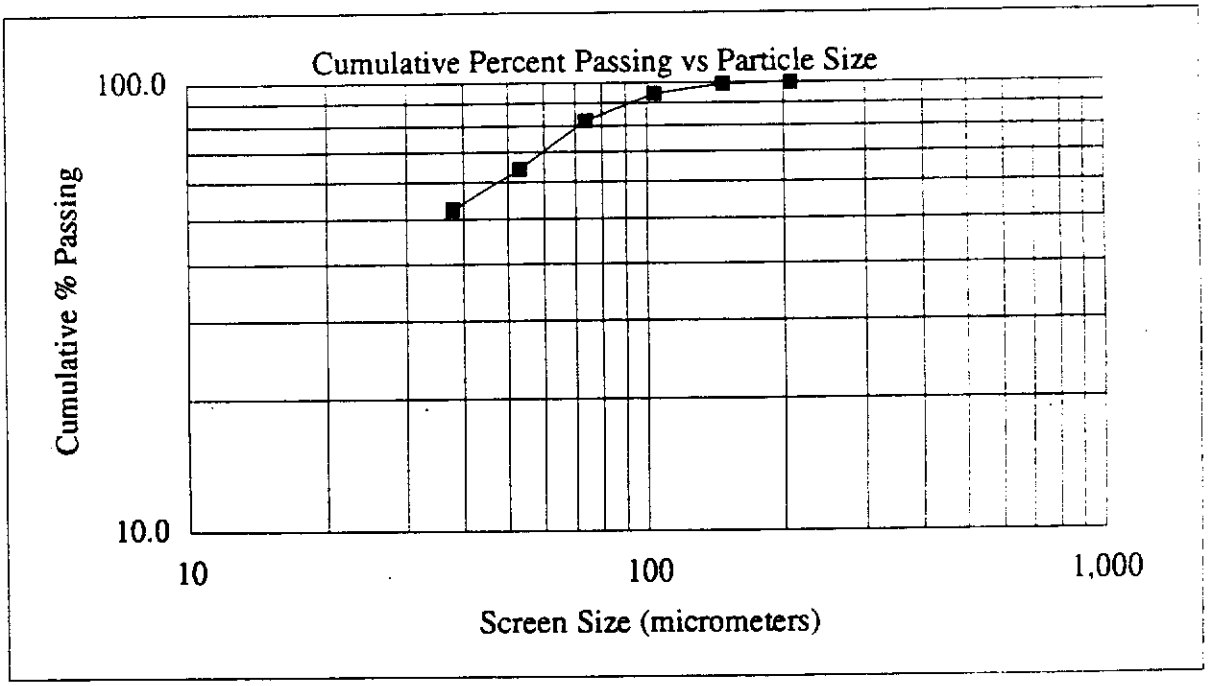
* Average calculated head from previous testwork. All others, except Au, direct assay heads.
Distributions based on heads as shown.

Company Wheaton River **Lakefield Research** **LR-1111**

Size Distribution Analysis

Sample: Rougher Tail **Test No.:** 8

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
65	208	0.1	0.1	0.1	99.9
100	147	1.4	0.8	0.9	99.1
150	104	8.2	4.9	5.8	94.2
200	74	20.0	12.0	17.8	82.2
270	53	30.6	18.3	36.1	63.9
400	38	19.2	11.5	47.5	52.5
Pan	-38	87.7	52.5	100.0	0.0
Total	-	**167.2**	**100.0**	-	-
K80	**72**				



Company

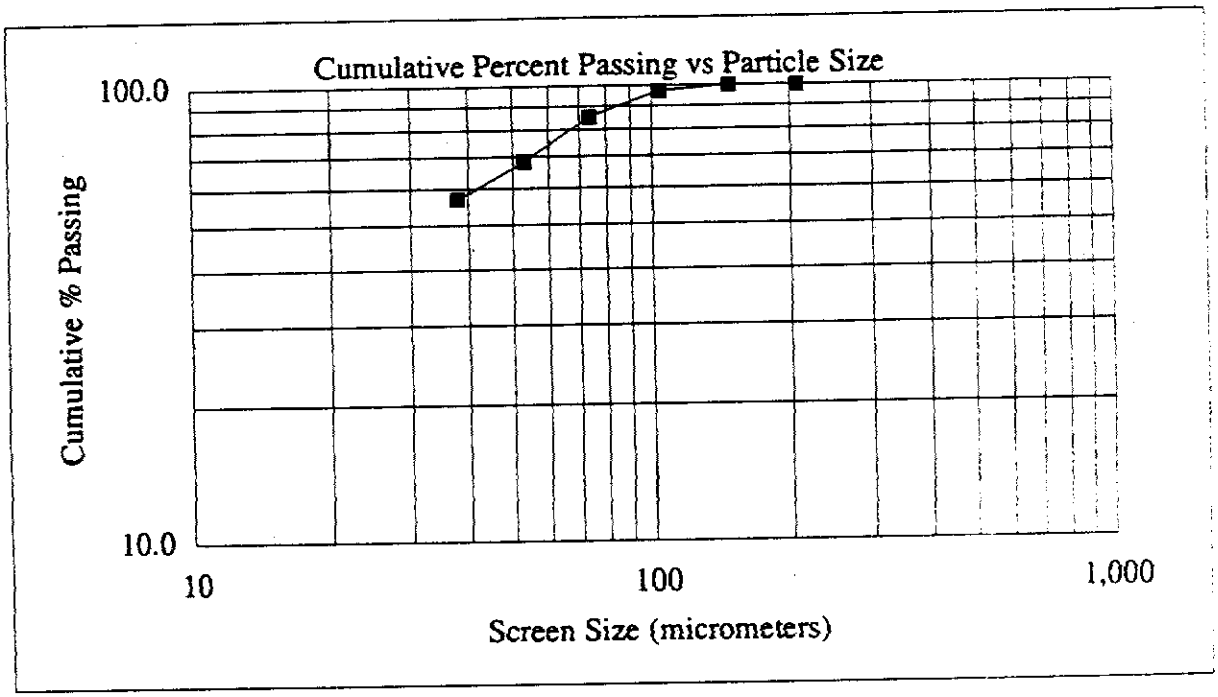
Lakefield Research

LR-4432

Size Distribution Analysis

Sample: Rougher Tail **Test No.:** B8

Size		Weight	% Retained		% Passing
Mesh (Tyler)	µm	grams	Individual	Cumulative	Cumulative
65	208	0.0	0.0	0.0	100.0
100	147	0.2	0.1	0.1	99.9
150	104	4.0	2.7	2.9	97.1
200	74	17.5	12.0	14.8	85.2
270	53	24.9	17.0	31.8	68.2
400	38	16.5	11.3	43.1	56.9
Pan	-38	83.3	56.9	100.0	0.0
Total	-	**146.4**	**100.0**	-	-
K80	**68**				



Test No.9 Project : 4432 Date : March 10/93
Operator: Jim

Purpose: To produce a bulk concentrate sample for future testwork.

Conditions: As outlined below.

Feed: 150 kilograms minus 10 mesh Skukum Creek Rainbow Composite.

Grind: 88 minutes per 30 kilograms at 65% solids in the 30 kg rod mill.

Conditions:

	Reagents, g/t			Time, minutes			
Stage	A350	R208	F557	Grind	Cond	Froth	pH
Grind				88			
Rougher 1	30	20	16.5		1	5	
Rougher 2	25	10	7		1	5	
Rougher 3	25	10	7		1	5	
Rougher 4	25	-	2		1	5	7.9
Rougher 5	25	-	2		1	5	7.7
Rougher 6	25	-	-		1	5	
Cleaner 1	-	-	-		1	15	
	10	-	-		1	10	
Scavenger	10	-	-		1	8	
	10	-	3.5		1	6	
	10	-	3		1	5	

Stage	Roughers	Cleaner 1 + Scavenger
Flotation Cell	Agitair	2000 g D-2
Speed RPM	1700	1500
% Solids		

Metallurgical Balance

Product	Weight		Assays, g/t		% Distribution	
	g	%	Au	Ag	Au	Ag
Cl Conc	24921	17.2	41.8	4651	89.6	94.2
Cl Tails	9660	6.7	2.21	240	1.8	1.9
Ro Tails	110597	76.2	0.90	44.1	8.6	4.0
Head(calc)	145178	100.0	8.01	848	100.0	100.0

*average Au assay of nine Ro Tail samples was 0.90 g/t.

APPENDIX C

Triton Development Corporation Report
Batch and Continuous CSTR Bio-Oxidation of Wheaton River Refractory Gold-Bearing Arsenopyrite Concentrate

BATCH AND CONTINUOUS CSTR BIO-OXIDATION OF WHEATON RIVER REFRACTORY GOLD-BEARING ARSENOPYRITE CONCENTRATE

Project No.: 93-4105

Prepared for:

Melis Engineering Ltd.
519 45th Street West
Saskatoon, Saskatchewan
S7L 5Z9
Attention: Mr. Lawrence Melis

September 21, 1993

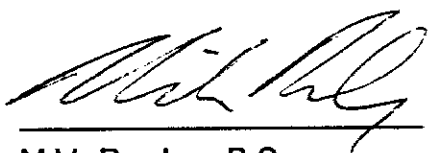
TRITON DEVELOPMENT CORPORATION

BATCH AND CONTINUOUS CSTR BIO-OXIDATION OF WHEATON RIVER REFRACTORY GOLD-BEARING ARSENOPYRITE CONCENTRATE

Project No.: 93-4105

Prepared by:

Triton Development Corp.
Industrial Biotechnology Division
1650 Pandora Street
Vancouver, B.C.
V5L 1L6



M.V. Rowley, B.Sc.
Process Microbiologist

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1.0 TERMS OF REFERENCE

Based on correspondence between Mr. Lawrence Melis of Melis Engineering Limited, and Mr. P. Brad Marchant of Triton Development Corporation in February of 1993, it was agreed to conduct bacterial leaching testwork using mixed *Thiobacilli* strains to enhance gold recovery from the Wheaton River refractory gold-bearing arsenopyrite concentrate.

Shakeflask and batch CSTR exploratory testwork was conducted throughout April, 1993. The objective of the exploratory work was to determine the gold extraction/sulphide oxidation relationship.

