

ROYAL OAK MINES Inc.
ARSENIC TRIOXIDE LEACHING AND CRYSTALLIZATION TESTWORK

Progress Report #3

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Dissolution of As_2O_3 from Giant's baghouse dust

Executive Summary

Testwork was conducted on Giant's baghouse dust to establish the gold association. Average results for two tests indicate that 67.3% of the gold was exposed (free milling), 10% was associated with arsenates and 22.7% was associated with sulfides and iron oxides. In order to establish overall gold recoveries and confirm results obtained so far, tests with larger samples are recommended. It is suggested that these tests be conducted at Canmet (Ottawa) or at a commercial lab (Lakefield or Hazen).

Results from hot water leach testwork conducted at 60 minutes of residence time and 95°C, showed the same trend for arsenic recovery versus %solids observed at 30 minutes of residence time. Arsenic recovery is very sensitive to the %solids for both residence times, requiring dilute slurries to be effective.

Additional testwork will be conducted, at different temperatures, to establish the lowest process temperature that can be used without loss of arsenic recovery.

A purification test conducted using a column arrangement to percolate pregnant solution through a bed of activated carbon, indicates that activated carbon is effective in removing antimony and iron from solution. However, it appears to be non selective, also removing arsenic from the pregnant solution.

Two tests have been conducted to evaluate the dissolution of baghouse dust, at 3°C. Tests were conducted for one hour, at 38.5% solids. On average, 2.95% of the arsenic, 0.35% of the antimony and 2.4% of the iron were dissolved in distilled water which assayed 15 g/L of arsenic, 14 ppm antimony and 225 ppm iron.

Feed Material

The testwork presented on this report was conducted on BHD Composite September 97, a composite sample obtained by sampling baghouse dust for a period of four weeks (September 1 to 26, 1997). Average assays for this composite, taking into account all assays conducted to date were:

Arsenic	67.72%
Antimony	1.10%
Iron	1.72%
Gold	0.133 oz/ton

Selected samples were submitted for assay at three different assay labs: Lakefield Research, Maxxam Analytics and Taiga Environmental Laboratory. Results are presented on Tables 1 and 2 and Graphs 1 to 3. Results for arsenic assays conducted by other labs were higher than those obtained by Giant five times, and lower four times. The same trend was observed for antimony assays. Results for eight iron assays by other labs were lower than those obtained by Giant. Only one assay, by Taiga, was higher than Giant's.

Gold Association Tests

Two tests were conducted, on approximately 50 g of sample, to establish the occurrence of gold in baghouse dust samples. Figure 1 presents the flowsheet for test AS-97-066. In this test, the first step was a cold wash to remove arsenic prior to cyanidation. In test AS-98-021, the first step was a hot wash, similar to our standard hot water leach tests. A summary of results is presented on Table 3, below. On average, 67.3% of the gold was exposed (free milling). Part of this gold was leached by cold or hot washing (5.3% and 9.7% respectively) and its recovery by activated carbon or ion exchange resins will be investigated. On average, 10% of the gold is associated with arsenates and 22.7% is associated with sulfides and iron oxides. Gold association with silicates is not available, due to the small amount of residue obtained (less than 2 grams).

Results indicate that the residue from hot water leach will require additional treatment to increase the recovery from 67.3%. It has been suggested that this residue be recycled to the roaster to liberate gold that may be locked up. In order to establish overall gold recoveries and confirm results obtained so far, hot water leach tests with larger samples are recommended. A sizable amount of residue would be produced in such tests and would then be treated according to the envisaged flowsheet(s). Pilot plant facilities will be required to conduct the larger hot water leach tests. As Giant Mine does not have such facilities, it is suggested that these tests be conducted at Canmet (Ottawa) or at a commercial lab (Lakefield or Hazen).

Table 1

BHD September Composite Head Sample Bag 22			
	Giant	Lakefield	Maxxam
Aluminum (g/t)		5500	2540
Antimony (%)	1.05	1.16	1.39
Arsenic (%)	66.09	68.50	58.10
Barium (g/t)		15	2
Beryllium (g/t)		< 1.0	<0.1
Cadmium (g/t)		< 5.0	1.1
Calcium (g/t)		3900	3540
Chromium (g/t)		14	11.3
Cobalt (g/t)		20	17.1
Copper (g/t)		350	143
Iron (%)	2.50	1.50	1.61
Lanthanum (g/t)		< 50	
Lead (g/t)		490	453
Lithium (g/t)			2.9
Magnesium (g/t)		2600	2270
Manganese (g/t)		80	94.1
Mercury (g/t)			14.3
Molybdenum (g/t)		< 10	1.9
Nickel (g/t)		44	41.3
Phosphorus (g/t)		62	41
Potassium (g/t)		1600	178
Selenium (g/t)		< 50	< 1
Silicon (g/t)			429
Silver (g/t)			3.1
Sodium (g/t)		390	185
Tellurium (g/t)		< 10	
Thallium (g/t)			0.13
Tin (g/t)		< 20	
Titanium (g/t)			12.7
Uranium (g/t)			< 50
Vanadium (g/t)			10.9
Yttrium (g/t)		< 5.0	
Zinc (g/t)		170	137
Zirconium (g/t)			1.27

Table 2

BHD September Composite Head Sample Bag 12		
	Giant	Taiga
Antimony (%)	1.04	0.91
Arsenic (%)	68.07	64.48
Iron (%)	1.56	1.61

FC				
	Giant	Lakefield	Maxxam	Taiga
Antimony (%)	0.32	0.28	0.28	0.22
Arsenic (%)	6.76	8.68	6.64	7.87
Iron (%)	26.25	21.1	18.6	22.3

