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ISSN 0543-5846
METABK 56(1-2) 237-240 (2017)
UDC – UDK 622.3:622.368:666.85.517:437.6=111

SPATIAL VARIABILITY CHANGE OF MgO CONTENT IN JELSAVA MAGNESITE DEPOSIT (SLOVAKIA)

Received – Primljeno: 2016-10-04
Accepted – Prihvaćeno: 2016-11-28
Preliminary Note – Prethodno priopćenje

The presented paper deals with the study of the spatial variability changes of MgO content within the Jelšava magnesite deposit in Slovakia. The geostatistical structural analysis was used to study the spatial variability changes of the MgO content within three mining sectors A, B and C, localised in different parts of the deposit. The results show some important connections between the variability of MgO content and the structure setting of the deposit with utilization for the magnesite processing in the metallurgy.

Key words: mining sector, magnesite deposit, MgO content, geostatistical analysis, Slovakia

INTRODUCTION

Magnesium oxide (MgO) represented raw material for metallurgy, technical industry and environmental using. The world magnesite resources are estimated at over 12 billion tonnes, being concentrated in few countries (China, mine production: 5,77 million MT), whereby in the European space they are in Austria (220 000 MT), Slovakia (200 000 MT) and Spain (200 000 MT) mainly [1]. The Chinese dead-burned magnesite is used mainly for its steel industry, the remainder is exported primarily to the Europe and the United States whereby the countries eliminate Chinese Mg imports with antidumping duties. For metallurgy, where dominated chemical processing over Mg extraction by thermal reduction or electrolytically [2], chemical composition related with variability of quality, mainly the MgO content of the raw material is the most important.

The pure magnesite contains 47,8 % MgO and 52,2 % CO_2. The pure mineral is found occasionally as transparent crystals resembling calcite [3].

The Jelšava magnesite deposit belongs to the genetic Veitsch-type (like Austrian deposits), coarse crystalline magnesite. It is the fifth most important area of the primary magnesite sources worldwide. The deposit situated in the Western Carpathians went through several phases of deformation associated with the development of the Alpine orogeny; the deposit structure and distribution of MgO are very heterogeneous. The aim of the paper is to study the MgO variability change and its connection to the structural setting of the Jelšava deposit. The study focused on a comparison of the spatial variability models of MgO content within three individual mining sectors, localised in the different parts of the studied deposit.

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METHODS

In the area of Dúbrava massif there were several methods of geological exploration implemented to clarify the structural tectonic evolution of the deposit. The main research focused on the structural mapping of six mining horizons 220, 323, 390, 400, 450 and 482 m (ASL). The genesis and evolution tectonic structures were monitored and reviewed in the mining sector A, B and C and their surrounding area. The main fault structures are spatially localized to individual mining level maps. The measurements were processed in the geological maps in scale 1: 1000. The prepared maps were transferred into the real coordinate system to derive the spatial position of the dislocation structures that are the result of a number of deformation stages. The non-uniformity of the tectonically disturbed parts of the deposit affects the spatial variability of MgO content in the Jelšava deposit.

A geostatistical structural analysis [4] was used to study the spatial variability of MgO content within three separated sectors in the Jelšava magnesite deposit. The analysis focused on the MgO content %; as a main component of the magnesite mineralisation within the Jelšava magnesite deposit.

The geostatistical analysis consists of a calculation of the directional experimental variograms, and fitting of the basic structures of the spatial variability [4]. The directional experimental variogram was calculated as follows:

$$\gamma(\hbar) = \frac{1}{2N(\hbar)} \sum_{\alpha=1}^{N(\hbar)} \left(z(\mathrm{x}_\alpha) + z(\mathrm{x}_\beta) \right)^2, \qquad (1)$$

where $z(\mathrm{x}_\alpha)$ and $z(\mathrm{x}_\beta)$ are a pair of two values located at x_α and x_β, separated by a lag $\hbar$. The lag is defined by a class of separation vectors between the pairs of values for a given distance and angular tolerance. $N(\hbar)$ represents the number of pairs of values $z(x_\alpha)$ and $z(x_\beta)$ falling into the lag $\hbar$.

Data description

The variograms were modelled for three mining sectors A, B and C (Figure 1), located on the same level 350 m (ASL). Geographically, the sector A is located in the western part of the deposit (Dúbrava area), sector C in the eastern part of the deposit (Miková area), and the sector B is located between this two sectors. The sectors B and C are rotated in azimuth N97°E, which represents a general direction of the main axis of the magnesite lenses within the carbonates. The sector A is rotated in direction N75°E, which represents a different rotation of the magnesite ore lenses position within the carbonates. This different rotation was observed during the mining-geological survey of the deposit.

