Proceedings of the 5th International
Scientific and Practical Conference
«International Scientific Discussion:
Problems, Tasks and Prospects»

(September 19-20, 2022).
Brighton, Great Britain

No
125

GEOLOGY, MINERALOGY AND SOIL SCIENCE

DOI 10.51582/interconf.19-20.09.2022.014

Creation of natural typing of sections of different thickness of the C_8^H coal seam of the «Dniprovska» mine (Ukraine) according to the germanium content

Ishkov Valerii Valeriiovych[1], Kozii Yevhen Serhiiovych[2], Kozar Mykola Antonovych[3], Chernobuk Oleksandr Ivanovych[4], Pashchenko Pavlo Serhiiovych[5], Dreshpak Oleksandr Stanislavovych[6], Diachkov Pavlo Anatoliiovych[7], Vladyk Danyil Volodymyrovych[8]

[1] Candidate of Geological and Mineralogical Sciences, Associate Professor,
Department of Geology and Mineral Prospecting
Dnipro University of Technology, Ukraine;
Senior Research Fellow, Laboratory of Studies of Structural Changes Rocks
M.S. Polyakov Institute of Geotechnical Mechanics of the NAS of Ukraine; Ukraine

[2] Candidate of Geological Sciences, Director of Educational and Scientific
Center for Training of Foreign Citizens;
Dnipro University of Technology, Ukraine;
Associate Professor of the Department of Civil Engineering,
Construction Technologies and Environmental Protection;
Dnipro State Agrarian and Economic University, Ukraine

[3] Senior Research Fellow, Candidate of Geological Sciences,
M.P. Semenenko Institute of Geochemistry;
Mineralogy and Ore Formation of the NAS of Ukraine; Ukraine

[4] Deputy Director of Department of Strategic Production Planning;
Georgian Manganese; Georgia

[5] Candidate of Geological Sciences, Senior Research Fellow,
Laboratory of Studies of Structural Changes Rocks;
M.S. Polyakov Institute of Geotechnical Mechanics of the NAS of Ukraine; Ukraine

[6] Candidate of Technical Sciences (Ph.D), Associate Professor;
Department of Technological Engineering of Materials Processing;
Dnipro University of Technology; Ukraine

[7] Senior Lecturer;
Department of Transport Systems and Technology;
Dnipro University of Technology; Ukraine

[8] Student;
Department of Geology and Mineral Prospecting;
Dnipro University of Technology; Ukraine

Proceedings of the 5th International Scientific and Practical Conference «International Scientific Discussion: Problems, Tasks and Prospects»

(September 19-20, 2022). Brighton, Great Britain

No 125

GEOLOGY, MINERALOGY AND SOIL SCIENCE

Abstract.
The method of creating an objective (natural) typification of sections of the coal seam of the Dniprovska mine of different capacities according to germanium concentrations has been established and substantiated. The constructed dendrograms of clustering of coal seam areas by Ge content can be used as a basis for developing a natural typification of coal seams for geological and economic evaluation. This will make it possible to make maximum use of already available information and interpret the obtained results in geological and genetic concepts, which provides the possibility of its use for the complex use of mineral raw materials, solving strategic issues of sustainable development of Ukraine.

Keywords:
Germanium
Dendrogram
coal seams
clusters
enrichment zones

Proceedings of the 5th International Scientific and Practical Conference «International Scientific Discussion: Problems, Tasks and Prospects»

(September 19-20, 2022). Brighton, Great Britain

No 125

GEOLOGY, MINERALOGY AND SOIL SCIENCE

The relevance of research the content of germanium in coal seams is due to the possibility of its industrial extraction and use as a valuable accompanying component. Currently, coal is the main estimated source of Ge in Ukraine, China, Uzbekistan, as well as in Russia. Ge coal deposits are developed in England, Canada, USA, Ukraine, Russia, etc.

The research carried out is particularly relevant to the decision of the National Security and Defense Council of Ukraine dated July 16, 2021 "On stimulating the search, extraction and enrichment of minerals that are of 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 decision is 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.

