

PAH NEWS PIX

- **MINING BOOM EXPECTED TO CONTINUE**
- **BHP BILLITON ACQUIRES 76% OF WMC RESOURCES**
- **CODELCO AND MINMETALS FORMALIZE JOINT VENTURE**
- **NORANDA AND FALCONBRIDGE COMBINE**

CALENDAR

- **AUSTMINE 2005**
July 5–6, 2005
Brisbane Convention & Exhibition Centre
Brisbane, Australia
e-mail: lorraine.ward@informa.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
- **XXVI International Mining Congress (Expominex 2005)**
October 12–15, 2005
World Trade Centre
Boca del Rio, Veracruz, Mexico
e-mail: coordinacion@expominex2005.com.mx

Model What You Mine

In scuba diving, there is a saying “Plan your dive and dive your plan.” In aviation, the saying is “plan your flight, fly your plan.” In other words... you have to know what you want to accomplish before you have any realistic expectation of success. In the mining business, it could be said “Model your mine, mine to your model.” While the academic side of our collective psyche yearns for elegance in our understanding of the geology and metallurgy of a deposit, the practical side knows that in the final analysis, it’s all about the money! Our resource models should reflect that simple fact. The purpose of this article will be to illustrate some of the more novel applications of block models, and discuss the benefits of modeling not just grade, but recovery, density, hardness, size fraction, alteration and any factor affecting the economics of the project.

In the mining profession, a major part of a project and mine plan is the block model, the swiss-army knife of the mining engineer. For readers that aren’t familiar with mining software, a block model is a simplified representation of an ore deposit, that can be thought of as a stack of computer-generated cubes that represent small volumes of rock in a deposit. The blocks are assigned a grade by a number of different estimation methods (like kriging). The geologist or engineer uses this model to develop mine plans and production schedules.

In a simple metallic deposit, the exploration drilling program produces samples, which are assayed for content, entered into a database, then used by a modeling package to estimate grade. The linkage between metal content and value is linear and intuitive. The connection between hardness and value may only be apparent when the grinding circuit fails to perform as planned.

Most of the more advanced operators incorporate grade-recovery curves into their block models to better predict metal production, but even this is a relatively simple step that has been available to the engineer for over twenty years. Nonetheless, these first recovery-modeling efforts were simply the opening rounds in the integration of values other than metal content into the block model. The present generation of software can easily incorporate multiple ore types and multiple regression correlations of almost any deterministic relationship into a block model.

But these “simple” models do not readily apply to all deposits, and it could be said that the simple models are becoming few and far between. For all of the technical capability that exists, many organizations still focus on a single key component, often excluding or failing to collect critical data needed for the successful prediction of project performance.

■ **MINING BOOM EXPECTED TO CONTINUE**

PricewaterHouseCoopers (PWC) stated that the results of its latest mine review indicates that the global mining boom, which has been evident over the past few years, will continue. The 2005 issue of mine* states that "The rise in commodity prices has caught investors' attention and mining stocks have outperformed both the S&P 500 and the Dow Jones Industrial Average over the last three years." PWC says that with depleting reserve bases, companies will need to grow their reserves to remain in business. It is therefore likely that consolidation in the industry, hostile and friendly, will continue. If new reserves are not gained through acquisition then they will need to be found through exploration. Copper reserves in the US and Peru only have a 30-year life expectancy, while gold is even less, with just over 20 years left in Australia, and less than 20 years of reserves in South Africa, the world's largest producer.*

■ **BHP BILLITON ACQUIRES 76% OF WMC RESOURCES**

BHP Billiton, the world's largest mining company by market cap, now holds 76.25% of WMC Resources, the world's fifth largest nickel producer. With the acquisition, BHP Billiton will become the world's second largest copper producer and the third largest nickel producer. Two of the world's four largest copper mines, Chile's Escondida and WMC's Olympic Dam, will now be controlled by BHP Billiton. Olympic Dan is also the world's largest known uranium deposit.

■ **CODELCO AND MINMETALS FORMALIZE JOINT VENTURE**

China Minmetals and Corporacion Nacional del Cobre de Chile (Codelco) have embarked on a \$2 billion joint venture that will see Minmetals invest in Codelco's \$550 million Gaby project. Codelco has stated that the alliance will bring significant benefits and assist them in developing their copper projects through a new form of financing. According to Chilean law, Codelco cannot have partners for its existing projects, but can include them in new deposits or operations. The 50/50 joint venture is expected to secure a stable, long-term copper supply for Minmetals.

