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ANALYTICAL-GEOMETRICAL METHOD FOR ASSESSING THE OREBODY GEOLOGICAL COMPLEXITY

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ABSTRACT
The method proposed for assessing the geological profile complexity and the orientation of changeability can be used for determining the geometry of the development and extraction workings, for devising a methodology for standardising ore loss and contamination, for building up a quality control system, etc.

The orebodies which are being mined by the mining companies are pulsating systems. The natural factors and the raw materials market situation determine the pulsation of the geological (industrial) reserves of the company (Topalov S. et. al. 2000). The quantitative evaluation of the natural conditions and, in particular, the company and market reserves, is probabilistic. Despite the strictness of the design and engineering solutions on working the orebody, their implementation depends on a certain probability. It is close to 1 for well-explored orebodies with simple chemical, mineralogical, structural, etc. composition and close to 0 for geologically complex and insufficiently explored orebodies.

The degree of exploration of the orebody and its geological complexity are closely interrelated for well-known reasons. The exploration methodology depends on the geological complexity. Unfortunately, no quantitative standard has been elaborated so far for regulating the geological complexity of the Bulgarian ore deposits. Such a standard would solve the problems related to: the ratio between drilling and mining exploration works; the geometry and density of the exploration grid; the methods and techniques of sampling; the obtaining of single solutions by applying the three-index classification of reserves and resources adopted in this country.

The methodological approach to assessing the geological complexity would significantly facilitate: the standardization, planning and control of losses and contamination in mineral extraction, subsoil protection, etc.

The difficulty in assessing quantitatively the geological complexity of the orebody (or its sections) arises out of the hypothetical character of the output geological data. The methods of interpolation and extrapolation, limited by the location of the sampling points (selected statistical sample) are essential for the geological solutions.

The complexity of the orebody, depending on the stages and tasks of the geological exploration and mining cycle, is proposed to be subdivided into geological and mining-geological (Попов В.Н. и др. 1996). The assessment is designed to be made by using an *integral index* which should involve: geological factors by degree of their changeability which assess the deposit quantitatively and have an influence on the accuracy of evaluation of the predicted mineral resources, on the rational extraction of valuable minerals from the Earth's crust and on the technical and economic indices for the activity of the mining company. We suggest that the mining-geological complexity model be grapho-analytical and be expressed by the topofunction of the type V = f (x,y,z).

According to (Попов В.Н. и др. 1996), the assessment of the mining-geological complexity should be carried out by an index which has to meet the following requirements:

- zero dimension - the different geological indices are expressed by dimensionless variables without losing the physical sense thus enabling us to compare the orebody areas;
- spatial relationship - reflecting the character of change when solving particular engineering problems;
- taking into account the discrete and continuous character of the geological indices;
- possibility for formalisation of the qualitative and descriptive factors;
- versatility, flexibility and reliability of the constructed volumetric model capable of being used in the planning and management of mining operations.

The requirements to the index mentioned above can be implemented by a method based on the mining-geometrical relationships (Христов Ив. 1974). In its analytical part the method is based on the theory of random functions - the normalised correlation function:

$$\rho_x(\tau) = \sigma_1^2 e^{\alpha_i(\tau)} + \sigma_2^2 e^{\alpha_j(\tau) . \cos\beta_j(\tau)}$$

where:

σ_1^2 and σ_2^2 are variances of the random and regular (periodic) components in the distribution of the geological index;

$\alpha_{i,\,j}$ - an index of the degree of reduction of the correlation between the spatial indices;

ß - angular velocity of the periodic (regular) component of the changeability in the geological index.

Fig. 1 shows the graphs of the normalised, reduced to a variance=1, auto-correlation function of the change in the copper content along a given direction in the orebody which is being extracted by open-pit mining methods. 1 designates the graph plotted on the basis of data from detailed exploration drill-holes and 2 designates data from the exploitation exploration. The figure shows clearly that along with the random component whose variance for graph 1 equals σ_1^2, with a standard deviation σ_1 = 0.87 (basic component), there is also a regular component with a variance of σ_2^2 and a standard deviation σ_2 = 0,38, with a period T_1 equal to four times the sampling grid size.

