Uncertainty Assessment in Grade Estimation through Geostatistical Simulation

Phelps Dodge
Chino Mine, NM

The purpose of this study was to characterize blasthole (local) and exploration hole (composite) assays for the Chino Mine, Lee Hill region using classical statistics and geostatistical analyses. Geostatistical simulations were employed to provide a better understanding of the variations associated with copper grade estimations and to determine uncertainties associated with estimation.

Blasthole and composite data were delineated into four areas of similar geology throughout the Chino Mine orebody. Classical statistics were applied to all data sets by computing means and variances assuming normal and lognormal distributions. Confidence limits were applied to lognormal distributions for asymmetrical data limits. Classical statistics were then applied to determine the degree of log-normality of copper values.

Estimating Minimum Exploration Drillhole Spacing

Blasthole and composite data sets were used for variogram modeling and the number of blastholes systematically reduced and modeled until the resulting variogram no longer replicated the full (original) data set variogram. The results of this process are shown with the top two plots of Figure 1. The absolute minimum number of blastholes for which a stable variogram could be modeled while preserving important data statistics corresponded with a maximum exploration hole spacing of 45 ft within all geologically similar areas. Thus a drillhole spacing of 45 ft was deemed acceptable to fully model local variability and measure uncertainties.

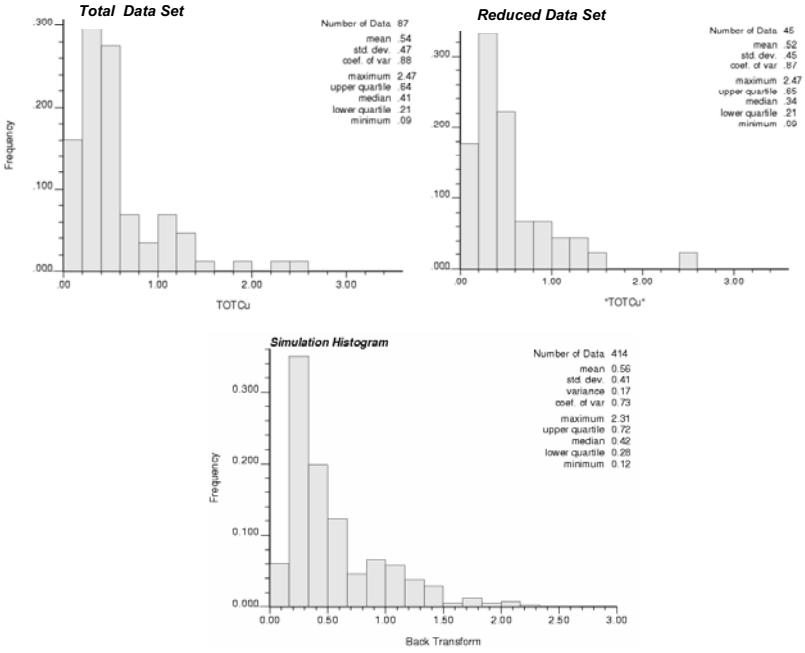

Fig. 1 Histograms for the total data set, reduced data set and simulation showing the means and standard deviations

Sequential Gaussian simulations were executed with the reduced blasthole number randomly selected from the original exploration hole data set to develop a set of Kriged blocks that provided quantitative measures of uncertainty. Confidence intervals associated with simulations were determined and uncertainties associated with global estimates were assessed.

Conclusions drawn from the study

- Classical statistics applied to the blastholes and exploration holes data sets was an important step in determining the degree of log-normality of the copper values. On a local scale, defined by the close blastholes spacings, lognormal distributions exhibited various degrees of skewness whereas, on the global scale, the distribution of exploration holes grades tended to be highly lognormal.

- The arithmetic mean was higher than both than a two-parameter and three-parameter lognormal means for all composite data. This attests to the highly lognormal nature of the composite (global) data set and shows that lognormal statistics may be required for a more conservative estimate of the mean.

- Blasthole data exhibited lognormal means significantly lower than arithmetic means. The 2-parameter means for the complete blasthole data areas were lower than the arithmetic mean, while the 3-parameter fit gave a higher estimation of the mean. The lognormal mean calculated for the reduced blasthole data set ranged both lower and higher around the arithmetic mean in the differing geological data sets.

- Mean values determined using Sichel's t-estimator were nearly identical to the 2-parameter lognormal means in all cases. This served to verify the validity of the calculation of the 2-parameter lognormal mean.

- Cumulative frequency distribution plots of simulations provided a good measure of estimation uncertainty when compared with similar plots of the same data set.

- Simulated grade block model maps containing high grade blocks spatially corresponded with the location of high grade blocks indicated by blasthole samples. This correspondence was not well defined for exploration holes because local variability could not be predicted with composite simulation.

- Simulation decreased the confidence interval and therefore uncertainty associated with the estimation of the true mean was reduced as shown in Figure 2.

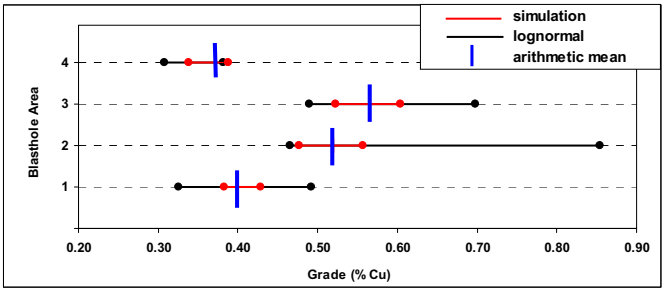

Fig. 2 Ninety-percent confidence intervals for means computed using Gaussian simulation and assuming a lognormal distribution showing arithmetic means for four geologically similar areas in the Lee Hill region of the Chino Mine orebody

Acknowledgements

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