DETERMİNATİON OF ORE DOMAİN USİNG DİSTANCE FUNCTİON AND TRUNCATED GAUSSİAN SİMULATİON İN GOL-E-GOHAR İRON ORE

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Abstract: Determination of ore body domain is the main step at the beginning of a mining project. The mine designing, mining and processing plant planning would be implemented based on this domain. Traditional methods characterize this domain graphically without considering error and uncertainty, but geostatistics is a powerful tool, capable of determining this domain using spatial statistics. Ore domain is a district variable that can be modeled by different simulation methods, such as truncated Gaussian simulation (TGS). TGS simulates the domain according to the simulation of a Gaussian function and the rock type rule. Also, there are simple equations that can be applied for determination of ore domain, for example, distance function (DF) methods. DF defines the ore boundary by the Euclidian distance between two different points, then calibrating these distance values. In this study, statistical and geostatistical validations were applied to find the best simulation. The DF and TGS results were compared by assessing confusion matrices, overall error, and precision of the modeled domains. Moreover, different plans, and sections were qualitatively compared. Qualitative validations and comparisons, along with statistical and geostatistical validations indicated that TGS is a more efficient way to model the ore domain. Both methods were applied to study Gol-e-Gohar mine and results showed that in comparison with DF, TGS is capable of creating more precise domain simulations. In smaller scales, TGS algorithm is able to reproduce anisotropies better, while in larger scales DF can reproduce variability and anisotropies better than TGS algorithm.

Keywords: Geostatistics, Ore Domain, Truncated Gaussian simulation, Distance Function.

INTRODUCTION

Geological simulation is a key step prior to resource estimation. Exact definition of boundaries of grade domains leads to a correct estimation. Traditional methods are commonly used for domain modeling but they cannot determine the uncertainty. Geostatistical methods such as TGS and DF are capable of considering the uncertainty and creating different realizations of boundaries. Current study compares these methods to find out more about their applications. DF method which was first proposed by researchers form Alberta University is based on Euclidian distance between two dissimilar points. But in TGS method, first the discrete variable is transformed to a continuous variable, and after conducting simulation procedure, it is retransformed to the discrete space.

METHOD

The definition of the distance function is the distance to a dissimilar data point and is mainly defined as the distance from the boundary that separates two different domains. This value is calculated for all available data. The sign of distance is positive or negative depending on the location of the data, which is either inside or outside the domain. The absolute values of distances increase as the points get away from the boundary. This distance data is then used to estimate the distance on a regular grid. The boundary is located on a transition band where the sign of estimated distance values changes.

TGS method simulates one or more Gaussian variables at every data location within the studied area, and then uses a flag to transform these Gaussian values into premium geological domains. The continuity of rocktypes is determined by the variogram calculated by the simulation .A flag is a graphical sketch of the domains' orders and contacts that is drawn based on geological information. The main steps in a truncated Gaussian simulation are as follow:

Step 1: Estimation of two factors controlling the simulation results: (I) thresholds that truncate the Gaussian random field into the domains which are determined by the flag (rocktype rule), the proportions of each domains, and (II) the variogram model of this Gaussian variable that should reproduce the spatial relationship between the hard data.

Step 2: While the domains are known for each sample, the corresponding Gaussian values are unknown. After implementing the truncated rule, the domains reduce to rectangles. In this step, Gibbs sampler method can be used to generate Gaussian values using these intervals in respect to variogram model.

Step 3: Simulation of Gaussian values of variables at the grid nodes. In this case, any simulation approach, such as the sequential Gaussian or the turning band, can be implemented on the Gaussian variable in this step. In current study, the turning band algorithm is used.

Step 4: In the last step, the flag is used to convert the Gaussian values at grid nodes back into the domains.

DISCUSSION

In order to evaluate TGS results, two steps of validation were applied; statistical and geostatistical validations. Statistical validation checks out the reproduction of each category proportion. The variance and proportions of realization must be convergence around the values of hard data (fig.1).

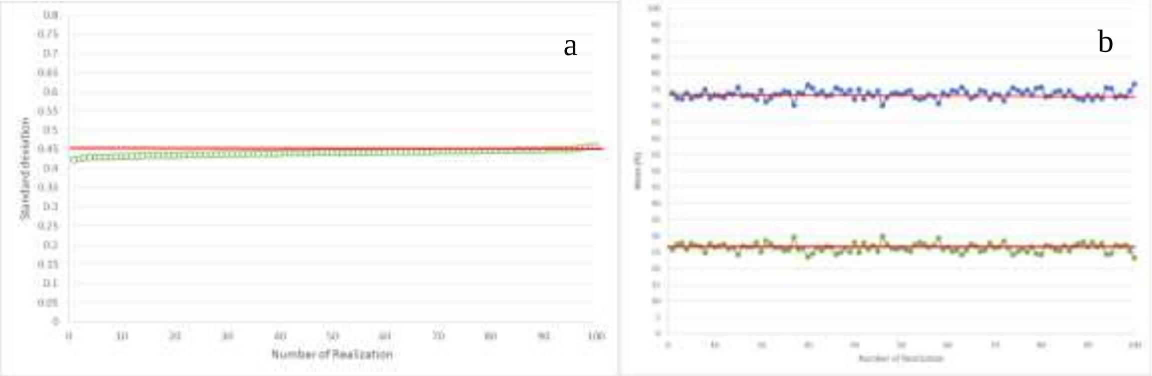

Fig.1. Reproduction of variance (a) and proportions (b) for each realization in TGS method.

