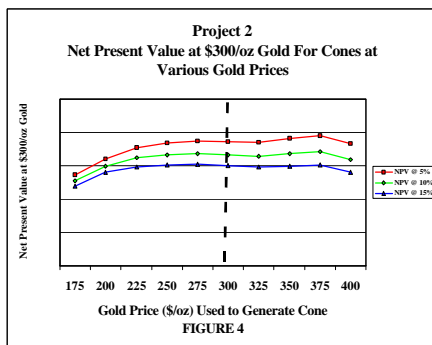


\$300 is used in the NPV analysis, while varying the price in the cone analysis, the result is two peaks on the NPV curves, as seen on Figure 4, rather than one, as seen in the previous projects. In this case, the NPV increases up to a gold price of \$275, then it drops off before starting to climb again at a price above \$325. This tends to indicate significant rewards after paying for the incremental waste stripping.



This particular project consists of two pits that are less than 200 meters apart. When reviewing the NPV results for the pits individually, the picture is quite different than when reviewing the combined results. For Pit 1 the NPV curve has only one peak at \$200 gold and then a significant downward trend in the NPV as the gold price used in the cone increases. Pit 2, on the other hand, has two peaks, one at \$275 and the other at \$375. Since Pit 2 provides over 80 percent of the tonnes and ounces, it is the controlling factor when the project is viewed as a whole. This

demonstrates that when designing pits for a project, the application of the same gold price to all of the pits may not be the best approach for the project. In this case, the smaller pit was designed using the \$200 cone, while the larger pit was designed using the \$300 and \$350 cones.

**Conclusions**

In evaluating projects, it can be extremely beneficial to look at the effects of gold price on a project, and to examine the effects of gold price on contained ounces, ore tonnes, and strip ratio (production parameters) as well as the effects on NPV. The conclusions reached from the production parameters can be significantly different from those reached from an NPV analysis. With an NPV analysis, the effect of the time value of money is more significant as the length of the project increases as the result of mining a large pit. Quite often with a larger pit, low-grade material is delaying the production of higher grade material and thus effecting the NPV.

The examination of the effects of gold price can be done in an extremely detailed fashion or in a short time frame as this was. Either way, the benefits to the project can be significant. When choosing the approach to use in the analysis, always review the overall complexity of the project and bear in mind the final

parties that will receive the results. The end result is that management needs to decide whether maximizing ounces or NPV is the overall goal of the project.

A side issue not addressed in this paper, but that should be kept in mind, is that performing a sensitivity analysis with the final project cash flow by simply increasing and decreasing price and cost, may not accurately reflect the impact on the project. When varying these parameters in this fashion, a linear relationship is assumed, when in actuality the deposit reacts more along the lines of a step function. Additionally, there is a tendency to forget that if the price changes, it is probable that the pit will be redesigned. Keeping these factors in mind, it can be beneficial to use the results of the various cone runs in the final project cash flows simply as a check.

*This month's article was provided by Susan R. Poos, P.E., Senior Mining Engineer, [srp@pincock.com](mailto:srp@pincock.com).*

**COMING NEXT MONTH:**

- Valuating a Resource Project as an Option



**PINCOCK ALLEN & HOLT**  
Delivering smarter solutions

Pincock, Allen & Holt is a consulting and engineering firm serving the international mineral resource industry. This information bulletin is published as a free information service for friends and clients. Your comments and suggestions are always welcome. Contact Pincock, Allen & Holt • 274 Union Blvd., Ste. 200, Lakewood, Colorado 80228 • TEL 303.986.6950 • FAX 303.987.8907 • [www.pincock.com](http://www.pincock.com)



### PAH NEWS PICKS

- PRODUCTION AT GRASBERG INDONESIA TO BE LIMITED TEMPORARILY
- GLAMIS GOLD LTD. ACQUIRES STAKE IN MEXICAN PROPERTY
- BATTLE MOUNTAIN GOLD COMPANY EXPANDS PROJECTED PRODUCTION FOR PHOENIX PROJECT
- GOOD NEWS FOR PAN AMERICAN SILVER CORPORATION IN PERU
- DE BEERS TO INVEST IN PRECIOUS STONES, GOLD AND SILVER IN INDIA