RC				
	Giant	Lakefield	Maxxam	Taiga
Antimony (%)	0.16	0.19	0.186	0.14
Arsenic (%)	1.47	1.85	1.48	1.4
Iron (%)	34.63	28.8	27.5	29.6

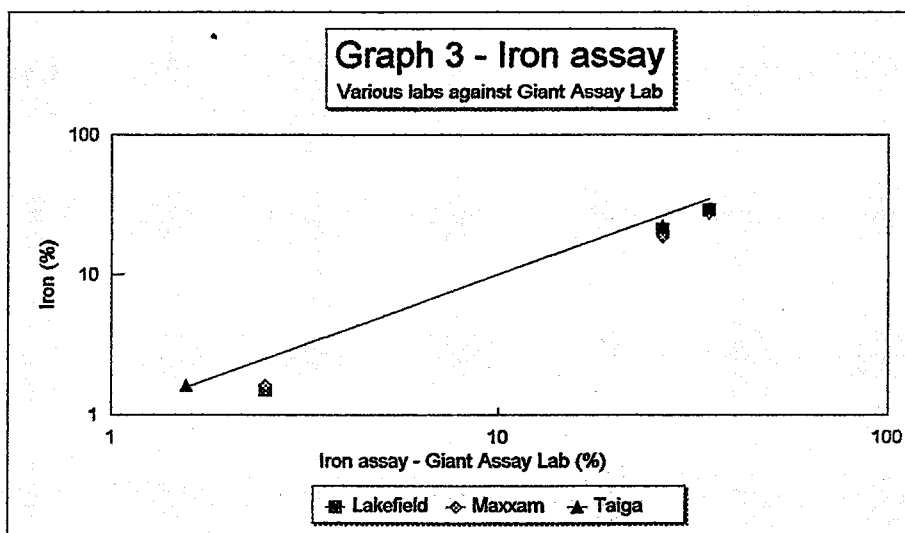
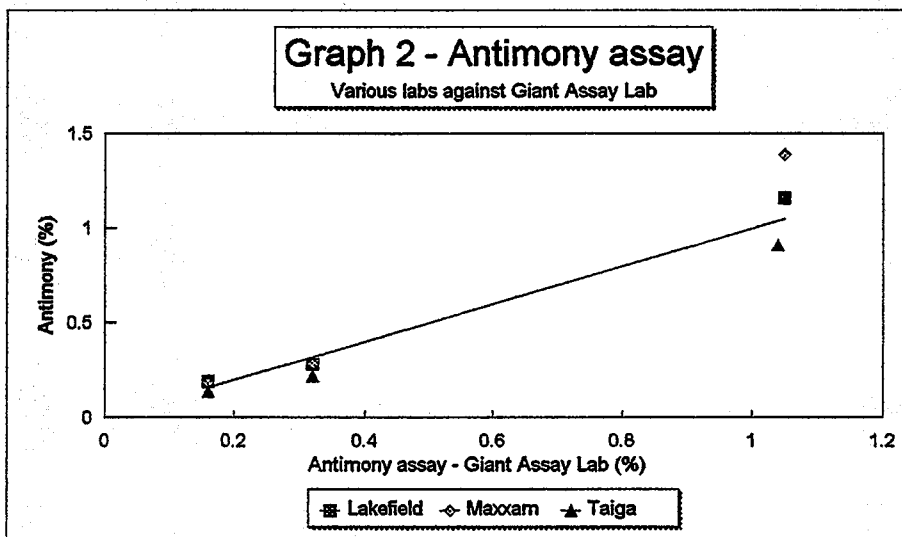
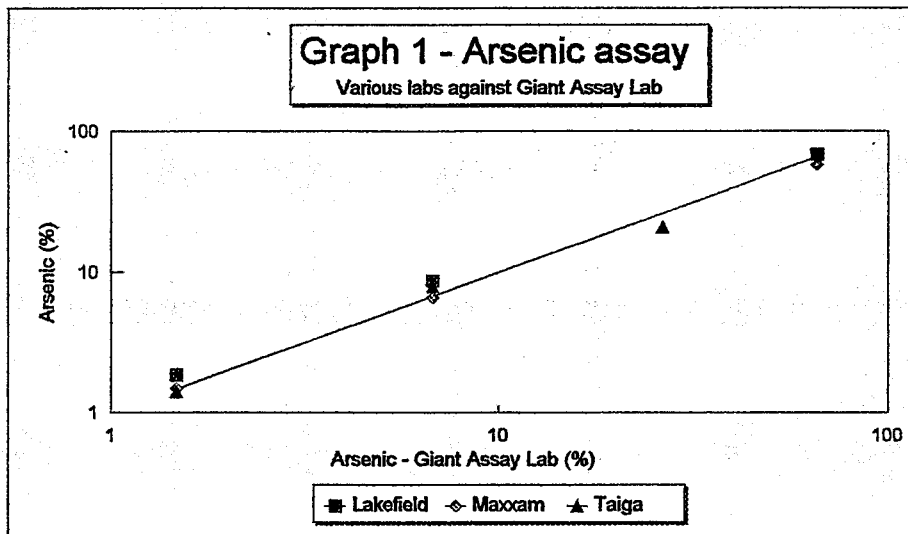