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, it is first of all necessary to have information about the nature of distribution and the level of concentration of this element in coal. In order to obtain such information, the authors carried out detailed studies of the distribution of germanium over the area and in the cross-section of the coal seam $c_8^н$ of the Dniprovska mine field.

Recent achievements. 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 [1-79]. The methods of natural typification of coal deposits by the content of accompanying elements and oil deposits of the Dnipro-Donetsk Basin by the content of metals were substantiated. At the same time, the analysis of the methods of objective (natural) typification of coal seam areas of different strength according to Ge concentrations in the coal seam has not been performed before.

Purpose of the research. To establish and substantiate the most effective method of creating an objective (natural) typification of sections of the coal seam of the Dniprovska

GEOLOGY, MINERALOGY AND SOIL SCIENCE

mine of different thickness according to Ge concentrations.

Research methods. The factual basis of the work was the results of 370 Ge analyzes performed after 1981 in the central certified laboratories of production geological exploration organizations of Ukraine from the material of seam samples obtained by production and scientific research enterprises and organizations and measurements of seam thickness. In a number of cases, they were supplemented with analyzes of seam samples taken by the furrow method from duplicate cores and mining operations with the participation of the authors and employees of the geological service of the coal mining enterprise and production geological exploration organizations in the period from 1981 to 2013.

Ge content was determined by quantitative emission spectral analysis. 7% of duplicate samples were sent to internal laboratory control. 10% 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 is tested using the Student's criterion, and the significance of the average random error, which is tested using the Fisher criterion. Since the above-mentioned errors at the significance level of 0.95 are not significant, the quality of the analyzes is recognized as satisfactory.

With the help of Excel 2016 and Statistica 13.3 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 distribution law of germanium was established. During the construction of the graphs, all values of Ge concentrations and thickness of the seam were normalized to bring the sample to the same scale regardless of the units of measurement and the scale of the samples.

As is known, the typification procedure is the systematization of objects according to a priori given features. Cluster analysis, taxonomy, pattern recognition, and factor analysis are usually used for this purpose.

It is important that, unlike other methods used in solving typification problems, cluster analysis does not require a priori assumptions about the data set, which does not impose

GEOLOGY, MINERALOGY AND SOIL SCIENCE

restrictions on the presentation of the studied objects, allows analyzing natural indicators of various types of data (interval data, frequencies, binary data, etc.). The use of cluster analysis for the purpose of typification has a number of advantages, as it allows the division of a large number of studied objects and features into groups or clusters that are homogeneous in the appropriate sense, as well as to reveal the internal structure (at different hierarchical levels) of the sample population. At the same time, like any other method, cluster analysis has certain disadvantages. In particular, the composition and number of clusters depends on the selected grouping criteria ("classification strategies"), and the application of different methods corresponding to different conceptual approaches to the selection of taxa to the same samples can lead to significantly different results. Thus, a characteristic feature of cluster analysis, unlike other methods of multivariate statistics, is the strong dependence of the obtained results on the a priori assumptions of the researcher at the substantive level. In our case, a priori assumptions include: lack of hypotheses regarding the number of clusters, their structure on forms; achieving maximum visualization of the breakdown of coal seam sections of different capacity by classes at different scale levels; establishment of a clustering method (algorithm) for the most stable division of the entire set of samples under consideration.

In the cluster analysis, it is considered that: a) the selected characteristics allow, in principle, the desired division into clusters; b) units of measurement (scale) are chosen correctly. Thus, the choice of scale in classification procedures plays a significant role. To bring the raw data to the same scale, we normalize it, which is what we did.

To achieve the goal set in the work, in the process of research, clustering was carried out using various methods, which are implemented in the most popular professional statistical software platforms "STATISTICA" and "SPSS"; their analysis was performed and the choice of the most optimal of them was substantiated.

Excel 2016, Statistica 13.3 and IBM SPSS Statistics 22 versions were used in the work.

