KCA

Kappes, Cassiday & Associates

7950 Security Circle • Reno, Nevada USA 89506 • Telephone: (775) 972-7575 • FAX: (775) 972-4567

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# Technical Advances in Precious Metals Heap Leaching

by

Daniel W. Kappes

Heap leaching for various metals has been around for at least 500 years, and cyanide technology for leaching precious metals has been used for over a century. The combination of the two processes took place in the late 1960's, and now accounts for the majority of process operations in the western United States (though conventional process plants still produce more metal). The most profound development in recent months has been the vast increase in interest throughout the world.

The size of U.S. heap leach operations ranges from a few hundred tonnes per day to over 18,000 tons per day:

> The Little Bald Mountain Mine of Northern Dynasty, Inc., produces 4.1 grams gold per tonne (value US$ 57.00) from approximately 50,000 tonnes per year (300 tonnes per day during a short operating season) which it mines from an underground mine, crushes, agglomerates, and stacks using a conveyor system.
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> The Rochester Mine of Coeur d'Alene Mines Corporation recovers approximately 33 grams silver per tonne and 0.2 grams gold per tonne (value US$ 9.70) from over 18,000 tons per day of ore.

## Recent Economic Developments

Recent technical developments in heap leaching are all classed as evolutionary rather than revolutionary, but the net effect may be revolutionary. They have resulted in significantly better economics and lower risks. Operating costs in dollars per ton of ore treated have decreased ten to twenty percent in the past three years, and some mines are now operating profitably on ores producing less than US$7.00 metal per ton of ore. Typical costs at medium-size operations are US$10.00 per ton including mining ($5.00), processing ($3.50) and project overheads ($1.50).

Capital costs for heap leaches are typically in the range of US$ 1500.00 per daily tonne of ore capacity for the processing facilities, and US$ 3000.00 per daily tonne for all facilities including purchase of mine and crushing equipment and working capital. Costs of installations at remote sites outside developed countries can be as much as twice these costs, because more infrastructure must be developed and development times are much longer.

Very low operating costs apply to the heap leach processing of mine waste which must be removed from the pit for other mining purposes. This material can be stacked without crushing on top of old heaps and leached for a cost of less than $2.00 per ton. In project planning for open cast mining operations, the includion of a process credit for such low-value tonnage can dramatically decrease the effective stripping ratio.

When compared with conventional mills, heap leaching requires much less capital. Two mines placed into operation in Nevada in 1986, both with a capacity of 4000 tons ore per day, illustrate the difference:

> The Hog Ranch Mine - an open pit mine with heap leach - had a total capital cost of $7 Million. Mining and crushing were performed by a contractor, but even if they had been done in-house the capital cost would have been only US$10 Million.
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> In contrast, the Paradise Peak mine - an open pit mine with a conventional agitation milling facility - cost US$80 Million.

Because heap leach equipment is simple and can be built in a modular form, it has now become economic to develop very small, remote gold and silver orebodies which need chemical leaching techniques. For instance, our company recently shipped a container-mounted plant to a site in the Sudan, a country with almost no industrial infrastucture, for a 300 tonne per day operation.

The following table presents the tonnage/grade relationship at which it becomes justifiable to develop typical properties in remote Australian locations (Australia has a very favorable tax and cost structure. For projects elsewhere in the world, multiply the grade by 1.5):

| Tonnes | Grams Gold/tonne |
|---|---|
| 5 Million | 1.0 |
| 2 Million | 1.7 |
| 500,000 | 2.7 |
| 100,000 | 3.0 |
| 50,000 | 5.0 |

## RECENT TRENDS IN TECHNOLOGY

### Site Topography and Heap Height.

Heap leaches can be made to conform to almost any topography. The trend is to keep the heaps as close as possible to the mine even if this means adapting the heap to a less than ideal site. The term "valley leaching" has been coined to describe heaps in which the base of the heap is enclosed within a dam which has the capacity to retain winter runoff or large floods. First used at Landusky-Zortman, Montana, several years ago, the technique has been successfully applied at many operations including the 18,000 ton per day silver heap leach of Couer d'Alene Mines, Inc., Rochester, Nevada.

While the toe of the heap must be keyed into level ground, some heaps are being constructed with internal pad slopes as steep as 30 percent (18 degrees). Limited operating experience indicates that plastic leach pads retain their integrity on such slopes provided that careful construction sequences are followed.