Figure 1 - Gold Association Test As-97-066

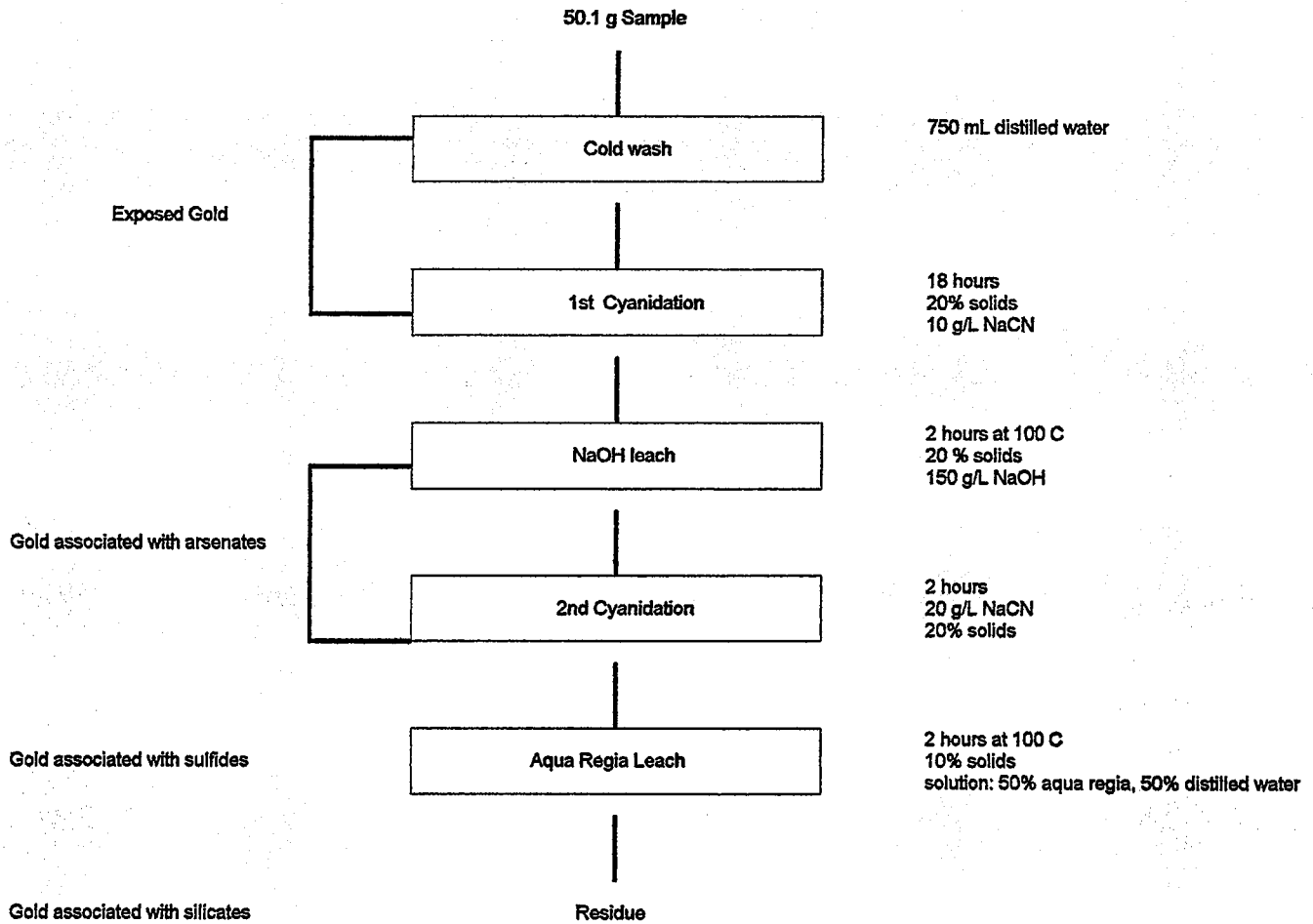


Figure 2 - Gold Association Test As-98-021

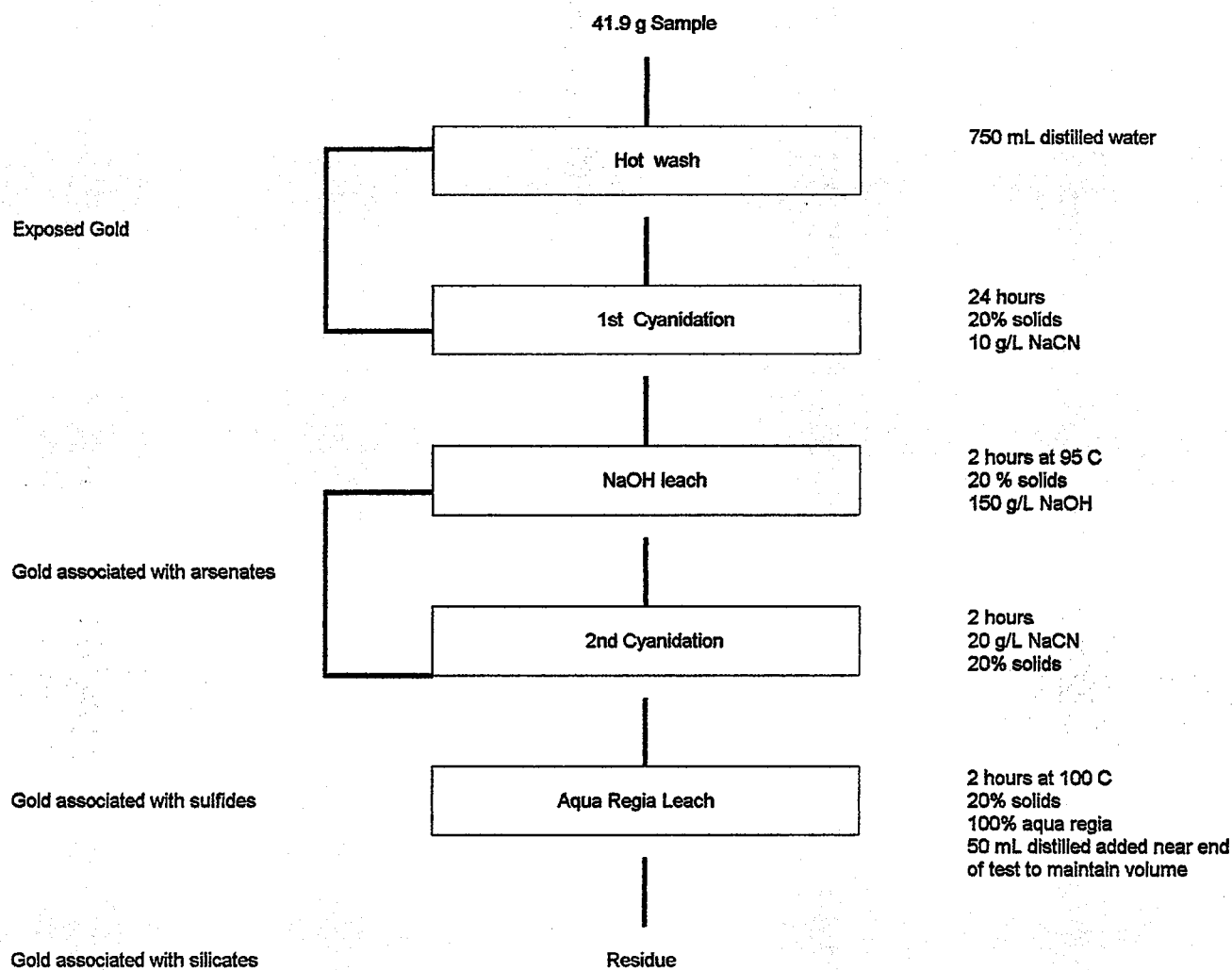


Table 3 - Gold association tests

	As-97-066	As-98-021	Average
Exposed gold (%)	65.4	69.1	67.3
Gold associated with arsenates (%)	14.4	5.6	10
Gold associated with sulfides (%)*	20.2	25.2	22.7
Gold associated with silicates (%)	n/a	n/a	n/a
Residue (oz/t)	n/a	n/a	n/a
Backcalc head (oz/t)	0.167	0.150	
Assay head (oz/t)	0.134	0.133	

* This stage also recovers gold associated with iron oxides

Hot Water Leach Tests

Results of tests reported on Progress Report #2, showed a sharp decrease in arsenic recovery with an increase in %solids, for 30 minutes of residence time. This report presents results for additional testwork that has been conducted to investigate the effect of %solids on arsenic recovery, at 60 minutes of residence time. Tests were conducted at 95°C, at the following %solids: 5.3, 6.0, 6.9, 8.2 and 10.1%. It took approximately 30 minutes to heat the slurry from room temperature to 95°C. Time zero was the time when the slurry reached 95°C.

Arsenic recovery as a function of %solids is presented on Tables 4 and 5, and Graph 4. Table 5 and Graph 4 also contain data for arsenic recovery at 30 min of residence time. %solids has a dramatic impact on arsenic recovery, for both residence times. As the %solids increases, arsenic recovery decreases. The highest arsenic recovery was achieved at 5.3% solids, 60 minutes of residence time (88.0% on average). Residence time does not appear to have an effect on arsenic recovery, in the range investigated.

