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Results of the correlation analysis of the relationship between germanium, beryllium and fluorine in the coal seam $c_8^в$ of the "Dniprovska" mine of Western Donbas

The general relevance of research of germanium content in coal seams is explained by the possibility of its industrial extraction and use as a valuable accompanying component. Currently, coal deposits are considered as the most important mineral raw material base for the industrial production of germanium [1]. Special relevance of the performed research provides a solution of the National Security and Defense Council of Ukraine dated July 16, 2021 "About stimulation of the search, extraction and enrichment of minerals that have strategic importance for the sustainable development and defense capability of the state" and Decree of the President of Ukraine No. 306/2021, which introduces this solution into effect. In these documents, germanium ores are included in the list of strategic importance for the sustainable development and defense capability of the state.

Previously, toxic and potentially toxic elements were mainly studied in coal seams of various geological and industrial areas of Donbas [2]. At the same time, research of the connection of germanium, beryllium and fluoride in the coal seam $c_8^в$ of the Dniprovska mine field had not been carried out before.

The purpose of the work is to investigate the features of the relationship between germanium, beryllium and fluoride concentrations in the coal seam $c_8^в$ of the Dniprovska mine.

The factual basis of the work was the results of 370 quantitative spectral analyzes of coal in the $c_8^в$ seam within the Dniprovska mine for germanium, beryllium and fluoride, performed after 1981 in the central certified laboratories of production geological exploration organizations of Ukraine from the material of reservoir samples obtained by production and research enterprises and organizations and the authors personally.

Ten percent of duplicate samples were sent to internal laboratory control. Twelve percent of duplicate samples were subjected to external laboratory control. The quality of the results of the analyzes (correctness and reproducibility) was evaluated as the significance of the average systematic error, which was tested using the Student's criterion, and the significance of the average random error, which in turn was tested using the Fisher test. Since all these errors at the significance level of 0.95 turned out to be insignificant, the quality of the analyzes was recognized as satisfactory.

First of all, analytical calculations of the correspondence of the empirical distributions of the studied elements to the normal distribution were performed. For this purpose, the Kolmogorov-Smirnov, Shapiro-Wilk, Lilliefors and Pearson xi-square agreement criterions were calculated. In all cases, the results of the

calculations confirmed the non-compliance of the studied samples with the normal or lognormal distribution law. Thus, for a more realistic assessment of the central tendency of the content of germanium, beryllium and fluoride, instead of the values of the arithmetic mean, it is necessary to use the median values.

Then the values of germanium, beryllium and fluoride content were normalized according to the formula:

$$X_{i\ norm.} = (X_i - X_{i\ min})/(X_{i\ max} - X_{i\ min}),$$

where $X_{i\ norm.}$ is the normalized unit value of the element content, X_i is the unit value of the element content, $X_{i\ min}$ is the minimum value of the element content, $X_{i\ max}$ is the maximum value of the element content.

In this way, the calculated normalized values of oil samples from each deposit were processed using the STATISTICA 11.6 program, in which the calculation of descriptive statistics, correlation and regression analyzes and graphical visualization of the results of the performed studies were performed.

Performing a correlation analysis between the contents of germanium and beryllium allowed to establish a direct weak relationship between the concentrations of these elements, which is 0.37. Based on the results of the regression analysis, a linear regression equation was calculated (the graph of the regression equation is shown in Fig. 1):