GEOLOGY, MINERALOGY AND SOIL SCIENCE

Research and Discussion. In order to develop a methodology for choosing the most effective method of creating an objective (natural) typification of coal seam sections of different strength according to Ge concentrations, the general sample, taking into account the number of samples, was divided into 10 private samples, the main characteristics of which are shown in Table 1.

To perform cluster analysis in the professional software platforms "STATISTICA" and "SPSS" a family of hierarchical agglomerative methods, two-input unification and iterative divisive method of averages is proposed.

Table 1

Main characteristics of private samples of Ge contents

Private samples	1	2	3	4	5	6	7	8	9	10
thickness interval, m	≤ 0,45	0,45 – 0,50	0,50 – 0,55	0,55 – 0,60	0,60 – 0,65	0,65 – 0,70	0,70 – 0,75	0,75 – 0,80	0,80 – 0,85	≥ 0,85
Number of samples	35	40	35	19	26	44	58	47	27	22
Normalized median values of Ge content	0,73	0,60	0,48	0,44	0,34	0,28	0,22	0,18	0,14	0,12

The two-input unification method is relatively rarely used for simultaneous clustering of both observations and variables. In this case, it is expected that both observations and variables simultaneously contribute to the detection of clusters, which are further interpreted in geological terms. The main imperfection of the method are problems with the conceptual interpretation of the results, which are a consequence of the fact that the distance between different clusters can be determined by differences in variables. The problematic nature of the conceptual interpretation of the results of the analysis does not allow for its use as an optimal method of solving the task of typing.

The use of the iterative divisive method of K-means for the optimal typification of sites by Ge content also has

GEOLOGY, MINERALOGY AND SOIL SCIENCE

significant imperfections. It is characterized by the problem of suboptimal solutions inherent in all iterative divisive methods, which consist in sometimes unsuccessful initial divisions of sample populations. Its use implies the existence of a priori hypotheses regarding the number of clusters, and the result of clustering, presented in the form of a system of tables, does not allow to clearly and unambiguously identify and visualize the typification structure. The indicated shortcomings of the method do not allow it to be considered as optimal for the typing of seam sections by Ge content.

The family of hierarchical unifying methods implemented in the used programs refers to the most frequently used methods of cluster analysis. All of them consist of a sequential combination of the most similar objects, which can be visualized in the form of a tree diagram - a dendrogram (which graphically displays the hierarchical structure of the object similarity matrix). This clarity of clustering results is a significant advantage of these methods. As a rule, the objects that are clustered are indicated horizontally in the dendrogram, and the value of the interclass distances at which they are combined (merging coefficient or the merging distance) is indicated vertically. At the same time, as a result of the analysis, non-overlapping groups of clusters are formed, and each cluster is an element of a wider cluster at a higher level of similarity. According to the method of grouping, all hierarchical agglomerative methods in the used programs are divided into the following: the method of single connection ("nearest neighbor"); full connection method ("farthest neighbor"); varieties of the "average link" method - the unweighted "average link" method ("unweighted pairwise average") and the weighted "average link" method; weighted centroid method and Ward's method. In addition, interclass distances can be used in all of the above methods - Euclidean distance (or its square), Manhattan distance ("distance of city blocks"), Chebyshev and Minkovskyi metrics, linear correlation coefficient. With regard to the features of the solved grouping problem, the most optimal is the use of the Euclidean distance as a measure of similarity.

Let us consider in more detail the possibilities of using

GEOLOGY, MINERALOGY AND SOIL SCIENCE

hierarchical agglomerative clustering methods for the construction of typification of seam sections by Ge content.

The single connection method forms clusters based on the principle of having at least one connection between objects. As a result of the operation of this method, clusters appear as long "chains" "linked together" only by individual elements that happened to be closer than others to each other. Despite the fact that its results are invariant to monotonic transformations of the similarity matrix and the use of the method does not limit the presence of "coincidence" in the data, its practical application for the purpose of typing causes certain difficulties.

On the example of the results of the clustering of deposits by Ge content (Fig. 1), it can be seen that the entire set of deposits, as it approaches the end of the clustering process, forms clusters 1 and 2, which in turn consist of the correspondingly nested subclusters 1.1, 1.2, 1.1.1, 1.1 .2, etc. Analysis of fig. 1 does not allow to determine the number and structure of clusters contained in the source data, and it also significantly complicates the establishment of the number and structure of clusters at other scale levels.