Continuous CSTR testwork was conducted in June and July, 1993, to determine the relationship between retention time, iron/arsenic oxidation, and gold extraction. The concentrate was bioleached at two grind sizes (as-received and rod-milled to > 99% passing 325 mesh) to appraise the effect of particle size on gold extraction and leach kinetics.

2.0 EXPERIMENTAL PROCEDURES

2.1 Sample Description

A 1 kg sample of Wheaton River ore labelled "4432 Melis Aurum" was received on 5 March 1993. A 24 kg sample of Wheaton River sulphide concentrate was delivered by Mr. Jack Jarvi of Melis Engineering Limited on 22 March 1993. Samples were assayed for gold, silver, iron, copper, arsenic, lead, zinc, silica, sulphur, and sulphate. Sulphide content is calculated by difference from the sulphur and sulphate assays. I.C.P. analyses were also conducted on both samples.

2.2 Shakeflask Amenability

Shakeflasks were initiated with 50 mL of dilute mineral salt nutrient solution (termed '9K'), pulped to 5.0 % solids (2.6 g per 50 mL), inoculated by a 5 mL pulp transfer from a stock culture, and maintained at 30°C on a shaker at approximately 200 cycles per minute. Two cultures were utilized. Culture A was developed on an arsenopyrite ore, and culture B was developed on an arsenopyrite concentrate. Each set of new flasks was monitored closely to maintain a pH of < 1.8 with additions of dilute H_2SO_4. Redox, pH, and dissolved iron and arsenic were monitored to evaluate the performance of the bacteria. New flasks were inoculated every two weeks by standard serial culturing techniques.

2.3 Batch Reactor Bio-Oxidation

Batch testwork was performed with standard CSTR (Continuous Stirred Tank Reactor) technology. Batch reactor testwork was conducted in an acrylic reactor vessel, baffled and mechanically agitated to provide a homogenously suspended pulp. The reactor was aerated with CO_2-supplemented compressed air to provide sufficient CO_2 and O_2 in solution. Reactor temperature was maintained at 35°C with a submersible heater, and evaporative loss was compensated for with additions of fresh water.

The reactor was prepared for inoculation by suspending the as-received concentrate in modified 9K nutrient salt medium. Before inoculation the pH of the pulp was adjusted to 1.8 with H_2SO_4 and allowed to stabilize. pH adjustment continued as required after inoculation until the rate of microbial sulphide oxidation was sufficient to eliminate the need for acid additions. Inoculation was performed by adding 40 mL of supernatant and 2 mL of pulp from each of flasks 4105-1-1 and -2-1. This later proved to be an insufficient inoculating mass to maintain a desirable redox potential in the reactor.

Solution samples were withdrawn three times weekly for determination of dissolved iron, copper, and arsenic, while redox, pH, and temperature readings were obtained daily. Dissolved oxygen was monitored periodically to ensure that the oxidation kinetics were not oxygen limited. Samples for solution assay were obtained by filtering a small volume of pulp to obtain a 1 mL sample for assay.

Pulp samples were withdrawn from the reactor at two points during the operation of the batch reactor. A final sample was obtained at termination of the batch reactor testwork to provide a total of three samples, each with a different degree of biooxidation. Pulp samples were filtered and resuspended (washed) three times with fresh water before entering cyanidation bottles for gold extraction determination.

2.4 Continuous System Bio-Oxidation

A 7.2 L, two-bioreactor continuous bioleach system was constructed using a 5.0 L first reactor, a 2.2 L second reactor, and feed and product containers. Feed consisted of concentrate suspended in 9K nutrient solution by continuous agitation. A peristaltic pump added fresh feed to the first reactor every two hours. From the first reactor, the bioleach pulp overflowed into the second reactor, and then into the product container.

The bioreactors were identical in construction to the batch reactor described above. The operation of the continuous system, however, differed in several regards. Firstly, 3 L of batch reactor pulp was used as inoculum, removing the redox problems noted in the batch testwork. Secondly, no attempt was made to compensate for evaporative losses in the reactors. Finally, feed and product volumes were recorded daily.

The system fed as-received concentrate until day 41 (22 June), from which point concentrate rod-milled to >99% passing 325 mesh was utilized. On day 41, pulp samples were withdrawn from each reactor and washed with three decant/fresh water repulp stages, as described in section 2.4, below. The resulting residues were used in cyanidation tests CP1-1 and CP1-2. Assay results on these residues suggested an accumulation of gold in the first reactor, and a subsequent depletion in the second. This unusual occurrence was confirmed by fire assays conducted on bioleach solution samples, as discussed in section 3.1., below.

After sampling the reactors for cyanidation testwork on day 41, the volume of pulp removed from each reactor was replaced with an equal volume of new feed using fine-ground concentrate instead of the as-received material in the system at that time. This addition sped the transition of the system to a new steady-state with the fine-ground concentrate.

With termination of the bioleach testwork, the entire contents of each bioreactor was washed three times by successive settle/decant/wash phases. Due to the extremely fine (> 99% passing 325 mesh) material, the use of flocculant was required.

2.5 Cyanidations

Bottle-roll cyanidations were performed at the parameters specified on the reporting spreadsheets. Free NaCN determinations were done by titration with $AgNO_3$, and pH adjustments were made with additions of $Ca(OH)_2$.

Batch bioleach residues were washed three times in a flotation cell prior to cyanidation to eliminate residual acid and dissolved metals. SiO_2 assays are used to determine weight loss during bioleaching.

Continuous bioleach residues were washed by three consecutive decant/repulp stages, with each repulp using an extra volume of water. In this manner, the third and final wash stage used three times the volume that was initially decanted.

2.6 Assays

Analyses were performed by VanGeoChem Labs and CDN Labs, both of Vancouver, B.C., and by Min-En Labs, North Vancouver, B.C.. Analyses for Fe, As were performed by I.C.P. and Atomic Absorption Spectrophotometry (A.A.), while analyses for Cu, Pb, and Zn were performed by A.A. only. Gold and silver in residues were determined by standard fire assay.

2.7 Culture Maintenance

A sample of the bacteria developed in this test programme is currently maintained in a shakeflask at the Triton Development Corporation laboratory.

3.0 DISCUSSION OF RESULTS

3.1 Continuous System Data

Arsenic Precipitation

The precipitation of arsenic in the CP2 residues is suspected for two reasons. Firstly, the arsenic residue assays, included in the oxidation summary spreadsheets, suggest a decrease in arsenic extraction between the as-received (CP1) and fine-ground concentrate (CP2) samples. Bioreactor solution assays, however, indicate that arsenic extraction increased with the finer material.

Also in contradiction with the CP2 residue arsenic assays are the iron and sulphide residue values. Of particular interest are the arsenic extraction, iron extraction, and sulphide destruction values. These three values usually correlate well. A comparison of iron extraction and sulphide destruction between CP1 and CP2 suggest that the fine-ground material (CP2) is much more thoroughly oxidized, as is anticipated due to the increased reaction surface area. The CP2 arsenic extraction values, however, do not follow the trend set by the iron and sulphide assays.

In this manner, the CP2 residue arsenic assays are regarded as not accurately representing the quantity of arsenic actually extracted. The actual arsenic extraction from both CP2 residues is predicted to be > 98 %, based on the above information.

Gold Losses to Bioleachate

Bioleaching enhances gold recovery from refractory ores and concentrates by utilizing bacteria to dissolve the sulphide minerals that occlude the gold from extraction. In the great majority of cases, the gold remains in the host mineral even when a significant proportion of the sulphide matrix that encases it has been metabolized into solution. Although very rare, cases have been noted where gold was observed to leave the host mineral during oxidation.

As noted in section 2.3, the first residue assays from the continuous system suggested the occurrence of this phenomenon in the bioleaching of the Wheaton River concentrate. Residue and bioleachate assay results were as follows:

Summary of Gold and Silver Fire Assay Results

	First Reactor		Second Reactor	
	Residue	Bioleachate	Residue	Bioleachate
CP1:				
Au (g/t)	84.1	0.29	35.0	1.20
Ag (g/t)	10600	43	8500	51
CP2:				
Au (g/t)	33.2	0.00	22.6	1.00
Ag (g/t)	2920	49	3320	88

From these results it was suggested that, in the case of CP1 gold assays, gold was liberated from the concentrate and accumulated at the base of the first reactor, unable to reach the overflow to the second reactor due to its high S.G. In this manner, the pulp overflowing into the second reactor contained primarily the gold still held in the concentrate. Due to the fine size of the gold it is likely that some quantity was buoyed sufficiently to reach the second bioreactor, however. It should be noted that reactor agitation was maintained at a standard bioleach speed throughout this test programme, and that daily observations were made of reactor health (temperature, aeration, agitation, pH, and redox), from which no build-up of solids was noted.

The results of cyanidation test with the CP1 first reactor residue (test CP1-1) yielded a calculated head of 60.18 g/t, although the assayed head was 84.1 g/t. This discrepancy is attributed to the order of the sampling. In standard bioleach-cyanidation sampling procedure, two pulp samples are taken in quick succession from each reactor. The first sample from each reactor is small (200 mL) and used for assay purposes only. The second sample from each reactor (800 mL) reports to cyanidation. It is suggested that most of the accumulated gold was withdrawn with the smaller pulp sample withdrawn from the first reactor. This CP1 first reactor residue assayed at 84.1 g/t gold, as listed above. To achieve a more similar assayed head value for the CP1-1 test sheet, the head grade of 42.86 g/t was used, considering weight loss incurred during bioleaching of the sample. A complete explanation of all bioleachate volume and assayed head calculations are included below in section 3.2., below.

To avoid similar problems of sample timing the final reactor pulp sampling (CP2 series, at termination), the entire first and second reactor contents were washed whole. Samples for assay and cyanidation were split from the resulting first and second reactor pulps to obtain identical samples. The results of these residue assays suggest a substantial loss of gold and silver to bioleachate. Since gold is lost from exposed surfaces during biooxidation, it is anticipated that a finer particle would permit a greater

rate of gold loss, due to the increased surface area for both biooxidation and gold loss. Unfortunately, this loss is not entirely compensated for in the bioleachate assays. Due to gold unaccounted for in CP2 residues, a poor calculated head/assayed head balance results from cyanidation tests CP2-2 and CP2-4. Test CP2-1, however, achieved a reliable assayed head/calculated head balance by utilizing the head grade of 42.86 g/t and considering weight loss, similar to test CP1-1.