They are missing a golden opportunity since the block model can be tuned to predict performance.

A classic example of opportunities lost in mine modeling is the use of total copper content when estimating value for an oxide SX-EW project. The exploration staff may have decided early in the project that the samples should be assayed for total copper, but from a metallurgical standpoint the total copper may be of limited use if it is in a sulfide form. The economic driver of the project is recoverable copper, which can be a different question. PAH has seen a number of different approaches to this, such as acid-soluble copper, which are often tied to a series of metallurgical response tests to generate a revenue estimate. Some operators are incorporating multiple solubility-based tests, and using a regression formula to create a better prediction of recoverability.

The oxide gold operators need to be aware of the recovery relationship as well. In most cases, the oxide gold ores will readily leach, while the value of gold tied up with sulfides is not as easy to recover in an oxide processing circuit, and the incremental cost of oxidizing the ore through bio-leaching or roasting quickly renders low-grade ores uneconomic. Total gold assays (either fire or AA in this case) are misleading, and some means of assigning value must be employed, such as CN-soluble. This is the reason that many column tests (or similar test of leach performance) are required for accurate economic models of heap-leach projects, and is the reason that lenders and independent engineers focus so intently on metallurgically-available metal.

A more subtle example is the effect of processing on concentrates. Simply

because a concentrate can be produced does not automatically indicate that the concentrate is marketable. Bismuth and arsenic are classical examples of contaminants in a copper concentrate, for example. In these cases, the contaminant elements must be analyzed and accounted for in the resource model, and the relationship dictating the quantity of contaminants in the concentrate should be clearly understood. Many smelters accepting the concentrate may have penalties for contaminants that deduct from the copper value in the concentrate.

Industrial minerals are notoriously difficult in this regard. Phosphate deposits and mineral sand deposits are classical examples of the requirement to integrate metallurgy into the block model. The Central Florida phosphate deposits are sensitive to particle size, product content, and contaminants, all of which have an impact on mining decisions. Depending on the company involved, as few as three and as many as six particle size fractions can be taken for each exploration sample, with the clay fraction deemed unrecoverable, with one or two pebble fractions and two or three float fractions. Each fraction can be analyzed for phosphate, magnesium, calcium, and other constituents. In the float fractions, the samples can be subjected to bench-scale float tests to develop additional samples. At one point, it may be determined that even a simple drilling database could quickly exceed 50 separate determinations for each sample, and could require a similar number of samples in the block model. But the result of this level of investigation is crucial to determining the economic value of each mining block. The model must reflect the metallurgy and expected recoveries.

CAUSES OF FAILURE

While most mining professionals would quickly concede the need to model metallurgy as a 'blinding flash of light', the truth is that many projects often overlook at least part of the impact of metallurgy on economics. Such errors are probably the second-most common problem PAH encounters, behind reserve estimation errors (and the linkage between these two problems runs deep). The causes behind these problems can be attributed to the following errors:

Switching from Raw Prospect to Potential Project

At the earliest stages of exploration, the geologists are correctly in charge, seeking to understand the ore genesis, controlling structures, trends and associated features. Often these locations are remote and require logistical support, and there are the inevitable problems associated with drilling, sample preparation, and assaying. It is not difficult to understand that metallurgy is not a high priority, particularly if the geologist has not been involved with operating mines and processing plants.

But there comes a point when a target can no longer be considered a raw prospect. The geologists at some point have a fair understanding and some mineralized holes. The actual point where a deposit makes the transition is a matter of judgment, but at this point, a metallurgist and mining engineer should take a look at the data and possibly pull a few samples. These should be checked for initial thoughts on processing, and any information that may be needed to establish processing characteristics should be added to the analysis. Suffice to say that the original drilling

should be re-logged to pick up this information.

It should also be noted that this first pass review may not pick up all of the needed information, and the initial process assumptions may be wrong. This may result in a need to re-assay the samples again in the future. Retention and preservation of core, splits, and chips is clearly a good idea.

Acquired Projects

The role of the independent exploration company, or junior companies, cannot be understated in the mining business, particularly in metals and especially in gold and precious metals or diamonds. Often as not, these companies lack either the resources, expertise or inclination to bring these projects to production, therefore, the processing considerations of the deposit are often neglected until a potential buyer comes forward.