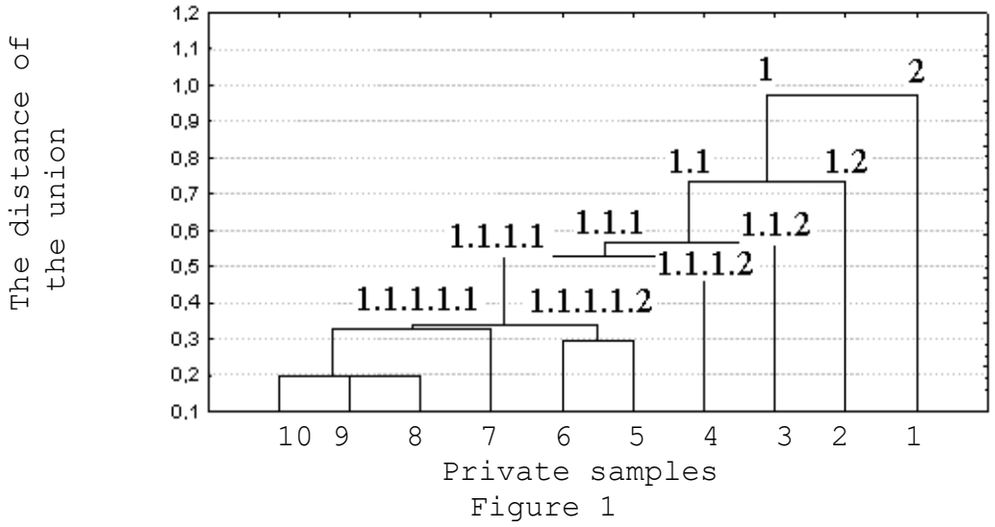

Figure 1

Dendrogram of the results of clustering by the method of single connection of areas by Ge content. Legend: 1, 2, 1.1, 1.2, 1.1.1, 1.1.2, 1.1.1.1, 1.1.1.2, 1.1.1.1.1, 1.1.1.1.2 – clusters

GEOLOGY, MINERALOGY AND SOIL SCIENCE

The full connection method (Fig. 2), unlike the method discussed above, imposes stricter requirements for combining objects into one cluster. In this case, there is a tendency to detect relatively compact hyperspherical (in multidimensional space) clusters combining similar objects. Here, the distances between clusters are determined by the largest distance between any two objects in different clusters (ie, the most distant neighbors).

