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Heterogeneity Assessment for Grade Engineering in Complex Ore Bodies

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ABSTRACT

Traditional methods of resource modelling and mine planning rely upon geostatistical methods applied to exploration drill core data to derive a three dimensional model of the distribution of metal grades. The resulting block model is a primary input into mine planning. However, block attributes are averaged or interpolated over a complete block, meaning that information at smaller scales is lost to the planning process. New mining methods, such as the development of more accurately controlled blast designs, continuous miners for hard rock and sensors for rock properties allow excavation to be much more selective than traditional blasting, and provide data for driving earlier separation of waste from ore. Selectivity can be optimised if the resolution of resource models matches or exceeds the spatial resolution of selective mining technologies.

Opportunities for selective mining increase with heterogeneity, so methods are required for estimating the distribution and characteristics of heterogeneity within an ore-body. This work presents candidate definitions of heterogeneity, and explores how heterogeneity can be measured and inferred within ore-bodies.

To achieve this, anonymised datasets from two mines were utilised. Each mine dataset provided attributes from assays of both resource drilling and blast-hole samples. The blast-hole data included over 200,000 points spatially distributed over a ~2-3 km region up to 200m in depth.

Whereas attributes and heterogeneity can be calculated at sample locations in space, they involve substantially different supports. Attributes are defined point-wise (or at most over the support of the sample assay); measures of heterogeneity require multiple samples and correspondingly larger spatial scales. Each

of the heterogeneity measures calculates heterogeneity at a location in space defined over a spherical support. All samples within a spherical volume of a given radius are found and form a sample set for that location.

Four heterogeneity metrics were calculated over the sample sets. These were borrowed from techniques in statistical distribution, information theory, and geo-statistics. Distribution measures included percentiles and moments. More specifically, percentiles were calculated at 10%, 25%, 75% and 90%. Moments included the coefficient of variation, skewness and kurtosis. Information theory included the entropy of the sample set attributes. Finally, the geostatistical measures included the range, sill and nugget of the sample sets local variogram.

Three approaches were utilised to rank the performance of the heterogeneity measures. These include geological relevance, range, and predictability.

The level of geological relevance was assigned to the accuracy of a logistic regression model to map between the heterogeneity and lithography code. Range was based purely on the extent to which the heterogeneity extended throughout the orebody. This was quantified by the range of the corresponding metric's variogram. Predictability was ranked based on the ability to predict heterogeneity in the lower 50m of the blast-hole data, based on the upper blast-hole heterogeneity and the entire drill-hole heterogeneity dataset.

Heterogeneity metrics were then scored based on their performance across the range of attributes.

The results show that based on the measures employed the set of percentiles are more predictive and geologically relevant than the other metrics.