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LABORATORY HEAP LEACH TESTING COMPARISION
OF SMALL & LARGE SCALE TESTS

Presented at the Workshop Conference on Economics & Practice of Heap Leaching in Gold Mining
Cairns, Queensland Australia, August 1988

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ABSTRACT
Laboratory column leach tests were conducted on four different gold ores. Both small scale tests on 40 to 80 kilogram samples and large column tests on 9 to 10 tonne samples were performed. Comparisons of the recovery rates and chemical consumptions between the two sizes of tests are presented.

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, and collecting the effluent solutions. The effluent solutions are then put through a column of activated carbon to recover the gold and silver in solution. Zinc precipitation may also be used for silver ores or if the ore contains a signification amount of the soluble silver in addition to gold. The length of the leach time in the tests is mainly a function of how quickly the precious metals are recovered from the ore. At the completion of the tests, the tailings are assayed and the recoveries determined from the calculated head grades. The amount of ore to be used for a test is partly a function of the crushed size to be tested, i.e. the coarser the crush size the larger the sample size for the column. A typical small scale laboratory column test on ore crushed to minus 12 millimeter would usually be conducted in a 100 to 150 millimeter diameter column 2 meters in height containing approximately 20 to 45 kilograms of ore. A small scale laboratory column test on the same ore crushed to 50 millimeter would be conducted in a 200 to 300 millimeter diameter column 2 meters in height containing approximately 80 to 200 kilograms of ore. Larger scale tests can also be run by increasing the column heights and/or column diameters.

Conducting larger scale tests results in increased cost for sample procurement, preparation, and running of the test. The additional data obtained from the larger scale tests, however, do not always justify the increased costs. Column tests conducted on four different gold ores in both small and large scale columns have shown that the results from the large scale tests do not vary significantly from the smaller columns.

TEST PROCEDURES
Small and large scale column leach tests were run on four gold ore samples designated A through D. The tests were all conducted as continuously drained, drip leach tests. In the small column leach tests conducted in 150 and 230 mm diameter columns 2 meters in height, alkaline cyanide solution was applied to the columns at a rate of 10-12 liters per hour per square meter 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, with lime and cyanide added, if necessary, before recycling through the columns.

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

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Table 1. Column Test Conditions

ORE	ORE SIZE	COLUMN DIAMETER	ORE WEIGHT	ORE HEIGHT	CHEMICAL ADDITIONS KILOGRAM PER TONNE[1] CEMENT	LIME	AGGLOMERATED
A	- 38 mm	1.2 m	10.62 t	6.4 m	0	0	NO
A	- 38 mm	0.23 m	87 kg	1.8 m	0	0	NO
B	- 38 mm	1.2 m	9.56 t	6.53 m	3.0	0.5	YES
B	- 38 mm	0.23 m	83 kg	1.76 m	0	0	NO
B	- 38 mm	0.23 m	68 kg	1.78 m	3.5	0	YES
C	- 19 mm	1.2 m	9.62 t	6.86 m	0	2.5	NO
C	- 19 mm	0.15 m	40 kg	1.61 m	0	2.5	NO
D	- 38 mm	1.2 m	9.07 t	5.94 m	0	0	NO
D	- 38 mm	0.23 m	80 kg	1.78 m	0	0	NO

[1] *Chemicals added prior to leaching*

Table 2. Column Test Results

ORE	ORE SIZE	COLUMN DIAMETER	ORE WEIGHT	DAYS LEACHING	% Au RECOVERED	CALCULATED HEAD Au g/t	CHEMICAL CONSUMPTION KILOGRAMS PER TONNE NaCN	$Ca(OH)_2$
A	- 38 mm	1.2 m	10.62 t	80	80.5	5.62	0.41	0.65
A	- 38 mm	0.23 m	87 kg	87	80.7	6.58	1.08	0.66
B	- 38 mm	1.2 m	9.56 t	63	90.9	1.88	0.31	0.65
B	- 38 mm	0.23 m	83 kg	36	90.4	1.78	0.51	0.38
B	- 38 mm	0.23 m	68 kg	59	90.9	1.88	1.11	0.70
C	- 19 mm	1.2 m	9.62 t	61	85.7	1.92	0.34	2.72
C	- 19 mm	0.15 m	40 kg	59	83.0	1.82	0.56	2.75
D	- 38 mm	1.2 m	9.07 t	60	86.7	1.54	0.45	0.55
D	- 38 mm	0.23 m	80 kg	60	85.4	1.64	1.00	0.62

through the carbon column. In the small column tests on Ores A, B, & C, only one batch of solution was used. In these tests, the columns sat dormant for 24 hours while the pregnant solution was run through the carbon columns.