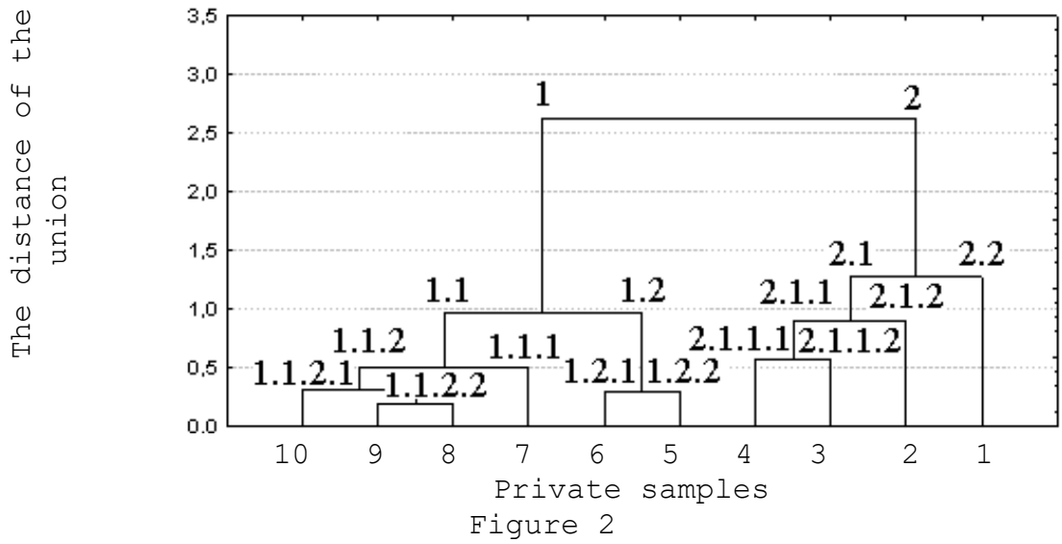

Figure 2

Dendrogram of the results of clustering by the method of complete connection of areas by Ge content. Legend: 1, 2, 1.1, 1.2, 1.1.1, 1.1.2, 1.1.2.1, 1.1.2.2, 1.2.1., 1.2.2, 2.1, 2.2, 2.1.1, 2.1.2, 2.1.1.2, 2.1.1.1 – clusters

Comparison of Fig. 1 from Fig. 2 allows us to reveal a number of advantages of clustering using the method of complete connections. At the same time, if the dendrogram obtained during clustering by the method of single linkage quite convincingly indicates the number and structure of clusters (Fig. 1), then when clustering by the method of complete linkages, there is some change in the areas between clusters and in general, when comparing the results of both methods of identifying the final structure and number of deposits in clusters (Fig. 1, Fig. 2) are not so obvious. In addition, in both cases, the use of only the dendrogram

GEOLOGY, MINERALOGY AND SOIL SCIENCE

without the involvement of primary data makes it difficult to assign individual objects to one or another cluster, and the structure of the clusters itself is rather poorly revealed.

The "average connection" method was developed by Sokel and Minchener in 1958 as a compromise between the single and full connection methods. In version STATISTICA 13.3 and IBM SPSS Statistics 22, two varieties of the method are implemented: the unweighted "linkage average" method ("unweighted pairwise average") and the weighted "linkage average" method. In the first variant of the method, the distance between two clusters is calculated as the average distance between all pairs of objects in them, and in the second, in addition, the size of the clusters (ie, the number of objects contained in them) is used as a weighting factor. Using the number of objects contained in a cluster as a weighting factor assumes "good quality" of the analysis in the presence of clusters of unequal size in the sample. The results of the clustering of reservoir sections by Ge content by both methods in the form of dendrograms are shown in Fig. 3 and fig. 4. The analysis of the given dendrograms allows us to come to the conclusion that in the case of the division of reservoir sections by Ge content, the results of the cluster analysis, respectively, by the methods of unweighted average connection and weighted average connection, in our case, completely coincide.

The weighted centroid method uses the distance between their centers of gravity as the distance between clusters (objects). In fig. 5 shows a dendrogram of the results of clustering by the weighted centroid median method of reservoir sections by Ge content. The analysis of this dendrogram, in contrast to the ones presented earlier (Fig. 1, Fig. 2, Fig. 3 and Fig. 4), allows not only to achieve the most stable division of the entire set of areas under consideration, but also to maximize the visualization of the division of objects by classes into at different scale levels in the absence of a priori hypotheses regarding the number of clusters and their shape.

At the same time, the presence and structure of clusters is clearly distinguished, regardless of the large-scale level of their formation, the sequence of unification of individual deposits and their groups into the resulting cluster is clearly traced.

GEOLOGY, MINERALOGY AND SOIL SCIENCE

The presence of these advantages in this case makes it possible to make maximum use of already existing information for the development of natural typifications of areas of coal seams according to Ge content and to interpret the obtained results in geological terms.

