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Application of dynamic anisotropy for the resource estimation improvement in Pisani Skali ore occurrence, Bulgaria

Използване на динамична анизотропия за подобряване оценката на ресурсите в рудопроявление Писани скали, България

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Introduction

In the past years, the use of geostatistical methods has become common practice when considering the possibility of investing in a new mining operation or deciding on expanding current mining activities. The classical interpolation methods ignore the spatial anisotropy and spatial correlation of the data, and as a result are proved as inaccurate (Sousa, 1990; Armstrong, 1998). In vein deposits, the gold grades are characterized by highly positively skewed distribution in which a small number of higher grade samples can cause overestimation in the surrounding low grade estimation blocks.

The kriging is one of the most often used interpolation techniques for geostatistical estimation of the resources and reserves as the Ordinary Kriging (OK) is the most widely used kriging method (Wackernagel, 2013). In the ordinary kriging, usual practice is to use of a global oriented search ellipse, aligned to the major direction of the continuity of mineralization. The main problem with this kind of grade interpolation is that it does not actually reflect the local changes in the ore bodies with complex geometry shapes. The use of ordinary kriging methodology in such case may lead to grade underestimation because some structurally continuous samples do not fall within the uniform search ellipse (Zabrusky, 2013). On the other hand, the use of Dynamic Anisotropy (DA) search method in the estimation process allows local rotation of angles of the variogram model and search ellipsoid. Thus, it will enable the search ellipse to continuously change its dip and dip direction in accordance with the sampling information.

This work is aimed as a test whether the DA grade interpolation method applied in OK estimation process could improve the grade estimation on the curved ore bodies in one vein type ore occurrence in Bulgaria.

Applying of the Dynamic Anisotropy search method on the Pisani Skali ore body estimation

Pisani Skali ore occurrence is situated at about 25 km SW from the town of Velingrad and it is hosted in the Rila-Rhodope granite batholith. It is represented by one main zone located in Kalachburun sector of the ore occurrence and three minor zones (Vidinli, Mladenova, 2016). The ore is deposited in subparallel veins. The analysis results from zone 1 exploration are represented in this study. According to Vidinli and Mladenova (2016), ore zone 1 appears to be the main ore-bearing structure. It is followed at about 3 km, with direction of 30–60° and slope of 60–80° to NW. The thickness of the ore zone 1 varies from 10 to 40 m. On the surface it is clearly outlined by ancient works along almost its entire length.

The Dynamic Anisotropy technique allows each estimation block to have different orientation of the ellipse, depending on the surrounding ore body geometry. To achieve this, the trend surfaces that follow the changes in dip and dip direction of the mineralization (as observed in the core logging) were created in the Leapfrog software. In the block model were added additional attributes to store the dip and dip direction from the surfaces geometry. During the estimation process, these attributes are selected for each block and the ellipsoid is oriented exactly as per the values in its attributes. It was envisaged that this method of interpolation would improve the perceived grade continuity and reduce the impact of the information effect that could be in result of insufficient samples.

Results and discussion

Two models are created and compared in this study: one – using the traditional method with uniform search parameters (uniform anisotropy parameters and variogram model parameters are shown in Table 1) and other one – based on the DA method, both in the Surpac software. The used projection is UTM North zone 34, WGS-1984.

The process of local anisotropy surface construction includes three steps in general: (1) obtaining the initial anisotropy orientation angles, (2) cleaning possible errors of these initial angles, (3) assigning the values of these angles at the same resolution of the final grade block model for the purposes of grade estimation (Machuca-Mory et al., 2015).

The Pisani Skali gold occurrence has been chosen as object of study because it consists of different ore bodies with large variations in their orientations. The use of global search ellipse with averaged dip and dip direction does not well reflect the gold grade continuity and the estimation process should be separately done for each domain. For the purpose of DA method, for each ore body was created

Table 1. Variogram modeling parameters

Uniform anisotropy parameters		
Ellipsoid plunge		24.9°
Ellipsoid bearing		71.0°
Ellipsoid dip		40.1°
Major/semi-major		1.77
Major/minor		5.04
Variogram model parameters		
Model type	Spherical	
Nugget		0.14
Structure	Sill	Range, m
1	0.86	51.48