For geostatistical validation of TGS, reproduction of variogram was measured. As fig.2 shows, the variograms in the main directions are reproduced by the realizations. The confusion matrix is used to find the best realization. The best realization is No. 38 that correctly estimates the ore and waste, with 82.97% and 86.50% accuracy, respectively.

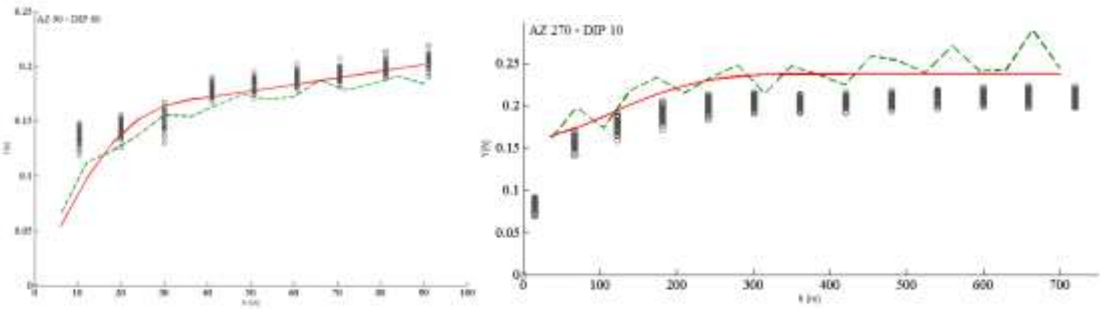

Figure 2. Experimental (green dashed lines), modeled (red solid lines) and post simulation indicator variograms (dots) of the ore domain.

The best calibration parameter for this case was 25. The uncertainty band is located between distance function values of -25 to +25. The possible boundary is located in this band that is modeled by a simple simulation procedure.

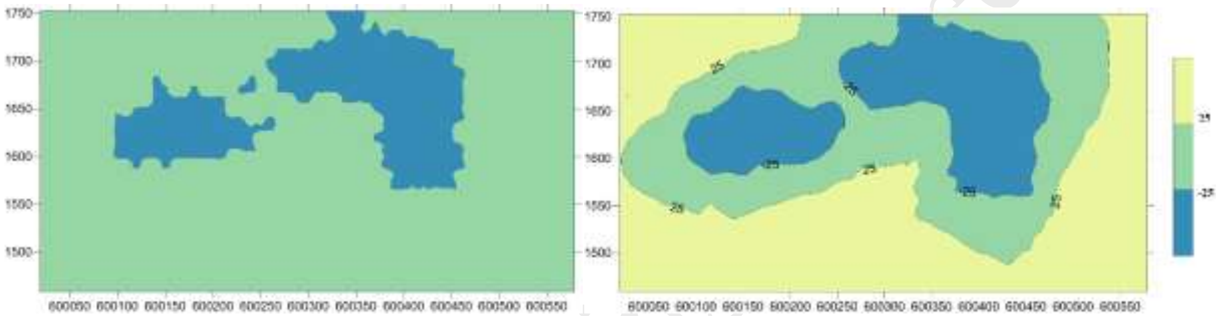

Fig.3. the uncertainty band (left) and the final domains boundaries (right).

The confusion matrix is calculated for evaluation of the TGS and DF results in this case study. As Table1 suggests TGS is more accurate than DF but DF can model a less noisy boundary (fig.4).

Table 1. The confusion matrix elements for TGS and DF methods.

Method	**The overall accuracy (%)**	**Ore domain accuracy (%)**	**Waste domain accuracy (%)**
TGS	85.11	82.97	86.50
DF	67	57.58	42.42

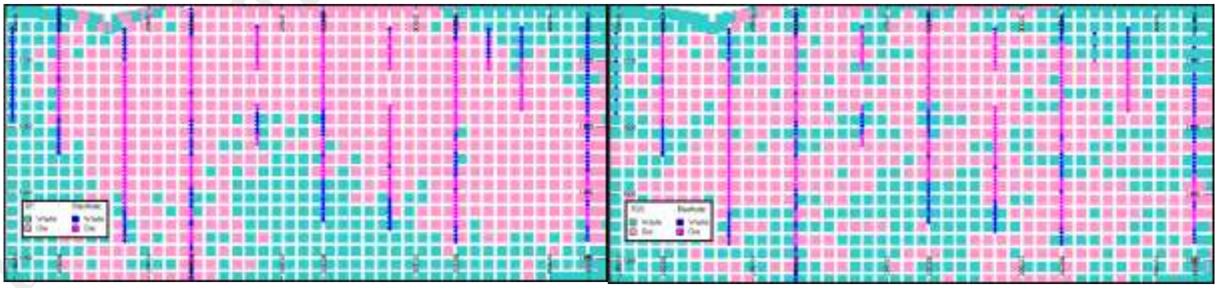

Fig.4. thequalitative comparison between TGS (left) and DF (right) results, N-S section in X=101500 m.

CONCLUSIONS

Prior to tonnage- grade estimation, ore body modeling can be applied for portioning the whole deposit that leads to a better understanding of grade distribution. TGS and DF methods are used for ore body modeling that are practical for complex geological settings. Validation of results defines that TGS method is a suitable method for ore body modeling and can reproduce the initial circumstances. TGS is more accurate than DF for ore-waste domains modeling but DF can produce less noisy boundaries. Both methods correctly reproduce the direction of mineralization (E-W direction with 10^0 dip to the East).

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