PRECIOUS METALS HEAP LEACHING
SIMPLE - WHY NOT SUCCESSFUL?

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by

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Heap leaching for the recovery of precious metals starts by dumping piles of mined ore on an impervious base, and sprinkling it with cyanide solution to dissolve the gold and silver. Once a heap is started, the leach solutions are merely recycled through the heap and then through a simple metals extraction circuit, for several days or months until the "target" recovery is achieved. For an operating heap of several thousand tons, the only moving parts might be two pumps and an air compressor.

What could be simpler? Surprisingly, of 22 heap leach operations included on a "quick-and-dirty" list made in preparation for this talk, eleven have been failures. Since the list contains several well-publicized, very successful leaches, the failure rate no doubt exceeds 50%.

Maybe some sinister space-warp brings a small corner of the Bermuda Triangle into every heap-leacher's backyard. Or perhaps, appearances are deceptive: Is the process full of unknowables which trap the unwary engineer?

Fortunately, the Bermuda Triangle theory doesn't bear up under close examination. And while there are some unknowables, they appear to account for few if any of the failures.

Much of the problem lies with the inherent nature of the heap leach process. It is ideal for use on the small property, by the small company. Three major problems can face the small company:

1. It can't afford to follow the proper technical path;
2. It can't distinguish between good technical advice and bad; or it just can't find the good;
3. It can't manage the good technical help once it has found it: promoters, managers and technicians are rarely a compatible mix.

In big corporations, the money is usually available, and the personality problems are usually alleviated by inserting one or more layers of technical management between the "technicians" and the "promoters". In small companies, there is often no middle ground: the promoter either makes too many of the technical operating decisions, or else he gives "carte blanche" to the technical operator.

For something specialized like a heap leach, the technical operators are usually drawn from the ranks of consultants, of which there are three types:

1. Those who do a good job;
2. Those with too many irons in the fire;
3. Those with too few marbles in the head.

Perhaps all consultants fall, at one time or another, into every category. What's the answer for the small company? There may not be one, but a few good guidelines to follow are:

1. Especially in the early conceptual stages of heap leach design, get at least two independent studies which include property review, systems design, and overall costs. Accept the one that's most conservative, or form a compromise that doesn't defy logic.
2. Select a technical manager who accepts the compromise design, and who is willing to commit himself exclusively to the project.
3. Don't change technical plans half-way into a project for reasons of management or budget "expediency".

Of course, blaming all the failures on management is a nice way to avoid the technical issues. The rest of this paper presents some of the technical questions to be answered in making the "heap leach" decision.

1. WHAT SHOULD THE OVERALL PLAN BE?

The development of the property should follow a series of well-defined steps, including those listed below:

a. Find some ore. This step should be obvious, but it apparently isn't. Heap leaching may be inexpensive, but it isn't free. At least three operations have failed because the heaps were built with material that wasn't ore even at the projected operating costs!

b. Evaluate the metallurgical geology. Metallurgical testing is only as good as the samples tested. Before testing begins, try to segregate the deposit into blocks according to differences in: mineralogy, extent of oxidation, clay content, and permeability (as measured by water drop absorption). Test each block separately, or at least test a good composite sample.

c. Perform sufficient laboratory tests. These tests may include small bucket leach tests on one or more crushed ore sizes, and high-column leach tests.

d. Perform a field test, if chemical reactivity or permeability problems are expected.

e. Allow adequate time and money to begin production. One medium-sized operation began full production 6 months after making the decision to proceed, but some important decisions were poorly made and costs were high. Generally allow one year from the beginning of the lab test program, and an additional 6 months if a large field test is needed.

2. WHAT CAN SMALL BUCKET TESTS TELL?

The first phase of the testing program usually consists of bucket leach tests on 50-pound samples of ore, crushed to various sizes. The tests are run for 60 days or longer, and they can be used to determine a variety of factors including those in the following list:

a. Recovery as a function of leach time and rock size, which is important in deciding whether or not to crush the ore.

b. The recoverable silver-to-gold ratio, which must be known for the selection and design of recovery systems.

c. Rock acidity and soluble base-matals content, factors which influence the heap height, and the selection and amount of leach chemicals required.

d. Obvious percolation problems; though the lab tests can't identify the seriousness of the problem, they can indicate that careful heap loading methods might be needed.

Laboratory tests have their limitations. They can't, for instance, tell much about the important decision to open-pit mine using ripping instead of drilling and blasting; and they can't say much about how ores with percolation problems should be loaded onto the heap.

3. ARE TALL COLUMN TESTS NECESSARY?

Tests can also be run in narrow laboratory columns up to 20 feet or more high. These tests can be important in determining chemical reactivity problems or giving further information about permeability problems. If the small bucket tests indicate such problems, tall column tests are absolutely necessary; they are a good idea for all ores.

4. HOW MUCH TIME AND MONEY SHOULD BE ALLOWED FOR THE LAB TESTS?

The lab testing program on a normal ore will cost approximately $3500 per sample. Since the bucket tests will usually run for 60 days, at least four months should be allowed for completion of testing. The questions to be answered during the lab test program are important, and it should not be by-passed.

