Gravity Leaching — The ACACIA Reactor

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ABSTRACT

Gravity Leaching of high-grade gravity gold concentrates, such as Knelson Concentrates, with the ACACIA Reactor represents a new generation of concentrate treatment methods. The ACACIA Reactor is a complete packaged plant for the maximising of gold recoveries from gravity gold concentrates. This paper will introduce the process technology and provide process results from the Porgera ACACIA Reactor installation.

The advantages of the ACACIA Reactor are many, and justification for installation has been varied. The typical advantages of the process include:

- increased recovery of gold from the Knelson Concentrate;
- no return of high-grade table tails, often grading several thousand g/t, into the mill circuit;
- reduction in tails grades of slow leaching gold;
- reduction in the requirement for operating staff by the removal of the manual tabling process and replacing with a fully automated treatment system;
- improved security by removing the tabling step where operating staff come into direct contact with visible gold;
- improved health and safety, by the removal of the treatment steps for the table concentrate, which often include operators handling corrosive chemicals and the production of sulphur and arsenic compound fumes; and
- improved metallurgical accounting, by allowing daily head grade calculations.

The ACACIA Reactor was developed by Anglogold for Union Reef's Gold Plant and has been in production for over two years, and has proven to be a low cost, high recovery, mechanically reliable method for the processing of gold concentrates. Such has been the success of the plant, there are now four full installations of the processing plant, including Anglogold Union Reef's, Anglogold Sunrise Dam, PACMIN Carosue Dam and Porgera Joint Venture.

BASIC FLOW SHEET OF THE ACACIA REACTOR

The ACACIA Reactor relies on a simple flow sheet, with a design that incorporates few moving parts. Due to the simple design of the unit it will allow easy integration into a gold room, and the use of site standard components. The basic flow sheet is simple and involves eight major process steps:

1. transfer of concentrate from the day storage hopper;
2. prewashing of the concentrate to remove fines;
3. mixing of leaching reagents;

4. leaching;
5. recovery of the pregnant solution and washing of the residue;
6. discharging of the leach residue;
7. electrowinning of the gold from the pregnant solution; and
8. disposal of electrowinning tail.

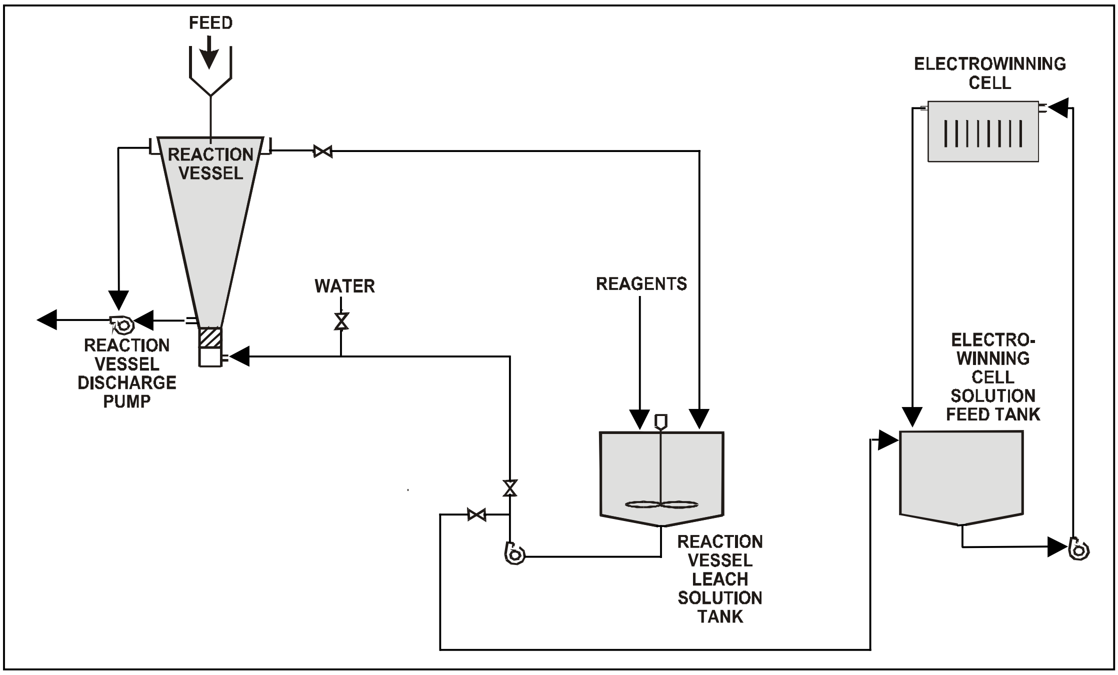

Figure 1. Basic flow sheet of the ACACIA Reactor.