Antimony recovery as a function of %solids is presented on Tables 6 and 7, and Graph 5. Antimony recovery decreases as %solids increases, for both residence times. Higher antimony recovery was achieved at 30 minutes of residence time, in the range of %solids from 5.3 to 8.2%. In the range from 8.2 to 10.1%, similar recoveries were achieved for both residence times. At 5.3% solids and 60 minutes of residence time, average antimony recovery was 16.6%. Iron recovery decreases with an increase in %solids, as shown on Tables 8 and 9, and Graph 6. At 5.3% solids and 60 minutes of residence time, iron recovery was 0.9%, more than double of the recovery achieved at 30 minutes of residence time (0.4%).

ROYAL OAK MINES Inc.**ARSENIC TRIOXIDE LEACHING AND CRYSTALLIZATION TESTWORK****Table 4**

Hot Water Leach Tests

Test conditions: 60 min, distilled water, 95 C

Test #	%solids	Arsenic			Corr Concentration (g/L)	Head	
		Recovery (%)	Av. Rec. (%)	Concentration (g/L)		Backcalc (%)	Assayed (%)
97-013	5.3	91.9	88.0	33.66	33.66	65.36	67.29
97-020	5.3	92.4		29.35	32.39	67.33	67.90
97-016	5.3	79.8		29.13	30.37	67.26	68.06
98-001	6.0	80.7	81.6	28.50	30.84	65.79	67.76
98-005	6.0	82.4		27.87	30.21	66.44	69.01
98-002	6.9	76.7	78.1	27.79	30.07	65.11	67.76
98-010	6.9	79.5		31.55	34.18	66.80	68.49
98-003	8.2	75.0	70.7	31.80	34.43	65.46	68.12
98-006	8.2	66.3		29.63	32.05	65.95	68.64
98-004	10.1	63.5	62.2	34.73	37.60	66.47	68.76
98-008	10.1	60.9		33.58	36.32	66.53	68.41