Gold Extraction

A summary of gold extraction from all testwork follows:

Test #	Conditions	Solids/ Residue	Target Retention in Bioleach (days)	Maximum Gold Extraction
4105-1	[NaCN] 2.0 g/L	> 99% -325 mesh	n/a	64.2 %
4105-2	[NaCN] 2.0 g/L	As-Received	n/a	58.1 %
4105-3	[NaCN] 2.0 g/L, CIL	As-Received	n/a	52.4 %
P1	[NaCN] 1.0 g/L	As-Received	Batch	45.1 %
P2	[NaCN] 1.0 g/L	As-Received	Batch	68.8 %
P3	[NaCN] 1.0 g/L	As-Received	Batch	82.0 %
CP1-1	[NaCN] 2.0 g/L	A-R, 1st Reactor	4	92.5 %
CP1-2	[NaCN] 2.0 g/L	A-R, 2nd Reactor	6	70.9 %
CP2-1	[CN^-] 0.5 g/L	-325#, 1st Reactor	4	92.4 %
CP2-2	[CN^-] 0.1 g/L	-325#, 2nd Reactor	6	69.9 %
CP2-3	[CN^-] 0.2 g/L, CIL	-325#, 2nd Reactor	6	54.9 %
CP2-4	[CN^-] 0.5 g/L	-325#, 2nd Reactor	6	73.8 %

Gold extractions of 92.4 and 92.5 % have been achieved from first reactor residues where the problem of gold loss and solution fouling (eg. arsenic precipitation) are at a minimum. Future testwork should examine the effect of coarser particle size, as well as shorter retention time, on gold extraction in a continuous circuit of approximately 40 L capacity.

3.2 Explanation of Calculations - Tests CP1-1 to CP2-4

The following calculations describe gold values only. Values for silver were obtained identically, but are not detailed here.

3.2.1 Test CP1-1 - First Bioreactor, As-Received Concentrate

Weight of Bioleachate
To determine the weight of bioleach solution relevant to weight of bioleached solids used in the test:

$$\frac{\text{113 g \{weight used in cyanidation test\}}}{\text{521 g \{reactor solids, 38.09 \% loss\}}} \times \text{4767 mL \{total bioleachate\}}$$

= **1034 mL** of first reactor bioleachate is relevant to 113g of residue.

Assayed Head
Determined from the head assay of 42.86 g/t gold by considering first reactor weight loss (38.09 %), as follows:

$$\frac{\text{42.86 g/t}}{(1 - 0.3809)} = \textbf{69.23 g/t} \text{ \{gold grade of first-reactor-bioleached solids\}}$$

3.2.2 Test CP1-2 - Second Reactor, As-Received Concentrate

Weight of Bioleachate
To determine the weight of bioleach solution relevant to weight of bioleached solids used in the test:

$$\frac{\text{104 g \{weight used in cyanidation test\}}}{\text{157 g \{reactor solids, 57.53 \% loss\}}} \times \text{2098 mL \{total bioleachate\}}$$

= **1390 mL** of second reactor bioleachate is relevant to 104 g of residue.

Assayed Head
Determined from the assayed value of 35.00 g/t gold by considering gold lost to the second bioreactor leachate:

35.00 g/t x 157.3 g = 5505.5 ug gold in total second reactor solids

1.2 g/t x 2098 mL = 2517.6 ug leached in second bioreactor

$$\frac{(5505.5 + 2517.6)}{157.3 \text{ g}} \quad \begin{matrix}\text{\{total gold in second reactor\}} \\ \text{\{bioleached weight of solids\}}\end{matrix} = \textbf{51.01 g/t}$$

3.2.3 Test CP2-1 - First Bioreactor, Fine-Milled Concentrate

Weight of Bioleachate
To determine the weight of bioleach solution relevant to weight of bioleached solids used in the test:

$$\frac{113\ g\ \{\text{weight used in cyanidation test}\}}{620\ g\ \{\text{reactor solids, 26.32 \% loss}\}} \times 4767\ mL\ \{\text{total bioleachate}\}$$

= **869 mL** of first reactor bioleachate is relevant to 113g of residue.

Assayed Head
Determined from the head assay of 42.86 g/t gold by considering first reactor weight loss (26.32 %), as follows:

$$\frac{42.86\ g/t}{(1 - 0.2632)} = \mathbf{58.17\ g/t}\ \{\text{gold grade of first-reactor-bioleached solids}\}$$

3.2.4 Tests CP2-2,3,4 - Second Reactor, Fine-Milled Concentrate

Weight of Bioleachate
To determine the weight of bioleach solution relevant to weight of bioleached solids used in the test:

CP2-2:

$$\frac{87.5\ g\ \{\text{weight used in cyanidation test}\}}{268.4\ g\ \{\text{reactor solids, 27.53 \% loss}\}} \times 2098\ mL\ \{\text{total bioleachate}\}$$

= **684mL** of second reactor bioleachate is relevant to 87.5 g of residue.

CP2-3 and CP2-4:

$$\frac{90\ g\ \{\text{weight used in cyanidation test}\}}{268.4\ g\ \{\text{reactor solids, 27.53 \% loss}\}} \times 2098\ mL\ \{\text{total bioleachate}\}$$

= **704mL** of second reactor bioleachate is relevant to 90 g of residue.

3.2.4 Tests CP2-2,3,4 - Calculations [cont'd]

Assayed Head

First reactor solids represent second reactor material before additional biooxidation. Therefore, the first reactor residue assay (33.20 g/t) can be used to determine total gold available in the second reactor with consideration of second reactor weight loss:

370.4 g x (1 - 0.2632) = 272.9 g {second reactor total solids at first reactor weight loss}

272.9 g x 33.20 g/t = 9060.3 ug gold total in second reactor

$$\frac{9060.3 \text{ ug}}{268.4 \text{ g}} \quad \begin{matrix}\{\text{total gold in second reactor}\} \\ \{\text{bioleached weight of solids}\}\end{matrix} = \mathbf{33.76\ g/t}$$

4.0 CONCLUSIONS

Gold extractions of 92.4 and 92.5 % were achieved from first reactor pulp samples in a 7.2 L continuous circuit operating at a first reactor target retention time of 4 days. Rod-milling the concentrate to >99 % passing 200 mesh was shown to have little benefit in gold extraction, and caused problems in the gold and silver accounts, as well as fouling bioleach solutions with arsenic precipitate. The concentrate demonstrated the unusual property of gold loss during bioleaching of the host arsenopyrite. Also demonstrated was a trend of increased gold extraction with slightly elevated cyanide levels (approximately 0.9 g/L NaCN).

Additional testwork is recommended to examine the effect of coarser particle size, as well as shorter retention time, on gold extraction in a continuous circuit of approximately 40 L capacity.

APPENDIX 1

Preliminary Gold Extraction Test and Head Assay Results

TRITON DEVELOPMENT CORPORATION

Project #93-4105 - Wheaton River/Melis Engineering Gold Bioleach

ASSAY SUMMARY	Element	Units	Ore	Concentrate
Results of Fire Assay:	Au	g/t	10.18	42.86
	Ag	g/t	998.0	4664.1
Results of Conventional Assays:	Total S	%	4.33	20.66
	S as SO4	%	< 0.01	< 0.01
	SiO2	%	73.67	23.80
	As	%	1.91	6.50
	Cu	%	-	0.40
	Fe	%	5.30	18.66
	Pb	%	-	9.08
	Zn	%	-	10.31
Results of I.C.P. Analysis	Al	%	0.61	0.30
	Ba	ppm	120	8
	Bi	ppm	47	< 3
	Ca	%	0.76	0.32
	Cd	ppm	216.2	> 1000
	Co	ppm	10	13
	Cr	ppm	80	31
	K	%	< 0.01	< 0.01
	Mg	%	0.26	0.13
	Mn	ppm	1302	937
	Mo	ppm	66	186
	Na	%	2.42	4.80
	Ni	ppm	36	78
	P	ppm	0.03	0.02
	Sb	ppm	378	1711
	Sn	ppm	28	74
	Sr	ppm	55	20
	U	ppm	< 5	< 5
	W	ppm	449	< 3

TRITON DEVELOPMENT CORPORATION
CYANIDATION TEST FOR GOLD EXTRACTION AND GOLD EXTRACTION PROFILE

PROJECT #: 93-4105
TEST#: 4105-1
SAMPLE: Wheaton River Refractory Gold-Bearing Sulphide Concentrate
SAMPLE PREP: Rod milled to 100% -325 mesh
CONDITIONS: Pulp Density: 33%, [NaCN] Target 2 g/L, pH Target 11.0

1) METALLURGICAL BALANCE

PRODUCT		WEIGHT g	ASSAY Au g/t	ASSAY Ag g/t	DISTRIBUTION Au %	DISTRIBUTION Ag %
Solution	0 hour	800	0.20	97.8	0.9	4.3
	1 hour	789	2.89	274.0	13.0	11.8
	3 hour	778	6.20	466.0	27.4	19.9
	6 hour	767	10.10	700.0	44.0	29.4
	24 hour	756	12.10	944.0	52.0	39.1
	48 hour	745	14.80	1030.0	62.6	42.0
	72 hour	734	15.40	1118.0	64.2	44.9
Residue		394	15.98	2550.6	35.8	55.1
Assayed Head		400	42.86	4664.1	-	-
Calculated Head		-	44.00	4564.4	100.0	100.0

2) TEST CONDITIONS AND REAGENT CONSUMPTION

TIME (hours)	SAMPLE	pH	Ca(OH)2 Add'n (g)	[NaCN] (g/L)	NaCN Add'n (g)	NaCN Cons. (kg/t)	Cum. NaCN Cons. (kg/t)
0.0		7.09	0.60			0.00	0.00
0.5		11.04	0.00			0.00	0.00
3.0		10.72	0.05		1.61	0.00	0.00
3.0	0 hour	10.98	0.00	2.00	0.00	0.00	0.00
4.0	1 hour	11.45	0.00	0.89	0.82	2.24	2.24
6.0	3 hour	11.52	0.00	1.23	1.00	1.41	3.65
9.0	6 hour	11.63	0.00	1.29	2.00	2.41	6.07
27.0	24 hour	11.61	0.00	2.97	0.00	1.86	7.93
51.0	48 hour	11.51	0.00	2.68	0.00	0.63	8.56
75.0	72 hour	11.30	0.00	2.59	0.00	0.24	8.80