1. Transfer of concentrate from the day storage hopper

The ACACIA Reactor utilises a conventional technology concentrate storage hopper for the day storage of a batch of concentrate. The hopper is designed to provide surplus capacity, but is generally designed to have an active volume to match the Reactor size (ie 0.5 m^3, 1.0 m^3, 2 m^3, etc.)

2. Prewashing of the concentrate to remove fines

The pre-washing stage is the most critical stage of the process and must be carefully controlled to ensure maximum recovery from the ACACIA Reactor. The pre-wash cycle removes any fines that may be entrained in the gravity concentrate. These fines are therefore eliminated from causing future problems with the electrowinning. The fines are either sent to the grinding circuit or directly to the CIP circuit.

3. Mixing of leaching reagents

Using the Reactor feed tank, the leach solution is mixed. The leach solution typically includes concentrated cyanide, caustic solution, and the leach accelerant LeachAid. While other oxidants can and have been tested, LeachAid has been shown to provide the greatest process stability and offers significant process flexibility while maximising overall recoveries. The reagent is commercially available worldwide.

4. Leaching

The deslimed solids are subjected to an upflow of leach solution. The upflow of solution causes expansion of the solids bed to allow a 'fluidised bed' to form in the reactor. Leach times required are site specific, but generally high leach recoveries can be achieved in less than eight hours. To allow daily running of the Reactor, the Leach cycle must be complete within 16 hours.

5. Recovery of the pregnant solution and washing of the residue

The pregnant solution must be recovered at the completion of leaching. This is achieved simply by draining from the bottom of the Reactor into the leach feed tank. The solids are then washed to remove the residual pregnant solution entrained within the solids.

6. Discharging of the leach residue

The leach residue tails are pumped back to the mill circuit from the Reactor. Careful design of water injection points, pump inlets and outlets, and oversizing of the pump has resulted in all coarse, heavy material being removed from the Reactor at the completion of a cycle.

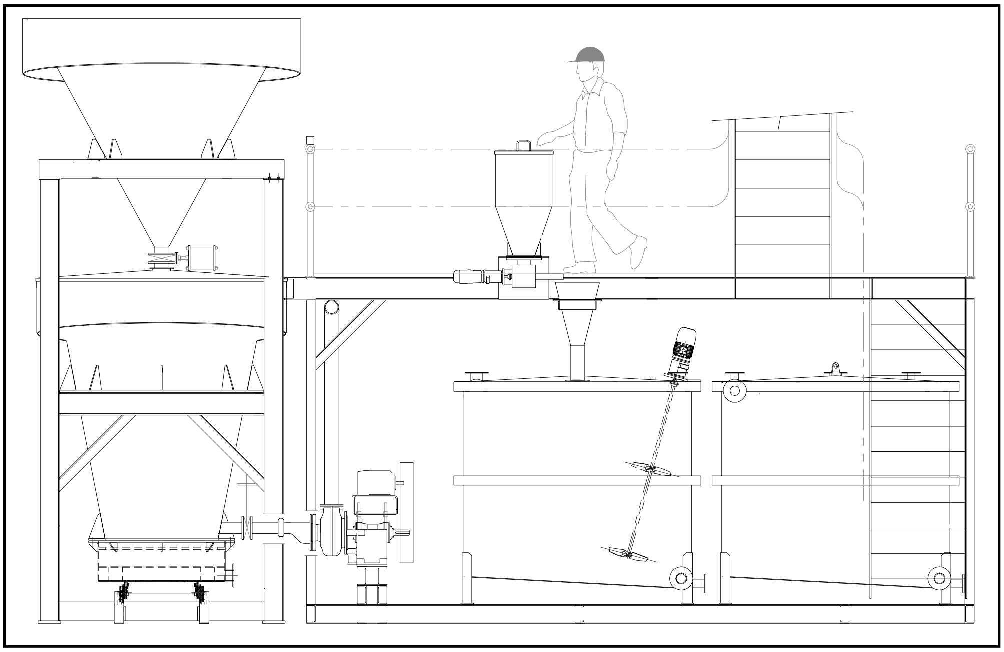

Figure 2. General arrangement of the ACACIA Reactor.

7. Electrowinning of the gold from the pregnant solution

Two basic options exist at this point. One option is to transfer the pregnant solution to the main eluant tanks for electrowinning with the rest of the plants solution. The other option is to use a dedicated electrowinning system. In the dedicated electrowin circuit the solution is transferred from the leach feed tank, to the electrowin feed tank. The solution is then pumped through a dedicated electrowinning cell, typically for 16 hours.