### CALENDAR

- **New York Investment in Mining Conference**  
May 31-June 1, 2000  
New York, New York  
e-mail: [iiconf@iiconf.com](mailto:iiconf@iiconf.com)
- **ELKO EXPO**  
June 15-17, 2000  
Elko, Nevada  
Tel: 1-800-248-3556
- **Mining 2000, Australia**  
September 19-22, 2000  
Melbourne, Victoria, Australia  
e-mail: [enquiries@mining2000.com.au](mailto:enquiries@mining2000.com.au)
- **MINExpo 2000**  
October 9-12, 2000  
Las Vegas, Nevada  
e-mail: [kboscia@nma.org](mailto:kboscia@nma.org)

## Open Pit Mine Design— What is Floating Cone Analysis?

Open pit and strip mines form the basis of most surface mining operations. Most computer software used in the design of these operations assumes that the excavation equipment will be either a dragline or truck and loader pairing. Computerized methods for designing either type of pit require a model describing the geological and physical characteristics of an orebody and the surrounding material.

“Automatic” computer methods usually refer to some type of optimization algorithm to determine the ultimate pit outline. An optimization program is often used as the first step in the pit design, and different economic or physical criteria may be used to create different designs. For example, pits may be generated for different market prices of a metal or other mineral of interest, varying the physical conditions, and/or different return rate hurdles. The two most “popular” algorithms are described below.

**Floating Cone.** Each ore block in a model has a “cone” of material above, which must be removed in order to mine the ore block. This method calculates the value of ore and waste contained in all possible cones within the deposit, and produces a mineable shape based on the input parameters.

**Lerchs-Grossman.** This optimizing technique uses a directed graph. A net economic value for each block in the deposit is calculated and the algorithm then selects the combination of blocks that produces the highest net-value mineable shape. This method also considers that the block(s) above an ore block must be removed before the ore block of interest can be economically mined.

### Cone Analysis with Net Present Value

#### Introduction

In today’s volatile gold market, it has become very important to understand the nature of an orebody in terms of the effect of changes in prices and costs on the mineable ounces. It is no longer enough to simply generate a cone based on the gold price that is going to be used in the economic analysis. By looking at a series of cones that are generated over a range of gold prices, the effect of changes in price can be examined. Depending upon the deposit and the goals of the company, the critical factor to consider could be the contained ounces, total ore tonnes, strip ratio, or net present value. The decision of which is

*Continued*

■ **PRODUCTION AT GRASBERG INDONESIA TO BE LIMITED TEMPORARILY**

Freeport-McMoRan Copper & Gold Inc., in consultation with the Government of Indonesia, has voluntarily agreed to limit production at the open pit to an average of 200,000 metric tons of ore per day until completion of technical studies of the Wanagon Basin. This follows the reported slippage of overburden waste at the Wanagon Basin on May 4, 2000 that caused a wave of water and material to overtop the Wanagon Basin spillway and enter the Wanagon valley. The technical studies will review the causes and environmental effects of the overflow, and are being undertaken in cooperation with the Indonesian Government through DOME and BAPEDAL

■ **GLAMIS GOLD LTD. ACQUIRES STAKE IN MEXICAN PROPERTY**

Glamis Gold has acquired the Mexican assets of Cambior Inc. for US \$7 million. The acquisition includes a 50-percent interest in the Metates project in Durango State, and 50 percent of the Cerro San Pedro Project in San Luis Potosi held jointly with Metallica Resources Inc., as well as several exploration projects. The Cerro San Pedro Project has received an environmental impact statement and land-use license from the state and federal governments, and has proven and probable reserves of 64 million tonnes grading 0.62 grams gold per tonne and 24.5 grams silver per tonne. Glamis is also presently constructing the San Martin gold mine in Honduras.

