PINCOCK Perspectives

ISSUE NO. 69 — August 2005

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CALENDAR

- **Gold & Precious Metals Investment Conference**
  September 7–8, 2005
  The Mirage
  Las Vegas, Nevada
  e-mail: iiconf@iiconf.com

- **XXVII Convencion Minera - EXTEMIN 2005**
  September 12–16, 2005
  Arequipa (TECSUP)
  Lima, Peru
  e-mail: msovero@iimp.org.pe

- **Exposibram XI Brazilian Mining Exhibit**
  September 20–23, 2005
  Exhibition Pavillion of Expominas
  Minas Gerais, Brazil
  e-mail: singular@aul.com.br

- **2005 Heavy Minerals Conference**
  October 16–19, 2005
  Sawgrass Marriott Resourt
  Ponte Vedra Beach, Jacksonville, Florida
  e-mail: meetings@smenet.org

A Basic Primer on Mine Design

Introduction

In June 2005, we presented a Pincock Perspectives on building a successful mine model. The progression of mine models goes from geologic model (geology & structure) to mineral model (assay or grade) to a full mine model (economic). Once you have a good model the next step is to develop a mine design. Often the first step of design is optimization by using a "floating cone," or Lerchs-Grossmann (LG) algorithm to develop an optimum pit shell which is then used as the basis for the ultimate pit design. For the purposes of this discussion, references will be to open pit mining although many of the same design factors affect underground mining only in a slightly different way.

With all the software tools available to the mining engineer, some consider mine design to be an afterthought. But, as a good engineer knows, and the SEC reiterates, to have a proven and probable reserve requires a feasible mine design (acceptable mining method).

Pit Optimization

Pit optimization techniques were developed in the 1960s and 1970s. The "floating cone" and Lerchs Grossmann techniques are the standard optimization pit limit design algorithms. Optimization tools make pit design easier, but they do not replace pit design. These are tools that start with a mine economic model predicated on block value, required slope angle, and other factors, and ultimately will identify those blocks which can be mined or should be left in place. Most algorithms employ a break-even analysis for the last block mined. Under no circumstance is the output from a pit optimization analysis a reserve.

Design Packages

Many mine planning software packages now have ramp packages

PHILIPPINES OPEN FOR MINING

The Philippines Chambers of Mines is hoping that a Supreme Court decision earlier this year ruling that foreign owned companies could hold 100% of large mining projects will encourage resource companies to invest in Philippines mining projects. Previously, foreign miners had been on their own in dealing with numerous issues that would emerge in trying to get a project up and running. The state is now taking a proactive role in ensuring success. The Philippines Government has appointed "account officers" for 59 of the most advanced projects to assist the owners in progressing their projects through the various stages. While the miners are rewarded for their labors, at least 50% of a project's revenues are seen as being beneficial to the Philippines.

PANTANAL ENVIRONMENTAL PROTECTION DISCUSSED

Governmental delegations from Brazil, Bolivia, Paraguay, Argentina and Uruguay and NGOs are discussing measures for the environmental protection of the Pantanal area. The delegations are meeting to evaluate the impact of the transport, mining, energy and agriculture sectors on what is the world's biggest swampland. The Pantanal is an open swampland bordering Bolivia and Paraguay, and is bigger than France.

