The Basis of the Recoverable Resources Model

Bruna Novillo, J.[1], Bassan, J.[2], Rossi, M.[3]

(1) Geology Superintendent, Technical Services Management, Minera Alumbrera Ltd., Hualfín 4139, Belén, Catamarca, Argentina (2) Senior Geologist. Ingeniero Jacobacci, Rio Negro, Argentina. (3) Geostatistician GeoSystems International, Delray Beach, Florida, EEUU.

Summary

A recoverable resources model is based on a specific investment for a project in the exploration stage. This entails associated risks where people, from field assistants to the company's board of directors that are responsible for the project, will have a direct control over the endogenous variables such as sampling, geological model interpretation and budget directly associated with the exploration techniques for a specific area or metallogenic zone.

These exploration techniques include DDH or RC drilling that chiefly facilitates the understanding and construction of a 3D geological model in the subsoil.

If the exploration project succeeds in recovering market value mineral, the exploration project will turn into a recoverable resources model.

These resources of a certain economic value will reach their best value if adhered to current regulations that are de facto certifications. These regulations derive from the requirements established by some Stock Exchanges for the mining companies to report resources as company assets. These regulations preserve and are used as a guide to take steps in the development of the mining resource.

Introduction

The geological exploration is an investment activity carried out in a geographic area to find and assess mineralized bodies of interest for the development of future mining projects.

The geological exploration projects, as well as any investment project, should be prepared, analyzed and approved by means of the application of technical and economic concepts that maximize the return on investment.

Nevertheless, the cost of an exploration project does not involve a one-time risk but a series of investment increases that deliver relevant information that add or reduce value to the areas explored.

This information helps define the future activities that will be suitable to carry out; otherwise, it allows the investment to be ruled out for the exploration of an unappealing area.

During the development of an exploration activity, many consecutive investment decisions are made. These are going to determine different actions according to the experience, vision and interpretation of the people responsible, as well as the exploration stage and the budget allocated to the project under consideration. The decision to continue or to rule out a certain project will depend on the quantitative (including the political and government regulatory rules) and quality interpretative characteristics of the professionals in charge of the project.

The main exploration goal is to generate value through the extension of the resources and the life of the mines, increasing the cash flow and maximizing the NPV.

Bases of the Recoverable Resources Model

In order to continue or to rule out a project in the exploration stage, a geochemical analysis of the exploration site will represent a quantic value that will impact directly on the statistics of the population of samples as well as on the qualitative interpretation by the professional geologists, engineers and technicians. Other analysis with complementary tools for drilling such as geophysics will assist in the project interpretation and in the thorough definition or ruling out of the drilling target.

Even though geophysics is not as tangible as a soil sample, trench, RC (Reverse Circulation) or DDH (Diamond Drill Hole) drilling and surface geologic mapping, it has proved to be of great importance in the definition of some type of deposits.

If the project succeeds, recoverable resources can be estimated and therefore, be given an economic market value, seeking investors in the international markets, most commonly under some well-known regulations such as the Australian (JORC), Canadian (CIM guides approved by the different Canadian stock exchanges), SEC (Government Office in the United States), Certification Code for Exploration Prospects, Mining Resources and Reserves (Chile) and the European and South African codes.

Certain requirements or regulations need to be complied with in order to reach this market value. Thus, when any type of deposit is modeled, all the available information is used. This information comes chiefly from the samples collected which will provide geological information to carry out the corresponding interpretation, both being the main bases for geostatistics. This tool will allow us to build, by means of an interpolation method, a resources and reserves model.

This model will be the base of the economic value for the project in the market, depending on the market economic conditions at that time to raise the expectations or rule the project out, in addition to other series of technical, environmental and social risk factors.

1) Sampling

The sample is a piece or a portion extracted from a whole by means of methods that allow it to be considered as a representative of that whole.

Almost all the decisions made in regard to a mining project, from the exploration stage to the closure of the mine, are based on the value obtained from sampled material. These decisions involve very important economic sums.