■ **BATTLE MOUNTAIN GOLD COMPANY EXPANDS PROJECTED PRODUCTION FOR PHOENIX PROJECT**

Battle Mountain Gold has significantly improved the economics of their Phoenix Project in Nevada by increasing the projected milling rate using the newly revised reserve base. The final feasibility study due for completion in June 2000 is based on a 21,500-ton-per-day base case with a 30,000-ton-per-day target case, predicated on a US \$300 gold price. Estimated capital expenditures are estimated at US \$189 million. The Phoenix Project is currently one of the few gold projects under development in North America. Permitting of the project at both state and federal levels is in progress, and a draft environmental impact statement (EIS) is expected around June 30, 2000.

the most critical to the project should control the pit design.

When examining the results of the pit analysis in terms of these factors, different trends will appear, such as the determination that contained ounces and ore tonnes are generally represented by a step function rather than a linear function. In this case, if the break (step) occurs near the target gold price, the question is then whether to design at the top of the break or the bottom. These results can also be used in the project cash-flow sensitivity analysis to provide a more detailed analysis, rather than the simple approach of just varying the gold price in the cash flow.

In the past, some companies evaluated and developed projects by simply examining them at a particular gold price. Maximizing ounces has been another standard used on the development of projects. Over the past couple of years, the volatile gold market has shown these may not be the best ways to evaluate projects. A simple way to look at the effects of changing gold price on a project is to run a series of floating cones or Lerchs-Grossman cones at various gold prices. There are more complex ways to analyze projects; however, by keeping it simple, conclusions can be reached easily and the results can be explained to people without technical backgrounds.

Two different projects were evaluated by generating a series of cones at various gold prices, and by examining the results in terms of ounces produced, ore tonnes, strip ratio, and net present value. The results show that contained ounces is a step function, and that evaluations based on

contained ounces and net present value can produce completely different conclusions.

**Approach**

Floating cones were generated for each project using a range of gold prices. When all of the cone runs were complete, the results in terms of contained ounces, ore tonnes, and strip ratio were summarized and graphed in a spreadsheet. These results were then incorporated into simplified cash flows in order to determine the net present value of the cone. The cash flows used the same recoveries and operating costs as in the cone analysis, and a constant US \$300 per ounce gold price. By using a constant gold price in the cash flows, while varying the gold price in the cones, the advantages or disadvantages of designing at a specific gold price can be examined, since the comparison is made on an equivalent basis.

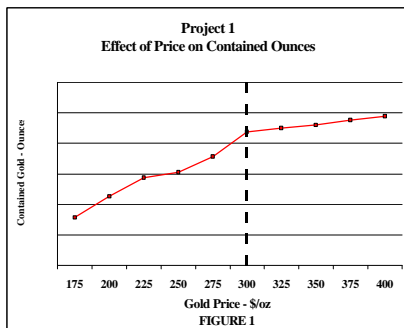
**Results**

To protect client confidentiality, the graphs do not show the values on the y-axis. (The dashed vertical line is US\$300). Additionally, the projects are described in general terms in order to maintain confidentiality.

**Project 1**

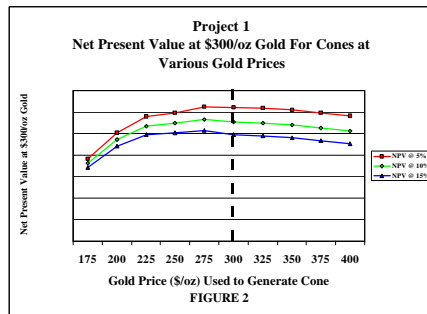
Project 1 is a heap leach disseminated gold property in the western U.S. The effect of changing the gold price results in similar trends for the contained ounces, ore tonnes, and strip ratio. Figure 1 illustrates the contained ounces trend. Between a gold price of \$300 and \$350, the trend lines are

relatively flat with a slight upward trend from \$350 to \$400. This indicates that as long as the gold price remains above \$300, a design using any of the cones between \$300 and \$375 would be reasonable. There is a significant drop in ounces, tonnes, and strip ratio as the gold price decreases from \$300 to \$250. This indicates that a gold price of \$300 is high enough to pay for a large piece of incremental waste stripping which exposes a significant amount of ore. Notice that the trend line again flattens out from \$250 to \$225 before dropping significantly. This trend demonstrates that the recovery of gold from disseminated deposits follows a step function rather than a linear trend, with the step being a result of incremental stripping.



