https:// doi.org/10.59911/conf.mpmgg.2024.9
UDC 550.42:553.94

FEATURES OF THE STATISTICAL RELATIONSHIP OF GERMANIUM WITH ASH CONTENT OF THE COAL SEAM C_4 «SAMARSKA» MINE OF WESTERN DONBAS

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The relationship between the germanium content and the ash content of coal seam c_4 of the Samarska mine in the Pavlohrad-Petropavlivka geological and industrial area of Western Donbas was studied and analyzed. The correlation coefficient between the germanium content and the ash content of the coal formally indicates the presence of a weak direct correlation. The analysis of the constructed graph of the regression equation between coal ash content and germanium concentration shows the complex character of this relationship, which is due to the mineral features of the phase composition of the inorganic component of coal.
Key words: germanium, coal seam, ash content of coal, regression equation, mine field.

ОСОБЛИВОСТІ СТАТИСТИЧНОГО ЗВ'ЯЗКУ ГЕРМАНІЮ ІЗ ЗОЛЬНІСТЮ ВУГІЛЬНОГО ПЛАСТА C_4 ШАХТИ «САМАРСЬКА» ЗАХІДНОГО ДОНБАСУ

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Досліджено та проаналізовано зв'язок між вмістом германію і зольністю вугілля пласта c_4 шахти Самарська Павлоградсько-Петропавлівського геолого-промислового району Західного Донбасу. Коефіцієнт кореляції між вмістом германію та зольністю вугілля пласта вказує формально на наявність слабкого прямого кореляційного зв'язку. Аналіз побудованого графіку рівняння регресії між зольністю вугілля та концентрацією германію свідчить про складний характер цього зв'язку, що обумовлений мінеральними особливостями фазового складу неорганічної складової вугілля.
Ключові слова: германій, вугільний пласт, зольність вугілля, рівняння регресії, поле шахти.

Coal is the most important source of germanium in Ukraine. For an objective geological and economic assessment of the possibility of simultaneous extraction of germanium from coal, waste and products of its processing and planning of the most effective organizational and technical measures in this regard, first of all it is necessary to have information about the character of the distribution and the level of concentration of this element in coal and coal-bearing rocks. In order to obtain such

information, detailed studies of the distribution of germanium over the area and in the cross-section of the coal seam c_4 of the Samarska mine field were performed.

The research relevance of the germanium content in coal seams is due to the possibility of its industrial extraction and use as a valuable accompanying component [1].

The special relevance of the conducted research is given by the decision of the National Security and Defense Council of Ukraine dated July 16, 2021 "About stimulating the search, extraction and enrichment of minerals that have strategic importance for the sustainable development and defense capability of the state" and the Decree of the President of Ukraine No. 306/2021, which implements this decision in effect. In these documents, Ge ores are included in the list of strategic importance for the sustainable development and defense capability of the state.

Analysis of previous studies. Previously, the peculiarities of the distribution of "small elements" that belong to the group of "toxic and potentially toxic elements" in the coal seams of some mines and geological and industrial areas of Donbas were investigated [2]. In work [3], the main regularities of the distribution of germanium over the area and in the cross-section of some coal seams of the Pavlohrad-Petropavlivka geological and industrial area of Donbas were considered.

The purpose of the research. This work is devoted to the establishment and analysis of the relationship between germanium concentrations and the ash content of coal seam c_4 of the "Samarska" mine.

Research methods. An important feature of geochemical research is the impossibility of directly observing the processes of migration of chemical compounds, their dispersion and concentration in geological objects at different hierarchical levels. In such cases, consideration of the dynamics of geochemical processes is traditionally performed by comparing statistical data and analyzing cartographic materials regarding the distribution of chemical elements and their compounds in the objects under consideration. Further, the obtained results are interpreted taking into account physico-chemical and geological features. That is, obtaining information about the distribution of chemical elements in geological objects is the first stage of research, which goes from the generalization of the actual material, through its theoretical understanding to the verification of the revealed regularities by research. Germanium content was determined by quantitative emission spectral analysis. With the help of Excel and Statistica 16.0 programs, at the initial stage of processing primary geochemical information, the values of the main descriptive statistical indicators were calculated, frequency histograms of the content were constructed and the germanium distribution law was established. The number of statistical "windows" was calculated according to the Sturges' formula. During the construction of graphs and calculation of correlation

coefficients, all values of germanium concentrations and coal ash content were normalized according to the formula:

$$X_{норм} = (X_i - X_{min}) / (X_{max} - X_{min}),$$

where, X_i is the result of a single determination of the concentration of the element, X_{max} - is the result of the maximum determination of the concentration of the element;

X_{min} - is the result of the minimum determination of the concentration of the element;

Rationing was carried out to bring the samples to one scale.

Research results and discussion. Within the field of the Samarska mine, the concentration of germanium in coal seam c_4 varies from 1.3 g/t to 23.5 g/t. The average arithmetic value of the germanium content in the seam is 7.3 g/t.

The correlation coefficient between the germanium and ash content of the seam is 0.22, which indicates the existence of a weak direct correlation between them according to the Chedok scale. It should be noted that despite its small value, this correlation coefficient, as in the previous case, is statistically significant at a confidence interval of 0.95. Linear regression equation that characterizes the relationship between these parameters: Ge = 0.2082 + 0.2293 x Ad (the graph of the equation is shown in Fig. 1). At the same time, we believe that the relationship between these indicators is more realistically characterized by the polynomial cubic regression model: Ge = 2226 + 0.5887 x Ad – 2.6995 x Ad2 +2.8339 x A^d3 (the graph of the equation is shown in Fig. 2).