The samples are important because[1]:

- They provide geological information to define the geometry of the deposit, to understand the mineralization controls and to determine the quantity and the quality of the existing mineral resource.
- They should represent a much greater volume than the material sampled. They should represent not only the mineralization grade but also all the mineralogic and quality characteristics, the presence of mineralization contaminants, metallurgical behavior, geophysical and geotechnical response, and other important characteristics for the mineral extraction.
- Resources and values are estimated so that a technical and economic assessment can be developed. Commonly a ±30% margin of error for a final Feasibility Study and a ±50% margin of error for a Pre-feasibility Study are accepted.

- All the sampling procedures (protocols), preparation and analysis should be available in writing; the supervision personnel should be in charge of the appropriate training for the drilling equipment operators (Figure 1).
- The errors associated with every stage of the sampling are generally represented as variances with respect to the real value. These variances, measured each step of the process, are additive; rarely do they compensate each other.

Every sample carries a series of errors; some of them related to the geological characteristics of the sampled material, other errors are related to the sampling techniques used and to the analytical and preparation techniques. The processes of collection and handling of samples and the subsequent laboratory data are subjected to quality controls (QA-QC) that ensure precision, accuracy and representativeness of the sample in relation to the values obtained. The initials QA-QC, stand for Quality Assurance, determined by the set of pre-established and systematic activities necessary to ensure that a particular activity or operation achieves an acceptable degree of quality; and Quality Control, the set of techniques and activities of operational nature used to determine the quality level actually achieved[2].

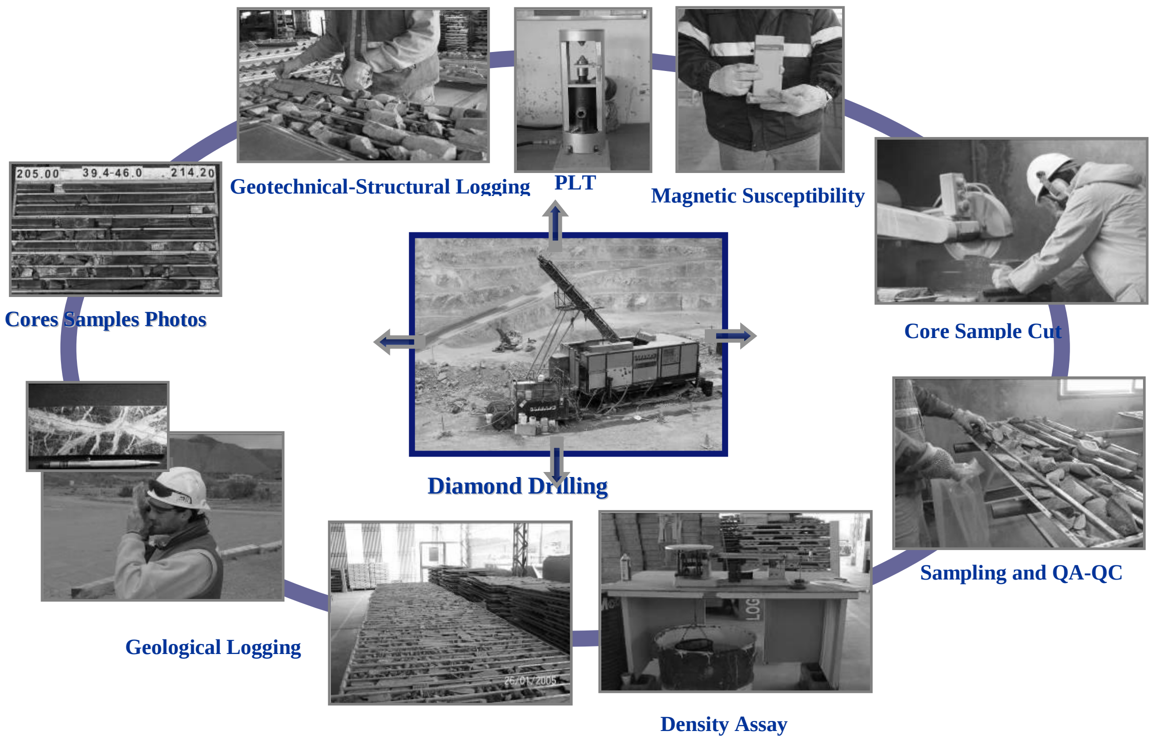

Figure 1: treatment, processes and assays of diamond core samples.

