

PAH NEWS PIX

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CALENDAR

- **21st Annual Mineral Exploration Roundup**
January 26–29, 2004
Westin Bayshore Resort and Marina
Vancouver, B.C., Canada
email: roundup2004@chamberofmines.bc.ca
- **106th National Western Mining Conference and Exhibition**
February 3–6, 2004
Hyatt Regency
Denver, Colorado
email: colomine@coloradomining.org
- **9th Annual Investing in African Mining Conference**
February 10–12, 2004
Cape Town International Convention Centre
Cape Town, South Africa
email: iconf@iiconf.com
- **2004 SME Annual Meeting & Exhibit**
February 23–25, 2004
Colorado Convention Center
Denver, Colorado
email: sme@smenet.org

Reconciliation of Reserves

This newsletter is the first of two articles on the subject of reconciliation. This month will focus on the first stage of reconciliation: comparing the ore reserve/resource estimate to the production reported from the mine. The second article will appear in next month's Pincock Perspectives.

During the conduct of an audit for lending institutions, securities exchanges or corporations, the resource model is considered one of the high-impact risk elements for most mining projects. For "green-fields" projects (i.e. no production history), PAH normally employs a combination of manual checks with statistical and geostatistical tests of the resource model. For operating properties; however, the reconciliation of the resource model to actual production is an added requirement, and is in many respects the 'gold standard' for verification of project reserves.

Reconciliation is often more than a basis for calibration of the resource model. When monitored on a regular basis, the reconciliation process will quickly uncover problems with grade control, sampling, assay lab techniques, mining methods, processing problems and a host of other technical problems.

Reconciliation is a simple concept that is often difficult to apply. A resource and reserve model is simply a prediction of the tonnes and grade of material that will be encountered during the execution of a mine

plan, and that will be ultimately sold to some customer. The reconciliation process should document this predicted material from the exploration model, through the mining process, through the milling process, and to final sales. Simply put, the reconciliation is comparing the predicted production against the actual production.

The difficulty arises from the sheer number of ways that the resource prediction can go wrong in mining. PAH typically segregates mining reconciliation problems into the following stages:

- ◆ Model to Mine Reconciliation – or comparing the resource model prediction to the actual production as reported by the mine;
- ◆ Mine to Mill Reconciliation – comparing the mine reports to the tonnes, grade and metal processed by the mill; and;
- ◆ Mill to Sales Reconciliation – which matches the mill metal production reports to the sales results.
- ◆ Stockpiling – This category falls between the mine and the mill, and examines the problems encountered with stockpiling strategies.

A central concept in reconciliation is that of time: a reconciliation must consider and

■ GABRIEL'S ROMANIA GOLD MINE CONSTRUCTION BEGINS IN 2005

Canada's Gabriel Resources Ltd. announced construction of its Rosia Montana gold mine in Romania is scheduled to begin during the second quarter of 2005. The start date had been delayed by six months due to ongoing problems with obtaining environmental permits. The project also received criticism from ecologist, rights groups and historians who were concerned about the relocation of thousands of villagers and potential for damage to nearby archaeological sites. The Rosia Montana project is expected to be Europe's biggest open-cast mine with potential to produce 500,000 ounces of gold annually.

■ IMPROVEMENTS EXPECTED AT OBUASI MINE

Miners at Ghana's giant Obuasi gold mine hope that the takeover of the Ashanti Goldfields' mine by South Africa's AngloGold will mean improvements at the mine and the possibility of better wages. In October, Ghana's government approved a \$1.48 billion bid from AngloGold to buy Ashanti Goldfields, which included Obuasi, the country's largest mine. AngloGold has said it will invest \$190 million immediately to fund the mine, which could allow excavation at Obuasi to go deeper than the current 5,000 feet floor. AngloGold hopes to complete its takeover of Ashanti in the first quarter of 2004. The merger will create a company with approximately 7.3 million ounces of annual gold output, rivaling U.S. Newmont Mining Corporation for top ranking in the sector.

■ SELECTED COMPANIES TO REVIEW LAS BAMBAS RESULTS

Companies on the short list to take part in the sell-off of Peru's Las Bambas copper deposit received results of a recent exploration of the deposit. Eleven companies have been pre-selected to view the data, which includes the results of 2,500m of drilling. Companies privy to the data include: Southern Peru Copper Corporation, U.S. miner Phelps Dodge, Anglo-Australian mining house BHP Billiton, London-based Rio Tinto, and Brazilian mining giant CVRD. No date has been set for the auction of the deposit, but it is expected to occur in the first quarter of 2004. Land ownership disputes, which have recently been settled, made it difficult for Peru's government to auction off the deposit. The Las Bambas deposit is located in Apurimac and has proven reserves of 40.5Mt grading 2% copper and exploration potential of more than 500Mt.

compare production related to a specific period of time. More importantly, the length of time considered in a reconciliation is a major consideration of how close the agreement should be; longer time periods should result in better reconciliation, and can reveal trends in the project. Note that comparison of multiple years of production in one massive mined volume can be misleading, particularly if the operational cutoff grades change over time.