When considering in detail the features of the distribution of germanium in coal seams, it is obvious that it is necessary to take into account the probable forms of this element.

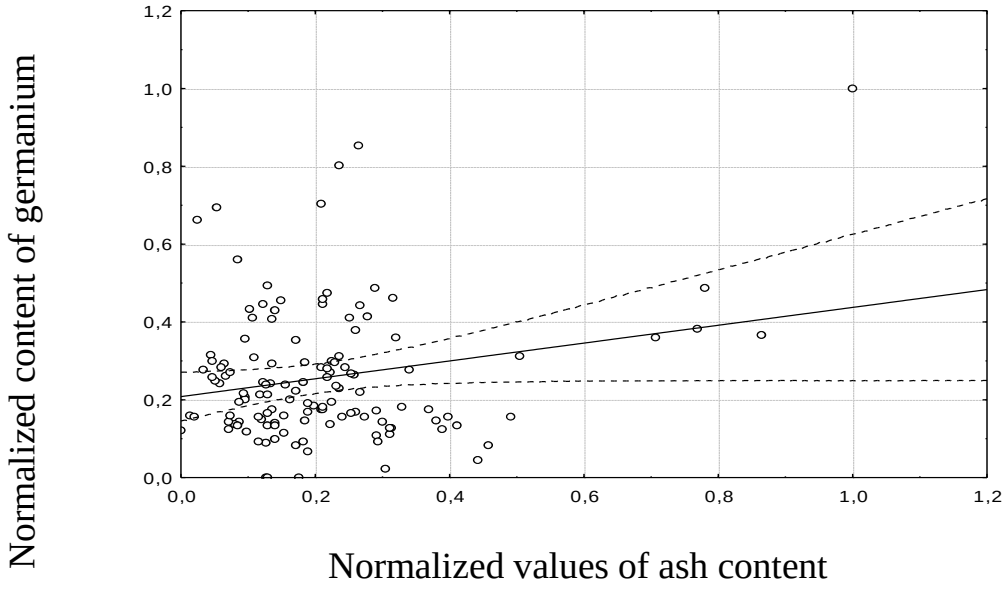

Fig. 1 Graph of the regression equation between the normalized concentrations of germanium and the normalized values of ash content of coal seam c_4 of the Samarska mine field (linear model)

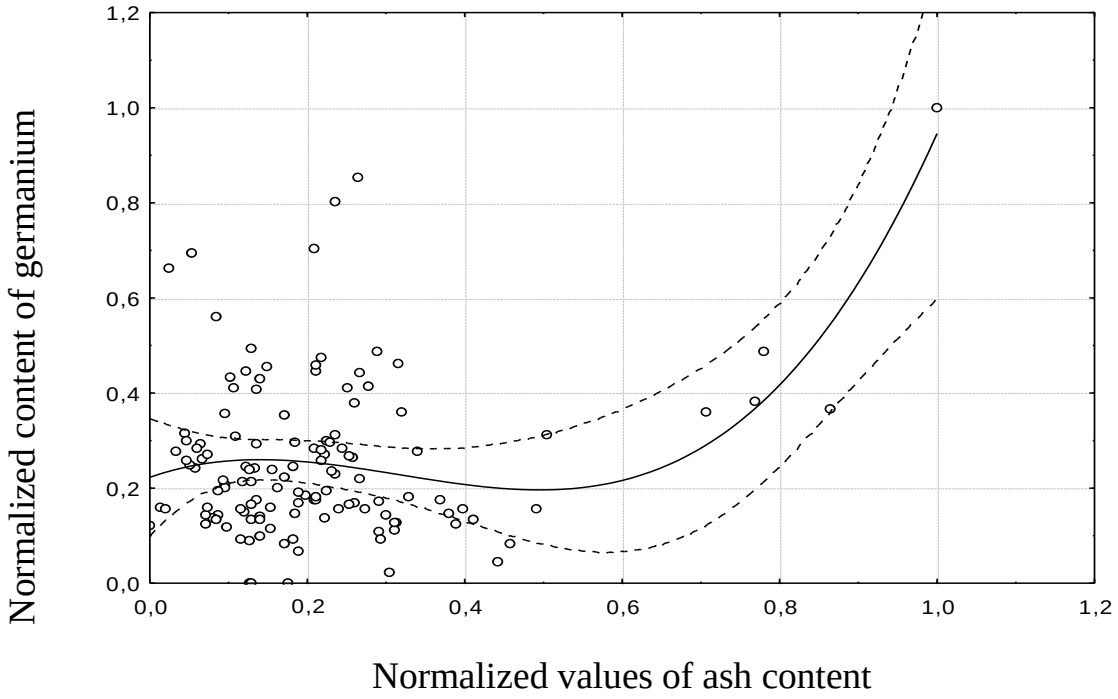

Fig. 2 Graph of the regression equation between the normalized concentrations of germanium and the normalized values of ash content of coal seam c_4 of the Samarska mine field (polynomial model)

Conclusions. The correlation coefficient between the germanium and coal ash content of the seam is equal to 0.22, which formally indicates the presence of a weak direct correlation between them. The analysis of the constructed graph of the regression equation between coal ash content and germanium concentration shows the complex character of this relationship, which is due to the mineral features of the phase composition of the inorganic component of coal. The calculated regression equations between the germanium content, thickness of the coal seam and the ash content of the coal will allow to predict its concentration in the coal seam. These equations can be used for short-term and medium-term forecasting of germanium content in mining mass extracted by mines.

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