

AMMONIA LEACH PROCESS

PROCESS DESCRIPTION

Ammonia increases the solubility of arsenic in water. Available information, from Seidell, indicates that the solubility of arsenic at 30°C increases from 2.3 g As_2O_3 / 100 g solution with no ammonia to 20.5 g As_2O_3 / 100 g solution with 2.8 g of NH_3 / 100 g solution (~36.5 g NH_3 / L, 2.15 M). The higher solubility is obtained at about 0.8 moles NH_3 / mole As. The effect of NH_3 addition on arsenic solubility is illustrated in the accompanying figure.

Addition of more ammonia to the solution results in precipitation of NH_4AsO_2 . One mole of added ammonia causes the crystallization of one mole of the ammonium arsenate. No information is available about the effect of the added ammonia on other dissolved species in solution.

Little information is available about the effect of ammonia addition on antimony solubility. Work performed by Brian Cross and Larry Connell in 1979 showed that antimony solubility increased with arsenic as ammonia was added, resulting in products consistently above 0.20% Sb. No information is available, however, about the effect of increased ammonia concentration on the dissolved antimony. If arsenic crystallizes as NH_4AsO_2 and antimony remains in solution, we have a process. A second possibility for preventing antimony from reporting to the arsenic is by complexing it with tartarate ion and absorbing the complex on activated carbon.