The large 1.2 meter diameter by 7.3 meter column tests were run in the same manner as the small column tests on Ore D. Each day the pregnant solution from the previous 24-hour leach period was measured, sampled, and then pumped through a column of activated carbon. The barren carbon column effluent from the previous 24-hour leach period was also measured, sampled, and chemicals added if necessary before recycling to the column. Flow rate of the on-flow solution was maintained at 10-12 liters per hour per square meter of column cross-sectional area.

COLUMN TEST RESULTS

The four ores tested were all oxide ores. Table 1 lists the test conditions for each of the column tests. All column tests on Ores A, C, and D, and one of the small column tests on ore B, were conducted on un-agglomerated ore. In the tests on Ore C, which was slightly acidic, 2.5 kilograms of hydrated lime per tonne was blended with the ore before loading into the columns. The large column test and one of the small column tests on Ore B were conducted on material agglomerated with 3 kilograms of cement and 0.5 kilograms hydrated lime per tonne of ore.

Figures 1, 3, 5, and 7 present graphs of the gold recovery versus days leaching for the column tests on the individual ores. For each ore that was tested, gold recoveries were faster in the smaller column tests during the initial 30 to 45 days of leaching. After 45 days the leach rates for the small and large columns were similar. Overall gold recoveries in the tests were essentially the same regardless of test size.

Figures 2, 4, 6, and 8 present graphs of the gold recovery versus solution-to-ore ratio (tonnes of effluent solution per tonne of ore). The tests on Ores A, B, and C show that when gold recovery is plotted as a function effluent solution out of the columns, the curves are essentially identical between the two different sizes of column tests.

The small column test on Ore D, however, showed lower recoveries than the large column test for the same volumes of effluent. The results indicate that the onflow rate of solution to the small column test over the duration of the test, which was twice the flow rate used in the small column tests on the other three ores, was higher than required for this scale of test.

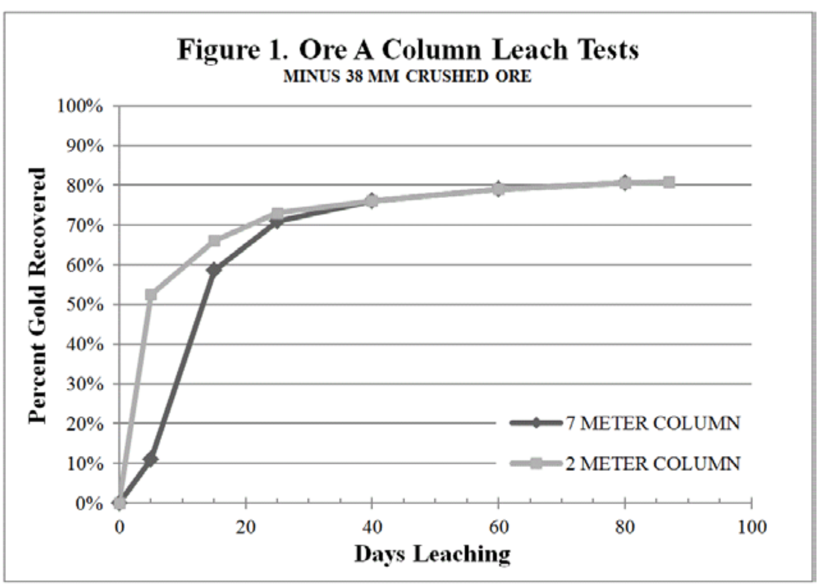
Table 2 presents a summary of the column tests including the chemical consumptions. All ores tested showed the same consumption of hydrated lime for the same period of leaching regardless of the column size.

Sodium cyanide consumption, however, was between 39 and 72 percent lower in the large column tests. One reason for the higher cyanide consumptions in the small diameter column test is that the containers holding the leach solutions have a larger surface area per unit volume than the containers used in the large diameter column tests. This allows more contact of the leach solutions in the small diameter column tests with carbon dioxide in the air. This results in the formation of carbonic acid which then decomposes a portion of the cyanide present.

CONCLUSIONS

The results of the column test on the four different ores tested have shown that small scale laboratory tests on 40 to 80 kilogram samples can provide essentially the same data on ore leachability as large scale tests on several tonnes of the same material. The smaller scale tests consistently show higher cyanide consumptions, however, the values obtained can be factored down when doing economic feasibility studies on processing of the ores.