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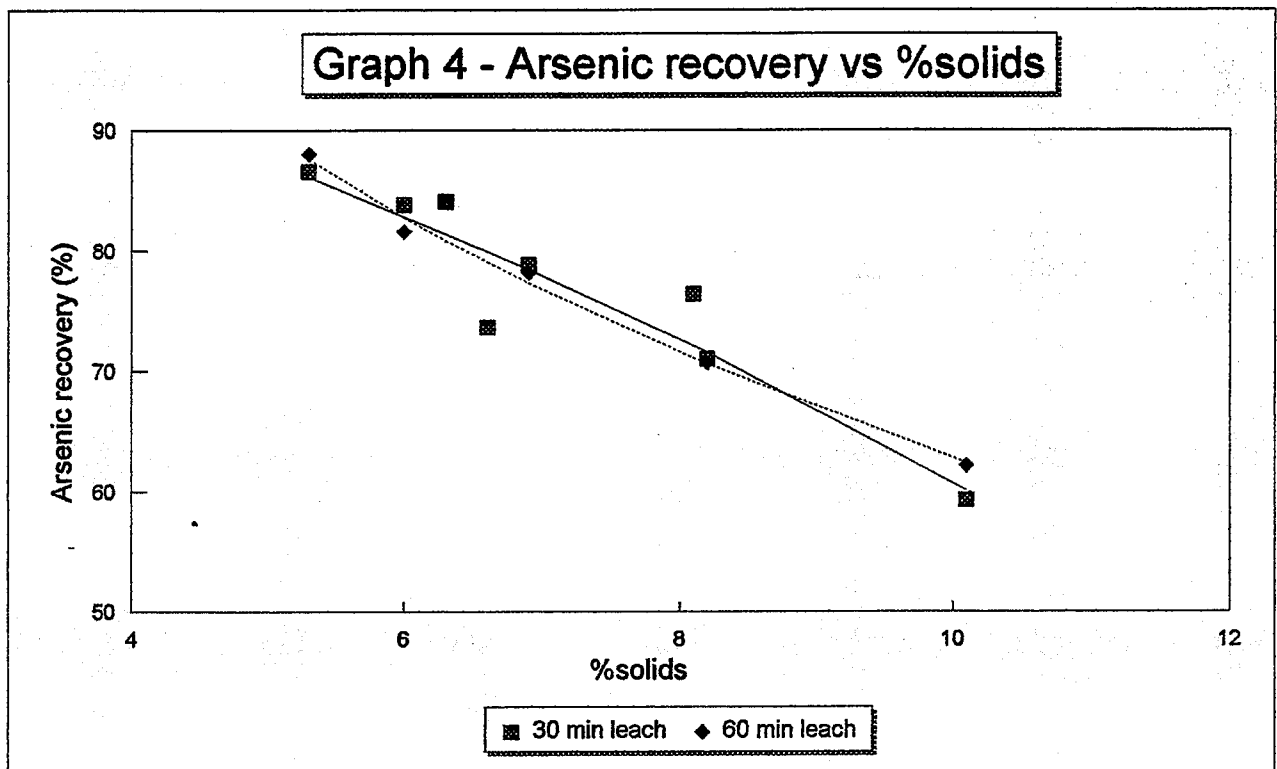
ARSENIC TRIOXIDE LEACHING AND CRYSTALLIZATION TESTWORK

Table 5

Hot water leach tests

Test conditions: distilled water, 95 C

%solids	Average arsenic recovery (%)		Arsenic recovery (%)	
	30 min leach	60 min leach	Fitted 30 min leach	Fitted 60 min leach
5.3	86.6	88.0	86.1	87.6
6.0	83.8	81.6	82.8	82.7
6.3	84.1		81.4	80.8
6.6	73.6		79.9	79.0
6.9	78.8	78.1	78.4	77.3
8.1	76.4		72.1	71.1
8.2	71.0	70.7	71.5	70.6
10.1	59.3	62.2	60.1	62.4



ROYAL OAK MINES Inc.**ARSENIC TRIOXIDE LEACHING AND CRYSTALLIZATION TESTWORK****Table 6**

Hot Water Leach Tests

Test conditions: 60 min, distilled water, 95 C

Test #	%solids	Antimony			Corr Concentration (ppm)	Head	
		Recovery (%)	Av. Rec. (%)	Concentration (ppm)		Backcalc (%)	Assayed (%)
97-013	5.3	15.0	16.6	79	79	1.05	1.13
97-020	5.3						
97-016	5.3	18.2		94	98	1.05	1.18
98-001	6.0	16.2	16.9	79	85	1.03	1.04
98-005	6.0	17.5		77	83	1.03	1.09
98-002	6.9	14.0	14.5	76	82	1.07	1.04
98-010	6.9	15.0		80	87	1.01	1.02
98-003	8.2	11.6	11.9	70	76	1.02	1.04
98-006	8.2	12.1		77	83	0.99	1.07
98-004	10.1	8.5	8.9	66	71	1.01	1.06
98-008	10.1	9.3		72	78	1.01	1.04