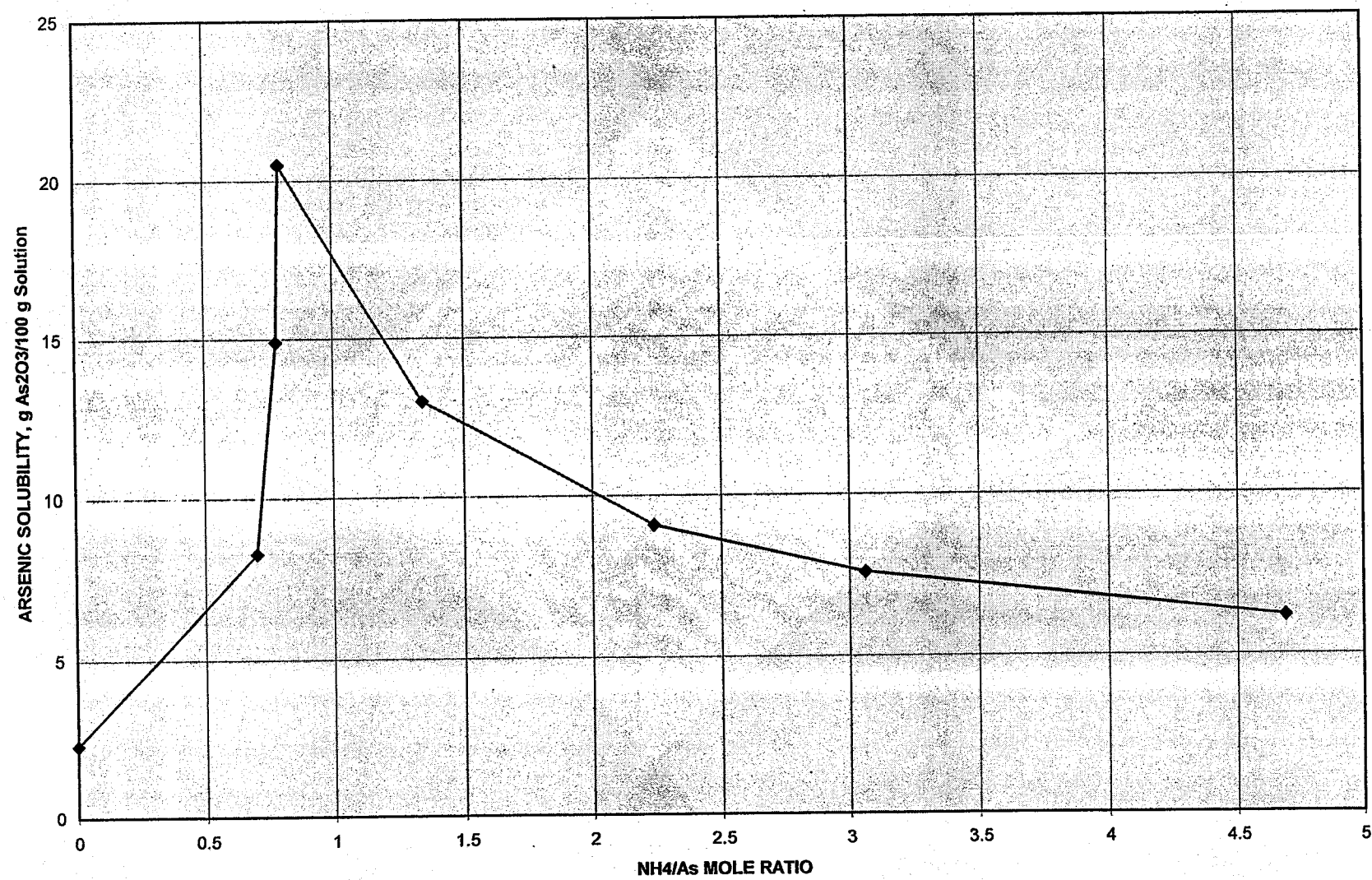
HOT WATER LEACH PROCESS

PROCESS DESCRIPTION

Arsenic solubility increases in water with increased temperature. The solubility of antimony also increases, but insufficient information exists about the solubility of antimony. A question also exists about the total solubility of the arsenic contained in the Giant flue dusts. Information about the recoverability of gold contained in the flue dust also needs to be obtained.

Arsenic is recovered from solution by reducing the temperature of the solution. Antimony precipitates with the arsenic. The concentration of antimony in the arsenic needs to be verified. A possible way of preventing the antimony from reporting to the arsenic product is by complexing it with tartarate ion prior to the cooling and arsenic precipitation. The solution would then be reheated and contacted with activated carbon to remove the antimony-tartarate complex from solution. The hot solution would then be contacted with fresh arsenic feed. A second possible means of removing antimony is by formation of an oxychloride complex. This is not favored because of the potential for chloride attack of tanks.

EFFECT OF NH₄/As RATIO ON ARSENIC SOLUBILITY



30°C

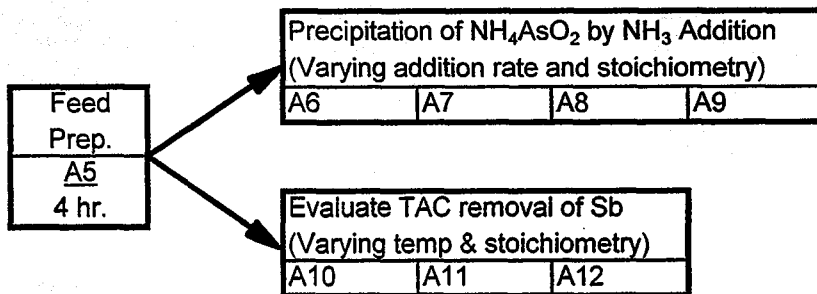
ROYAL OAK MINES (GIANT MINE)
Arsenic Process Development