Model to Mine Reconciliation

The more difficult stage of reconciliation is a comparison of the exploration model to the mining results. This stage of the reconciliation process focuses upon the comparison of identical volumes of material, one as predicted from the resource model, and the other from the mine production reports. The basis of most open-pit production reports is the blasthole model or 'packet' model, which is developed with the more uniformly-spaced blasthole data. Underground techniques for production monitoring are more variable.

While the long-range mine plans are guidelines for development, only the actual (or as-built) mining limits within a given time period should be considered. The long-range plan limits are rarely useful in reconciliation, since the long-range mine plans are not closely followed in most operations.

A simple illustration of the resource reconciliation process is provided in Figures 1 through 6 (see page 4). A simple application of model-to-mine reconciliation would involve the following:

- ◆ The exploration model normally forms the basis of long range forecasts (3 years and beyond) (Figure 1).

- ◆ Mine plans are developed from the exploration model (Figure 2).
- ◆ As mining progresses to a new bench or level, blastholes or infill drilling provides a more detailed picture of the resources, which normally varies from the exploration data (Figure 3).
- ◆ Following changes to the ore location, mine plans or other causes, the actual mining limits are different from the original plan (Figure 4)
- ◆ The exploration model basis for the reconciliation is drawn from the actual mining limits and the exploration model (Figure 5). The original long-range mine plans are not relevant for the reconciliation.
- ◆ The mine production report is drawn from the actual mining limits and the blasthole resource estimates (Figure 6).

At this point in the reconciliation process, only the model and the mine are reconciled. There is no requirement that the tonnes and grade agree exactly, but clearly a closer agreement is preferable, since most production costs are correlated more to tonnage than metal. Typically, reconciliation on more difficult commodities, such as gold or platinum group metals, should be less than 10% on tonnes, grade and metal over a years time. More well-behaved commodities (porphyry copper or iron) should be closer to 5%. Coal in most cases should also reconcile to within 5%.

PAH also recommends that the entire volume of material mined be reconciled, not just the ore-grade material. Waste and sub-grade material can comprise a significant portion of the operating costs, and confirming the volume mined is a

simple gross check on material balances. Furthermore, in acid-generating waste dumps, the material may be crucial to determination of reclamation costs.

Reconciliation of the model to the mine is complicated by any number of issues. If a relatively large time period is under consideration, it is likely that the operational cutoff grades have changed, which requires that the volume of material mined under one set of cutoffs must be kept separate from other cutoff grade periods. If a cutoff grade is changed between surveys, then the comparability of the reconciliation is disrupted. If cutoff grades are changed, they should either be changed at the end-of-month closing, or an intermediate survey should be conducted.

In cases where an indirect method of measuring grade is used, such as radiometric measurement in uranium, or magnetic measurement in iron, calibration of the measuring equipment is crucial and should be conducted regularly. Furthermore, the results of the calibration should be clearly documented and available in the case of audits, and changes to the calibration must be considered in determining the quality of reconciliation.

Dynamic models, or models that incorporate blasthole data and are updated frequently, are often used by mistake in the reconciliation process. The value of dynamic models lies in improved grade estimates for revenue forecasts. The long-range predictive power of the original modeling methods must be calibrated against the wider-spaced exploration and in-fill drilling. Including blasthole information in the reconciled model can create an illusion of long-range confidence while effectively calibrating the blasthole model against the blasthole data. In

general, the exploration model should only be modified with either new geological interpretations or new drilling, and the results of any model changes should be carefully documented.

There are a number of subtle problems associated with reconciliation. In the mine environment, accurate data is difficult to come by. Volumetric measurements in any realistic sense are generally no better than one or two percent accurate. The density that relates the volume to a tonnage is itself an estimated value: even homogeneous models will see density variations of a few percentage points. Grade estimates are similarly prone to considerable variation. Repeat assays on splits from the same pulp sample can easily vary five percent between samples, not even considering the myriad problems that arise from sample collection and preparation. Furthermore, there is a wide range of problems associated with geological constraints and geostatistical estimation.

Discussion of the implications and resolution of each of these individual issues can and does fill entire books. In many cases, the best the operator can accomplish is an unbiased estimate with a minimum variance in the assumptions. In terms of reconciliation, of course, these issues combine to make longer time periods more closely reconcilable than short time frames.

Next Month: Closing the loop – Mine to mill reconciliation, mill to smelter reconciliation, and smelter/refiner to sales reconciliation.