The four ores tested were oxide ores that did not contain any significant amounts of cyanides or reactive sulfides. The ores were also tested at crush sizes of 38 and 19 millimeters. For ores that are chemically reactive or ores that are being considered for leaching at run-of-mine size, large scale test are recommended that will allow for larger sample sizes and ore heights approaching that of production heaps.



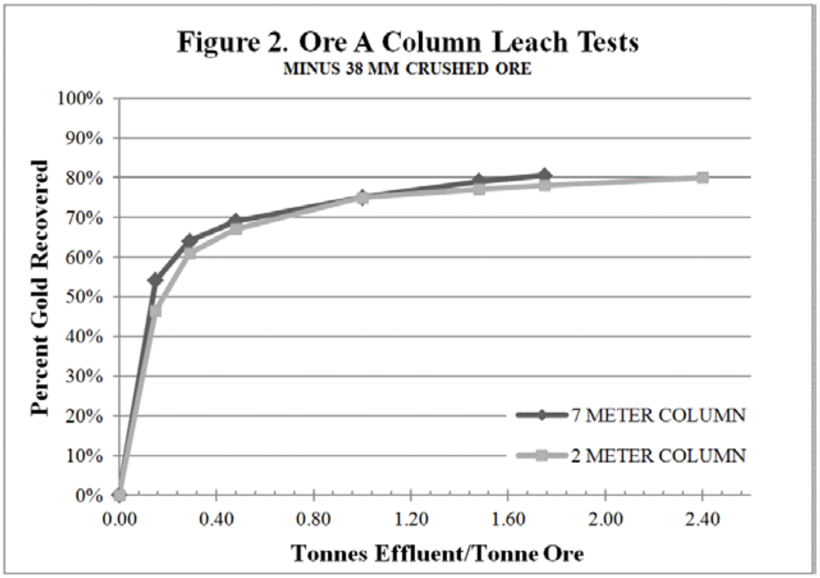


Figure 2. Ore A Column Leach Tests
MINUS 38 MM CRUSHED ORE
Percent Gold Recovered
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
0.00
0.40
0.80
1.20
1.60
2.00
2.40
Tonnes Effluent/Tonne Ore
7 METER COLUMN
2 METER COLUMN

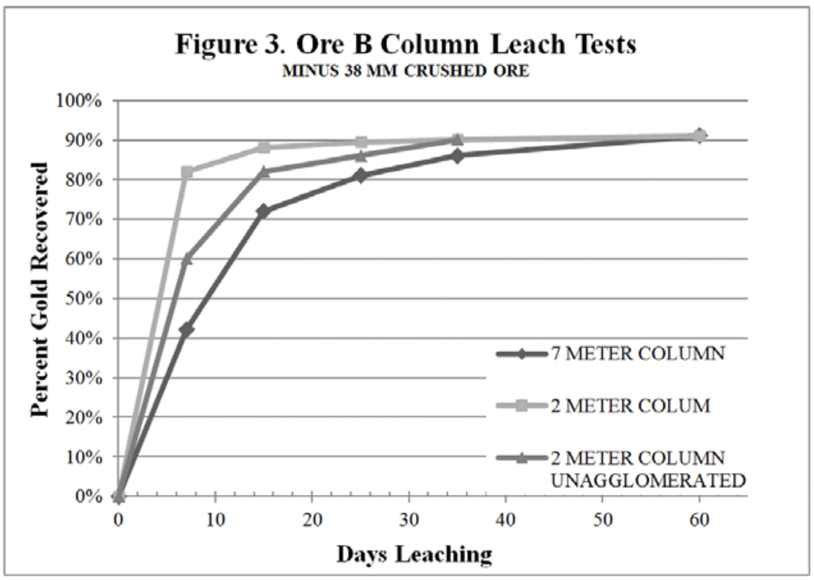


Figure 3. Ore B Column Leach Tests
MINUS 38 MM CRUSHED ORE
Percent Gold Recovered
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
0
10
20
30
40
50
60
Days Leaching
7 METER COLUMN
2 METER COLUM
2 METER COLUMN UNAGGLOMERATED