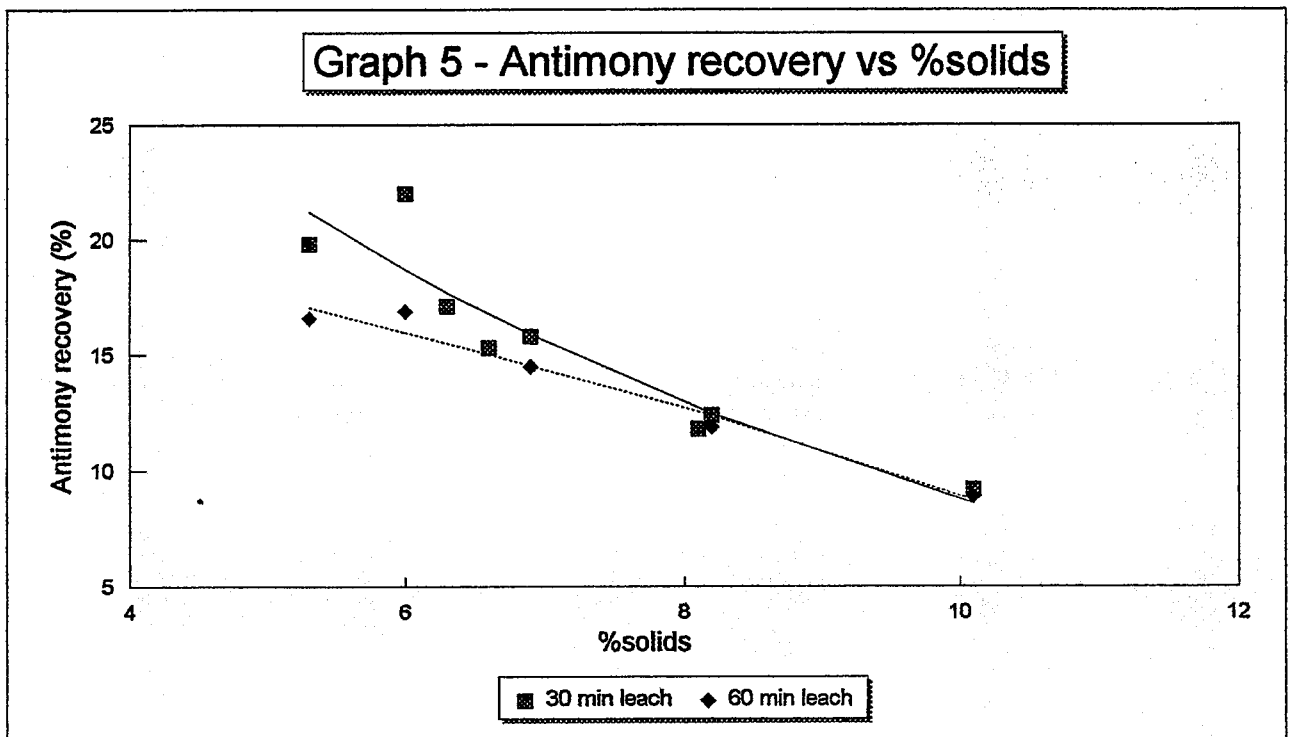
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ARSENIC TRIOXIDE LEACHING AND CRYSTALLIZATION TESTWORK

Table 7

Hot Water Leach Tests

Test conditions: distilled water, 95 C

%solids	Average antimony recovery (%)		Antimony recovery (%)	
	30 min leach	60 min leach	Fitted 30 min leach	Fitted 60 min leach
5.3	19.8	16.6	21.2	17.1
6.0	22.0	16.9	18.7	16.0
6.3	17.1		17.7	15.5
6.6	15.3		16.8	15.0
6.9	15.8	14.5	15.9	14.5
8.1	11.8		12.7	12.6
8.2	12.4	11.9	12.5	12.4
10.1	9.2	8.9	8.6	8.7



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Table 8

Hot Water Leach Tests

Test conditions: 60 min, distilled water, 95 C

Test #	%solids	Iron			Corr Concentration (ppm)	Head	
		Recovery (%)	Av. Rec. (%)	Concentration (ppm)		Backcalc (%)	Assayed (%)
97-013	5.3	1.0	0.9	9.0	9.0	1.67	1.63
97-020	5.3	0.8		5.0		1.58	1.61
97-016	5.3	0.9		7.0	7.3	1.54	1.67
98-001	6.0	0.6	0.5	4.4	4.8	1.33	1.50
98-005	6.0	0.3		3.2	3.5	1.80	1.57
98-002	6.9	0.4	0.4	3.6	3.9	1.37	1.50
98-010	6.9	0.4		3.6	3.9	1.58	1.57
98-003	8.2	0.3	0.4	3.2	3.5	1.60	1.57
98-006	8.2	0.4		3.6	3.9	1.48	1.57
98-004	10.1	0.2	0.3	3.2	3.5	1.54	1.57
98-008	10.1	0.3		3.6	3.9	1.57	1.50