REAGENT CONSUMPTION: NaCN: 8.80 kg / tonne solids
Ca(OH)2: 1.63 kg / tonne solids

TRITON DEVELOPMENT CORPORATION
CYANIDATION TEST FOR GOLD EXTRACTION AND GOLD EXTRACTION PROFILE

PROJECT #: 93-4105
TEST#: 4105-2
SAMPLE: Wheaton River Refractory Gold-Bearing Sulphide Concentrate
SAMPLE PREP: As Received
CONDITIONS: Pulp Density: 33%, [NaCN] Target 2 g/L, pH Target 11.0

1) METALLURGICAL BALANCE

PRODUCT		WEIGHT g	ASSAY Au g/t	ASSAY Ag g/t	DISTRIBUTION Au %	DISTRIBUTION Ag %
Solution	0 hour	800	0.16	54.6	0.7	2.2
	1 hour	789	3.27	272.0	14.7	10.7
	3 hour	778	6.05	502.0	26.9	19.4
	6 hour	767	9.49	738.0	41.6	28.2
	24 hour	756	12.38	976.0	53.5	36.7
	48 hour	745	13.28	1046.0	56.5	38.8
	72 hour	734	13.86	1068.0	58.1	39.0
Residue		397	18.45	3085.6	41.9	61.0
Assayed Head		400	42.86	4664.1	-	-
Calculated Head		-	43.74	5022.7	100.0	100.0

2) TEST CONDITIONS AND REAGENT CONSUMPTION

TIME (hours)	SAMPLE	pH	Ca(OH)2 Add'n (g)	[NaCN] (g/L)	NaCN Add'n (g)	NaCN Cons. (kg/t)	Cum. NaCN Cons. (kg/t)
0.0		7.00	0.50			0.00	0.00
0.5		11.27	0.00			0.00	0.00
3.0		10.35	0.07		1.59	0.00	0.00
3.0	0 hour	10.97	0.00	2.00	0.00	0.00	0.00
4.0	1 hour	11.43	0.00	1.10	0.65	1.83	1.83
6.0	3 hour	11.52	0.00	1.34	0.80	1.19	3.02
9.0	6 hour	11.67	0.00	1.90	0.50	0.96	3.98
27.0	24 hour	11.75	0.00	1.96	0.00	1.18	5.16
51.0	48 hour	11.71	0.00	1.78	0.00	0.40	5.56
75.0	72 hour	11.66	0.00	1.53	0.00	0.51	6.07

REAGENT CONSUMPTION: NaCN: 6.07 kg / tonne solids
Ca(OH)2: 1.43 kg / tonne solids

TRITON DEVELOPMENT CORPORATION
C.I.L. CYANIDATION TEST FOR GOLD EXTRACTION EVALUATION

PROJECT #: 93-4105
TEST#: 4105-3
SAMPLE: Wheaton River Refractory Gold-Bearing Sulphide Concentrate
SAMPLE PREP: As Received
CONDITIONS: Pulp Density: 33%, [NaCN] Target 2 g/L, pH Target 11.0, 20 g/L Carbon

1) METALLURGICAL BALANCE

PRODUCT	WEIGHT g	ASSAY Au g/t	ASSAY Ag g/t	DISTRIBUTION Au %	DISTRIBUTION Ag %
Solution 72 hour	770	0.17	216.0	0.9	9.1
Carbon	18.7	429.86	24972.7	52.4	25.7
Residue	396	18.21	3006.2	46.8	65.2
Assayed Head	400	42.86	4664.1	-	-
Calculated Head	-	38.47	4558.7	100.0	100.0

2) TEST CONDITIONS AND REAGENT CONSUMPTION

TIME (hours)	SAMPLE	pH	Ca(OH)2 Add'n (g)	[NaCN] (g/L)	NaCN Add'n (g)	NaCN Cons. (kg/t)	Cum. NaCN Cons. (kg/t)
0.0		7.02	0.45			0.00	0.00
0.5		11.13	0.00			0.00	0.00
3.0		10.17	0.08		1.61	0.00	0.00
3.0	0 hour	11.03	0.00	2.01	0.00	0.00	0.00
4.0	1 hour	11.36	0.00	0.96	0.75	2.10	2.10
6.0	3 hour	11.50	0.00	1.78	0.88	0.28	2.38
9.0	6 hour	11.67	0.00	1.96	0.43	1.86	4.24
27.0	24 hour	11.79	0.00	1.83	0.00	1.36	5.60
51.0	48 hour	11.76	0.00	1.78	0.00	0.12	5.72
75.0	72 hour	11.73	0.00	1.53	0.00	0.50	6.22

REAGENT CONSUMPTION: NaCN: 6.22 kg / tonne solids
Ca(OH)2: 1.33 kg / tonne solids

APPENDIX 2

Shakeflask and Batch Tank Testwork Results

TRITON DEVELOPMENT CORPORATION
Project# 93-4105 - Wheaton River/Melis Engineering Bioleach

PHASE I - SHAKEFLASK AMENABILITY/CULTURE DEVELOPMENT
First series shakeflasks (inoculated from Triton cultures)

Date		Time	Day	Flask 4105-1-1 Culture A 5% Solids, Ore		Flask 4105-2-1 Culture B 5% Solids, Ore	
				pH	Redox (mV)	pH	Redox (mV)
Mar	15	11.00		6.54		6.36	
1993	16	13.00	0	1.79	438	1.78	467
	17	13.00	1	1.95	459	1.78	413
	18	13.00	2	1.85	483	1.79	377
	19	10.00	3	1.69	518	1.72	397
	22	11.75	6	1.60	571	1.69	629
	23	8.50	7	1.58	617	1.65	635
	24	11.25	8	1.58	630	1.66	649
	25	9.00	9	1.61	649	1.67	666
	26	5.25	10	1.54	640	1.63	674

Second series shakeflasks (inoculated from first series)

Date		Time	Day	Flask 4105-1-2 Culture A 5% Solids, Conc.		Flask 4105-2-2 Culture B 5% Solids, Conc.	
				pH	Redox (mV)	pH	Redox (mV)
Mar	26			1.94		1.93	
	26	17.00	0	1.83	345	1.83	372
	29	11.00	3	1.75	463	1.83	424
	30	8.25	4	1.76	448	1.87	461
	31	8.25	5	1.83	487	1.89	496
Apr	1	8.25	6	1.91	528	1.93	541
	2	8.50	7	1.89	588	1.83	561
	5	8.25	10	1.55	660	1.61	587
	6	8.33	11	1.49	667	1.58	597
	7	8.50	12	1.47	668	1.53	625
	8	8.50	13	1.41	674	1.49	639
	9	14.50	14	1.40	680	1.49	663

TRITON DEVELOPMENT CORPORATION
Project# 93-4105 - Wheaton River/Melis Engineering Bioleach

PHASE I - SHAKEFLASK AMENABILITY/CULTURE DEVELOPMENT
Third series shakeflasks (inoculated from second series)

Date		Time	Day	Flask 4105-1-3 Culture A 5% Solids, Conc.		Flask 4105-2-3 Culture B 5% Solids, Conc.	
				pH	Redox (mV)	pH	Redox (mV)
Apr	9	15.00	0	1.60	495	1.62	479
	10	16.00	1	1.75	510	1.83	492
	11	16.00	2	1.84	540	1.92	518
	12	8.25	3	1.80	600	1.85	549
	13	8.50	4	1.64	647	1.71	631
	14	8.50	5	1.59	660	1.62	652
	16	9.00	7	1.43	678	1.49	679
	19	8.33	10	1.31	699	1.33	695
	20	8.25	11	1.36	698	1.38	692
	21	8.25	12	1.47	702	1.44	693
	26	8.50	17	1.25	710	1.27	706

TRITON DEVELOPMENT CORPORATION - Industrial Biotechnology Division
Project# 93-4105 - Wheaton River/Melis Engineering - FeAsS Concentrate Bioleach

PHASE II - BATCH TANK SCOPING TESTWORK

Date		Time	Day	Temp (C)	pH	Redox (mV)	Conc. H2SO4 (mL)	Pulp Volume (L)	Fe (mg/L)	As (mg/L)
Mar	25	14.50		31.1	4.23	189	7.3	5.20		
	26	17.00		41.2	4.65	126	9.0	5.20	1114	188
	26	21.50	0	33.5	1.80	240	2.0	5.20	1104	198
	27	13.00	1	35.0	1.84	230		5.20	1223	205
	28	16.00	2	35.1	2.14	222	5.0	5.20	1408	208
	29	11.00	3	35.6	1.91	260		5.20	1410	208
	30	8.25	4	35.0	1.74	305		5.20	1428	212
	31	8.25	5	35.7	1.68	299		5.20	1339	211
Apr	1	8.25	6	35.9	1.66	368		5.20	1357	239
	2	8.25	7	36.0	1.69	412		5.20	1687	504
	3	11.00	8	36.1	1.68	453		5.20	2593	1424
	4	12.50	9	34.1	1.74	478		5.20	3903	2924
	5	8.25	10	34.1	1.72	438	*	3.70	3888	3105
	5	15.50	10	34.7	1.75	432		3.70	3870	3278
	5	16.50	10	32.0	1.76	429	**	3.70	2793	2439
	6	8.25	11	34.7	1.82	408		3.70	2813	2379
	6	17.50	11	34.7	1.81	399		3.70	2725	2309
	6	18.00	11	30.7	1.82	395	***	3.70	2015	1752
	7	8.33	12	34.6	1.89	388		3.70	2004	1768
	8	8.33	13	35.0	1.90	379		3.70	2028	1770
	8	18.00	13	34.8	1.89	376		3.70		
	9	14.50	14	34.6	1.85	369		3.70	2105	1795
	9	15.00	14	34.2	1.85	391	****	3.70	2155	1798
	10	16.00	15	35.0	1.77	449		3.70	2288	2010
	11	14.00	16	34.9	1.80	468		3.70	2770	2612
	12	8.25	17	34.8	1.82	473		3.70	3570	3192
	13	8.33	18	35.4	1.80	543		3.70	4888	4456
	13	18.00	18	35.4	1.75	568	*****	2.14	4970	4506
	14	8.25	19	35.4	1.63	586		2.14	5383	4810
	15	8.00	20	35.5	1.46	622		2.14		
	16	8.75	21	36.4	1.34	648		2.14	8390	5110
	17	12.00	22	34.5	1.26	670		2.14		
	18	13.75	23	33.8	1.22	667		2.14		
	19	8.33	24	34.1	1.16	675		2.14	12230	5020
	20	8.25	25	34.1	1.14	688	******	2.14	12890	5040

* First bioleached pulp sample withdrawn for cyanidation.
** First solution exchange, 1000 mL.
*** Second solution exchange, 1000 mL.
**** Reactor re-inoculated with 46 mL from each of flasks 4105-1-2 and -2-2.
***** Second bioleached pulp sample withdrawn for cyanidation.
****** Third bioleached pulp sample withdrawn for cyanidation.

