RESOURCE/RESERVE ESTIMATION USING MICROMINE SOFTWARE – GOLD AND BASE METAL PRACTICE

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ABSTRACT: The paper covers the resource estimation steps followed when using Micromine software and demonstrates the benefits of a computerised estimation approach. The procedure combines traditional methods of reserve calculation developed empirically on international epithermal gold-base metal deposits. The benefits include rapid project evaluation, reproducibility of estimates, ease of sensitivity analyses and cost savings.

Key words: Micromine, resource estimation, geostatistics.

Fundamentals

Epithermal gold-polymetallic deposits are commercially attractive due to their rapid payback and high return potential compared with other types of gold-polymetallic deposits. Various geometric methods when reconciled with production often give inconsistent estimates, though time consuming to prepare where a large number of data are utilised. Modern computer based estimation is fast, able to handle a large data volumes, and to make full allowance for the geometry and spatial continuity of mineralisation.

It is always important that the computer model reflects the geological model, and that estimation technique developed primarily on certain *in situ* mineralisation is not applied to the deposit without due consideration to the differences between deposit types. The most important aspect of geological modelling of epithermal deposits is the correct interpretation of the lithological units and structural relationship between host rocks and mineralisation. In many cases epithermal deposits are structurally complex that require detailed sectional interpretation, honouring geologically logged units, alterations, grade

assays, and formation characteristics. The shapes defined from interpretation are complex with numerous intercalations and segregated ore packets. Often the general shapes are carried through from section to section and appear geologically continuous.

All epithermal style deposits have natural high- and low-grade areas. It is important, therefore, that the variation is retained and that the grade contours reflect the reality of mineral deposition. Consequently, the drill hole grades should be reflected in the computational model and not masked by unrealistic smoothing while the model itself should be based on established, proven principles that can be modified with easy to accommodate variants.

Epithermal deposits are multi-element deposits and individual geological interpretation of every modelled element provides for better understanding of mineralogical zoning and grade distribution within the deposit. With Micromine software a three-dimensional approach is used for interpretation of mineralisation and modelling.

Mineralisation types

Understanding and presentation of the geological model is a critical factor prior to resource estimation. Most importantly it must encompass all the exploration data and types of mineralisation that relate to the physical-chemical environments under which the deposit was formed. The most often encountered physical-chemical environments for ore deposition are: structurally controlled elements (veins), surrounding metasomatic halo (replacement) and overhead stockwork system (explosive breccia). Two epithermal deposits have been chosen for the purpose of this study: high-sulphidation Ungay Malobago Au-Cu-Zn-Pb-Ag deposit (the Philippines) and low-sulphidation Muzhievo Au-Pb-Zn-Ag deposit (Ukraine), respectively.

Weathering has a significant effect on the distribution of precious and base metals where the mineralisation is totally remobilised in the weathered horizons. The ratio of base of complete oxidation to that of partial oxidation averages to 1:3. Precious metals are strongly depleted close to the surface, but are potentially economic in the partially oxidised transition zone. By contrast, lead, zinc and, especially, copper are significantly depleted throughout the weathered zone.

Cut-off grades

Estimation of epithermal gold-polymetallic deposit requires a combination of geological understanding, technical or economical requirements and geostatistics. Delineation of the geological boundaries of main structural elements like stockwork and veins is necessary. It is essential that the cut-off grade be applied early in the estimation process to eliminate those parts of the deposit, which clearly contain background grades and irrelevant to the mineralisation. The geological modelling requires establishing a natural (geological) cut-off grade for all elements. Consequently, economics such as cut-off grade can be applied to the block model, which is constrained by the geological model. The block model can be further queried at a range of higher cut-off grades to obtain the head grade and to forecast tonnage available at higher cut-off grades.

Prior to cut-off grade calculation it is always useful to utilise those features that place technical constraint on the resource such as maximum overburden thickness and minimum mineable thickness, water table, impurity content, etc. These become very significant at the stage where estimated mineralisation be considered as ore reserve. Where dilution is allowed Micromine will create a new composite file that can then be used for interpretation.

Domaining

Epithermal deposits are usually characterised by multiple domain. Domain is typified as an area where grade and geological characteristics form a single population. Domains used in resource estimation should reflect the geological characteristics of the deposit. For example, the geologically well-defined vein zone and hangingwall have hard boundaries and thus are attributed to individual domains. Conversely, the footwall may be gradational and areas of associated stockwork mineralisation would have soft boundaries. In this case the domain should include a veneer of waste grades to construct a model progressing from waste background rock to stockwork.

Resource estimation methodology with Micromine

Resource estimation with Micromine includes the following steps.