5. IS FIELD TESTING NECESSARY?

Field tests, even small ones, are very expensive and are not always an absolute necessity. For ores with no permeability or chemical reactivity problems, and which are being leached at crushed sizes, the recovery from large field heaps of several hundred or thousand tons is very closely predicted by 50-pound laboratory bucket tests.

Figure 1 shows typical recovery curves, for a soft ore (nearly pure clay), and for a much harder ore. It's interesting to note that ores with heap permeability problems often show the highest laboratory recoveries. The field results can be disappointing unless the heap is built so that it percolates uniformly and at an acceptable rate.

Field tests should always be run where:

a. samples for laboratory tests can't be representative either geologically, or because of the rock size distribution (for instance if the rock is to be leached without crushing);

b. the ore is soft, and permeability might be seriously affected by the method of mining or of loading the field heap;

c. the ore shows chemical reactivity problems by consuming lime or cyanide in the lab tests.

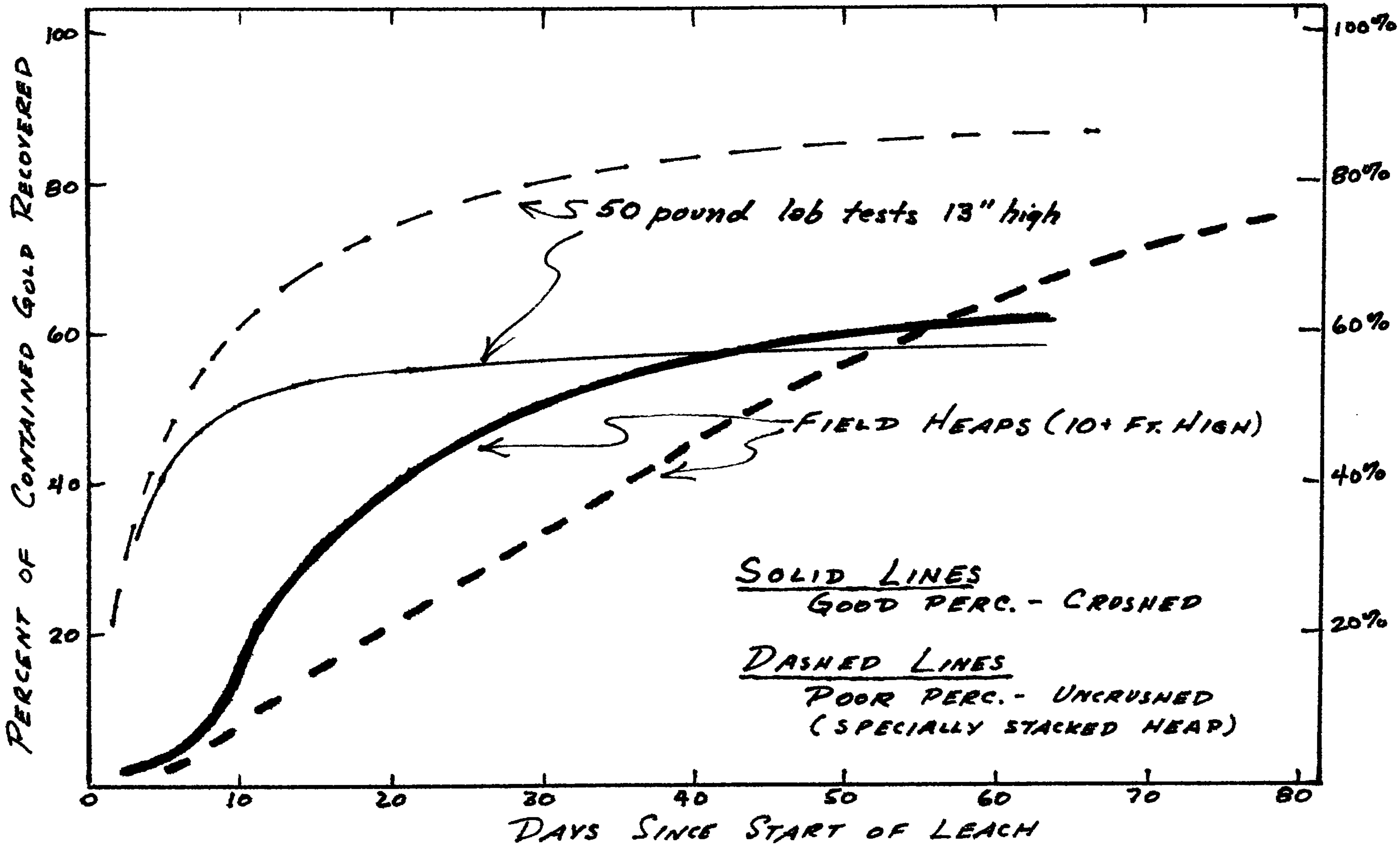

FIGURE 1. TYPICAL LAB AND FIELD TEST RECOVERY CURVES FOR CHEMICALLY UNREACTIVE ORES

If field tests are run, they should be run on heaps large enough to contain at least 50% of the tonnage under the highest part of the heap, and the heap should be about the same height as subsequent production heaps. Thus, for an operation with 12-foot-high heaps, the minimum test size is about 1500 tons.