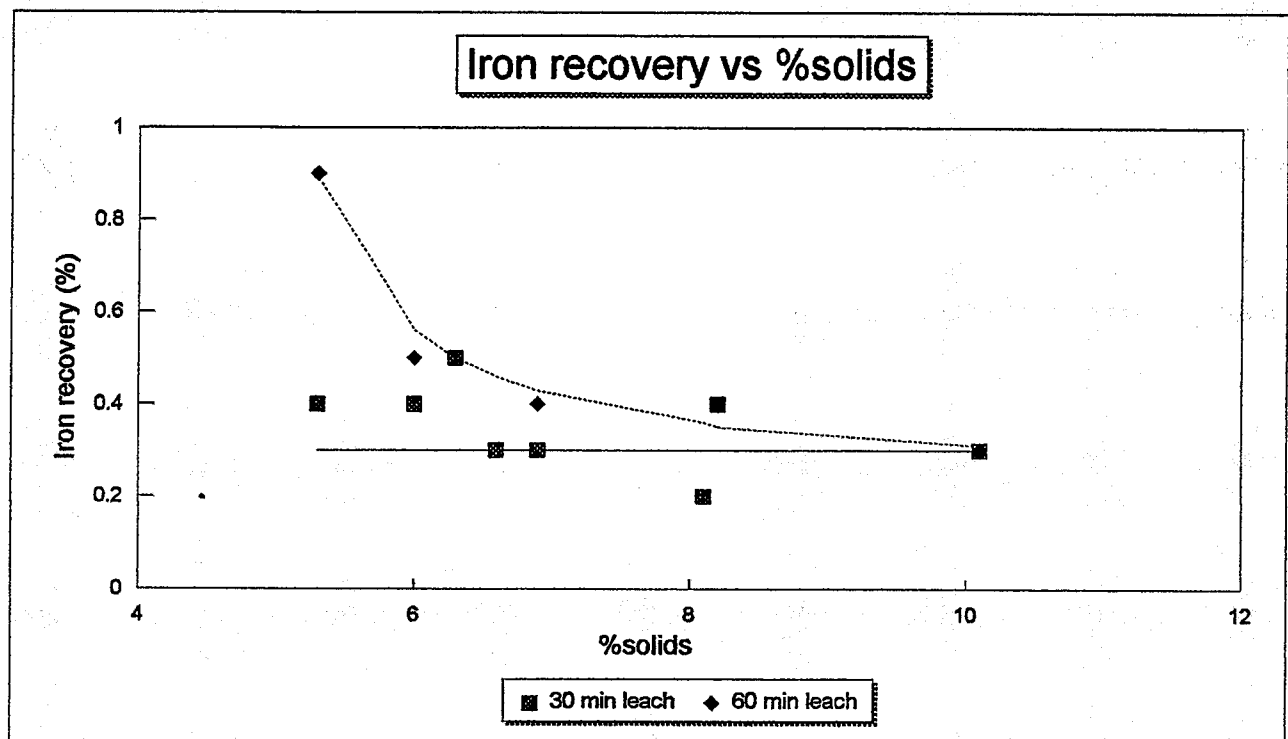
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ARSENIC TRIOXIDE LEACHING AND CRYSTALLIZATION TESTWORK

Table 9

Hot Water Leach Tests

Test conditions: distilled water, 95 C

%solids	Average iron recovery (%)		Iron recovery (%)	
	30 min leach	60 min leach	Fitted 30 min leach	Fitted 60 min leach
5.3	0.4	0.9	0.3	0.9
6.0	0.4	0.5	0.3	0.6
6.3	0.5		0.3	0.5
6.6	0.3		0.3	0.5
6.9	0.3	0.4	0.3	0.4
8.1	0.2		0.3	0.4
8.2	0.4	0.4	0.3	0.4
10.1	0.3	0.3	0.3	0.3



Increasing the residence time from 30 to 60 minutes did not increase arsenic recovery. The next series of solubility tests will establish arsenic recovery as a function of temperature. The objective is to determine the lowest temperature that can be used in the leach stage without loss of recovery.

Purification tests

Results for a purification test (As-97-017) are presented on Tables 10 and 11, and Graphs 7 to 9. Pregnant solution was percolated through a column containing 80 g of activated carbon, at an average rate of 19.9 mL/min. A 1 inch internal diameter, 2 ft high plexiglass column was used. Height of carbon in the column was 32.5 cm.

The pregnant solution was obtained by dissolving baghouse dust for 30 minutes, at 5.3% solids and 94°C. 80.9% of the arsenic, 17.8% of the antimony and 0.3% of the iron were recovered by the hot water leach.

Tables 10 and 11, and Graphs 7 to 9 present concentration of arsenic, antimony and iron in the column effluent as a function of time. Concentration in the effluent increases with time, for arsenic and iron. Antimony concentration in the effluent remains at approximately 2 ppm for the first 20 minutes, after which it increases with time. At the end of the test, the effluent concentration was 16 g/L arsenic, 7.6 ppm antimony and 0.9 ppm iron. Pregnant solution concentration was 23 g/L arsenic, 69.6 ppm antimony and 2 ppm iron.

A total of 48.6% of the arsenic, 5.76% of the antimony and 27% of the iron originally contained in the pregnant solution reported to the effluent. At the end of the test, the column was backwashed with 1000 mL of distilled water to recover any solids entrapped in the column. The recovered solids were filtered, dried, weighed (0.0074 g) and assayed (0.34% antimony and 1.69% iron, corresponding to 0.06% of the antimony and 9.6% of the iron originally contained in the pregnant solution). Assays for the activated carbon are not available.

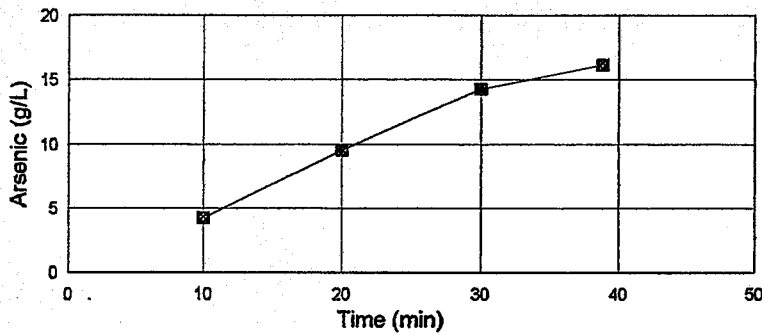
Solids that precipitated from the pregnant solution were recovered, weighed (0.0785 g) and assayed. They were found to contain 0.34% antimony and 1.69% iron. These correspond to 10.3% of the antimony and 7.9% of the iron originally contained in the pregnant solution.

Results for this test indicate that activated carbon effectively removes antimony and iron from the pregnant solution. Unfortunately it does not appear to be selective, as the results indicate that arsenic was also removed from solution.