8. Disposal of electrowinning tail

At the completion of electrowinning the final tails solution can either be partially recycled, or can be sent to leach feed, where the residual chemicals have added value to the CIP train. It is not recommended to recycle the total solution as it will result in build up of Na^+ levels in the solution with potential precipitation of aurocyanide complex.

PREFERRED OXIDANT

Considerable testwork has been invested into determining the preferred oxidant for the ACACIA Reactor. Five oxidants were reviewed including air, oxygen, perborate, hydrogen peroxide and a chemical oxidant (Staunton and Nicol, 1999).

The testwork indicated that there were two preferred oxidants, hydrogen peroxide and the chemical oxidant. To-date the chemical oxidant preferred by ConSep is LeachAid. LeachAid is far more stable, and could be added in one dose, as a solid, at the start of the leach reaction. LeachAid is also classed as a non-hazardous material, making it a safe, clean and simple option. Hydrogen peroxide needs to be added continuously, reacts with cyanide, and is a hazardous material.

The major advantage that has not yet been fully explored is that the commercially available oxidant LeachAid is a non-oxygen based oxidant. This has enabled ACACIA Reactor sites to elevate their temperatures in the leach cycle, with the advantage of improved leach times and overall recovery increases. These are yet to be fully quantified, but qualitative analysis has indicated much improved reaction kinetics are experienced at sites running between 50 and 65°C.

ACACIA REACTOR INSTALLATIONS

The ACACIA Reactor is now installed and running in four sites, with a further two units in manufacture in ConSep’s workshops. By April 2002 there will be ACACIA Reactors installed in Australia, Papua New Guinea, North America and Africa. Added to the considerable results generated from the various installations, ConSep and the worldwide network of partners have conducted testwork at many sites around the world. Testwork for the ACACIA Reactor is conducted using a directly scaled 50 kg per batch pilot plant. This unit can be run on the exact reagent configuration and sequence timing of the full-scale plants, and has produced results representative of the final plant.

All ACACIA Reactors have produced very similar results, and the data below represents results from testwork and commissioning of the ACACIA Reactor at the Placer Dome managed Porgera Joint Venture Gold Plant in Papua New Guinea. Porgera installed the ACACIA Reactor to replace an amalgamation circuit on site. The recoveries of the amalgamation circuit were generally reported to be around 50 per cent, with the tails reporting to the leach circuit via the pressure oxidation circuit. Due to the lower than expected recoveries achieved by the amalgamation circuit, Porgera investigated intensive cyanidation as an alternative, with site purchasing an ACACIA Reactor in July 2001.

Figure 3. Porgera Model CS3000 ACACIA Reactor.

TESTWORK RESULTS FROM PORGERA JOINT VENTURE GOLD PLANT

A range of testwork was carried out by ConSep on site at Porgera. The final testwork conducted consisted of four leach tests carried out with varying reagent addition rates.

Test PC1

Aiming to determine leach recovery with no accelerant addition, air only leaching. Estimated concentrate grade of 1.5 per cent Au, solids mass ~24 kg, producing leach conditions as follows:

Solution volume	190 litres
Cyanide addition	5 kg
Caustic addition	0.6 kg
LeachAid addition	0

Test PC2

Aiming to determine leach recovery with low accelerant concentration. Estimated concentrate grade of one per cent Au, solids mass ~23 kg, producing leach conditions as follows:

Solution volume	80 litres
Cyanide addition	1200 g
Caustic addition	280 g
LeachAid addition	150 g

Test PC3

Aiming to determine leach recovery with high accelerant concentration. Estimated concentrate grade of one per cent Au, solids mass ~23 kg, producing leach conditions as follows:

Solution volume	80 litres
Cyanide addition	1200 g
Caustic addition	280 g
LeachAid addition	600 g

Test PC4

Aiming to determine leach recovery with high accelerant concentration in the presence of high cyanide addition. Estimated concentrate grade of 1.5 per cent Au, solids mass 21.7 kg, producing leach conditions as follows:

Solution volume	80 litres
Cyanide addition	1600 g
Caustic addition	280 g
LeachAid addition	500 g