6. WHAT IF FIELD TESTS ARE FINANCIALLY IMPOSSIBLE?

One of the most common approaches to leaching by the small company is to plan on using the first "production" heap as the test heap. Unfortunately, while lip service is paid to its "test" function, almost everything else about its operation implies that it is hardly a test. It is important that the small company does not fool itself about the test function. The most important achievement is to learn to recognize a test:

- It's a test ONLY if the product isn't needed to pay the bills.
- It's a test ONLY if operations stop until the results can be evaluated (which is usually a minimum of 4 months after solution application begins).

For many small deposits, field tests are very difficult to justify. The tests are very expensive. Costs start at $50,000 and may exceed $200,000 for one test on a few thousand tons of mined, crushed rock.

There are some alternatives if the field tests can't be run:

a. If the lab tests indicate severe percolation problems, find another deposit.

b. For moderate percolation problems, PLAY IT AS SAFE AS POSSIBLE. Stack the first production heaps low, less than 10 feet high, using equipment that doesn't have to be driven on the heap. Low heaps have higher costs for pads and recovery systems, but the extra costs are seldom prohibitive.

c. Mine the ore by drilling and blasting. Ripping with a bulldozer might be less expensive, but it's much more difficult to predict the rock sizes. Also, ripping usually creates a much higher percentage of pulverized rock than blasting.

7. SHOULD THE ROCK BE CRUSHED?

The lab tests will indicate if crushing is economically justifiable, and for some ores may show it to be necessary. For the small-tonnage deposit, portable crushers are usually available on a rental or contract-crushing basis; usually the charge includes a mobilization fee of $10-20,000 plus a per-ton charge.

Proper selection of the crusher is very important. Very often rental crushers aren't capable of the advertised output. Even when they work, adding the crushing "bottleneck" consumes already-short management time and greatly increases the risks for a small operation. It complicates even the very large operations. If the tradeoff is between crushed size and leaching time (for instance, 30 days versus 90 days), it is usually better not to crush. A good rule of thumb for the small operation: Avoid crushing if at all possible; if it's necessary. select a crushing system with PROVEN capabilities.

8. HOW SHOULD GOLD AND SILVER BE RECOVERED FROM SOLUTIONS?

There are three basic recovery systems which have been used on production operations, and all have been developed to the point where there is very little risk of their total failure. For ores which are almost pure silver, sodium sulfide precipitation can be used. The method is inexpensive and functional, but in the startup stages of the field leach there are usually lots of product handling problems to be solved, so extra technical help is required.

For silver, mixed silver-gold, or high-grade gold ores which leach rapidly, the traditional zinc precipitation methods may often be the best choice.

Activated carbon adsorption columns have been widely used on heap leaches, and have the advantages of low initial cost and negligible operating costs and problems. The system is ideally suited to low-grade or slow-leaching ores, especially if silver is absent. If silver constitutes over 20% of the recoverable dollar value (that is, if the silver to gold ratio exceeds 5 to 1), it is usually necessary to include a carbon stripping circuit as part of the field circuit.

8. HOW CRITICAL IS GOOD CONTROL OF THE MINING OPERATION?

It is NOT the goal of a heap leach operation to move large tonnages of rock inexpensively. Like any mining operation, grade control is important. Equally important, is the need to avoid mixing clay or carbonaceous waste rock with otherwise good ore on the heap.

Use of contractors for mining and hauling can have significant cost benefits for heap leach operations. The economic prospectuses of small operations often include a passage that reads something like "The contractor has provided a firm bid to mine and haul 20,000 tons of ore for $3.00 per ton".

Unfortunately, all too often the bid price does not take into account the difference between a mining operation and a dirt-moving operation. Bids are meaningless unless the contractor knows about and agrees to the restrictions on what and how to mine, sample and segregate ore from waste.

A few good guidelines to follow are:

a. Hold extensive discussions about the mining details BEFORE trying to establish a cost figure; make sure the details are at least in writing, if not in the formal contract.

b. Always design the leach operation to accomodate more than the planned-for tonnage. It is much nicer to be leaching waste along side of ore, than to be leaching waste while the ore is sitting in a stockpile.

9. HOW IMPORTANT IS THE METHOD OF LOADING THE HEAP?

Nearly all heap leach operations have experienced percolation problems at some time or another. At least five have failed because the heaps didn't percolate (for most of these, the problems would have been obvious if lab testing had been done).

ALWAYS give extremely careful thought to the choice of heap height, and the design of heap loading methods.

Like every endeavor in the mining industry, each heap leach operation has its own unique challenges. The list above offers simplistic guides to meeting some of them, but it's only an adjunct to good common sense. In the last analysis, the failures - and successes - of heap leaching result from a complicated interplay between the natural properties of ore deposits, the ever-changing economic climate, and the personalities of the people involved.