APPENDIX 3

Batch Tank Residue
Cyanidation Test Results

TRITON DEVELOPMENT CORPORATION
BATCH TESTWORK FOR GOLD EXTRACTION PROFILE
PROJECT #93-4105 - Melis Engineering Wheaton River Bioleach

Weight Loss Determination

Assay	Units	Head	P1 1st Bioleach Residue	P2 2nd Bioleach Residue	P3 3rd Bioleach Residue
SiO2	%	23.80	29.50	32.10	45.96
Weight Loss	%	0.00	19.32	25.86	48.22

Oxidation Summary

Assay	Units	Head	P1 1st Bioleach Residue	P2 2nd Bioleach Residue	P3 3rd Bioleach Residue
As Assay	%	6.50	4.95	2.29	0.35
As Corrected Assay*	%	6.50	3.99	1.70	0.18
As Extraction	%	-	38.56	73.88	97.21
Cu Assay	%	0.40	0.19	0.15	0.07
Cu Corrected Assay*	%	0.40	0.15	0.11	0.04
Cu Extraction	%	-	61.48	71.83	90.42
Fe Assay	%	18.66	14.22	12.90	4.99
Fe Corrected Assay*	%	18.66	11.47	9.56	2.58
Fe Extraction	%	-	38.52	48.74	86.15
Pb Assay	%	9.08	10.90	11.50	17.40
Pb Corrected Assay*	%	9.08	8.79	8.53	9.01
Pb Extraction	%	-	14.71	17.30	12.60
Zn Assay	%	10.31	9.30	8.90	5.50
Zn Corrected Assay*	%	10.31	7.50	6.60	2.85
Zn Extraction	%	-	27.23	36.00	72.38
S= Assay	%	20.66	19.33	19.86	9.91
S= Corrected Assay*	%	20.66	15.60	14.72	5.13
S= Destruction	%	-	24.52	28.73	75.16

* Corrected for weight loss during bioleach

TRITON DEVELOPMENT CORPORATION
CYANIDATION TEST FOR GOLD EXTRACTION/SULPHIDE DESTRUCTION EVALUATION

PROJECT #: 93-4105
TEST#: P1
SAMPLE: Wheaton River Refractory Gold-Bearing Sulphide Concentrate
SAMPLE PREP: First Bioleach Residue
CONDITIONS: Pulp Density: 33%, [NaCN] Target 1 g/L, pH Target 10.5

1) METALLURGICAL BALANCE

PRODUCT	WEIGHT g	ASSAY Au g/t	ASSAY Ag g/t	DISTRIBUTION Au %	DISTRIBUTION Ag %
Solution 24 Hour	200	9.90	935.0	45.1	40.7
Residue	100	24.15	2730.0	54.9	59.3
Assayed Head	100	43.50	4890.0	-	-
Calculated Head	-	43.95	4600.0	100.0	100.0

2) TEST CONDITIONS AND REAGENT CONSUMPTION

TIME (hours)	SAMPLE	pH	Ca(OH)2 Add'n (g)	[NaCN] (g/L)	NaCN Add'n (g)	NaCN Cons. (kg/t)	Cum. NaCN Cons. (kg/t)
0.0							
0.5		2.58	3.13				
3.0		10.70	0.00		0.23		
3.0	0 hour	11.13	0.00	0.44	0.21	1.39	1.39
4.0	1 hour	11.04	0.00	0.72	0.08	1.54	2.93
6.0	3 hour	11.05	0.00	1.03	0.00	0.21	3.14
9.0	6 hour	11.12	0.00	0.53	0.16	1.00	4.14
21.0	18 hour	11.12	0.00	0.80	0.00	1.01	5.15
27.0	24 hour	11.06	0.00	0.56	0.00	0.48	5.63

REAGENT CONSUMPTION:			
	NaCN:	5.63	kg / tonne solids
	Ca(OH)2:	31.32	kg / tonne solids

TRITON DEVELOPMENT CORPORATION
CYANIDATION TEST FOR GOLD EXTRACTION/SULPHIDE DESTRUCTION EVALUATION

PROJECT #: 93-4105
TEST#: P2
SAMPLE: Wheaton River Refractory Gold-Bearing Sulphide Concentrate
SAMPLE PREP: Second Bioleach Residue
CONDITIONS: Pulp Density: 33%, [NaCN] Target 1 g/L, pH Target 10.5

1) METALLURGICAL BALANCE

PRODUCT	WEIGHT g	ASSAY Au g/t	ASSAY Ag g/t	DISTRIBUTION Au %	DISTRIBUTION Ag %
Solution 24 Hour	200	16.30	1120.0	68.8	44.1
Residue	100	14.78	2840.0	31.2	55.9
Assayed Head	100	47.65	5470.0	-	-
Calculated Head	-	47.38	5080.0	100.0	100.0

2) TEST CONDITIONS AND REAGENT CONSUMPTION

TIME (hours)	SAMPLE	pH	Ca(OH)2 Add'n (g)	[NaCN] (g/L)	NaCN Add'n (g)	NaCN Cons. (kg/t)	Cum. NaCN Cons. (kg/t)
0.0							
0.5		2.57	3.65				
3.0		10.31	0.00		0.12		
3.0	0 hour	10.70	0.00	0.30	0.26	0.57	0.57
4.0	1 hour	10.07	0.07	0.56	0.11	2.08	2.65
6.0	3 hour	10.43	0.06	0.70	0.09	0.86	3.51
9.0	6 hour	10.71	0.05	0.38	0.21	1.57	5.08
21.0	18 hour	10.97	0.00	0.68	0.00	1.50	6.58
27.0	24 hour	10.87	0.00	0.34	0.00	0.68	7.26

REAGENT CONSUMPTION: NaCN: 7.26 kg / tonne solids
Ca(OH)2: 38.35 kg / tonne solids

TRITON DEVELOPMENT CORPORATION
CYANIDATION TEST FOR GOLD EXTRACTION/SULPHIDE DESTRUCTION EVALUATION

PROJECT #: 93-4105
TEST#: P3
SAMPLE: Wheaton River Refractory Gold-Bearing Sulphide Concentrate
SAMPLE PREP: Third Bioleach Residue
CONDITIONS: Pulp Density: 33%, [NaCN] Target 1 g/L, pH Target 10.5

1) METALLURGICAL BALANCE

PRODUCT	WEIGHT g	ASSAY Au g/t	ASSAY Ag g/t	DISTRIBUTION Au %	DISTRIBUTION Ag %
Solution 24 Hour	200	27.40	3200.0	82.0	68.2
Residue	100	12.03	2990.0	18.0	31.8
Assayed Head	100	65.60	7860.0	-	-
Calculated Head	-	66.83	6566.4	100.0	100.0

2) TEST CONDITIONS AND REAGENT CONSUMPTION

TIME (hours)	SAMPLE	pH	Ca(OH)2 Add'n (g)	[NaCN] (g/L)	NaCN Add'n (g)	NaCN Cons. (kg/t)	Cum. NaCN Cons. (kg/t)
0.0							
0.5		3.48	5.03				
3.0		11.12	0.00		0.22		
3.0	0 hour	11.21	0.00	0.00	0.38	2.22	2.22
4.0	1 hour	10.87	0.00	0.00	0.49	3.80	6.02
6.0	3 hour	10.62	0.03	0.56	0.21	3.76	9.78
9.0	6 hour	10.60	0.05	0.17	0.30	2.87	12.65
21.0	18 hour	10.89	0.00	0.72	0.00	1.90	14.55
27.0	24 hour	10.80	0.00	0.40	0.00	0.64	15.19

REAGENT CONSUMPTION: NaCN: 15.19 kg / tonne solids
Ca(OH)2: 51.09 kg / tonne solids

APPENDIX 4

Continuous System Data

TRITON DEVELOPMENT CORPORATION - Industrial Biotechnology Division
Project# 93-4105 - Wheaton River/Melis Engineering - FeAsS Concentrate Bioleach

PHASE III - TWO-STAGE 7.2 L CONTINUOUS SCOPING TESTWORK

Date		Time	Day	FEED DATA Vol (L)	New (L)	Trans. (L)	System Ret'n (hours)	REACTOR #1 (5.0L) Temp (C)	pH	Redox (mV)	Conc. H2SO4 (mL)	Lime (g)	Fe (g/L)	As (g/L)	PERCENT EXTRACTION Fe	As
May	11	14.25						32.1	2.06		8.0					
	12	8.50	0					34.7	1.82							
	13	9.25	1					34.2	2.00	331	2.0					
	14	9.67	2					34.7	1.81	358						
	15	13.67	3					34.6	1.67	422						
	17	9.50	5					34.3	1.63	632						
	18	9.50	6					34.9	1.52	642						
	19	9.67	7					35.0	1.37	670						
	20	9.33	8					35.1	1.31	680						
	20	13.33	8							658						
	21	9.33	9					35.3	1.28	684						
	21	18.00	9					35.3	1.30	662						
	23	17.00	11					35.4	1.20	694						
	25	9.50	13					35.3	1.09	683						
	26	9.50	14					35.5	1.06	673						
	27	9.00	15					35.9	1.09	688						
	28	18.00	16	0.00	3.00			35.9	1.07	667						
	30	8.00	18	1.00	5.00	2.00	137	36.4	1.40	614						
	31	10.00	19	3.70	3.70	1.30	144	36.3	1.40	590			19.26	10.27	58.46	89.49
June	1	9.25	20	2.70	5.00	1.00	167	36.5	1.41	592						
	2	9.75	21	4.00	4.00	1.00	176	37.0	1.33	570			18.51	11.10	56.18	96.72
	3	9.15	22	3.20	3.20	0.80	211	36.1	1.24	584						
	4	9.50	23	2.20	5.00	1.00	175	36.0	1.13	584						
	7	9.00	26	1.60	5.00	3.40	151	36.1	1.15	535			12.80	7.30	38.85	63.61
	8	9.00	27	3.70	3.70	1.30	133	36.6	1.19	560						
	9	9.50	28	2.40	5.00	1.30	136	26.0	1.23	536						
	10	9.50	29	4.00	4.00	1.00	173	34.5	1.40	511			11.90	7.70	36.12	67.09
	11	9.67	30	3.50	5.00	0.50	348	34.4	1.35	513						
	12	13.00	31	5.00	5.00	0.00	-	33.3	1.79	520		40.0				