Multiple lifts are also becoming more common, following their successful use at Candelaria, Nevada, for several years. Theoretically and practically, the use of multiple lifts results in recovery delays and losses, but operators like the simplicity of a compact operation.

This points up one of the major needs of the heap leach industry: A method of monitoring heap leach performance so that an accurate recovery estimate can be made. Few if any heap leach operations know their recovery within ten percent, and as a result it is impossible to evaluate changes in heap design or operating techniques. Unfortunately, these monitoring problems are inherent in the nature of the method, and there is no easy solution.

To achieve better control, operators are utilizing more internal berms within the heap to capture and segregate solution from relatively small heap segments, and are measuring multiple flows with sampling devices and recording flumes.

## Finer Crushing

Since heap leach recovery increases with decreasing rock size, heap leach operations are beginning to push the conventional lower limit of crusher experience. Heap leaches on fine-crushed and agglomerated material are now beginning to replace conventional milling technology in some cases. We are currently installing an operation in Bolivia at which a low-grade silver ore will be dry-ground to 28 mesh, agglomerated and heap leached.

The introduction of the Barmac crusher has pioneered the use of "autogenous" impact crushers. This technology has become relatively well established in the sand and gravel industry, but is encountering resistance in the very conservative metal mining field. Nevertheless, Barmac and similar crushers are beginning to be installed, and several heap leach operations are planning to utilize such equipment to achieve crush sizes of 6 mesh (3.5 mm) or smaller. One of these is already in operation at the McLean Mine of Kemco, Inc., near Tonopah, Nevada.

Whereas older type impact crushers experienced high wear and downtime for parts replacement, the newer autogenous crushers can reduce ore to 6 mesh with a wear/replacement cost of $0.20 per ton and a downtime for parts replacement of less than one hour per day. These new crusher developments could have a significant expansive impact on the application of heap leaching.

## Conveyor Stacking

It is increasingly recognized that any compaction of the heap top surface results in a decrease in recovery. As a result, the use of conveyor transport and conveyor stacking systems is increasing. Specialized stackers and conveyor support packages are now available which permit the direct construction of a heap with a smooth top surface.

Most operations utilize a radial stacker operating from the base of the heap, and as a result the heap height is limited by the stacker size. Where the heap subbase is located on very steep or irregular slopes, the conventional stacker cannot function. Our company has recently specified (but not yet built) a modified version of the conventional stacker to work from the top of the heap at one such location. This stacker has the added advantage that the heap can be built to any desired height.

The Florida Canyon, Nevada, Mine of Pegasus Gold Corporation, in operation since 1987, utilizes a complete system of conveyor transport and a novel on-heap stacker built by R.A. Hanson Company; this stacker also permits unlimited heap height.

## Recovery Plants

The recovery of gold and silver from solution is still accomplished by either zinc precipitation or carbon adsorption. Some research is being done using resins to adsorb the gold and silver. However, the technology for removing the metals from the resin has not yet been adequately developed. It is unlikely that resins will replace carbon as the preferred adsorbing species in the near future.

Portable adsorption-desorption-recovery plants are now marketed which can be used for small- and medium-sized operations (300 to 3000 tons ore per day). For operations in environmentally-sensitive areas, portable plants offer the advantage that they can be removed at very low cost. These plants have the advantage of quick startup and low cost: the installed cost of a 1500 ton per day plant that includes all facilities for pumping solutions and producing a dore bar is less than $300,000.00. Of course, the plant cost is only a part of the total cost of a heap leach project. Total cost of a 1500 ton per day heap leach at a "grass roots" site, including permitting, site preparation, working capital, and prepayments to mining and crushing contractors, is usually about $2.5 Million.

Summary

The trend in heap leaching is its application to ores that had been considered for milling only. Conventional milling installations offer better operating cash flow characteristics and better percent recovery, but they can require substantially more development time and often show a lower return on investment.

In comparison with simple CIP plants at small, remote installations, heap leaching offers more flexibility to expand or contract throughput as the tonnage and grade of ore changes.

The heap leach process is not without its risks, however. In a CIP plant, the input of large amounts of energy for grinding and agitation permits more operating "leverage" to get the gold. The ability to rapidly change parameters and observe the results provides good operating control. Both of these factors decrease the importance of optimal initial design. In contrast, the heap leach process is difficult to change, and results do not show up quickly. The leach behavior of an ore must be understood in advance and the heaps must be constructed accordingly. The failure rate of heaps is relatively high - a result not of difficult technology, but of underestimating the importance of good business practice.