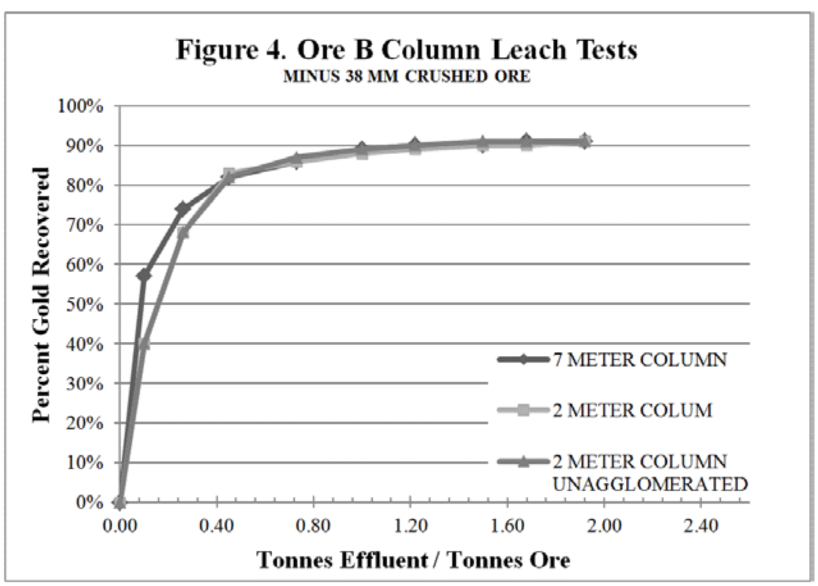


Figure 4. Ore B Column Leach Tests
MINUS 38 MM CRUSHED ORE
Percent Gold Recovered
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
0.00
0.40
0.80
1.20
1.60
2.00
2.40
Tonnes Effluent / Tonnes Ore
7 METER COLUMN
2 METER COLUM
2 METER COLUMN UNAGGLOMERATED

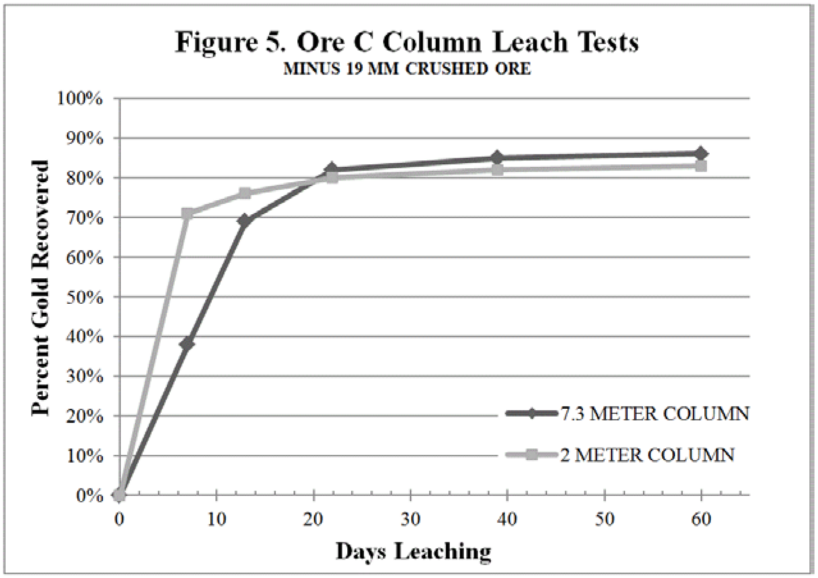


Figure 5. Ore C Column Leach Tests
MINUS 19 MM CRUSHED ORE
Percent Gold Recovered
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
0
10
20
30
40
50
60
Days Leaching
7.3 METER COLUMN
2 METER COLUMN