All the control programs[1]:

- Include blank, duplicate and standard samples. This is for measuring contamination, precision (the assay reproducibility) and accuracy (proximity to the true value).
- Precision is assessed with measures of dispersion (variance, coefficient of variation); accuracy is assessed with mean values and with the analysis of the differences between pairs of assays.
- A 5% to 10% of coarse material checks are recommended and the same for pulps (re-labeled), always keeping the process anonymous; the total of insertions of blank and standard samples is the same percentage, 5 to 10% of

the total. In 40 samples there is one of each control sample. (10% = 4 samples).

- The work is carried out with lot samples, not with individual samples. Acceptance criteria should be established for each lot using relative differences and quality control charts (blank and standard samples) in accordance with standard deviations; in addition these should be made according to time in order to analyze laboratory bias.
- All the abovementioned stages should be strictly controlled and checked to avoid delays, budgets out of control and unpleasant surprises.
- In every case, the quality control and the checks on the works carried out take as much or greater effort, time and budget than the original work. This is mainly due to the fact that many of these works involve personal judgments, models that cannot always be proved a priori, temporary assessments, iterations in the processes involved, etc.
- An efficient, organized and well presented quality control saves a headache in the future. If auditors or third parties need to review the information, the good execution and presentation of the quality control procedures win the battle before it begins.

2) Geological model

A geological model is the result of the process of generating a conceptual, graphic or visual representation of phenomena, systems or geological processes in order to analyze, describe, explain, simulate and predict those phenomena or processes[3].

The geological model is one of the bases for the construction of an economic and geostatistical block model and requires a comprehensive knowledge of the geology, alterations, structure, mineralization and genesis of the deposit (Figure

2). A base conceptual error may cause irreparable damages in the future mining business[4].

The value of a model lies in its reliability and predictability. A model is reliable when it can be audited and shows consistency and coherence. It is predictive when we can generate future mining plans based on this model.

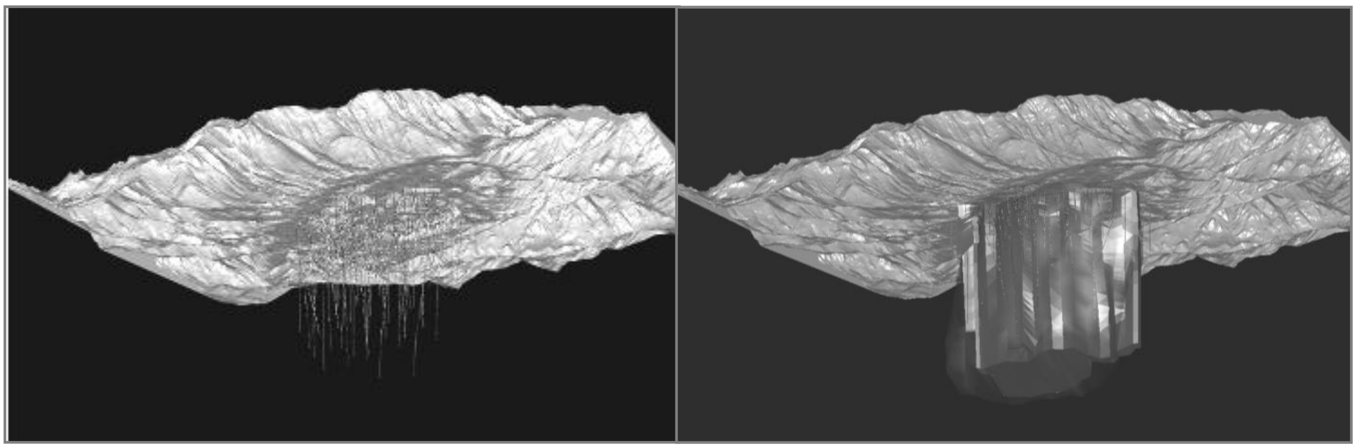

Figure 2: drilling, interpretation of the information and 3D conceptual modeling.