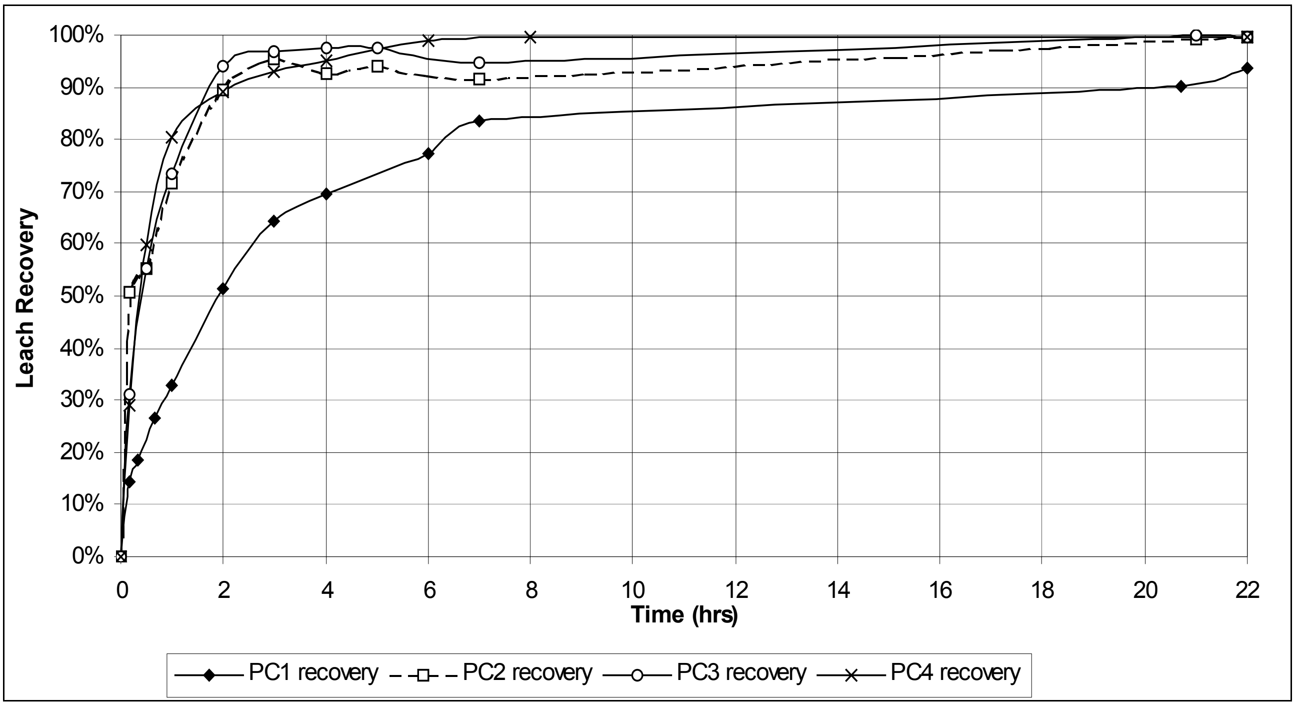

Figure 4. Porgera testwork recoveries.

TESTWORK CONCLUSION FROM PORGERA JOINT VENTURE GOLD PLANT

'It can be clearly seen from the primary concentrate leach tests the effectiveness of the leach accelerant leachaid in both increasing the leach rate and the overall recovery achieved.'

'It may be safely concluded from the leach test that with the addition of leachaid that plus 95 per cent recovery may be expected within 12 hours of leaching (indications are the time may be as short as six hours, 12 hours producing of the order of 98 per cent recovery), with a solids residue grade of less than 100 g/t Au.' (Rogan, 2001).

ACACIA REACTOR RESULTS FROM PORGERA JOINT VENTURE GOLD PLANT

The fully automated Model CS3000 ACACIA Reactor was installed and operational within a four week period on site. The unit has consistently produced recoveries well above the 95 per cent expected from the plant. In fact the four runs during performance testing (Table 1, Figure 5) all produced recoveries above 99 per cent. Recoveries since commissioning have been consistently above 98 per cent, often above 99 per cent. Recovery has been measured by taking pregnant solution grades and solid tails grades. PJV estimate that the installation of the ACACIA Reactor has increased overall recovery by over one per cent with a project payback of approximately two months (Stephenson, 2002).

The Porgera Plant has some new requirements that led to some changes to the standard functional description of the ACACIA Reactor. The most significant of these was the desire to complete the cycles within a 12-hour shift. As a result of this, careful consideration was given to minimising the length of each stage in order to maximise the available time for leaching. Leaches were able to be run for eight hour duration, and through using higher than usual dosage rates of reagents, it was possible to get over 98 per cent recovery in the eight hour period. The dosage rates were in line with the rates predicted by testwork undertaken by ConSep prior to installation of the full scale ACACIA Reactor.