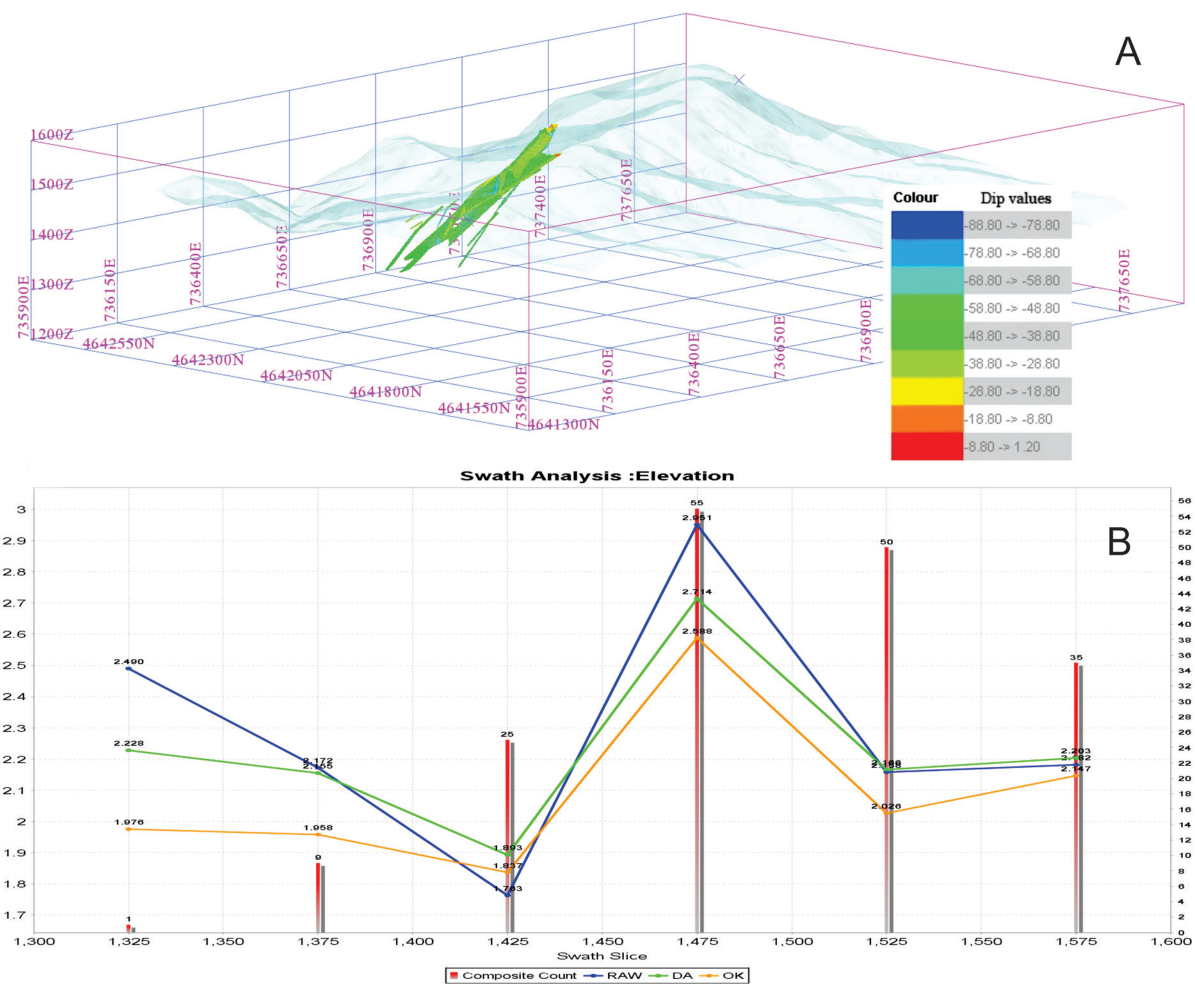

Fig. 1. Block modeling results: *A*, 3D model of the estimation domains and the local dip angles obtained for each block. The colors assigned to the attribute values of angles are shown in the legend; *B*, swath plots for sample (raw) data vs Ordinary Kriging (OK) and Dynamic anisotropy (DA) estimates at steps of 50 m in vertical direction.

a trend surface that follows the different variations in dip and dip direction of the mineralization. That surfaces ware created on a section basis by digitizing the lines of grade continuity. The flexibility to define local angles of the grade continuity is a significant advantage in this approach. The mean value of dip is –44.3 with standard deviation of 9.9. For the estimation process of each block, the search ellipsoid was set exactly as per the values in its orientation attributes (Fig. 1A).

The crossplots graph of the estimated gold grades shows significant differences between the results by the two models – using local anisotropies or using stationary global anisotropy. The observed differences in the estimated grades between the models reached up to 5 times the standard deviation of the estimated values. The coefficient of variation, standard deviation and variance as well as the skewness and kurtosis in the model based on the DA method are significantly lower. Swath plots were made to compare the trends of DA and OK estimates and sample data to determine how accurate the estimation is. The combined swath validation results at different elevations are plotted in Figure 1B. The swath plot is a one-dimensional graph in a specific direction of interest which represent the average contents plot calculated by moving window through the block model. The DA estimates show a closer trend to the sample data in most of the Zone 1 area.

Conclusions

Using the DA method in resource estimation process in vein type deposits could provide improved estimates than the traditional geostatistical methods. Instead of applying a domain based analysis with different search ellipses, DA method can be used as the search ellipse is oriented to follow the local trend of mineralization precisely. In this approach, the construction of trend surfaces is an important step that requires special attention to obtain correct values of dip and dip direction, in case of modelling the mineral resources of vein ore deposits.

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