TRITON DEVELOPMENT CORPORATION - Industrial Biotechnology Division
Project# 93-4105 - Wheaton River/Melis Engineering - FeAsS Concentrate Bioleach

PHASE III - TWO-STAGE 7.2 L CONTINUOUS SCOPING TESTWORK

Date		Time	Day	FEED DATA Vol (L)	New (L)	Trans. (L)	System Ret'n (hours)	REACTOR #1 (5.0L) Temp (C)	pH	Redox (mV)	Conc. H2SO4 (mL)	Lime (g)	Fe (g/L)	As (g/L)	PERCENT EXTRACTION Fe	As
	13	14.00	32	5.00	5.00	0.00	-	33.6	1.67	571						
	14	9.33	33	3.90	3.90	1.10	127	33.5	1.40	558			10.80	7.00	32.78	60.99
	15	9.25	34	2.90	2.90	1.00	172	33.6	1.33	582		30.0				
	16	9.00	35	1.50	5.00	1.40	122	34.0	1.63	587						
	17	8.50	36	3.70	3.70	1.30	130	34.1	1.42	600		20.0	16.30	11.40	49.47	99.33
	18	8.67	37	2.30	5.00	1.40	124	34.0	1.34	600		20.0				
	20	13.25	39	2.40	2.40	2.60	146	35.0	1.15	609		30.0				
	21	8.67	40	1.10	5.00	1.30	108	34.5	1.25	612			20.80	14.30	63.13	> 99
	22	9.25	41	4.30	4.30	0.70	253	34.2	1.32	618		30.0	23.50	14.90	71.33	> 99
	22	20.00	41	4.30	4.30	0.00	-	34.2	1.50	554						
	23	9.50	42	4.30	4.30	0.00	-	36.2	1.53	531		40.0				
	24	9.50	43	4.30	4.30	0.00	-	30.2	0.89	650						
	25	9.00	44	4.30	4.30	0.00	-	34.4	1.50	526						
	27	15.67	46	4.30	4.30	0.00	-	35.6	1.31	550						
	28	9.00	47	4.30	4.30	0.00	-	35.9	1.20	580		30.0	18.30	11.70	55.54	> 99
	29	9.50	48	4.30	1.60	0.00	-	35.7	1.01	617		40.0				
	30	8.67	49	0.60	3.75	1.00	167	35.6	1.33	607						
July	2	11.00	51	2.40	5.40	1.35	268	35.8	0.89	643		50.0	22.10	8.80	67.08	76.68
	5	9.50	54	2.20	2.20	3.20	159	35.8	1.37	632						
	6	9.50	55	1.30	4.30	0.90	192	35.9	1.26	646			21.10	11.30	64.04	98.46
	7	9.00	56	3.40	3.40	0.90	188	36.0	1.22	621		30.0				
	8	10.25	57	2.30	2.30	1.10	165	35.9	1.40	624						
	9	10.33	58	1.30	1.30	1.00	173	36.0	1.34	627			33.80	15.40	> 99	> 99
	10	10.50	59	0.50	0.50	0.80	218	36.2	1.14	625			29.20	13.20	88.63	> 99
					TOTAL: 35.65						Total H2SO4 Addition:	18.4 g				
											Total Ca(OH)2 Addition:	360.0 g				

TRITON DEVELOPMENT CORPORATION - Industrial Biotechnology Division
Project# 93-4105 - Wheaton River/Melis Engineering - FeAsS Concentrate Bioleach

PHASE III - TWO-STAGE 7.2 L CONTINUOUS SCOPING TESTWORK

Day	REACTOR #2 (2.2L) Temp (C)	pH	Redox (mV)	Conc. H2SO4 (mL)	Lime (g)	Fe (g/L)	As (g/L)	PERCENT EXTRACTION Fe	As	System Pulp Density (% w/w)	Product Volume (L)
	30.0	2.11		3.0						5.0	
0	32.2	1.88		1.0						5.0	
1	34.7	1.88	338	1.0						5.0	
2	34.5	1.75	344							5.0	
3	34.8	1.63	409							5.0	
5	34.3	1.71	573							5.0	
6	34.5	1.56	642							5.0	
7	34.9	1.47	662							5.0	
8	34.7	1.41	673							5.0	
8			653							6.0	
9	34.4	1.39	676							6.0	
9	34.6	1.37	653							8.0	
11	34.9	1.27	684							8.0	
13	34.3	1.28	686							10.0	
14	34.4	1.28	659							12.0	
15	34.2	1.23	675							12.0	
16	34.8	1.20	640							15.0	
18	34.3	1.20	656							15.0	1.48
19	33.6	0.98	650			23.22	12.66	70.48	> 99	15.0	0.92
20	33.7	0.96	651							15.0	0.74
21	33.4	0.95	653			25.35	14.10	76.94	> 99	15.0	0.70
22	33.9	0.93	648							15.0	0.87
23	33.2	0.90	644							15.0	0.70
26	33.9	0.89	593			19.20	8.80	58.28	76.68	15.0	2.53
27	33.7	0.91	613							15.0	0.81
28	33.5	0.96	608							15.0	0.88
29	33.4	1.11	600			18.00	8.70	54.63	75.81	15.0	0.83
30	34.2	0.97	604		40.0					15.0	0.29
31	34.6	1.65	590							15.0	0.00

TRITON DEVELOPMENT CORPORATION - Industrial Biotechnology Division
Project# 93-4105 - Wheaton River/Melis Engineering - FeAsS Concentrate Bioleach

PHASE III - TWO-STAGE 7.2 L CONTINUOUS SCOPING TESTWORK

Day	REACTOR #2 (2.2L) Temp (C)	pH	Redox (mV)	Conc. H2SO4 (mL)	Lime (g)	Fe (g/L)	As (g/L)	PERCENT EXTRACTION Fe	As	System Pulp Density (% w/w)	Product Volume (L)
32	34.8	1.55	613							15.0	0.00
33	34.3	1.23	609			20.70	9.40	62.83	81.91	15.0	0.33
34	34.9	1.10	629		32.0					15.0	1.20
35	34.9	1.66	610							15.0	1.31
36	34.2	1.37	633		20.0	21.40	14.10	64.95	> 99	15.0	0.95
37	34.0	1.45	626		10.0					15.0	1.46
39	34.6	1.15	638		20.0					15.0	2.18
40	34.5	1.33	635			23.70	14.50	71.94	> 99	15.0	0.98
41	34.2	1.39	639		10.0	21.50	13.70	65.26	> 99	15.0	0.83
41	34.2	1.70	500							15.0	0.00
42	34.7	1.16	613		20.0					15.0	0.00
43	34.9	1.39	610							15.0	0.00
44	34.4	1.37	641							15.0	0.00
46										15.0	0.00
47	34.5	1.15	681		20.0	25.40	12.60	77.10	> 99	15.0	0.00
48	34.5	1.27	666							15.0	0.00
49	34.3	1.31	651							15.0	0.91
51	34.1	0.91	673		30.0	23.30	12.40	70.72	> 99	15.0	1.20
54	34.9	1.53	661							15.0	2.38
55	33.5	1.38	666			23.40	13.10	71.02	> 99	15.0	0.78
56	34.0	1.32	633							15.0	0.72
57	33.5	1.38	661							15.0	0.76
58	33.5	1.40	660			37.40	17.00	> 99	> 99	15.0	0.74
59	34.2	1.11	627			34.70	14.80	> 99	> 99	15.0	0.60
	Total H2SO4 Addition:				9.2 g						TOTAL 28.08
	Total Ca(OH)2 Addition:				202.0 g						

APPENDIX 5

Continuous System Residue Cyanidation Test Results

TRITON DEVELOPMENT CORPORATION
CONTINUOUS BIOLEACH PROCESS FEASIBILITY TESTWORK
PROJECT #93-4105 - Melis Engineering Wheaton River Bioleach

Weight Loss Determination and Oxidation Summary for residues obtained on day **41** (as-received concentrate) - Used for tests **CP1-x**

Weight Loss Determination

Assay	Units	Head	1st Reactor Residue	2nd Reactor Residue
SiO2	%	23.80	38.44	56.04
Weight Loss	%	0.00	38.09	57.53

Oxidation Summary

Assay	Units	Head	1st Reactor Residue	2nd Reactor Residue
As Assay	%	6.50	0.85	0.19
As Corrected Assay*	%	6.50	0.53	0.08
As Extraction	%	-	91.90	98.76
Cu Assay	%	0.40	0.26	0.18
Cu Corrected Assay*	%	0.40	0.16	0.08
Cu Extraction	%	-	59.76	80.89
Fe Assay	%	18.66	11.60	6.00
Fe Corrected Assay*	%	18.66	7.18	2.55
Fe Extraction	%	-	61.51	86.34
Pb Assay	%	9.08	9.40	8.20
Pb Corrected Assay*	%	9.08	5.82	3.48
Pb Extraction	%	-	35.90	61.65
Zn Assay	%	10.31	8.90	6.40
Zn Corrected Assay*	%	10.31	5.51	2.72
Zn Extraction	%	-	46.55	73.64
S= Assay	%	20.66	17.76	10.53
S= Corrected Assay*	%	20.66	11.00	4.47
S= Destruction	%	-	46.78	78.35