Table 1. Commissioning results from Porgera Joint Venture.

Day	Unit	1	2	3	4
Total Gold in Solution	kg Au	26.6	31.9	19.8	15.8
Average Solids Residue grade	g/t	36.5	39.7	55.5	15
Mass of Concentrate	t	2.42	2.82	2.18	2.42
Total Gold in Residue	kg Au	0.088	0.112	0.121	0.036
Back-calculated con grade	g/t	11 052	11 347	9147	6561
Final Leach Recovery	%	99.7	99.7	99.4	99.8

CONCLUSION

The results from Porgera indicate that the full scale ACACIA Reactors performance closely mirrored that predicted by testwork. Testwork indicated that recoveries from the ACACIA Reactor of over 95 per cent were achievable within an eight hour leach time. These were the results required by site. Actual performance has resulted in recoveries of over 99 per cent within an eight hour leach time, using the same reagent stoichiometry as per the testwork.

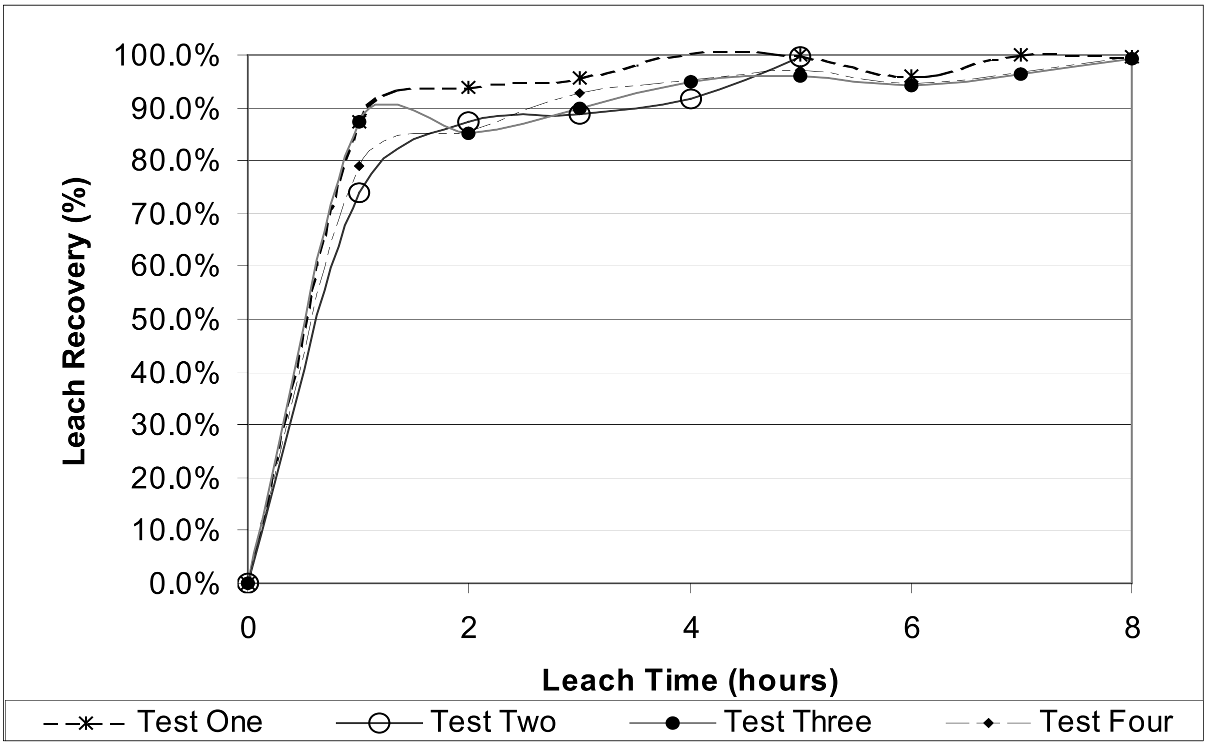

Figure 5. Porgera recoveries during commissioning.

Since commissioning Porgera Joint Venture metallurgical staff have been involved in a reagent optimisation program which has seen significant reductions in reagent dosages. The site has now moved from 12-hour per day running, to running a 24-hour process. This has allowed the site to realise a significant reduction in reagent consumption. Recoveries at Porgera are still reported to be above 98 per cent, and further optimisation of reagents is planned.

As a result of the ACACIA Reactor installation gold production has increased significantly from the gravity circuit, and overall plant recoveries are expected to increase as a result.

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