MINERAL CONTROL SYSTEM IN BAJO DE LA ALUMBRERA MINE, CATAMARCA, ARGENTINA

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ABSTRACT

The Bajo de La Alumbrera copper-gold porphyry deposit is located at an altitude of 2,600m in the Catamarca province, in the Northwest region of Argentina. The mine is the country's largest open cut project and boasts one of the lowest operating costs worldwide. YMAD (Yacimientos Mineros de Agua de Dionisio) owns the mining rights to the deposit. A joint venture has been formed named Minera Alumbrera Limited to develop the deposit. Minera Alumbrera Limited is owned by three mining companies: Xstrata (50%), Gold Corp (37.5 %) and Yamana Gold (12.5 %).
The Bajo de La Alumbrera deposit is situated within the Farallón Negro volcanic complex, in the Sierras Pampeanas, a region of basins and ranges controlled by gently to steeply dipping reverse faults on the eastern side of the Andes. The Alumbrera dacite porphyries were intruded approximately 7 million years ago into the roots of the Farallón Negro volcano.
The Ore Control System includes all in-pit processes to segregate and characterize blast material based on the factors that may directly affect its final value, from the standpoint of the mining business (including profit, cut-off grade and dilution).
The Ore Control System essentially segregates run-of-mine material based on: The metal content of blast rock , the blast rock type, performance at the crusher and the plant (including grindability and recovery) and other geological considerations such as: alteration, weathering, structures, clay and gypsum content, etc.
Based on the metal content (cut-off grade) and the geological features –both variables being closely related- blasthole material is classified into the following quality categories: waste rock, low grade, high grade and barren-core waste material. The material type, volume and final destination of blast material (concentrator or waste dump) are then ascertained. The (cut off) limit for each material type, including the coordinates of each vertex is provided to the surveyors in order to have the area staked out using colour flags and tape, based on field considerations.

INTRODUCTION

The Bajo de La Alumbrera copper-gold porphyry deposit is located at an altitude of 2,600m in the Catamarca province, in the Northwest region of Argentina. The mine is the country's largest open cut project and boasts one of the lowest operating costs worldwide. A total of 38.6 million tonnes of ore was milled during 2007 (70% from the pit and 30% from stockpiles) at an average grade of 0.56 % Cu and 0.67 g/t Au. Of this, 180,223 tonnes of copper concentrate was produced at an average grade of 25.84 % Cu, and 540,789 oz of gold in concentrate and 74,372 oz of gold in doré.

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The Bajo de La Alumbrera deposit is situated within the Farallón Negro volcanic complex, in the Sierras Pampeanas, a region of basins and ranges controlled by gently to steeply dipping reverse faults on the eastern side of the Andes. The Farallón Negro volcanic and intrusive complex was formed as a stratovolcano up to 6 kilometers high and some 16 kilometers in diameter, which evolved from more mafic pyroxene andesites to hornblende and biotite bearing andesites and dacites. This was followed by the emplacement of the dacite porphyries related to mineralization.

The Alumbrera dacite porphyries were intruded approximately 7 million years ago into the roots of the Farallón Negro volcano. Reconstruction of the volcanic complex suggests that the top of the exposed ore body was emplaced at a depth of approximately 2.5 km, although it appears that the porphyries hosting mineralization were not emplaced directly beneath the vent of the stratavolcano. The porphyry intrusions generated large-scale hydrothermal circulation that resulted in alteration and mineralization of some porphyry and their volcanic host rocks. Subsequent erosion has exposed the upper part of the volcano and its mineralized porphyry system at a level that is favorable to mining.

A total of seven distinctive porphyritic intrusions have been recognized. At an early stage these formed large porphyry stocks, which were later intruded by younger porphyry dykes. The dykes extend to the outer edge of the deposit and some form a radial pattern around the central stocks.

The alteration pattern consists of a potassic core surrounded by propylitic chlorite-epidote alteration. Feldspar destructive phyllic and argillic alteration overprints both the potassic and propylitic alteration assemblages.