* Corrected for weight loss during bioleach

TRITON DEVELOPMENT CORPORATION
CYANIDATION TEST FOR GOLD EXTRACTION AND GOLD EXTRACTION PROFILE

PROJECT #: 93-4105
TEST#: CP1-1
SAMPLE: Wheaton River Refractory Gold-Bearing Sulphide Concentrate
SAMPLE PREP: Continuous Bioleach, First Bioreactor Residue, As-Recieved Concentrate
CONDITIONS: Pulp Density: 33%, [NaCN] Target 2 g/L, pH Target 10.5-11.0

1) METALLURGICAL BALANCE

PRODUCT		WEIGHT g	ASSAY Au g/t	ASSAY Ag g/t	DISTRIBUTION Au %	DISTRIBUTION Ag %
Solution	0.5 hour	191	4.80	930	14.1	27.2
	1 hour	191	7.60	1030	22.9	31.2
	3 hour	191	12.10	1390	36.9	43.0
	6 hour	191	16.00	1550	49.8	49.3
	21 hour	191	23.00	1540	72.2	50.8
	45 hour	191	29.00	1850	92.5	61.7
	72 hour	191	25.00	1400	81.3	49.1
Residue		113	8.61	2680	14.3	44.4
Bioleachate (1)		1034	0.29	43	4.4	6.5
Assayed Head (2)		113	69.23	7534	-	-
Calculated Head (3)		-	60.18	6034	100.0	100.0

(1) Weight of bioleachate is determined by the weight of solids used in the test divided by the total weight of solids in the 5L bioreactor (with weight loss), multiplied by the total solution volume of the bioreactor (4767 mL), to determine the volume of bioleachate relevant to the CN residue weight.
(2) Determined from the head assay of 42.86 g/t by considering the weight loss of the sample (38.09 %).
(3) Determined from the total metal extracted and residue weight.
** NOTE ** The above calculations consider solution losses to sampling.

2) TEST CONDITIONS AND REAGENT CONSUMPTION

TIME (hours)	SAMPLE	pH	Ca(OH)2 Add'n (g)	[NaCN] (g/L)	NaCN Add'n (g)	NaCN Cons. (kg/t)	Cum. NaCN Cons. (kg/t)
0.0		4.79	1.70				
24.0	0 hour	10.09	0.00	2.29	0.44		
24.5	0.5 hour	11.28	0.00	0.98	0.24	6.08	6.08
25.0	1 hour	11.28	0.00	1.46	0.12	1.30	7.37
27.0	3 hour	11.30	0.00	0.79	0.36	2.18	9.56
30.0	6 hour	11.17	0.00	1.06	0.40	2.72	12.28
45.0	21 hour	11.14	0.00	0.08	0.59	5.21	17.49
49.0	25 hour	11.10	0.00	1.80	0.24	2.34	19.83
69.0	45 hour	10.89	0.00	0.15	0.37	4.93	24.76
92.0	68 hour	10.85	0.00	0.56	0.29	2.58	27.34
96.0	72 hour	10.83	0.00	1.77	0.00	0.52	27.87

REAGENT CONSUMPTION:			
	NaCN:	27.9	kg / tonne solids
	Ca(OH)2:	15.1	kg / tonne solids

TRITON DEVELOPMENT CORPORATION
CYANIDATION TEST FOR GOLD EXTRACTION AND GOLD EXTRACTION PROFILE

PROJECT #: 93-4105
TEST#: CP1-2
SAMPLE: Wheaton River Refractory Gold-Bearing Sulphide Concentrate
SAMPLE PREP: Continuous Bioleach, Second Bioreactor Residue, As-Recieved Concentrate
CONDITIONS: Pulp Density: 33%, [NaCN] Target 2 g/L, pH Target 10.5-11.0

1) METALLURGICAL BALANCE

PRODUCT		WEIGHT g	ASSAY Au g/t	ASSAY Ag g/t	DISTRIBUTION Au %	DISTRIBUTION Ag %
Solution	0.5 hour	196	3.60	880	14.5	32.3
	1 hour	196	5.40	1000	22.4	38.0
	3 hour	196	8.50	1460	35.7	56.4
	6 hour	196	10.50	1590	45.1	63.2
	21 hour	196	12.00	1600	52.8	65.9
	45 hour	196	16.00	1660	70.9	70.4
	72 hour	196	13.00	1250	59.2	55.9
Residue		104	3.78	1670	7.8	31.3
Bioleachate (1)		1390	1.20	51	33.0	12.8
Assayed Head (2)		104	51.01	9180	-	-
Calculated Head (3)		-	48.59	5334	100.0	100.0

(1) Weight of bioleachate is determined by the weight of solids used in the test divided by the total weight of solids in the 2.2L bioreactor (with weight loss), multiplied by the total solution volume of the bioreactor (2098 mL), to determine the volume of bioleachate relevant to the CN residue weight.
(2) Determined from the assayed value (35.00 g/t) by considering gold lost to bioleachate.
(3) Determined from the total metal extracted and residue weight.
** NOTE ** The above calculations consider solution losses to sampling.

2) TEST CONDITIONS AND REAGENT CONSUMPTION

TIME (hours)	SAMPLE	pH	Ca(OH)2 Add'n (g)	[NaCN] (g/L)	NaCN Add'n (g)	NaCN Cons. (kg/t)	Cum. NaCN Cons. (kg/t)
0.0		5.20	1.54				
24.0	0 hour	9.88	0.00	2.31	0.45		
24.5	0.5 hour	11.18	0.00	0.79	0.24	7.20	7.20
25.0	1 hour	11.27	0.00	1.67	0.07	0.63	7.83
27.0	3 hour	11.33	0.00	1.13	0.25	1.71	9.54
30.0	6 hour	11.28	0.00	1.50	0.20	1.69	11.23
45.0	21 hour	11.14	0.00	0.08	0.59	4.59	15.82
49.0	25 hour	10.78	0.00	1.38	0.32	3.25	19.07
69.0	45 hour	10.79	0.00	1.00	0.20	3.76	22.84
92.0	68 hour	10.80	0.00	1.44	0.18	1.12	23.96
96.0	72 hour	10.90	0.00	1.67	0.00	1.30	25.26

REAGENT CONSUMPTION:			
NaCN:	25.3	kg / tonne solids	
Ca(OH)2:	14.8	kg / tonne solids	

TRITON DEVELOPMENT CORPORATION
CONTINUOUS BIOLEACH PROCESS FEASIBILITY TESTWORK
PROJECT #93-4105 - Melis Engineering Wheaton River Bioleach

Weight Loss Determination and Oxidation Summary for residues obtained at termination (concentrate milled to >99% -325 mesh) - Used for tests CP2-x

Weight Loss Determination

Assay	Units	Head	1st Reactor Residue	2nd Reactor Residue
SiO2	%	23.80	32.30	32.84
Weight Loss	%	0.00	26.32	27.53

Oxidation Summary

Assay	Units	Head	1st Reactor Residue	2nd Reactor Residue
As Assay	%	6.50	1.20	0.96
As Corrected Assay*	%	6.50	0.88	0.70
As Extraction	%	-	86.40	89.30
Cu Assay	%	0.40	0.07	0.08
Cu Corrected Assay*	%	0.40	0.05	0.06
Cu Extraction	%	-	87.11	85.51
Fe Assay	%	18.66	4.32	2.90
Fe Corrected Assay*	%	18.66	3.18	2.10
Fe Extraction	%	-	82.94	88.74
Pb Assay	%	9.08	15.10	10.10
Pb Corrected Assay*	%	9.08	11.13	7.32
Pb Extraction	%	-	0.00	19.39
Zn Assay	%	10.31	1.62	1.72
Zn Corrected Assay*	%	10.31	1.19	1.25
Zn Extraction	%	-	88.42	87.91
S= Assay	%	20.66	2.72	1.81
S= Corrected Assay*	%	20.66	2.00	1.31
S= Destruction	%	-	90.30	93.65

* Corrected for weight loss during bioleach

TRITON DEVELOPMENT CORPORATION
CYANIDATION TEST FOR GOLD EXTRACTION AND GOLD EXTRACTION PROFILE

PROJECT #: 93-4105
TEST#: CP2-1
SAMPLE: Wheaton River Refractory Gold-Bearing Sulphide Concentrate
SAMPLE PREP: Continuous Bioleach, First Bioreactor Residue, Fine-Milled Concentrate
CONDITIONS: Pulp Density: 33%, [CN] Target 0.5 g/L ([NaCN] Target 0.94 g/L), pH Target 9.5 -10.5

1) METALLURGICAL BALANCE

PRODUCT		WEIGHT g	ASSAY Au g/t	ASSAY Ag g/t	DISTRIBUTION Au %	DISTRIBUTION Ag %
Solution	1 hour	194	12.50	1300	35.9	53.3
	4 hour	194	19.00	1620	57.7	70.7
	8 hour	194	22.00	1620	70.5	75.6
	24 hour	194	26.00	1800	86.9	88.0
	48 hour	194	26.00	1380	92.4	75.8
Residue		113	4.80	690	7.6	15.6
Bioleachate (1)		869	0.00	49	0.0	8.6
Assayed Head (2)		113	58.17	6330	-	-
Calculated Head (3)		-	63.02	4411	100.0	100.0

(1) Weight of bioleachate is determined by the weight of solids used in the test divided by the total weight of solids in the 5L bioreactor (with weight loss), multiplied by the total solution volume of the bioreactor (4767 mL), to determine the volume of bioleachate relevant to the CN residue weight.
(2) Determined from the head assay of 42.86 g/t by considering the weight loss of the sample (26.32 %).
(3) Determined from the total metal extracted and residue weight.
** NOTE ** The above calculations consider solution losses to sampling.

