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HEAP LEACH OR MILL?
ECONOMIC CONSIDERATIONS IN A PERIOD OF STABLE GOLD PRICES

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Until recently, the general expectation among mining companies and financial analysts has been that the price of gold would remain on a generally upward slope. The recent drop in the price of gold has caused many people to re-think the issue. Of course, the price of gold is singularly difficult to predict, so it is difficult to tell which concept is correct.

In the present financial situation, however, many junior gold companies are faced with the reality that money is hard to raise, and many senior gold companies find that they are facing a period of corporate losses even though they own solidly producing mines.

As engineering consultants, Kappes, Cassiday & Associates, has recently received several requests to review conventional milling projects to see if heap leaching is a more viable option. In regard to straight financial criteria such as return on investment and net present value, the question is usually fairly easy to answer. However, corporate decisions must often be based on less definable criteria. For instance, new stock issues tend to be more successful if they are larger, which tends to favor milling operations over heap leaches. The corporate issues are often subjective and difficult to generalize about, so this paper will concentrate on a few financial concepts.

Figure 1 shows very generalized plots of capital costs versus size for recent heap leach and milling projects. In reality, plotting individual projects does not show very clear curves since local conditions and corporate philosophy can result in very difficult capital costs for seemingly identical operations. Therefore, the cost/size relationships are shown as straight lines. A good rule of thumb is that the capital cost of a typical milling operation is about $6000 per daily tonne of capacity more than the capital cost of a heap leach on the same

Figure 1. Capacity Versus Capital Cost

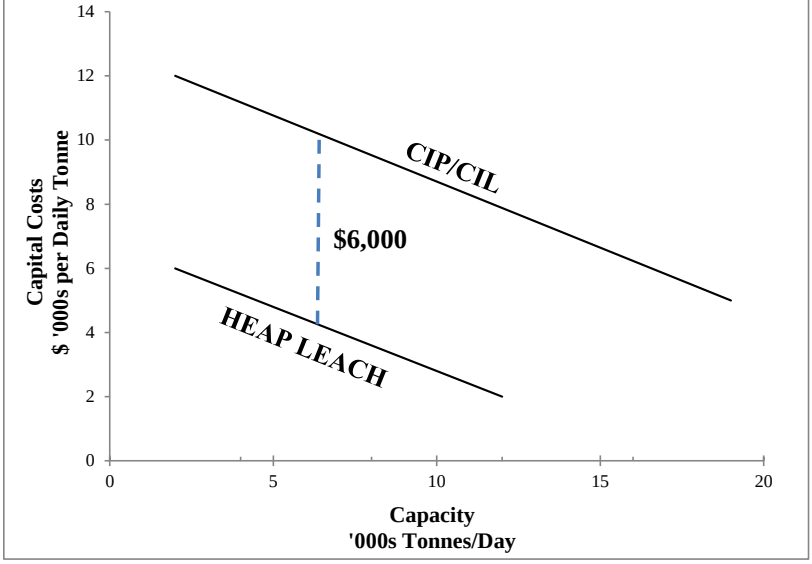

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Figure 2 - Differential Capital Cost

PER TONNE OF ORE

Differential Cost of Capital:	$6000 per daily tonne
Financial / Economic Debt Service Costs:	1.4 times cost of capital = $8400
A 6-year life at 350 days/yr, or 2100 days total, yields 2100 tonnes for each daily tonne of capacity and has the following Differential Capital Costs:	$8400/2100 = $4.00 per tonne

ore body (i.e, $2000-3000 per daily tonne versus $8000-9000 per daily tonne, including infrastructure and startup costs, but not including mine or mine equipment).

Figure 2 shows how the differential cost from Figure 1 translates into cost per tonne. As the figure shows, the different costs for a typical project is equal to $4.00 per tonne of ore treated.

The second line in Figure 2 uses a very simplified assumption as to the cost of capital, which is that the after tax cost of long term capital is approximately 1.4 times the amount of the capital. This assumption is reasonably correct for a normal feasibility study analyses, but the actual effect in a company with a mixture of debt and equity service might be quite different.

Operating costs represent the final component to be considered. Operating costs of a complete agitated leach plant can be as low as $4.00 per tonne processed, but are usually $6.00 for medium sized plants when all support and infrastructure costs are included. Operating costs of a large multiple lift heap leach can be as low as $2.00 per tonne treated. For medium sized typical heap leaches, an operating cost of $3.50 is more normal. The cost of a heap leach is very dependent on the need for cement agglomeration, and heap leach costs can increase to $5.00 per tonne where a lot of cement is required. The operating cost differential between the agitated plant and the heap leach is assumed to be $2.00 per tonne in Figure 3.

A typical conclusion from Figure 3, for an ore body containing 2.0 grams gold per tonne: if the ore shows 90% recovery in a mill (CIP, CIL or CCD leach plant), the heap leach recovery would have to be less than 59% for the mill to show a greater economic return.

Each project has different economic factors. Before choosing the high cost option of an agitated leach plant, it might be worthwhile to go through the simplistic exercise of creating Figure 3 with the applicable differential costs.

Other considerations in choosing between the process options have to do with perceived political and perceived technical risks:

POLITICAL RISK

In countries with very unstable political systems, the

Figure 3 - Differential Recovery Required To Justify Investment in Agitated Plant

Mill Capital Cost:	$4.00 per tonne more than heap leaching
Mill Operating Cost:	$2.00 per tonne more than heap leaching
Total Differential Cost:	$6.00 per tonne

Extra Percent Recovery Needed to Recover the Cost of the Mill (GOLD @ $300/oz or $9.64/gram)

ORE GRADE	EXTRA % RECOVERY
5.0 grams/tonne (0.146 oz/ton)	12%
3.0 grams/tonne (0.088 oz/ton)	21%
2.0 grams/tonne (0.058 oz/ton)	31%
1.0 grams/tonne (0.029 oz/ton)	62%

lower capital cost of the heap leach and the fact that the heap leach can often be under production twelve to eighteen months sooner than an agitated plant, provides inherently less risk.

TECHNICAL RISK

Technically, it is easier to achieve the design recovery in an agitated leach plant than in a heap leach, because the agitated leach plant is a more energy-intensive process that provides more options for "attacking" the ore. On the other hand, a paper presented several years ago by T. Peter Philip of Newmont (Second Joint AusIMM-AIME Conference, Cairns 1991) pointed out that the tendency of management is to over-estimate the reliability of the agitated leach plant as compared with the heap leach, and this may lead to the wrong choice.

CONCLUSION

The "flavor" of this presentation is obviously to point out that heap leaching should not be quickly dismissed. There are very good arguments for agitated leach plants in many situations. In Nevada, where a variety of gold leaching technologies are used and are generally well understood, there is a mixture of process applications. Nearly all operating mines which have mills also have heap leaches to treat low grade material. The tonnage of ore treated in heap leaches exceeds the tonnage treated in mills and there are more heap leach installations than mills. But, because mills generally treat higher grade ores, the majority of gold production in Nevada comes from mills. The message should be that heap leaching is not a "poor relation" to other treatment alternatives; it can be, but isn't necessarily, the best choice.