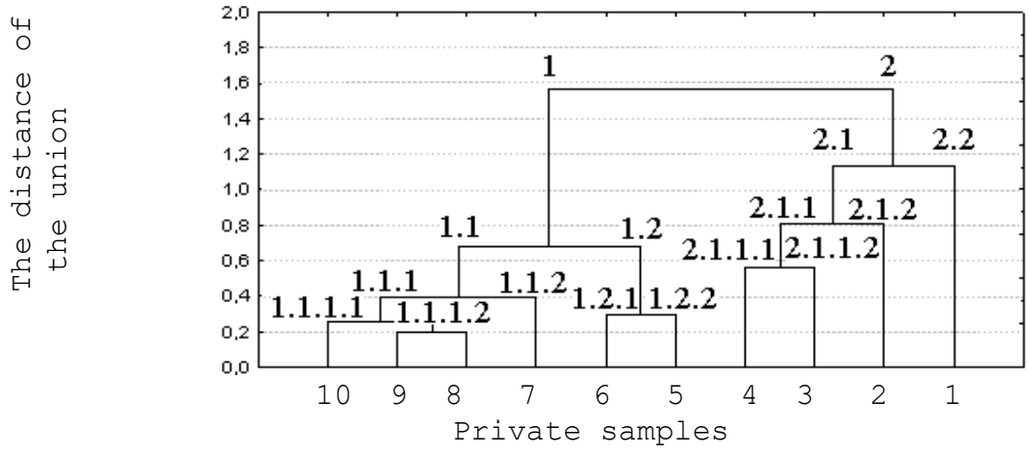

Figure 3

Dendrogram of the results of clustering by the method of unweighted average connection of plots by Ge content. Legend: 1, 2, 1.1, 1.2, 1.1.1, 1.1.2, 1.1.1.1, 1.1.1.2, 1.2.1., 1.2.2, 2.1, 2.2, 2.1.1, 2.1.2, 2.1.1.2, 2.1.1.1 – clusters

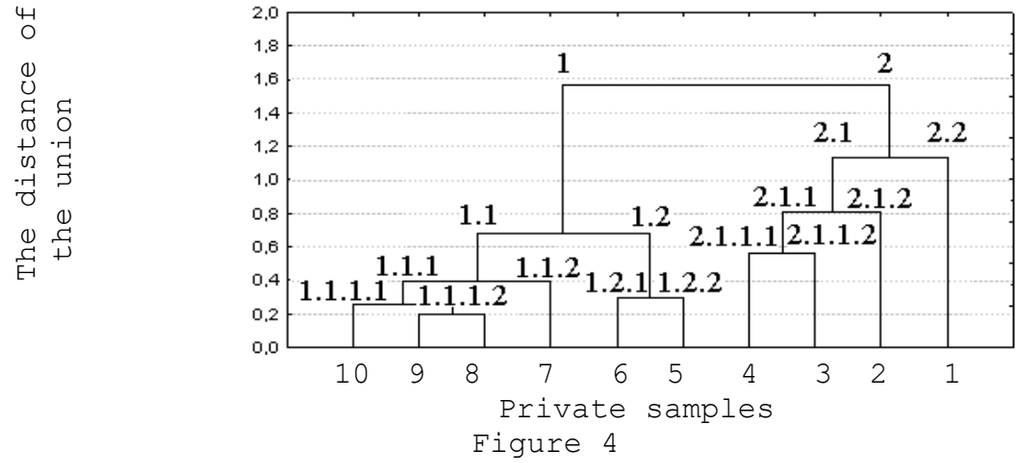

Figure 4

Dendrogram of the results of clustering by the method of weighted average connection of plots by Ge content. Legend: 1, 2, 1.1, 1.2, 1.1.1, 1.1.2, 1.1.1.1, 1.1.1.2, 1.2.1, 1.2.2, 2.1, 2.2, 2.1.1, 2.1.2, 2.1.1.2, 2.1.1.1 – clusters