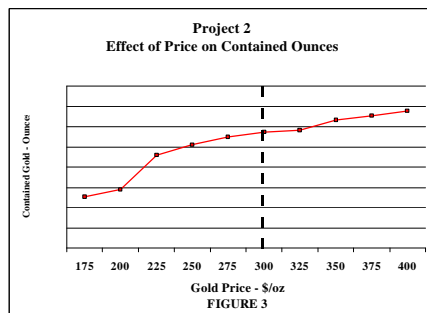
In Figure 2 the gold price is varied in the cone analysis but held at a constant \$300 in the cash flow and NPV analysis. This shows the effect of designing at one price and selling at another. In this case, if the gold price is \$300 throughout the project life, the best pit to design, based on NPV, would be the \$275 pit because at a \$300 gold price it has the highest NPV. There is really not much difference in the NPV between \$275 and \$325; but if you look back at Figure 1, with the sharp drop at \$300, there may be a

tendency to go with the \$275 pit. The best approach would be if the \$275 pit could be used as a Phase pit that allowed a push back to the \$325 or even \$350 pit, so that recovery of the resource could be maximized when the gold price increases.



### Project 2

This is a heap leach disseminated gold project in Latin America. It consists of two pits less than 200 meters apart, which produce significantly different trends when examined separately in the NPV analysis. Figure 3 shows the trend for contained ounces at various gold prices. As in Project 1, the contained ounces, ore tonnes and strip ratio all have similar trends. There are discontinuities at \$200 and \$325, once again demonstrating the tendency toward a step function rather than a linear trend.



For this project, the NPV curve is more interesting than the production curves. When a constant gold price of

#### ■ GOOD NEWS FOR PAN AMERICAN SILVER CORPORATION IN PERU

Pan American Silver Corp. has acquired a 72-percent interest in the Huaron Mine in Peru. This primary silver mine historically has produced over 220 million ounces of silver from 1912 to 1998. The mine is located in the famous Cerro de Pasco district of Peru, 300 kilometers northeast of Lima, and is in a historic mining district containing 12 silver mines that produce approximately 80 percent of the total silver production of Peru. In addition to the Huaron Mine, Pan American's concessions in Peru also include several known mineral occurrences and exploration targets.

#### ■ DE BEERS TO INVEST IN PRECIOUS STONES, GOLD AND SILVER IN INDIA

De Beers of South Africa is planning to spend up to US \$400 million in exploration and mining acquisitions in India. An initial investment to purchase 50 percent of Hindustan Diamond Company Ltd. is planned through the Mauritius-based subsidiary of De Beers Centenary (Mauritius) Ltd. In a proposal to the Indian Government, De Beers has stated that the initial investment of \$30 million is for prospecting, evaluation and trial mining phases in the region of Maharashtra.

#### INDUSTRY UPDATE—INTERNET MARKETPLACE

On May 14, 2000, fourteen of the world's leading mining and metals companies announced the creation of an independent, global Internet-based procurement marketplace.

The founding shareholders of the Internet site include Alcan Aluminium Ltd., Alcoa Inc., Anglo American PLC, Barrick Gold Corp., BHP Company Ltd., CODELCO, Companhia Vale do Rio Doce (CVRD), De Beers Consolidated Mines Ltd., Inco Ltd., Newmont Mining Corp., Noranda Inc., Phelps Dodge Corp., Rio Tinto, and WMC Limited. These companies represent over 60 percent of the market capitalization of the global mining and metals industry.

This Internet venture will bring together mining and metals producers and suppliers in more than 100 countries and will provide immediate access to procurement sources worldwide.