Database validation. Database validation is required to ensure the veracity of the data prior to interpolation. Data correction, error documentation and file checks are performed on the data. Correction replacement and documentation of all database errors are then conducted.

Exploratory data analysis. Distribution statistics, histogram, cumulative frequency and probability plots are examined and used for decomposition of populations from the probability plots. This includes calculation of natural cut-off grade and the balancing cut. Summary statistics are generated and used for comparison with estimation grades. Domain decisions are made and populations are separated where possible.

Geological interpretation and wireframing. Interpretation or outlining of mineralisation is conducted in section individually for all modelled elements by incorporating assay, geology and structural data. Wireframing involves the triangulation of outlines between sections to create wireframe solids. The solids are then validated and volume queries performed for each domain. In this case domains will be mineralised envelopes or geological rock types. Depth of weathering is determined and also domained.

Geostatistical analysis. Semi variograms are generated to gauge geostatistical parameters of grade distribution: nugget effect, lag and attitude of anisotropy. The variogram ranges are indicative of spatial continuity within the deposit. This is applied to the search ellipse attitude, in addition to the weighting of the Kriging algorithm. Direct and indicator semi variogram analysis is conducted on wireframe-restricted mineral lodes. Cross validation can be employed to check the quality of the variograms prior to interpolation.

Grade and specific gravity interpolation. Interpolation is the estimation of block grades from a mathematical algorithm that populates the block model. This requires the set up of project dimensions, definition of block size and the search neighbourhood. The interpolation method is dependent upon a number of factors including the number of domains and the exploration grid. Both classical statistical and geostatistical analyses will indicate the interpolation method to be applied, which could be Inverse Distance Weighting or Ordinary Kriging. The initial data file will be composite to equal length to avoid bias and to fit the geometry of the geological contacts.

Estimation of waste. Internal waste is wireframed inside the ore solids according to geological data. External waste (dilution skin) is modelled by expanding the existing interpretation outline by a specified distance; the expanded outline is then wireframed. In some cases the ore solid is sliced and then expanded and wireframed.

Modelling results. The results of the modelling exercise include a block model for the deposit in 3D coordinates, estimation of an ore reserve and sensitivity analysis that can be applied to risk assessment and 3D visualisation. The 3D viewer can be used to view proposed underground design and can be extended in Micromine to full animations of the mining project also in three dimensions. From this information the scale of the mining operation can be decided and the mining schedule can be designed. It is essential that accurate estimation of ore and waste volumes be conducted in order to support financial investments and to ensure profitable returns by having sufficient reserves to supply the processing plant for the scheduled project life. Overestimation will cripple the investment while underestimation will result in incorrect determination of the dump destinations while financial return will be reduced.

Resource reporting and categorisation. Micromine can be used to conduct a resource report at various cut-off grades facilitating the generation of grade-tonnage curves. Grade shells are constructed to assess local grade distribution. It is a good practice to generate a series of three-dimensional plots and sections for a visual check-up of modelled grades with the initial data. Categories of the resource block model are determined in various manners. In Eastern Europe the resources are classified in accordance with the density of a drill pattern or development grid. In the West the resource category reflects the results of variogram analysis, the number of samples and drill holes used to interpolate individual blocks and quality control results. In the latter case the resource categories will adhere to the JORC code criteria [1] and will reflect a measure of the level of uncertainty for the deposit.

Benefits

The benefit of estimating the resource/reserve in Micromine instead of by hand and in spreadsheets is that that more precise and accurate results

are realised. Precision is a measure of the reproducibility of a result when using the same method. Micromine provides a means of ensuring 100% precision with all steps saved as formsets. Formsets are the dialogue box settings, when the parameters have been entered. These can be saved for each routine and each step.

Accuracy is a measure of the exact content and is affected by bias. Micromine software can ensure more accurate results by allowing the input of all variables in the calculation. The ease of performing sensivity analysis by changing input variables is a major advantage of the application of Micromine. Micromine should also greatly reduce the amount of time taken in the estimation process. This will realise a cost and time saving that could be invested in risk analysis. Visualisation of the project is also a major advantage, this can be three-dimensional from which snapshots can be taken and included in reports. The benefit to management is significant as the estimation is far more transparent and is not a black box as a consequence of the visualisation.

Applications

The block model with interpolated grades is later used for optimisation of a preliminary layout of open cut and/or underground drives. Open cut and underground drives are designed within the optimised zone(s) by applying economic cut-off grade being derived from cash-flow calculation and sensitivity analysis. Mineable reserves are calculated within modelled and preliminary planned underground drives by utilising information on a selection method.

References

1. Australasian code for reporting of mineral resources and ore reserves (the JORC Code). 1999. 16 p.