The mining sectors were surveyed by drives and crosscuts that were sampled using the channel sampling. From the crosscuts, the fans of underground drillholes were drilled in the strike direction of the magnesite lenses. Unfortunately, it resulted in increasing of the variogram modelling uncertainty in the perpendicular direction (the direction of the thickness of the magnesite lenses). The basic statistical characteristics for the mining sectors of MgO content of 11 319 samples in total are given in the Table 1. The mining sector B shows an extremely different variance of MgO content.

The variance is much lower than the variance for the sectors A and C, that are very comparable. The low minimal values of MgO content within the sectors A and C are the outlier values, and they are/correspond-due to presence of the samples with high SiO_2 values -corresponding to the quartz nests.

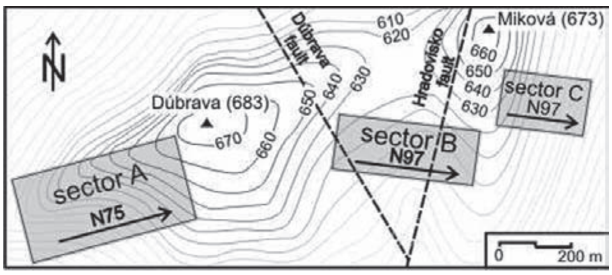

Figure 1 Spatial position of studied mining sectors within Ješava magnesite deposit with the main faults.

Table 1 **Basic statistics of the MgO content / %; of the studied mining sectors.**

Sector	Number	Min	Max	Mean	Var*
A	4 815	1,64	44,81	38,04	51,35
B	4 207	19,25	45,12	40,38	17,99
C	2 297	6,92	44,71	39,38	50,42

*Variance

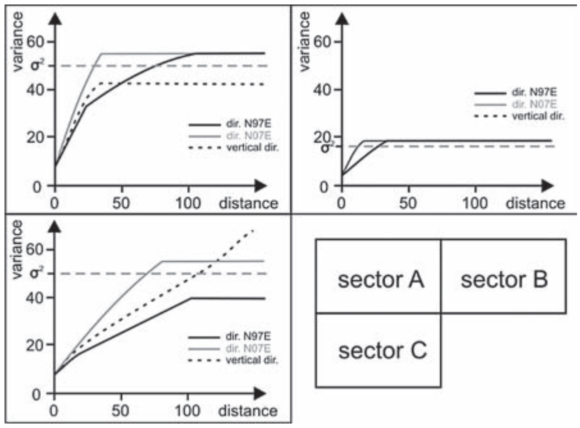

Figure 2 Variogram models of MgO content for three sectors showing different parameters of the spatial variability of MgO content within the Jelšava deposit.

RESULTS AND DISCUSSION

The aim of the variogram modelling was to measure the spatial variability level, range of the autocorrelation and rotation of the spatial anisotropy, and to compare the results for the mining sectors. Figure 2 shows the theoretical models of the change of MgO content variability within the individual sectors. The models consist of a nugget effect structure (discontinuity at the origin for distance 0 m) and one spherical structure of variabilty for MgO content of the sector B, and two spherical structures for MgO content within the mining sectors A, C.

The spatial variability of MgO content values within the mining sector A shows a strong geometrical anisotropy in the horizontal plane with a higher range of influence (cca 120 m) of the second spherical structure in the N75°E direction (main axis of the magnesite lenses in the Dúbrava part of the deposit). The different levels of MgO content variability between the horizontal and vertical plane indicate a zonal anisotropy. The same range of influence (cca 40 m) for the first spherical structure in the horizontal and the vertical direction indicates the isotropic behaviour of the variability for short distances.

Nevertheless, the lowest number of the samples available in the mining sector C in the eastern part of the Jelšava deposit (Miková hill), respects the model of variogram which corresponds most to the global model of variability of the deposit [5]. The model is characterised by a zonal anisotropy in the horizontal plane with the higher level of the variabilty in the N-S direction, and the higher range of influence in the perpendicular direction W-E (cca 120 m). Interesting is the rotation of the zonal anisotropy of the vertical plane in the western part of the deposit (Dúbrava hill) into the horizontal plane in the eastern part of the deposit (Miková hill). Similarly, as opposed to the increasing level of the variability of MgO content in the vertical direction with a low range of influence in the western part of the Jelšava deposit, the eastern part is characterised by a significant trend of the the variability increase of in the vertical direction. This fact is totally absent in the western part of the Jelšava deposit.