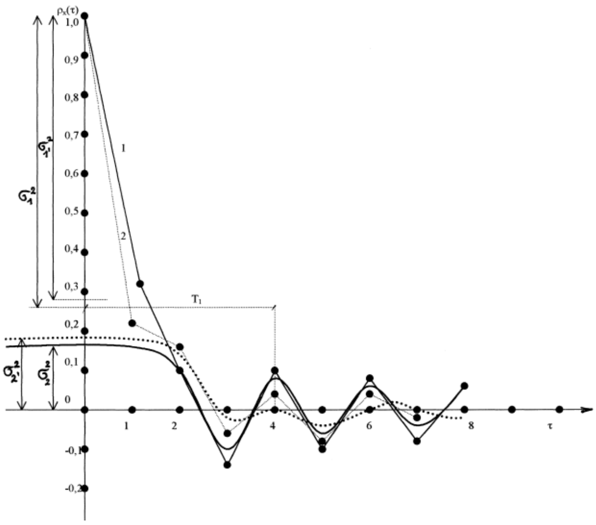

Figure 1

The graphical part of the proposed model is expressed both by what has already been shown in its analytical part and by the following sequence of graphic constructions:

- for each level the centre of gravity is defined hypothetically on the basis of a geological profile;
- straight lines are drawn through the centre of gravity whose orientation is defined by the value of a true bearing;
- the sampling points are defined for each straight line in order to study the geological index determining the orebody complexity and the values of s_1 and σ_2^2 are also defined;
- the values of σ_1 and σ_2 are plotted on separate radial diagrams whose origins coincide with the values of X and Y of the gravity centre of the mine level;
- the final points are connected with a closed polygon line which defines the dimensionless area of the random (regular) component in the changeability of the index; the orientation of the two types of changeability in the coordinate system of the mining operations;
- the circumference P in the figure is defined (the length of the closed polygon line) whose length is used as a decisive factor in assessing the complexity of the geological index.

Fig. 2 shows radial diagrams for the random component of the copper content for levels 1090, 1075, 1060 and 1045 (according to data from the detailed exploration at the Elatsite Mine), which are constructed on the basis of the character of the auto-correlation function (the values of the radius of auto-correlation) for the eight defined directions. The graphical basis for assessing the regular component is a derivative of the one shown in Fig. 2.

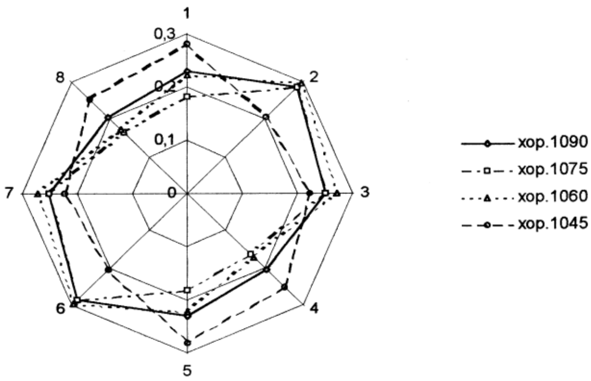

Figure 2

The results were obtained by using some standard application software packages (e.g. "*Statgraph - Plus*"), applications of Microsoft Office (Excel), application of a series of logical operations, etc.

From the analysis of the applied graphic models of the random component for the levels under study, viz. 1090, 1075, 1060 and 1045, with regard to copper content, it is possible to draw the following important conclusions:

1. In terms of non-homogeneity (based on data from detailed exploration) - level 1090 can be said be the most complex one, levels 1060 and 1045 can be said to be of similar complexity and level 1075 can be considered the least complex one with respect to the distribution of copper content.
2. With increasing the bulk of information (sampling data from the exploitation exploration) on the copper content, the random component for each level decreases as follows:

   on level 1090 by 61,5 %;
   on level 1075 by 62,0 %;
   on level 1060 by 63,5 % and
   on level 1045 by 55,9 %.

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