Localised Uniform Conditioning (LUC): A New Approach for Direct Modelling of Small Blocks

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Recoverable mineralisation at a given mining selectivity is traditionally modelled from sparse data grids by non-linear geostatistical techniques such as Uniform Conditioning. This method estimates the tonnage and grade of mineralisation which can be extracted as small selective minable blocks from large blocks (panels), whose grade is modelled by Ordinary Kriging. Uniform Conditioning technique estimates the proportions of recoverable mineralisation in each panel without specifying the actual locations of the economically extractable blocks. This inability to predict a spatial location of the recoverable mineralisation is a major disadvantage of the conventional Uniform Conditioning method. A new approach, called Localised Uniform Conditioning, has been developed to overcome this limitation. This method applies the grade–tonnage relationships modelled by the Uniform Conditioning technique to the spatial grade distribution patterns approximated by direct kriging of the small blocks from the sparse data grid. This approach estimates localised selective mining units grades conforming to the proper grade–tonnage curves obtained by the Uniform Conditioning method as well as maintaining the relative spatial grade distribution pattern indicated by the directly kriged small block grades. The advantage of this approach is essentially dependent upon the data available for ranking the small blocks within a panel in increasing order of their grade. Ordinary Kriging of the small blocks can be used for their ranking providing the kriged estimates produce a meaningful indication of the relative grade pattern. Where the data is sparse and not close to a panel, or their distribution is characterised by a strong short-range variability, the advantages of using the Localised Uniform Conditioning approach are more limited.

KEY WORDS: geostatistics; Uniform Conditioning; ore reserves.

INTRODUCTION

It is well known by the geostatistical community that linear regression based techniques are unsuitable for modelling grades of small blocks when data spacing is too broad in comparison with the estimated block sizes. All linear estimators, including Ordinary Kriging (OK) (Journel and Huijbregts, 1978), which is a popular method among resource industry practitioners, can produce smoothed assessments...
of the recoverable resources when applied to model small blocks which are not supported adequately by dense data spacing (Armstrong and Champigny, 1989; Ravenscroft and Armstrong, 1990; Pan, 1998).

Estimating the grade of the large blocks (panels) whose size is adequate to a given data spacing is impractical for technical and financial valuation of a mining project because it is necessary to estimate tonnage \( T_v \) and grade \( Z_v \) of mineralisation above a given economic cut-off \( z_C \) taking into account a proposed mining selectivity. In geostatistical terms, this task is known as estimation of the ‘recoverable resources’ of support \( v \), where a block of size \( v \) represents the smallest selectively minable unit (SMU).

At present, the common practise of estimating the ‘recoverable resources’ consists of modelling the grade–tonnage relationships for the given mining selectivity applying the change-of-support techniques. This approach predicts what portion of mineralisation can be economically extracted (i.e. above the given cut-off) at the given mining selectivity without the application of precise spatial locations of the recoverable resources. Tonnage \( T_v \) and grade \( Z_v \) of recoverable resources are estimated by a suitable non-linear geostatistical method (Rivoirard, 1994) which calculates the grade–tonnage relationships of the selectively minable units of size \( v \) from an empirically available sample (quasi-point) distribution. Uniform Conditioning (UC) is one of such non-linear geostatistical methods (Rivoirard, 1994; Chiles and Delfiner, 1999), which is often used in the mining industry for the modelling of recoverable resources (Assibey-Bonsu and Krige, 1999; Krige and Assibey-Bonsu, 2001; Abzalov and Humphreys, 2002a, 2002b).

The main disadvantage of the conventional UC method is its inability to predict a spatial location of the economically extractable mineralisation. The practical needs of the modern mining industry require a better understanding of a spatial distribution of the recoverable resources for a more accurate assessment of the technical and economic merits of the mining project. In other words, it is not sufficient to only know what portion of a panel contains mineralisation exceeding the economic cut-off value but it is also important to predict the local spatial locations of these economically extractable blocks of ore. Pioneering work of Assibey-Bonsu and Krige (1999) has explored the various opportunities to model direct and indirect distribution of recoverable resources based on volume–variance relationships. There were numerous attempts to model the ‘recoverable resources’ using the Conditional Simulation techniques (Ravenscroft, 1992; Krige and Assibey-Bonsu, 2001), which produced, in general, very encouraging results. However, this approach still remains very time consuming.

A new method for modelling grades of selectively minable units (SMU) called Localised Uniform Conditioning (LUC) is proposed in this paper. LUC enhances the Uniform Conditioning approach by localising the model results. Firstly, this technique calculates the grade distribution functions using a conventional UC