A typical response to metallurgical questions for early-stage projects is to try to gloss over the issue. This approach often works, and saves the seller money. Metallurgical testwork and consulting is not free, and a rigorous analysis for even a simple project can run into hundreds of thousands of dollars. Proper diligence in the acquisition will bring any lack of data into focus. From the buyers' perspective, the property is worth less because of the uncertainty associated with the metallurgy. Conversely, the seller now must accept a lower price.

At this point, the issue addressed in the first point comes into play, and the drill samples must be either re-sampled, or in a worst case, re-drilled. The alternative is to take the risk that sufficient information exists in the drill database to cover any future unforeseen metallurgical surprises.

■ NORANDA AND FALCONBRIDGE COMBINE

Noranda and Falconbridge are in the process of finalizing a merger. Noranda, who already owns 91% of Falconbridge, plans to acquire the remaining shares in a deal that will be finalized on June 30. The merger will create one of North America's largest base metal companies with combined assets of US\$12 billion at December 31, 2004 and combined revenue of US\$7 billion in 2004. The new combined company will be named Falconbridge Ltd. and will be the world's eighth largest copper producer and third largest producer of zinc and nickel. Noranda and Falconbridge's interest include 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.

PAH IS MOVING!

Effective June 27, 2005 our office will be located at:
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Minerals Corner—

Hanksite Na₂₂K(SO₄)₉(CO₃)₂Cl Sodium Potassium Sulfate Carbonate Chloride

Hanksite is one of just a few minerals that contains both carbonate and sulfate ion groups. Typically, it is classified with the sulfates, because there are more sulfate groups in its structure than carbonate groups. Hanksite usually grows as hexagonal prisms. Hanksite is colorless, white, yellow, gray, or green. Its crystals are transparent to translucent. Hanksite forms crystals in evaporative deposits; salt is one of the first minerals to crystallize. Hanksite crystals are typically large and well formed, and not very complex. Hanksite can be found in Searls Lake, San Bernardino County, Mono Lake, and Mono County, California.

Metallurgical Testwork Representativeness

Not only must metallurgical testwork test the deposit, but it must test all of the various areas of the deposit. Deposits are rarely homogeneous, therefore the tests must cover each of the ore types that are known. As a further backup, the samples should be spatially well-distributed throughout the deposit. Good examples of problems in this case would be gold deposits oxidized at the surface, grading into sulfides at depth, oxidation zones in base metal sulfide deposits, and increasing clay content as a function of depth in titaniferous beach sands.

Resolution of this problem requires that the project not rely exclusively on a few bulk samples or 'composites', which may be averaging out future recovery problems.

HOW TO BUILD A SUCCESSFUL MODEL

Basic Rules for Modeling

Mine models will evolve over time, but to maximize value, it is important to plan and gather as much information as possible upfront. This includes:

- 1) An understanding of the relationship between processing and the deposit. Management

should have a general understanding of the probable metallurgical approaches needed as soon as a credible target is identified.

- 2) Understand and re-evaluate factors that may not be directly tied to commodity content, but that effect value, such as hardness, mineral particle size, etc.
- 3) Include and model these factors into the block model.
- 4) Clearly document the relationships, to preserve the knowledge through staff turn-over, and to serve as a basis for refinements in future investigations. Note that this record may also serve as support for public listings.
- 5) Spend the money and do it right. Bad data has little or no value. Re-drilling is more expensive than re-sampling. Running a full-suite of analyses on some early drill holes may give a good indication of the important constituents for future sampling.
- 6) Building a good block model and performing appropriate statistical analyses will require many months of time. Allow enough time in the schedule.
- 7) It is easy to add additional data to a good model.

MINING THE MODEL

Model Reconciliation

You've heard the 'proof is in the pudding'. With mine models, the effectiveness of the mine model is based on its ability to predict and how well it reconciles with production, both in the mining and processing. It is important to track and maintain data for comparison to evaluate a model. Data to be tracked includes:

- 1) Mine blasthole data versus exploration drill hole data and the mine model.
- 2) Mine production tonnage and grade versus modeled tonnage and grade.
- 3) Mine reported production tonnage and grade versus process plant reported production tonnage and grade.
- 4) Process plant tonnage, grade and recoveries versus modeled tonnage, grade and recoveries.

These comparisons will help to validate the model and help to improve the predictability of the model over time.

This month's article was provided by the PAH's Mining Engineering Department.



PINCOCK ALLEN & HOLT

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