2) TEST CONDITIONS AND REAGENT CONSUMPTION

TIME (hours)	SAMPLE	pH	Ca(OH)2 Add'n (g)	[NaCN] (g/L)	NaCN Add'n (g)	NaCN Cons. (kg/t)	Cum. NaCN Cons. (kg/t)
0.0		5.30	1.14				
18.0		7.15	1.83				
19.0		9.15	0.36				
19.5	0 hour	9.37	0.67	0.94	0.211	0.00	0.00
20.0	0.5 hour	9.31	0.41	0.05	0.214	3.40	3.40
20.5	1 hour	9.44	0.29	0.22	0.218	1.60	5.00
23.5	4 hour	9.43	0.30	0.23	0.222	1.92	6.92
24.5	5 hour	9.75	0.10	0.51	0.118	1.48	8.40
27.5	8 hour	9.86	0.10	0.66	0.078	0.78	9.19
43.5	24 hour	10.00	0.00	0.13	0.177	1.60	10.79
45.5	26 hour		0.00	0.70	0.053	0.58	11.37
47.5	28 hour		0.00	0.54	0.085	0.74	12.11
49.5	30 hour		0.00	0.95	0.000	0.05	12.16
51.5	32 hour	10.10	0.00	0.75	0.071	0.34	12.51
67.5	48 hour	10.06	0.00	0.44	0.000	1.17	13.67

REAGENT CONSUMPTION:			
	NaCN:	13.7	kg / tonne solids
	Ca(OH)2:	45.9	kg / tonne solids

TRITON DEVELOPMENT CORPORATION
CYANIDATION TEST FOR GOLD EXTRACTION AND GOLD EXTRACTION PROFILE

PROJECT #: 93-4105
TEST#: CP2-2
SAMPLE: Wheaton River Refractory Gold-Bearing Sulphide Concentrate
SAMPLE PREP: Continuous Bioleach, Second Bioreactor Residue, Fine-Milled Concentrate
CONDITIONS: Pulp Density: 33%, [CN] Target 0.1 g/L ([NaCN] Target 0.19 g/L), pH Target 9.5 -10.5

1) METALLURGICAL BALANCE

PRODUCT		WEIGHT g	ASSAY Au g/t	ASSAY Ag g/t	DISTRIBUTION Au %	DISTRIBUTION Ag %
Solution	1 hour	116	13.50	800	44.9	21.4
	4 hour	116	14.00	1200	51.9	35.1
	8 hour	116	14.00	1680	57.4	52.2
	24 hour	116	16.00	1420	69.9	50.3
	48 hour	116	13.00	1200	65.8	48.7
Residue		88	7.03	2080	16.2	38.5
Bioleachate (1)		684	1.00	88	18.0	12.7
Assayed Head (2)		88	33.76	2969	-	-
Calculated Head (3)		-	43.44	5397	100.0	100.0

(1) Weight of bioleachate is determined by the weight of solids used in the test divided by the total weight of solids in the 2.2L bioreactor (with weight loss), multiplied by the total solution volume of the bioreactor (2098 mL), to determine the volume of bioleachate relevant to the CN residue weight.
(2) Determined from the first reactor residue assay (33.20 g/t) by considering second reactor weight loss.
(3) Determined from the total metal extracted and residue weight.
** NOTE ** The above calculations consider solution losses to sampling.

2) TEST CONDITIONS AND REAGENT CONSUMPTION

TIME (hours)	SAMPLE	pH	Ca(OH)2 Add'n (g)	[NaCN] (g/L)	NaCN Add'n (g)	NaCN Cons. (kg/t)	Cum. NaCN Cons. (kg/t)
0.0		5.84	0.79				
18.0		7.34	1.12				
19.0		9.19	0.24				
19.5	0 hour	9.44	0.06	0.19	0.049	0.00	0.00
20.0	0.5 hour	9.23	0.36	0.01	0.068	0.80	0.80
20.5	1 hour	9.50	0.20	0.01	0.056	0.77	1.57
23.5	4 hour	9.97	0.10	0.01	0.097	0.63	2.21
24.5	5 hour	10.71	0.00	0.03	0.048	1.09	3.29
27.5	8 hour	10.60	0.00	0.04	0.044	0.53	3.83
43.5	24 hour	10.16	0.00	0.01	0.027	0.54	4.37
45.5	26 hour		0.00	0.01	0.035	0.31	4.68
47.5	28 hour		0.00	0.01	0.029	0.40	5.07
49.5	30 hour		0.00	0.03	0.025	0.31	5.39
51.5	32 hour	10.24	0.00	0.01	0.028	0.31	5.69
67.5	48 hour	10.11	0.00	0.01	0.000	0.31	6.01

REAGENT CONSUMPTION:			
NaCN:	6.0	kg / tonne solids	
Ca(OH)2:	32.9	kg / tonne solids	

TRITON DEVELOPMENT CORPORATION
CYANIDATION TEST FOR GOLD EXTRACTION AND GOLD EXTRACTION PROFILE

PROJECT #: 93-4105
TEST#: CP2-3
SAMPLE: Wheaton River Refractory Gold-Bearing Sulphide Concentrate
SAMPLE PREP: Continuous Bioleach, Second Bioreactor Residue, Fine-Milled Concentrate
CONDITIONS: Pulp Density: 33%, [CN] Target 0.2 g/L ([NaCN] Target 0.38 g/L), pH Target 9.5 -10.5
C.I.L. @ 20 g/L Carbon

1) METALLURGICAL BALANCE

PRODUCT	WEIGHT g	ASSAY Au g/t	ASSAY Ag g/t	DISTRIBUTION Au %	DISTRIBUTION Ag %
Solution 48 hour	119	1.50	320	6.1	12.9
Carbon	3.78	428	34708	54.9	44.4
Residue	90	4.96	713	15.1	21.7
Bioleachate (1)	704	1.00	88	23.9	21.0
Assayed Head (2)	90	33.76	2969	-	-
Calculated Head (3)	-	32.75	3283	100.0	100.0

(1) Weight of bioleachate is determined by the weight of solids used in the test divided by the total weight of solids in the 2.2L bioreactor (with weight loss), multiplied by the total solution volume of the bioreactor (2098 mL), to determine the volume of bioleachate relevant to the CN residue weight.
(2) Determined from the first reactor residue assay (33.20 g/t) by considering second reactor weight loss.
(3) Determined from the total metal extracted and residue weight.
** NOTE ** The above calculations consider solution losses to sampling.

2) TEST CONDITIONS AND REAGENT CONSUMPTION

TIME (hours)	SAMPLE	pH	Ca(OH)2 Add'n (g)	[NaCN] (g/L)	NaCN Add'n (g)	NaCN Cons. (kg/t)	Cum. NaCN Cons. (kg/t)
0.0		5.83	0.79				
18.0		7.35	1.13				
19.0		9.20	0.24				
19.5	0 hour	9.44	0.05	0.08	0.049	0.00	0.00
20.0	0.5 hour	9.30	0.36	0.01	0.080	0.63	0.63
20.5	1 hour	9.59	0.21	0.01	0.082	0.89	1.53
23.5	4 hour	10.08	0.10	0.01	0.118	0.92	2.44
24.5	5 hour	10.84	0.00	0.18	0.048	1.09	3.54
27.5	8 hour	10.71	0.00	0.14	0.046	0.58	4.11
43.5	24 hour	10.41	0.00	0.01	0.056	0.69	4.80
45.5	26 hour		0.00	0.07	0.056	0.54	5.34
47.5	28 hour		0.00	0.13	0.041	0.54	5.88
49.5	30 hour		0.00	0.10	0.048	0.50	6.38
51.5	32 hour	10.57	0.00	0.18	0.035	0.43	6.81
67.5	48 hour	10.34	0.00	0.07	0.000	0.54	7.34

REAGENT CONSUMPTION:			
	NaCN:	7.3	kg / tonne solids
	Ca(OH)2:	32.0	kg / tonne solids

TRITON DEVELOPMENT CORPORATION
CYANIDATION TEST FOR GOLD EXTRACTION AND GOLD EXTRACTION PROFILE

PROJECT #: 93-4105
TEST#: CP2-4
SAMPLE: Wheaton River Refractory Gold-Bearing Sulphide Concentrate
SAMPLE PREP: Continuous Bioleach, Second Bioreactor Residue, Fine-Milled Concentrate
CONDITIONS: Pulp Density: 33%, [CN] Target 0.5 g/L ([NaCN] Target 0.94 g/L), pH Target 9.5 -10.5

1) METALLURGICAL BALANCE

PRODUCT		WEIGHT g	ASSAY Au g/t	ASSAY Ag g/t	DISTRIBUTION Au %	DISTRIBUTION Ag %
Solution	1 hour	109	14.00	1440	42.7	40.5
	4 hour	109	16.50	1820	56.0	56.8
	8 hour	109	17.00	2060	63.9	70.2
	24 hour	109	17.00	2240	70.5	82.8
	48 hour	109	16.00	1620	73.8	72.5
Residue		90	3.60	610	8.2	12.9
Bioleachate (1)		704	1.00	88	18.0	14.6
Assayed Head (2)		90	33.76	2969	-	-
Calculated Head (3)		-	43.72	4739	100.0	100.0

(1) Weight of bioleachate is determined by the weight of solids used in the test divided by the total weight of solids in the 2.2L bioreactor (with weight loss), multiplied by the total solution volume of the bioreactor (2098 mL), to determine the volume of bioleachate relevant to the CN residue weight.
(2) Determined from the first reactor residue assay (33.20 g/t) by considering second reactor weight loss.
(3) Determined from the total metal extracted and residue weight.
** NOTE ** *The above calculations consider solution losses to sampling.*

2) TEST CONDITIONS AND REAGENT CONSUMPTION

TIME (hours)	SAMPLE	pH	Ca(OH)2 Add'n (g)	[NaCN] (g/L)	NaCN Add'n (g)	NaCN Cons. (kg/t)	Cum. NaCN Cons. (kg/t)
0.0		5.83	0.78				
18.0		7.36	1.08				
19.0		9.20	0.23				
19.5	0 hour	9.50	0.05	0.94	0.148	0.00	0.00
20.0	0.5 hour	9.33	0.36	0.01	0.156	2.79	2.79
20.5	1 hour	9.64	0.20	0.08	0.142	1.66	4.45
23.5	4 hour	10.09	0.10	0.23	0.175	1.41	5.86
24.5	5 hour	10.93	0.00	0.45	0.079	1.68	7.54
27.5	8 hour	10.87	0.00	0.41	0.082	0.94	8.47
43.5	24 hour	10.56	0.00	0.23	0.107	1.14	9.61
45.5	26 hour		0.00	0.42	0.077	0.97	10.58
47.5	28 hour		0.00	0.69	0.038	0.53	11.10
49.5	30 hour		0.00	0.81	0.000	0.27	11.38
51.5	32 hour	10.69	0.00	0.63	0.049	0.23	11.61
67.5	48 hour	10.60	0.00	0.35	0.000	0.88	12.49

REAGENT CONSUMPTION:			
NaCN:	12.5	kg / tonne solids	
Ca(OH)2:	31.2	kg / tonne solids	