SPECIAL PROJECT NO. _____

TEST FLOWSHEET

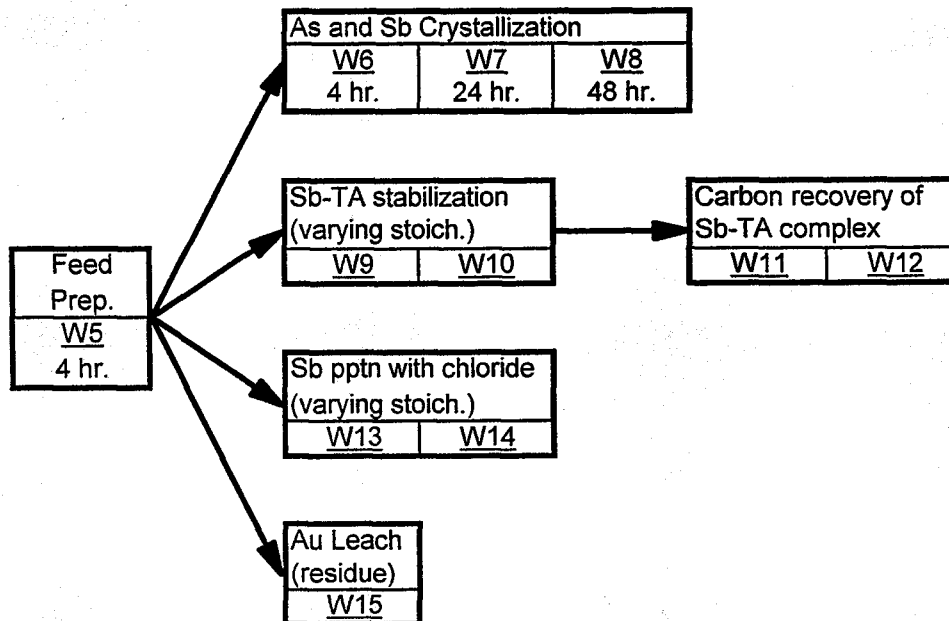
AMMONIA LEACH PROCESS

NH ₄ vs As and Sb Solubility at 30°C			
<u>A1</u> 4 hr.	<u>A2</u> 4 hr.	<u>A3</u> 4 hr.	<u>A4</u> 4 hr.



HOT WATER LEACH PROCESS

Temperature vs As and Sb Solubility			
<u>W1</u> 30°C 24 hr.	<u>W2</u> 50°C 24 hr.	<u>W3</u> 70°C 24 hr.	<u>W4</u> 90°C 24 hr.



Test No. A1 to A4

Purpose: To determine the relationship between ammonium ion (NH_4^+) concentration and arsenic and antimony solubility.

Conditions:

Test No.	<u>A1</u>	<u>A2</u>	<u>A3</u>	<u>A4</u>
NH_3 , g / 100 g soln.	2	2.4	2.8	3.0
Reag. NH_4OH , ml / 500 ml feed soln	47	60	73	79

Procedure:

1. Place about 300 ml of DI water in a 500 ml volumetric flask.
2. Add the required volume of reagent ammonium hydroxide and fill flask to the mark with DI water.
3. Pour the ammonium hydroxide solution into a 1-liter reactor.
4. Add arsenic flue dust containing more than 150 g of As_2O_3 .
5. Mix at 30°C for 4 hours.
6. Filter the pulp. Measure solution volume. Dilute a 10 ml solution sample to 100 ml for analysis.
7. Dry residue. Weigh and analyze.

Test No. A5

Purpose: To prepare solution for ammonium arsenate crystallization tests.

Procedure:

1. Place about 500 ml of DI water in a 1000 ml volumetric flask.
2. Add 146 ml of reagent ammonium hydroxide and fill flask to the mark with DI water.
3. Pour the ammonium hydroxide solution into an 8-liter reactor.
4. Repeat steps 2 & 3 three time (total solution volume = 4 L).
5. Add arsenic flue dust containing more than 1200 g of As_2O_3 . Mix at 30°C for 4 hours.
6. Filter the pulp. Measure solution volume and save at 30°C . Dilute a 10 ml solution sample to 100 ml for analysis.

Test No. A6 to A9

Purpose: To determine the relationship between ammonia addition and arsenic and antimony crystallization.

Conditions:

Test No.	<u>A6</u>	<u>A7</u>	<u>A8</u>	<u>A9</u>
NH ₃ , liters	11.5	10	11.5	13
Addition Time, minutes	120	60	60	60
Addition Rate, ml / min	96	167	192	217
Reag. NH ₄ OH, ml / 500 ml feed soln	47	60	73	79

Procedure:

1. Place 500 g of the pregnant solution from A5 in a 1000 ml reactor.
2. Stir and sparge in the required amount of ammonia at the required rate.
3. Stir for 1 hour after completion of ammonia addition.
4. Filter the crystals. Dry and weigh.
5. Measure solution volume. Dilute a 10 ml solution sample to 100 ml for analysis.

Test No. A10 to A12

Purpose: To evaluate Tartaric Acid / Activated Carbon removal of antimony from saturated ammonium arsenate solution.