Ore grades are controlled to some extent by lithology. The highest Cu-Au grades are associated with intense potassic and quartz-magnetite alteration of the two earliest mineralized porphyritic intrusions, in addition to the adjacent biotized or K-feldspar altered andesites. Younger porphyries are less mineralized or barren. The majority of the copper is primary chalcopyrite, which occurs as disseminations and/or in veinlets. There is a positive correlation between copper and gold grades in the deposit. Gold occurs in a textural association with early pyrite-chalcopyrite-magnetite as free gold grains in the 10 to 50 micron range.

METHODOLOGY

Definition

The Ore Control System includes all in-pit processes to segregate and characterize blast material based on the factors that may directly affect its final value, from the standpoint of the mining business (including profit, cut-off grade and dilution).

The Ore Control System essentially segregates run-of-mine material based on:

- The metal content of blast rock
- The blast rock type
- Performance at the crusher and the plant (including grindability and recovery)
- Other geological considerations such as: alteration, weathering, structures, clay and gypsum content, etc.

System Managers

Geologists and/or specialist engineers are responsible for the ore control system. Specialist training includes the computer skills to operate material characterization software. Such software uses a number of factors required to make decisions on routing or sending material to the correct destination. Likewise, identifying field issues arising during mining operations and providing a quick response to the changing scenarios inherently associated to dynamic operations that include a number of variables at play and having an impact on the business and operational outcome are also essential factors.

System Operation

It includes these stages in the following sequence:

1. Design: the drilling mesh is designed by the Mine Engineering Dept. The drilling mesh design depends on the drill-hole diameter and the geological features of the rock to be drilled (rock type, alteration, hardness, gypsum content and rock structure).

2. Topography: the drilling area is staked out by our mine surveyor in line with the map provided by the Mine Engineering Dept. The drilling mesh is therefore installed using a highly accurate GPS.

3. Drilling: our Services Dept. is responsible for drilling operations, following the surveyor activities. Drill holes are approximately 19 m deep.

4. Sampling: drill holes are sampled by technical experts and then filled with explosives for blasting and mining operations. Accuracy is an essential factor for this phase – operations must be successful on the first time because there will be no second chance! Standardized processes help minimize errors in field procedures in order to ensure improved quality control procedures. Sampling requirements should be strictly satisfied using a, rigorous but user-friendly sampling system.

   Quality control is an essential phase in our daily sampling practices and is intended to support and ensure quality assaying at Minera Alumbrera´s laboratory. To this end, field activities (including how samples are taken and crushed) should be closely monitored to develop chip-type tests for drillholes. Duplicate samples are taken and assayed at Minera Alumbrera´s lab with triplicate samples assayed by an external lab, including the relevant blank and standard control samples.

5. Crushing and Assaying: Once samples are crushed, a 8-10kg sample is assayed at Alumbrera´s chemical lab. A 300 gr sample is used by the ore control geologist for ore description, based on the geological features such as rock type, alteration, weathering, hardness, relative pyrite, lodestone and gypsum content. Samples are then numerically coded for database management using acQuire software. This process is replicated for analytical data provided by MAA´s lab.

