Paper Number: 1138

Pixel-Based Simulation Approaches for Profiling the Weipa Lateritic Bauxite Deposit

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The tropical laterite-type bauxite deposits are formed from the in-situ weathering (intensive leaching) of kaolinite, quartz and iron oxide minerals [1]. Due to the intensive leaching process, the extreme lateral variability is observed especially at the base of the regolith profile. Therefore, considering the large lateritic bauxite deposits, it appears to be more critical to estimate the geometry of the deposit than estimate the variability of the grade. The attributes that are taken into account when modelling the laterite-type bauxite deposit include Alumina (Al_2O_3%), Silica (SiO_2%), iron-oxide (Fe_2O_3%), Titania (TiO_2%) and loss on ignition (LOI). Of these attributes, Al_2O_3% and SiO_2% contents generally characterise the quality of the material being mined.

Being a blanket-type deposit, the variability of the abovementioned attributes tend to be rather uniform horizontally throughout the deposit whereas they tend to change significantly along the boreholes. For instance, alumina content generally increases with depth and sharply decreases at the elevations lower than the bauxite unit. Silica, on the other hand, follows the opposite pattern; that is, it generally decreases with depth and sharply increases at the elevations corresponding to the bauxite/ironstone contact [2]. The short sampling interval (0.25 m) strategy, therefore, ensures that the mineralogical contacts can be estimated correctly [3]. Given the resource reporting of these deposits, it is demonstrated that the grade could be precisely estimated even from the sparsely spaced borehole data [4]. However, unless the correct variability in the deposit geometry is accounted for, the resulting geological model will not reflect the accurate bauxite volume and will complicate the short-term mine plan due to the uncertainty in the material type being fed to the alumina refinery [2].

To overcome this operational difficulty, the pixel-based simulation techniques including sequential indicator simulation (SIS) and plurigaussian simulation (PGS) could potentially be utilised. Considering the SIS approach, the categorical variables are simulated conditionally to the original data and the previously simulated values. The conditional cumulative distribution function (ccdf) is first estimated by indicator kriging; it is then corrected for order-relation deviations and finally, a random variable is drawn from the corrected ccdf [5]. PGS, on the other hand, transforms the categorical variables, such as the rock types into continuous variables. This is achieved by a series of mathematical transformations, firstly by a Gaussian transformation and generating the indicator variables by applying the thresholds to the Gaussian variables [6]. As the simulation ensures the global accuracy (variogram reproduction), the actual geological structure is preserved. Once the correct geometry of the deposit is estimated, the grade estimation could then be carried out based on the previously estimated geometry. This methodology will be demonstrated in a case study in which SIS and PGS approaches will be used to simulate the lateritic bauxite deposit at Weipa. The performance of each technique will be assessed and the bauxite volume difference between the traditional geological modelling and the pixel-based simulation modelling will be compared.

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