$$Ge = 0{,}1794 + 0{,}2967 \cdot Be.$$

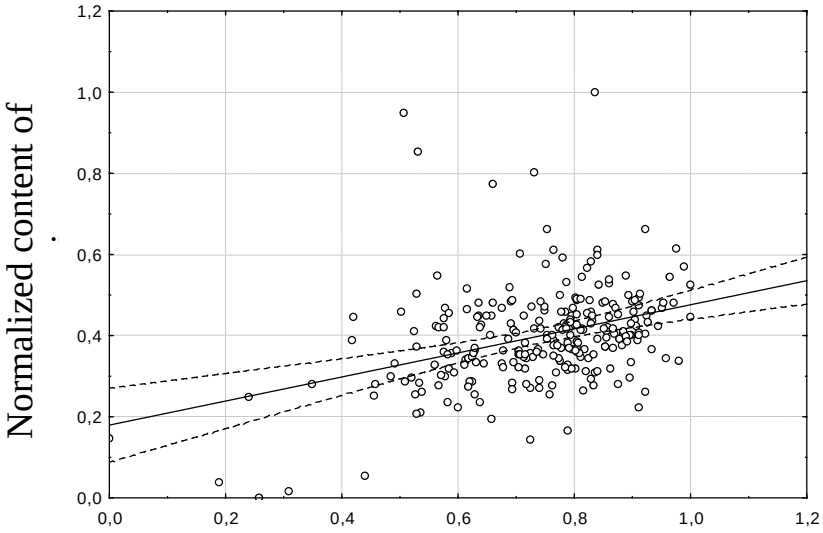

Fig. 1. Graph of regression equations between concentrations of germanium and beryllium

According to the results of the correlation analysis, a weak inverse relationship between germanium and fluoride concentrations was established, while the correlation coefficient is -0.36. According to the results of the regression analysis, a linear regression equation was calculated (the graph of the regression equation is shown in Fig. 2):

$$Ge = 0{,}4781 - 0{,}268 \cdot F.$$

In our opinion, the established weak but direct connection between germanium and beryllium indicates their joint accumulation in the contact zone of the coal seam, which occurs according to the "Zilbermints law".

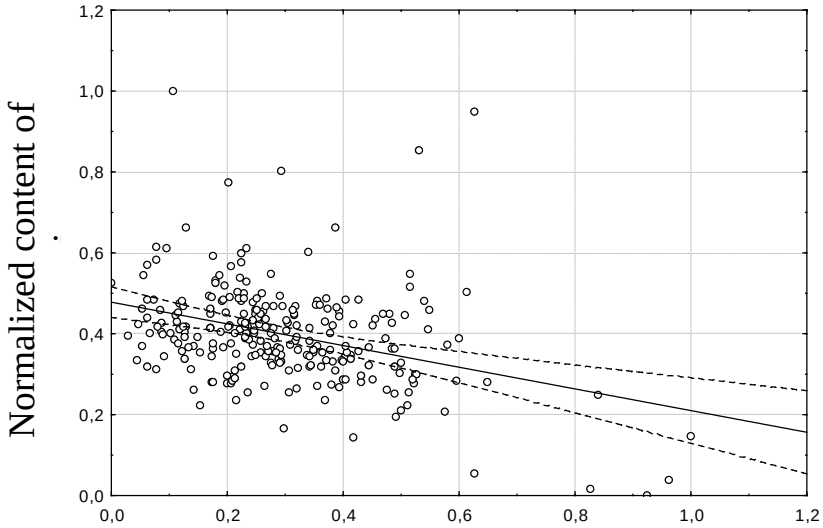

Fig. 2. Graph of regression equations between concentrations of germanium and fluoride

Conclusions. The analysis of the conducted studies shows: 1) the inconsistency of the empirical samples of the considered elements with the normal or lognormal distribution law, therefore, as a more realistic assessment of the central tendency of the contents of germanium, beryllium and fluoride, instead of the values of the arithmetic mean, it is necessary to use the median values; 2) the polymodality of the distribution of germanium, beryllium and fluoride is recorded, which, taking into account the geochemical features of these elements and their behavior in the general process of formation of the Donbas coal seam, allows us to assume the polygenicity of their accumulation in the coal seam; 3) an inverse weak relationship between the contents of germanium and fluoride, and a direct weak relationship between the concentrations of germanium and beryllium was established; 4) calculated regression equations make it possible to predict and interpret in geological terms the general trend of germanium concentration in the coal seam $c_8^в$ of the Dniprovska mine field by the content of fluoride and beryllium.

References

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