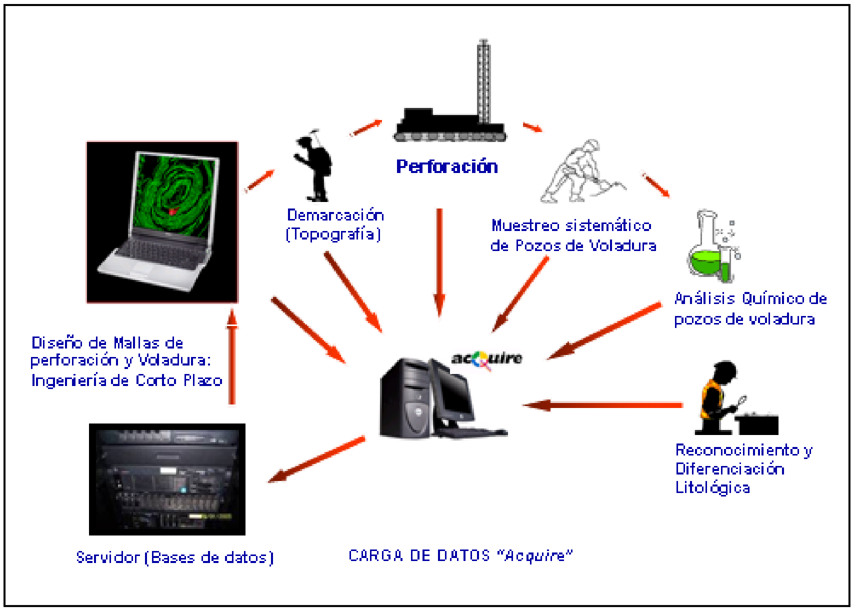

Figure 1: Ore control sequence

Geological database management and features

Specific software is now available for field Geological and Engineering data. Data is loaded in a database within a server, which acts as a data storeroom. Such database may be accessed and operated from a system computer.

In the past, data was kept in hard copies (mainly in books, files and charts and other tangible means for data storage). Nowadays, virtual files are available to ensure fast and efficient business data management, integration and control.

Minera Alumbrera´s data is stored at related databases within the SQL server. Data is systematically loaded using specific software. Mine geological data is processed using acQuire Data Model. Such software enables not only direct data uploading into the SQL Server, but also data sharing and management using other software (such as MineSight 3D).

AcQuire has been available at Alumbrera for five years now. acQuire´s strength lies in Geological and Geo-chemical Ore Control and Exploration, Geological and Geotechnical areas. The Environmental functionality still needs to be worked out.

Existing databases include: MAAOCS Ore Control System, MAAEXP Exploration System, MAAMPH2O Water Management System, and MAACeldasING, MAAPrismasING Geotechnical

Services Management System. For instance, MAAOCS now includes 202630 records with about 50-100 types of survey, geological and geochemical data gathered on a daily basis from remote areas, but integrated to Minera Alumbrera´s network. Such data is then loaded into our SQL server, and may be accessed and processed by other mine areas using other software.

MineSight-acQuire Data Processing and User Types.

Once server data is uploaded into the MineSight 3D System, it may be modeled by interpolation based on the desired variable (total copper, copper equivalent and gold content, rock, alteration, NAG, ANC, etc.).

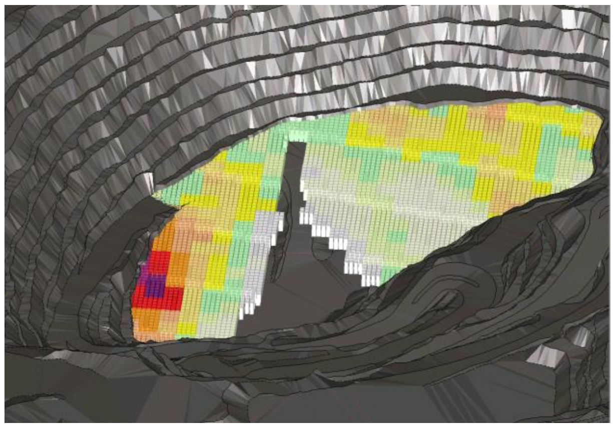

Figure 2: 3D view of 5x5x17m blocks of the blasthole copper model for a specific bench in the pit.

Based on the metal content (cut-off grade) and the geological features –both variables being closely related- blasthole material is classified into the following quality categories: waste rock, low grade, high grade and barren-core waste material. The material type, volume and final destination of blast material (concentrator or waste dump) are then ascertained. The (cut off) limit for each material type, including the coordinates of each vertex is provided to the surveyors in order to have the area staked out using colour flags and tape, based on field considerations.

Blast limits including range quality are then uploaded into our Dispatch system, together with the bench, mesh, rock and material type data, % Cu, gr/tn Au, pH, weathering, hardness and NAG levels. The Dispatch system sets the best automatic configuration for haul truck operations.

