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# COMPARISON OF VAT AND HEAP LEACHING BEHAVIOR IN LABORATORY EVALUATIONS OF GOLD/SILVER ORES

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## ABSTRACT

Heap and vat leaching are related methods of extracting gold and silver from ores at relatively low capital and operating costs. In heap leaching, ore is contacted with leach solution via sprinklers or drip tubes; subsequently, low solution-to-ore ratios are encountered. In vat leaching, the ore material is submerged in cyanide solution. The result is much higher instantaneous solution to ores ratios. Results of laboratory testing on various gold and silver ores using the two leaching techniques are presented.

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## INTRODUCTION

Laboratory column heap leach tests are routinely used to evaluate gold and silver ores for heap leaching. The tests are fairly straightforward and consist of placing the ore to be tested into an appropriately sized leach column, applying alkaline cyanide solution to the ore drop-wise, and collecting the effluent solution. The effluent solution is then put through a column of activated carbon to recover the gold and silver in solution.

The same apparatus can also be used to run vat leach tests. The main difference in the procedure is that the column is flooded with leach solution initially and the ore remains completely submerged for the duration of the test.

Laboratory scale tests on five different ores showed no significant differences in overall gold and silver recovery between heap and vat leaching. In four of the five ores tested, the heap leach tests showed faster recovery rates than the vat leach tests on the same ore. Chemical consumptions in the vat tests were generally higher than in the heap leach tests.

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## TEST PROCEDURES

### Heap Leach Tests

The heap leach tests were all conducted as continuously drained drip tests. Alkaline cyanide solution was applied to the columns at a rate of 10 to 12 liters/hour/square meter (0.004-0.005 gallons per minute per square foot) of column cross-sectional area over a 24-hour period. The pregnant solution exiting the columns over the 24-hour leach cycle was then sampled and run through a carbon column over the next 24 hours to recover the precious metals in solution. Carbon effluent solutions were then assayed and chemical additions made, if necessary, before recycling the solutions through the columns.

For the heap leach tests on Ores B through E, one batch of leach solution was used. After each 24-hour leach cycle where barren solution was applied to the ore, the columns were allowed to sit dormant while the pregnant solution collected was run through the carbon column.

In the heap leach test on Ore A, two batches of leach solution were used so that solution was continuously applied to the ore. While one batch of solution was being cycled through the leach column, the other was put through the carbon column.

| ORE | ORE SIZE | TEST TYPE | DAYS LEACHING | PERCENT RECOVERED Au | PERCENT RECOVERED Ag | CALCULATED HEAD Au g/T | CALCULATED HEAD Ag g/T |
|---|---|---|---|---|---|---|---|
| Table 1. VAT AND HEAP LEACH TESTS — Testing Recoveries and Calculated Head Assays | | | | | | | |
| A | - 6.3 mm | VAT | 60 | 83.8 | 79.3 | 24.62 | 56.2 |
| A | - 6.3 mm | HEAP | 60 | 83.0 | 77.8 | - | - |
| A | - 6.3 mm | HEAP | 80 | 84.4 | 80.6 | 24.21 | 49.4 |
| B | - 19 mm | VAT | 63 | 82.3 | | 1.75 | |
| B | - 19 mm | HEAP | 59 | 83.0 | | 1.82 | |
| C | - 19 mm | VAT | 63 | 71.7 | | 4.49 | |
| C | - 19 mm | HEAP | 60 | 72.0 | | 4.90 | |
| D | - 19 mm | VAT | 63 | 85.2 | | 1.85 | |
| D | - 19 mm | HEAP | 60 | 87.0 | | 1.85 | |
| E | - 38 mm | VAT | 46 | 95.7 | | 2.50 | |
| E | - 38 mm | HEAP | 40 | 94.9 | | 2.19 | |

**Table 2. VAT AND HEAP LEACH TESTS**

**Chemical Consumptions and Solution Flowrates**

| ORE | TEST TYPE | DAYS LEACHING | CHEMICAL CONSUMPTION kg/Tonne NaCN | CHEMICAL CONSUMPTION kg/Tonne $Ca(OH)_2$ | TONNES EFFLUENT PER TONNE ORE | AVERAGE* FLOWRATE lph/$m^2$ |
|---|---|---|---|---|---|---|
| A | VAT | 60 | 9.24 | 0.70 | 45.74 | 78.0 |
| A | HEAP | 60 | 3.36 | 0.11 | 4.65 | 8.1 |
| A | HEAP | 80 | 4.19 | 0.11 | 6.08 | 7.1 |
| B | VAT | 63 | 0.94 | 2.93 | 5.18 | 7.6 |
| B | HEAP | 59 | 0.56 | 2.25 | 2.61 | 3.9 |
| C | VAT | 63 | 1.22 | 0.48 | 5.13 | 7.6 |
| C | HEAP | 60 | 1.08 | 0.72 | 2.59 | 3.9 |
| D | VAT | 63 | 1.36 | 0.51 | 5.10 | 7.3 |
| D | HEAP | 60 | 0.84 | 0.71 | 2.34 | 3.9 |
| E | VAT | 46 | 2.44 | 2.08 | 3.64 | 6.4 |
| E | HEAP | 40 | 0.38 | 0.19 | 1.39 | 3.7 |