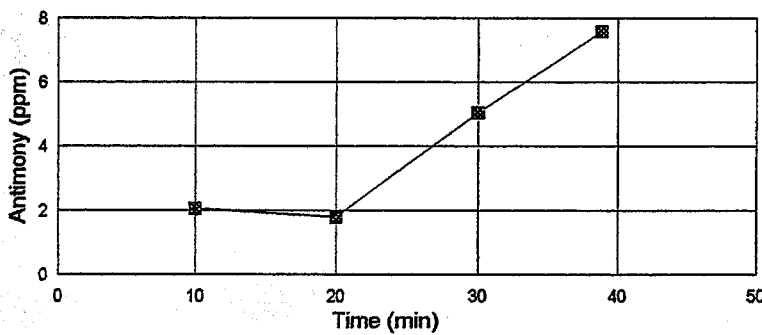
Table 10 - Purification test As-98-017
Activated Carbon Column

Time (min)	Percolation rate (mL/min)	corr Arsenic (g/L)	corr Sb (ppm)	corr Fe (ppm)
10	21.2	4.26	2.1	0.0
20	20.0	9.54	1.8	0.4
30	20.2	14.26	5.1	0.7
39	18.3	16.16	7.6	0.9

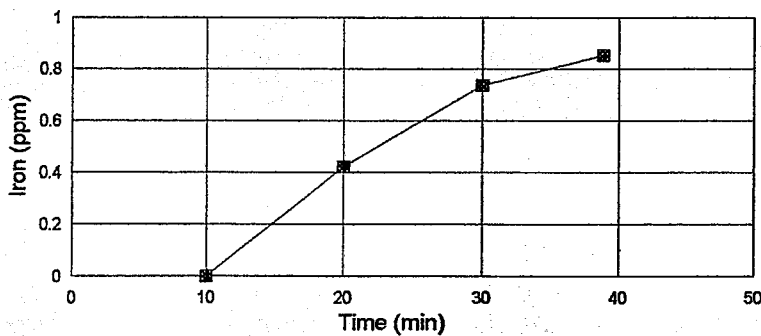
Graph 7 - Arsenic concentration in effluent vs time



Graph 8 - Antimony concentration in effluent vs time



Graph 9 - Iron concentration in effluent vs time



0.2700
0.0962
0.0785

Table 11 - Purification test As-98-017
Activated Carbon Column

Description	Weight (g)	% As	Vol (mL)	corr Vol (mL)	As (g/L)	Corr As (g/L)	As (g)	Distribution (%)
Effluent 1			212	202	1.45	4.26	0.3	
Effluent 2			200	190	9.06	9.54	1.8	
Effluent 3			202	192	13.55	14.26	2.7	
Effluent 4			162	152	15.17	16.16	2.5	
Total Solution			776				7.3	
Activated Carbon	79.5	n/a						
Total								
Pregnant Solution			650		23.16		15.1	

Description	Weight (g)	% Sb	Vol (mL)	corr Vol (mL)	Sb (ppm)	Corr Sb (ppm)	Sb (mg)	Distribution (%)
Effluent 1			212	202	0.7	2.1	0.1	
Effluent 2			200	190	1.7	1.8	0.3	
Effluent 3			202	192	4.8	5.1	1.0	
Effluent 4			162	152	7.1	7.6	1.2	
Total Solution			776				2.6	
Backwash solids	0.0074	0.34					0.025	
Precipitate	0.0785	5.92					4.6	
Activated carbon	79.5	n/a						
Total			776		12.7		9.9	
Pregnant Solution			650		69.6		45.2	

Description	Weight (g)	% Fe	Vol (mL)	corr Vol (mL)	Fe (ppm)	Corr Fe (ppm)	Fe (mg)	Distribution (%)
Effluent 1			212	202	0.0	0.0	0.00	
Effluent 2			200	190	0.4	0.4	0.08	
Effluent 3			202	192	0.7	0.7	0.14	
Effluent 4			162	152	0.8	0.9	0.13	
Total Solution			776				0.35	
Backwash solids	0.0074	1.69					0.13	
Precipitate	0.0785	0.13					0.10	
Activated carbon	79.5	n/a						
Total			776		0.7		0.58	
Pregnant Solution			650		2.0		1.30	

Leach Tests at 3°C

Two tests have been conducted to evaluate the dissolution of baghouse dust in water, at 3°C. Tests were conducted for one hour, at 38.5% solids. In the first test (AS-98-014), 5% of the arsenic, 0.3% of the antimony and 3.4% of the iron were dissolved. The pregnant solution assayed 27.2 g/L arsenic, 2.4 ppm antimony and 290 ppm iron. A concentration of 27.2 g/L of arsenic, at 3°C, is considerably higher than what would be expected from other results obtained in this work, as well as, data published in the literature. The residue contained 99.5% of the original weight and assayed 68.01% arsenic, 1% antimony and 1.63% iron.

In the second test (AS-98-018), 0.9% of the arsenic, 0.4% of the antimony and 1.4% of the iron were dissolved. The pregnant solution assayed 2.88 g/L arsenic, 25.9 ppm antimony and 160 ppm iron. The residue contained 95.9% of the weight and assayed 68.3% arsenic, 1.04% arsenic and 1.5% iron.

On average, 2.95% of the arsenic, 0.35% of the antimony and 2.4% of the iron were dissolved in distilled water. Average concentrations were: 15.04 g/L arsenic, 14.15 ppm antimony and 225 ppm iron. The residue contained, on average, 97.7% of the original weight.

Further tests will be conducted to obtain additional data for the dissolution of baghouse dust at 3°C.