Conditions:

Test No.	<u>A10</u>	<u>A11</u>	<u>A12</u>
Tartaric Acid, g	0.55	1.10	0.55
Temperature, °C	30	40	40

Procedure:

1. Place 500 g of the pregnant solution from A5 in a 1000 ml reactor.
2. Add the required amount of tartaric acid and stir for 15 minutes.
3. If required, heat the solution to the desired temperature.
4. Add 1 g of activated carbon and gently stir for 15 minutes.
5. Filter / screen out the carbon. Dry and weigh.
6. Measure solution volume. Dilute a 10 ml solution sample to 100 ml for analysis.

Test No. W1 to W4

Purpose: To determine the relationship between solution temperature and arsenic and antimony solubility.

Conditions:

Test No.	<u>W1</u>	<u>W2</u>	<u>W3</u>	<u>W4</u>
Temperature, °C	30	50	70	90

Procedure:

1. Place 500 ml of DI water into a 1-liter reactor.
2. Add arsenic flue dust containing more than 30 g of As_2O_3 .
3. Mix at the required temperature for 24 hours.
4. Filter the pulp. Measure solution volume. Dilute a 10 ml solution sample to 100 ml for analysis.
5. Dry residue. Weigh and analyze.

Test No. W5

Purpose: To prepare solution for arsenic crystallization and antimony removal tests.

Procedure:

1. Place 4000 ml of DI water into an 8-liter reactor.
2. Add arsenic flue dust containing more than 240 g of As_2O_3 . Mix at 90°C for 4 hours.
3. Filter the pulp. Measure solution volume and save at 90°C. Dilute a 10 ml solution sample to 100 ml for analysis.

Test No. W6 to W8

Purpose: To determine the relative crystallization rates of arsenic and antimony.

Conditions:

Test No.	<u>W6</u>	<u>W7</u>	<u>W8</u>
Temperature, °C	50	50	50
Crystallization Time, hours	4	24	48

Procedure:

1. Place 500 g of the pregnant solution from W5 in a 1000 ml stirred reactor in a 50°C water bath.
2. Stir for the required time and then filter the crystals. Dry and weigh.
3. Measure solution volume. Dilute a 10 ml solution sample to 100 ml for analysis.

Test No. W9 and W10

Purpose: To evaluate tartaric acid stabilization of antimony in a cooled arsenic solution.

Conditions:

Test No.	<u>W9</u>	<u>W10</u>
Temperature, °C	50	50
Crystallization Time, hours	24	24
Tartaric Acid Addition, g	0.55	1.10

Procedure:

1. Place 500 g of the pregnant solution from W5 in a 1000 ml stirred reactor and add the required amount of tartaric acid.
2. Stir in a 50°C water bath for the required time and then filter the crystals. Dry and weigh.
3. Measure solution volume. Dilute a 10 ml solution sample to 100 ml for analysis.

Test No. W11 and W12

Purpose: To evaluate activated carbon removal of the antimony-tartrate complex from arsenate solution.

Conditions:

Test No.	<u>W11</u>	<u>W12</u>
Solution from Test No.	W9	W10

Procedure:

1. Place 400 g of the solution from the crystallization test in a 1000 ml reactor.
2. Heat the solution to 90°C with stirring.
3. Add 1 g of activated carbon and gently stir for 15 minutes.
4. Filter / screen out the carbon. Dry and weigh.
5. Measure solution volume. Dilute a 10 ml solution sample to 100 ml for analysis.

Test No. W13 and W14

Purpose: To evaluate oxychloride precipitation of antimony from an arsenic solution.

Conditions:

Test No.	<u>W13</u>	<u>W14</u>
Temperature, °C	90	90
Crystallization Time, hours	24	48

Procedure:

1. Place 500 g of the pregnant solution from W5 in a 1000 ml stirred reactor.
2. Add 16.8 mg of NaCl (16.8 ml of 1 g NaCl/L solution) and stir for the required time. Filter the solution at 0.45 μ m. Dry and weigh any solids.
3. Measure solution volume. Dilute a 10 ml solution sample to 100 ml for analysis.

Test No. W15

Purpose: To evaluate the solubility of gold in the flue dust under standard cyanide leach conditions.

Conditions & Procedure:

Use standard Giant test procedure.