Some of the most important aspects to consider in order to develop an appropriate geological model are the following[1]:

- The geology applied to the resources and reserves estimation (at feasibility study level), should not be the same applied to exploration. At the same time, it is impossible to reliably estimate resources and reserves without the support and use of geological models.
- Determination and modeling of mineralization controls; use of lithology, structures, alteration, oxidation degree, etc.; but not all these factors are necessarily relevant.
- It is possible to add too much geology in the reserves calculation, which is unnecessary and sometimes counterproductive.

- Hence the importance to define Estimation (UGs) Domains (or Unities). This is equivalent to defining the stationary areas (in a statistical and geostatistical sense). The process is based on a combination of geology and statistics.
- The block models are tools for digitally modeling the geology and reserves of a deposit. The geometry of the model depends on the geometry of the deposit (Figure 3).

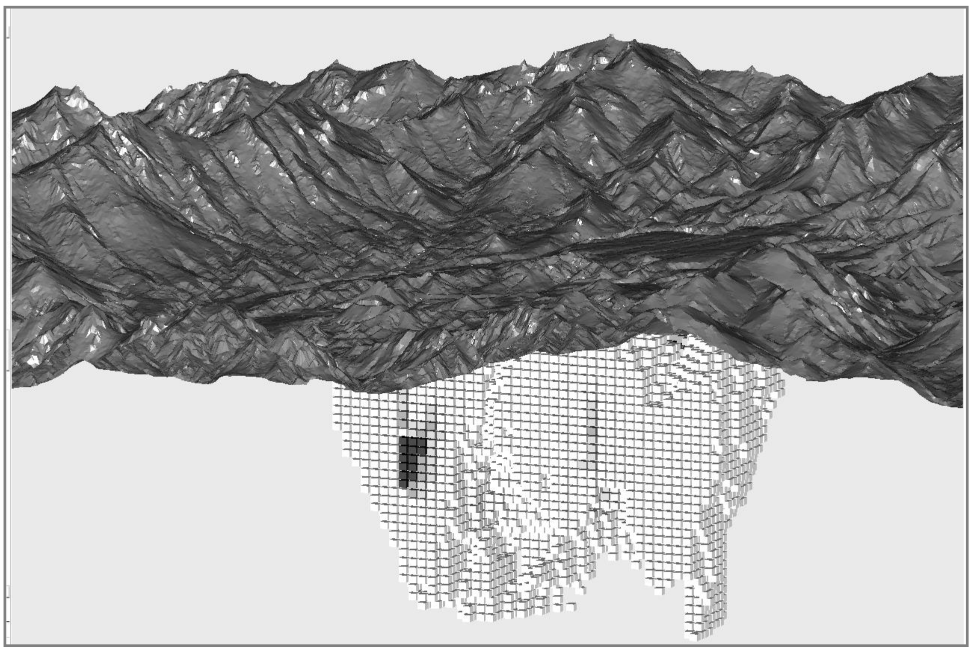

Figure 3: 3D block model of Cu%, showing the original topography.

- Only the geology that allows the prediction of the tonnage and the grade extracted in an operation is relevant; specifically, mineralization controls should be described and modeled.
- Development of a practical model with enough detail to achieve the goals proposed, but at the same time it should be as simple as possible.

- Communication and effective presentation of the work carried out; use of tri-dimensional models if possible. Always develop sections and plan views of quality presentation.

Factors to consider

Undoubtedly an important factor for the Exploration Management or for a modeling professional will come from the DDH>RC drilling and the symbol > is not arbitrary since RC is a low-cost and fast drilling method for obtaining subsoil information (this type of drilling requires a lot of quality control in the sampling or to comply with highly strict procedures in order for the sample to be representative and homogeneous).