Our modeling activities include:

- Digital field models
- 3D solid models
- Miscellaneous 2D and 3D (Cu, Au, Rock and other) models
- Geotechnical (structural, rock and other) models
- Environmental (NAG, ANC and pH) models

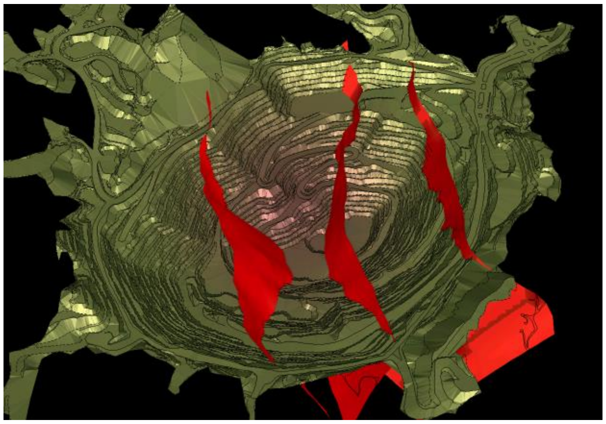

Figure 3: Digital DTM model of the pit and related faults, including lithology, alteration and mineralization.

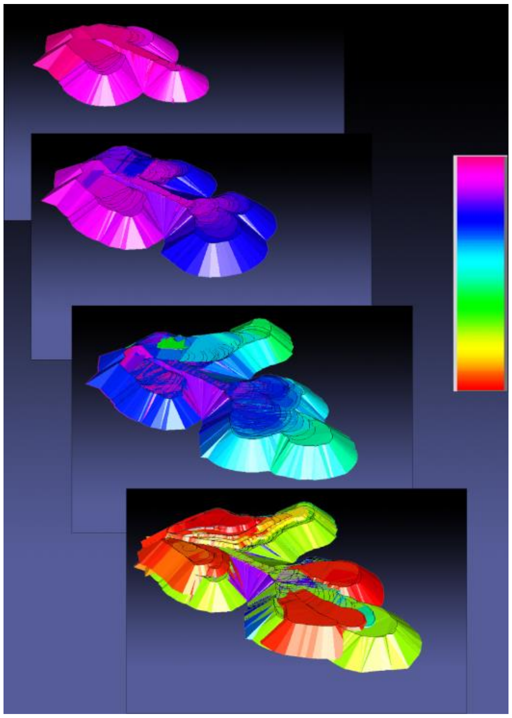

Figure 4: Digital waste dump development model.

These are used as supporting data for:

- Drilling operations: including lithology, hardness and fault models
- Blasting operations: including alteration, gypsum content, rock and structural models to identify the best rock fragmentation for excavation while improving shovel performance and primary crushing operations.
- Mine operations: models showing mining progress, material quality and location, metal location (diamond drilling and water pumping, tricones, etc) to avoid metal crushing

- Grinding operations: including RQD and rock hardness and alteration, grindability models to enhance crushing and grinding processes.
- Concentrator: including daily reports and weekly plans indicating Cu and Au grades, grindability domains, alteration, lithology and metallurgical recoveries.
- Environment: identifying the waste rock type (including barren core waste rock) to plan the final destination for each material for waste dump neutralization and encapsulation.

Control and reporting practices

Existing controls include grade reconciliation and control curves including mine and concentrator throughput, cross monitoring of material destination using our Dispatch model, field controls, monitoring blending rates for improved flotation and recovery and crushing, sampling and assaying quality controls.

Mining reports are developed on a weekly and monthly basis as well as daily ore feed reports, including grindability domain tonnage, Gold and Copper grades, soluble copper, pH, material hardness and identification of fresh, enriched or leached material.

Our weekly plan is developed based on the mining range provided by our Mine Engineering Department, in line with the budget prepared by our Long Term Engineering Department. The following considerations are also contemplated in such plans: cut-off grade, operational availability as well as mine and concentrator maintenance programmed. Such plan may be implemented strictly, changed or delayed for mechanic, weather or other contingencies affecting mine and concentrator operations. This report is referred to the concentrator as it specifies the quality of the material to be mined during the week in order to have the necessary precautions taken for material processing.

CONCLUSIONS

This is an essential process, having major implications on the mining business. All ore control processes, guidelines, standards and reconciliations are essential to identify and segregate payable and environmentally valuable material from waste material. This process is performed using MineSight 3D and acQuire mining software to ensure increased efficiency and effective short and long-term planning. Moreover, data is systematically stored in our database to allow geo-economic business audits.

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