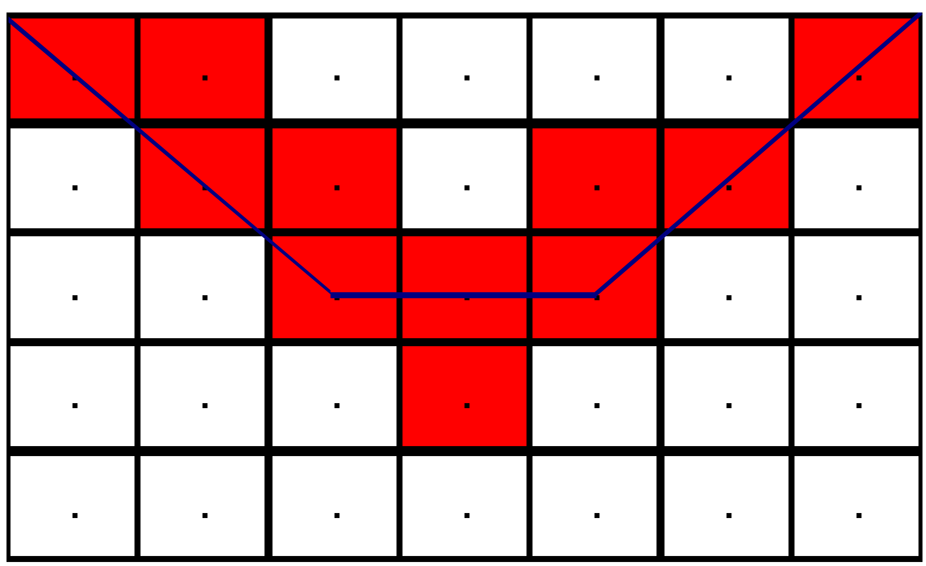
PERU APPROVES MINE CLOSURE REGULATIONS

Peru's government has approved regulations spelling out procedures for complying with and enforcing the mine closure law passed by congress in 2003 and updated in 2005. Mining operations must now present a mine closure plan within a year to the Ministry of Energy and Mines (MEM) and provide a financial guarantee to cover the closure costs. The government's next step will be to approve regulations to cleanup historical environmental liabilities left over from past mining activities.

and pit design tools. These tools can work from a variety of methods (i.e., bottom-up, top-down). Each method has some short-comings and an iterative process is suggested. For example, the pit optimization output can provide a contour map which often is a good starting point for a design. For a bottom-up design you develop a contour around the lowest bench elevation and project it upward with ramps. The ideal pit design often would exit at the lowest possible elevation, especially if it is on a hillside. The issue with a bottom-up design is that many times it will generate a ramp up to the highest elevation and miss the opportunity to exit the pit at a lower elevation. Likewise, a top-down design may leave ore in the bottom due to space limitations.

Contour Maps

Contour maps based on block models can sometimes be misleading. Many people do not realize it but many software packages will provide a pit design contour map based on mid-points. Mostly this happens because a block model has one specific mid-point. This means that the line that looks like the start of a ramp where the ramp exits the pit could actually be in another location at a different elevation. For example, say a ramp exits at a 6015 elevation, has an 8 percent grade, the model is based on 50 ft block dimensions (50 ft x 50 ft x 50 ft),



This is a depiction of what a contouring package will do to the pit bottom when it contours the block mid-points; note that the lowest block has only one point which cannot be contoured.

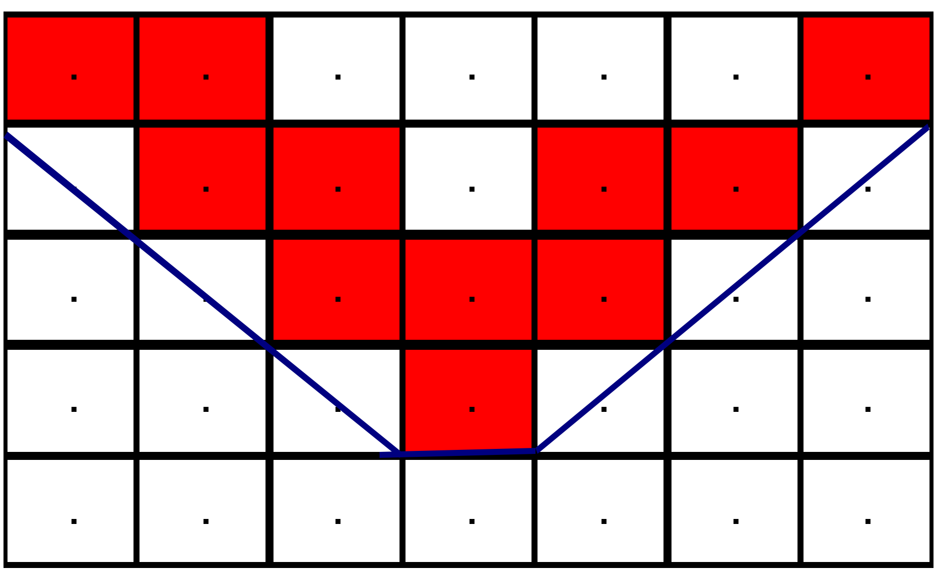
and the bench datum is 6000 elevation. The last contour will be the 5975 midpoint, labeled as the 5950 bench, which could be 500 ft in distance in plan from where the actual ramp needs to begin at the 6015 elevation. Some software packages avert this problem by looking at crest and toes and designing actual ramp segments.