Therefore, when DDH drilling is carried out, the quantitative and qualitative interpretation seems easier. It is important to bear in mind that if a DDH hole is developed and the survey is not recorded along its length, the risk of predicting the direction of the drill hole will increase as it is deepened. Thus, when it comes to defining a geological contact or determining the continuity of a vein-shaped deposit, this will not impact directly on the modeling of these characteristics at that moment but if this project starts production in the future, the question *waste material or ore?* will possibly come up.

Thus, it is very important to methodically carry out all the exploration stages and quality controls that are already well known by all the people in the metalliferous and non- metalliferous mining industry.

In a hypothetical case, if at the end of the first year of exploration when the budget has been analyzed and only a 30% to 40% of the budget has been used in DDH>RC drilling and no encouraging results obtained, this will probably facilitate the decision not to continue with the project in the first year of exploration. But, if that first year has been successful, the mining resources will be published and this will encourage and increase more liquidity and budget for the project. This is the moment when the discussion of whether to publish x resources with a 30% to 40% budget in the first year arises. That is, to make an initial estimation of tonnage –ore grade existing in the mineralized body in order to determine if the deposit is economically viable or not. Over the following year, with an increased budget, the deposit can be delineated with more knowledge and start to measure the mineralized orebody's volume, depth and grade to a level of detail, enough to carry out a technical-economic pre-feasibility study for the mining exploitation.

One of the things to consider in those first years of exploration in a project to potentially continue with subsequent stages is, if the publishing of x resources can be achieved with a 30% to 40% of that year's budget; the following year the budget can be increased to better delineate or increase the resources an x+1. At this point the qualitative vs. the quantitative discussion arises with different views that have to do with the development of the project and where it is very clear that if DDH>RC drilling systems enable the publishing of resources, the survey budget is increased and this may probably discourage the exploration that starts as the simple sampling of soil, trenches and mapping. This increases the risk of losing the knowledge of a new metallogenic area.

Even though this is not always the case and the exploration companies have all the organizational resources to face this type of scenarios, actually different problems can be observed in practice. Some examples may include surveys that are brought to an end when the mineral is found; isolated exploration holes without continuity or with quality and quantity predefined criteria; DDH holes with no survey deviation measurements; a great number of trenches or soil samples that do not include enough quality controls to be used in the estimation and publishing of mining resources.

Then the question is based on the abovementioned, where is the QA-QC in general?

If the first year of exploration is successful, what items of the budget will be increased? DDH or RC drilling? Will this choice depend on the market? Will this depend on the board of directors?
All these questions result in a direct influence for the continuation of the project in the exploration stage whether successful or not.

In this sense, the people with the knowledge and praxis that are involved in the exploration of a specific area of interest will have to put emphasis on the development and quality control in each of the methods and exploration stages, even when these are not a part of the estimation or simulation of a mining resource. Some exploration methods such as soil sample, geophysics, trenches should not be underestimated since they will probably be the necessary complement to define or delimit the different drilling areas so as to define the mining resources in the early stages of an exploration project.

Conclusions

The sampling quality controls and their direct coexistence with the geological model interpretation will directly depend on the experience of the people involved in any area of the Exploration Management. These people should put more emphasis on the exploration techniques that facilitate the compliance with regulations that have led to a de facto standard such as the Canadian, Australian regulations, etc. in order to publish the mining resources of a specific mineral in the market.

The different exploration stages and methods or techniques have or lead to risks associated with endogenous variables such as the knowledge factor of a new metallogenic area, depending directly on the solutions, quality controls and/or the certainty that the people in charge of the Exploration Management have, from the technician or field assistant to the board of directors. The set of these endogenous variables will impact directly on the budget of the area under consideration and its value in the market.

The exogenous variables will be harder to predict and estimate. This will require a good study and balance. Among these, there are non-technical variables that often times determine the works and the value of the exploration campaign results.

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