** Flowrate calculated over total period of test.*

## Vat Leach Tests

The vat leach tests were conducted as continuous up-flow leach tests. After the ore was loaded into the column, alkaline cyanide solution was pumped into the bottom of the column until all of the ore was completely submerged. The flow rate of the solution into the column was then maintained at 10 to 12 liters/hour/square meter of column cross-sectional area, with the exception of the vat test on Ore A, which was run at a flow rate of 100 to 120 liters/hour/square meter of column cross-sectional area. The pregnant effluent was sampled every 24 hours and run through a carbon column to recover the gold and silver.

The carbon effluent from the previous 24 hours was also sampled, assayed, and chemical additions made, if necessary, before recycling to the columns.

## Laboratory Test Results

The five ores tested were all oxide ores. Ores A-D were from the United States and Ore E was from Western Australia. The tests on Ore A were run on agglomerated material. The tests on Ores B-E were all conducted on un-agglomerated material.

Tables 1 and 2 present the results of the heap and vat column tests. As Table 1 shows, gold recovery was essentially the same in the heap and vat leach tests for all five ores tested. Ore A, which also contained over 1 ounce of silver per tonne, showed no significant difference in silver recovery between the vat and heap leach tests.

Tables 1 through 6 present graphs of the metal recoveries versus days leaching. As the figures show, with the exception of Ore A, recoveries were faster in the heap leach tests even though the average solution flow rate over the life of the tests was approximately 50 percent less than the vat tests on the same ore. The slightly faster rate seen in the vat leach test on ore A is probably due to the fact that the flow rate in the vat test was 10 times greater than in the heap leach test.

## CONCLUSIONS

The results of small scale laboratory leach tests on five different ores have shown that there is no significant difference on overall recoveries between heap and vat leaching. Previous work by one of the authors (1) has shown that scale-up in heap leach column test results in slower recovery rates but essentially the same overall recoveries. Additional testing at a larger scale is needed to see if this will hold true for vat leaching as well.

## REFERRENCES


1. Dix, Russel B. (1988), "Laboratory Heap Leach Testing Comparison of Small & Large Scale Tests." Workshop Conference – Economics and Practice of Heap Leaching in Gold Mining, Cairns Queensland, August 3-6, 1988, pp. 25-32.


**Table 5. ARUORA - ORE C**

| DAYS LEACHING | TEST 9360 VAT TEST Au % | TEST 8123 DRIP TEST Au % |
|---|---|---|
| 0 | 0.00 | 0.00 |
| 8 | 30.35 | 44.23 |
| 20 | 51.90 | 61.54 |
| 41 | 65.64 | 68.40 |
| 60 | 71.75 | 72.03 |

**Table 6. BIG BLACKFOOT - ORE D**

| DAYS LEACHING | TEST 9627 VAT TEST Au % | TEST 8189 DRIP TEST Au % |
|---|---|---|
| 0 | 0.00 | 0.00 |
| 9 | 55.55 | 70.31 |
| 20 | 75.92 | 78.50 |
| 41 | 83.33 | 85.43 |
| 60 | 84.93 | 87.03 |
| 63 | 85.18 | |

**Table 7. GLENDOWER - ORE E**

| DAYS LEACHING | TEST 9627 VAT TEST Au % | TEST 8189 DRIP TEST Au % |
|---|---|---|
| 0 | 0.00 | 0.00 |
| 7 | 77.85 | 89.45 |
| 17 | 93.15 | 92.50 |
| 40 | 95.51 | 94.95 |
| 46 | 95.75 | |

**Table 3. AMAX - ORE A**

| DAYS LEACHING | TEST 6703 VAT TEST | | TEST 6705 DRIP TEST | |
|---|---|---|---|---|
| | Au % | Ag % | Au % | Ag% |
| 0 | 0.00 | 0.00 | 0.00 | 0.00 |
| 7 | 66.16 | 62.20 | 63.31 | 55.56 |
| 20 | 76.33 | 71.35 | 75.07 | 67.37 |
| 40 | 81.34 | 76.23 | 80.45 | 72.93 |
| 60 | 83.85 | 79.28 | 83.00 | 77.79 |
| 88 | | | 84.84 | 80.57 |

**Table 4. ST. JOE - ORE B**

| DAYS LEACHING | VAT TEST | | DRIP TEST | |
|---|---|---|---|---|
| | Au % | T/SOLN | Au % | T/SOLN |
| 0 | 0.00 | | 0.00 | |
| 8 | 56.86 | 0.76 | 75.50 | 0.32 |
| 12 | | | | |
| 20 | 72.55 | 1.66 | | |
| 21 | | | 82.00 | 0.90 |
| 39 | | | 83.01 | 1.73 |
| 41 | 80.39 | 3.24 | | |
| 61 | | | 83.01 | 2.61 |
| 63 | 82.35 | 5.19 | | |