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Linear and non-linear resource estimation techniques applied in the Kanzi Phosphate project in the Democratic Republic of Congo

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ABSTRACT

The main aim of this project was to conduct a comparative analysis of the linear and non-linear estimation techniques used for a Kanzi Phosphate Project in the Democratic Republic of Congo. Kanzi phosphate is an elongated sedimentary unit with a north-south strike direction and a fairly flat dip angle. It was deposited between two graben structures.

The Kanzi phosphate was divided into the North and South areas. The North and South areas were treated as different domains because they are far apart. The geology and assay results of the intersected phosphate mineralization were used in defining the layers. The layering was noted in South Geo-Zone. This led the South Geo-Zone to be sub-divided vertically into three layers namely Top, Middle and Bottom layers. The Top and Bottom layers had low P_2O_5 grades and higher SiO_2 than the Middle layer. The Middle layer was the most laterally extensive layer than other layers.

Drillholes were done by the Aircore drilling technique and the samples were taken at 1m intervals. No compositing was done as all samples contributed equal statistical weights in terms of length and density measurements. The declustering was not done because the drillholes were well-spread.

The statistical evaluation of the domains showed that P_2O_5 is correlated to all other major variables (CaO, Al_2O_3, TiO_2 and SiO_2). A decision was taken to conduct mineral resource estimation on P_2O_5 only. Other block variables were estimated from the P_2O_5 using a linear regression relationship.

A 3-dimensional geological model was constructed for each domain. A model was filled with the blocks. A definition of the block sizes were based on the neighbourhood analysis, drillhole spacing and mining requirements. Half the drillhole spacing was used for X (125m) and Y (125m) dimensions and 5m thickness was used for Z dimension.

The traditional variograms for all the domains were created. Downhole variograms were used to determine the nugget effect. All variograms were omni-directional and have spherical models. The variogram ranges were used to guide the search volumes for both Ordinary Kriging (OK) and Inverse Distance Weighting (IDW). The estimation results from the OK and IDW techniques were comparable.

The data was pre-processed for Indicator Kriging (IK). The median cut-offs were selected and median variograms were calculated. It was assumed that all other indicators have similar variograms to that of the median indicator variogram. For estimation purpose, the cut-offs selected were 7.5%, 12.5%, 17.5%, 22.5% and 27.5%. These cut-offs were guided by processing characteristics on the Kanzi phosphate.

The results of the three estimation techniques (IDW, OK and IK) were analysed. The OK and IDW methods produced smoothed estimates. The OK and IDW methods defined the global resources well. The measure of uncertainty for OK was not clearly defined, partly due to widely spaced data.

The Median Indicator Kriging produced more useful results than the results produced by the OK and IDW methods and smoothing was minimized. As a probabilistic method, the Median Indicator Kriging defined the proportion of tonnages above the defined processing cut-offs.

The estimation methods were compared and ranked. The Median Indicator Kriging was the preferred estimation technique and was ranked high. The OK and IDW produced identical results and they were ranked low. OK performed like IDW as there were moderately mixed sample populations that were spatially integrated.

The recommendations to conduct conditional simulation, drill additional boreholes, estimate other variables using co-kriging and perform further processing studies were given. This will help in reducing risks and increase the geostatistical understanding of the phosphate resources.