This month's article was provided by Gerald D. (Dave) Crawford, P.E., Principal Mining Engineer dave.crawford@pincock.com

■ **ENERGY BILL ON HOLD TILL 2004**

A Senate filibuster has ended any hope of the energy bill being passed by Congress before it adjourn for the holidays. Inability to break the filibuster was due to a breakdown in party discipline, with seven Republicans voting in support of the filibuster. Chief concerns with the energy bill include the exemption of methyl tertiary-butyl ether (MTBE) manufacturers from possible future legal liabilities; an ethanol mandate which would allow gas refiners to use ethanol to reformulate their gasoline; and the cost of the bill, which would total roughly \$23.5 billion according to the Joint Committee on Taxation. Republicans in support of the filibuster included: Lincoln Chafee (R.I.), John McCain (Ariz.), John Sununu (N.H.), Olympia Snowe (Maine), Senate Republican Majority Leader William Frist (Tenn.), Susan Collins (Maine), and Judd Gregg (N.H.).

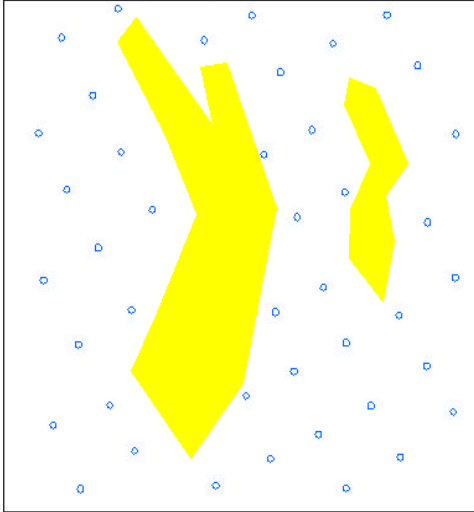
Check out PAH's redesigned web site at www.pincock.com

Minerals Corner—

**Actinolite
Ca₂(Mg,Fe²⁺)₅Si₈O₂₂(OH)₂,
Calcium Magnesium Iron
Silicate Hydroxide**

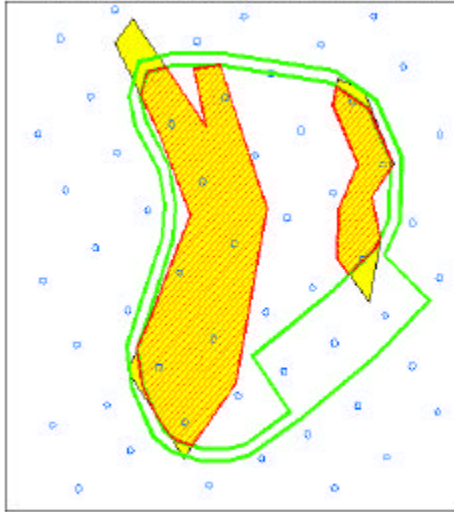
Actinolite belongs to a series with the minerals tremolite and ferro-actinolite. A series occurs when ions can freely substitute between each other. In the case of actinolite, when iron is predominant the mineral is ferro-actinolite and when magnesium is predominate the mineral is tremolite. Actinolite is the intermediate member. This mineral is usually green, white or gray and is a relatively common mineral in some metamorphic rocks. Actinolite come from the Greek, aktinos, meaning "ray" in allusion to it's fibrous nature. Actinolite is an ornamental stone used for carvings and jewelry. Byssolite, a variety of actinolite, is composed of microscopically fibrous crystals (asbestos), which is used for fire retardant materials and brake shoes and pads. Actinolite can be found in the Lake Baikal Region, Russia; China; New Zealand; British Columbia, Canada; and Taiwan.

Fig.1 - Exploration Model



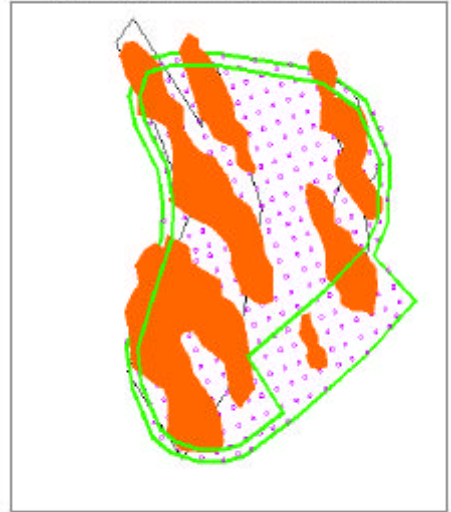
25 meter sample spacing, kriged ore outlines
153,000 tonne resource

Fig.2 - Exploration Model with Mine Plan



140,000 tonne reserve (toe basis)

Fig.3 - Blasthole Model with Mine Plan



7.3 meter blasthole spacing, kriged ore outlines
158,000 tonne resource

Fig.4 - Blasthole Model with Actual Mining



Dense data, Improved ore resolution
Modified mining plan

Fig.5 - Exploration Basis for Reconciliation



Exploration Resource within Actual Mining
108,000 tonnes predicted

Fig.6 - Mining Basis for Reconciliation



Blasthole-based ore limits within Actual Mining
104,000 tonnes mined



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