The model of variability of MgO content within the mining sector B shows completely different behaviour. There is a geometrical anisotropy with the main axis of the ellipse in the W-E direction (cca 40 m). This range of influence is only one third of the range of influence of the main axis of the anisotropy ellipse of the sectors A and C. This reduction of the spatial autocorrelation of MgO content indicates a presence of some spatial discontinuities, perpendicular to the strike of the magnesite lenses. The range of influence of the vertical direction is identical to the range of influence of the main axis of the anisotropy ellipse. It indicates the isotropy of the variability between the vertical direction and the strike of the magnesite lenses.

Based on the structural research and the results of the spatial variability geostatistical modelling , it can be concluded that probably all Alpine deformation phases, defined by Nemeth [6], had been applied in the Jelšava magnesite deposit. Figure 3 shows the various stages of deformation and the evolution of the recent structures on the deposit. The geological-structural research indicates the significant disproportions of the magnesite ore bodies in the different parts of the Jelšava deposit. Several authors have dealt with the problem of the interpretation of the structural setting and distribution of the ore bodies [7, 8, 9]. A tectonic disturbance of the rocks environment, surrounding the deposit, is absent in most of these works. The current structural setting of the deposit is reflected in the spatial variability of MgO content within the studied sectors. It points to the adjacent but tectonically and quantitatively different segments. This development may be related to several deformation stages. The most important is the one related to the reduction of the Gemericum area. The original sedimentation basin of the carbonate rock was subdivided into the systems of the overthrust structures. These overthrusts caused a tectonic thickening of the carbonate body. It assumes that both, the original position and thickness of the magnesite lenses, were different. The recent situation is the result of the tectonic thickening. The following Alpine post-mineralisation stage of deformations divided the deposit in the vertical direction as well. They sgnificantly affected the overall spatial distribution of the ore bodies and MgO content within them.

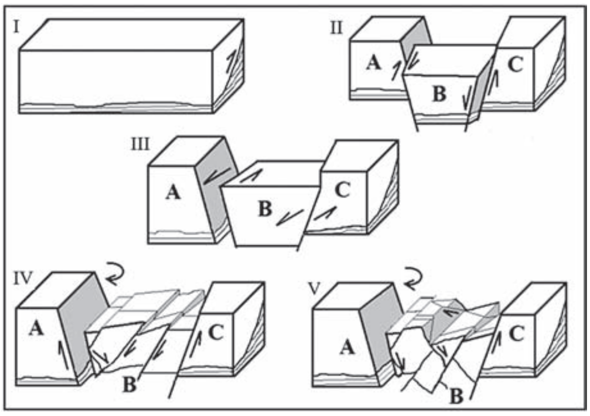

Figure 3 Genesis and evolution of the structural block between Miková and Dúbrava on the Jelšava deposit with the rough locations of the studied sectors (modified after [10]):
I. Collision, north-vergent overthrusting (AD_1).
II. Extension and normal-slip fault sytem, (AD_2 – post-collision –unroofing ?)
III. Change of trantension system–strike-shearing (AD_3)
IV. Extension, normal-slip fault and rotation (AD_4),
V. Recent-extension (AD_4)

CONCLUSIONS

The geostatistical structural analysis of MgO content within the three mining sector exhibits a very significant change of the spatial variability characteristics in three different parts of the Jelšava magnesite deposit. The spatial variability modelling shows that the levels of the variability of the MgO content are very similar in the peripheral parts of the Jelšava deposit. The differences are connected to the zonal anisotropy rotation and the presence of the content trend in the vertical direction in the eastern part of the deposit (sector C).

Apart from these factors, the level of the variability of MgO content in the central part of the deposit (sector B) is very low - only one third of the total variability is observed in the peripheral parts. The variability features, as the zonal anisotropy or a directional trend in the MgO content, are also absent. This points to the presence of spatial discontinuities within the central part of the studied deposit. From mining-geological mapping it is clear that this is tectonically significantly troubled area. Considering the fact that the highest MgO content (over 45 %) is localised within the sector B, it can be assumed that the highest quality of magnesite mineralization may be located in the tectonically disturbed parts of the deposit.

The crystalline magnesites typical for the Europe deposits are characterized by the variabile contents of MgO, as in Slovakia. The article presented one of the way how we can ensure the permant quality of MgO raw materials for metallurgy.

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Note: The English Language translation was done by T. Baranyiová, Bruck an der Leitha, Austria