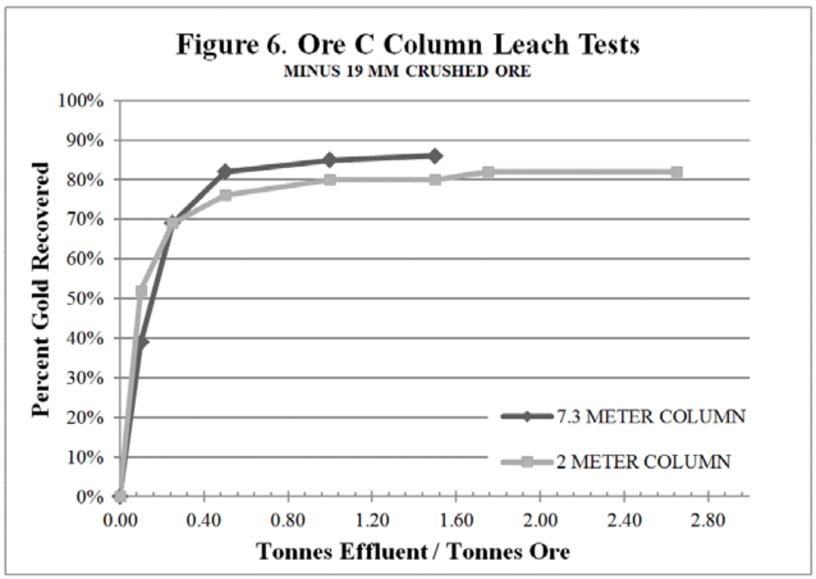


Figure 6. Ore C Column Leach Tests
MINUS 19 MM CRUSHED ORE
Percent Gold Recovered
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
0.00
0.40
0.80
1.20
1.60
2.00
2.40
2.80
Tonnes Effluent / Tonnes Ore
7.3 METER COLUMN
2 METER COLUMN

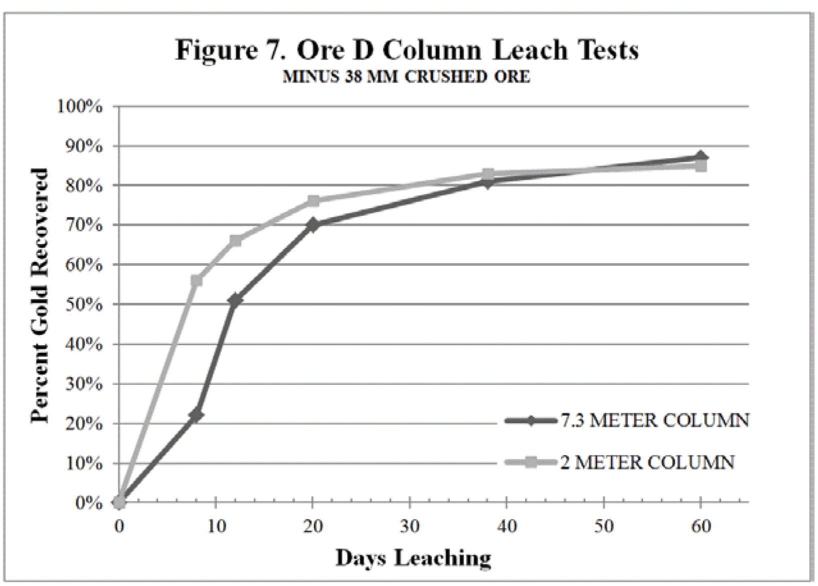


Figure 7. Ore D Column Leach Tests
MINUS 38 MM CRUSHED ORE
Percent Gold Recovered
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
0
10
20
30
40
50
60
Days Leaching
7.3 METER COLUMN
2 METER COLUMN

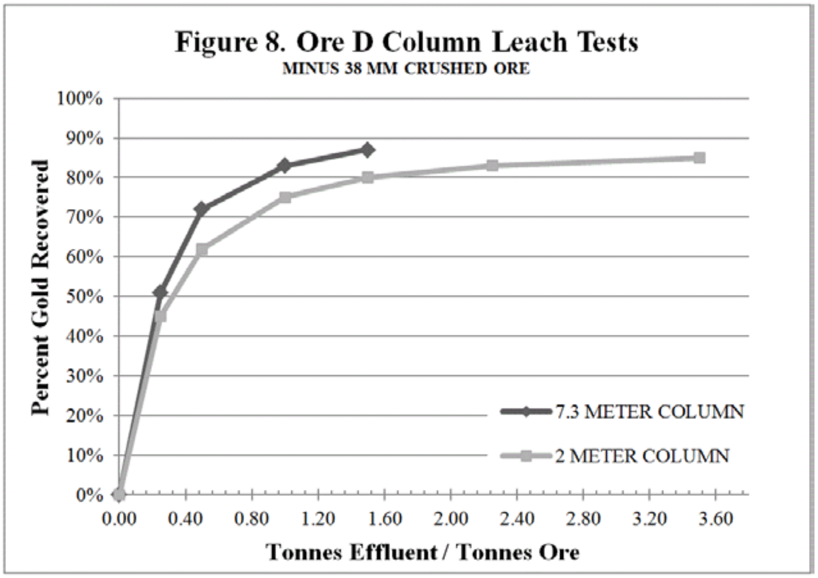


Figure 8. Ore D Column Leach Tests
MINUS 38 MM CRUSHED ORE
Percent Gold Recovered
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
0.00
0.40
0.80
1.20
1.60
2.00
2.40
2.80
3.20
3.60
Tonnes Effluent / Tonnes Ore
7.3 METER COLUMN
2 METER COLUMN