The other problem with contour maps is understanding what is being contoured. For example, using the same block dimensions as above, a single high grade block in the bottom of the pit may be mined by the optimization method, but not show up on a contour map - since a single point (the block mid-point) cannot be contoured. Ideally, the contouring routine would pick the bottom four corners of the block you want and contour around it, but more than likely, it contours the mid-point and could be off by one-half of a block width in width on either side and one to one and one-half blocks off in height. This is depicted in the drawings below. This problem can be averted with interactive computer design software where block plots are shown on each level as the pit is designed, so the user can choose which blocks to include and which to exclude.

DESIGNING FOR SUCCESS

Basic Rules for Mine Design

The first rule of mine design is that all cuts must have access for mine



This is what you thought you were getting when you ran the pit optimization.

■ *XSTRATA BUYS 19.9% STAKE IN FALCONBRIDGE*

Swiss resources group Xstrata has acquired a 19.9% state in Falconbridge, a copper, nickel and zinc producer. The acquisition will allow Xstrata to make a future bid for the entire company, if it decides to do so, without facing interference from rival bidders and will provide significant exposure to nickel for the first time. Falconbridge, formed from a recent merger with Noranda, holds interest in the Antamina copper-zinc mine in Peru, the Collahuasi and Lomas Bayas copper mines and the Altonorte copper smelter in Chile, and the Falcondo ferronickel plant and mines in the Dominican Republic. Xstrata processes coal, alloys, copper and zinc in the Americas, Europe, Africa and Australia, and has interest in the Alumbrera copper-gold mine in Argentina.

Minerals Corner—

Rutile TiO_2

Rutile, a major mineral source of the element titanium, is typically about 60% titanium and 40% oxygen. It can have some iron present, sometimes up to 10%. Rutile is one of the most common titanium minerals. Rutile is typically a brownish red and can be found in other shades excluding black. It has a metallic luster and a pale brown streak. Its crystals are prismatic, vertically striated or furrowed. Because of its lightweight, high strength, and non-corrosive metal, Rutile is commonly used in aerospace, automobiles, sports, and medicine. However, its primary use is as a paint pigment. It replaced lead as the most common paint pigment used in the manufacture of paint. Other uses include a coating for tiles, and it is used to treat the air, both to preserve fruits and vegetables and to remove pollution.

equipment. If the equipment cannot get to the cut, it cannot be mined. This is especially important on hillsides where the uppermost cuts are very narrow. Often additional barren material must be excavated to get sufficient room for the equipment. These access ramps need to be included in the design. If the ramps are internal to the pit design, they should still be shown as temporary ramps that are mined out as the cuts advance. Ideally the interactive design software has a "shadow line" that projects a minimum operating width for design so upper hillside cuts have sufficient width, even if they require over-excavation.

The second rule is that the design should not compromise the geotechnical stability. If a 45 degree slope is called for, the design should not over-steepen a cut just to get access. The ideal interactive design software projects crests and toes up or down based on slope requirements so that geotechnical requirements are not violated.

The third rule is to know and understand the deposit. By working through multiple floating cone optimizations at multiple product prices, you can get a good indication of which areas are mined and in what sequence. Most early phases are based on mining the highest grade first. Looking at multiple pit shells will give an indication of where to place ramps, where a ramp should exit the deposit, and where phases would make logical sense for operational efficiency.

The last rule is to design to maximize operating efficiency. Cuts that are too narrow restrict access and cause operational delays. Although the equipment may be able to operate in a 100' width, allow at least two times this width for ease of operation if possible. Drilling and blasting operations also require operating room, often on the same bench as excavation. Minimum widths should be factored into the pit design so there is sufficient room to turn around in the bottommost cuts.

In summary, we stress the need to understand the capabilities and limits of your mine design tools. Understand what comes out of your contouring packages. Make sure you have room for ramps, internal and external, and access into all cuts. Now, back to the drawing board!

This month's article was provided by Rick Lambert, P.E., Manager of Mining Engineering & Geological Services
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