GEOLOGY, MINERALOGY AND SOIL SCIENCE

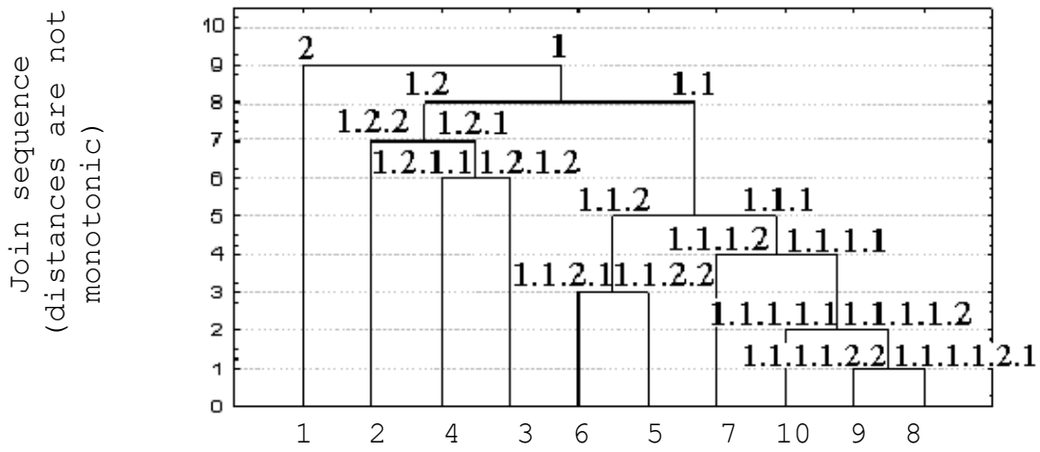

Figure 5

Dendrogram of the results of clustering by weighted centroid median method of plots by Ge content. Legend: 1, 2, 1.1, 1.2, 1.1.1, 1.1.2, 1.1.1.1, 1.1.1.2, 1.2.1, 1.2.2, 1.2.1.1, 1.1.2.1, 1.1.2.2, 1.1.1.1.1, 1.1.1.1.2, 1.1.1.1.2.1, 1.1.1.1.2.2 – clusters

Conclusion. As a result of the conducted research, it was established that the use of the weighted centroid median method of cluster analysis, which is implemented in the professional statistical software platforms "STATISTICA" and "SPSS", is the most optimal for the subjectivity-free researcher of the division of coal seam sections by Ge content into the appropriate taxa.

The constructed dendrograms of clustering of coal seam areas by Ge content can be used as a basis for developing a natural typification of coal seams for geological and economic evaluation. This will make it possible to make maximum use of already available information and interpret the obtained results in geological and genetic concepts, which provides the possibility of its use for the complex use of mineral raw materials, solving strategic issues of sustainable development of Ukraine.

References:

[1] Kozii Ye.S., Ishkov V.V. (2017). Coal classification of main working seams of Pavlohrad-Petropavlivka geological and industrial district on content of toxic and potentially toxic elements. Collection of

GEOLOGY, MINERALOGY AND SOIL SCIENCE

scientific works "Geotechnical Mechanics". No. 136, pp. 74-86.

[2] Ишков В.В., Козий Е.С. (2014). О классификации угольных пластов по содержанию токсичных элементов с помощью кластерного анализа. Збірник наукових праць НГУ. № 45. С. 209-221.

[3] Ішков В.В., Козій Є.С. (2019). Кластерний аналіз вмісту токсичних і потенційно токсичних елементів у вугільних пластах Красноармійського геолого-промислового району Донбасу. Матеріали міжнародної науково-технічної конференції «Форум гірників». С. 241-251.

[4] Kozii Ye.S. (2021). Toxic elements in the c_1 coal seam of the Blahodatna mine of Pavlohrad-Petropavlivka geological and industrial area of Donbas. Geo-Technical Mechanics, No.158, pp.103-116. https://doi.org/10.15407/geotm2021.158.103

[5] Koziy, E.S. (2018). Arsenic, beryllium, fluorine and mercury in the coal of the layer $c_8^в$ of the «Dniprovska» mine of Pavlogradsko-Petropavlovskiy geological and industrial district. Dnipropetrovsk University Bulletin Series-Geology Geography. Vol. 26. No. 1, pp. 113-120. https://doi.org/10.15421/111812

[6] Nesterovskyi V., Ishkov V., Kozii Ye. (2020). Toxic and potentially toxic elements in the coal of the seam $c_8^н$ of the "Blagodatna" mine of Pavlohrad-Petropavlivka geological and industrial area. Visnyk Of Taras Shevchenko National University Of Kyiv: Geology, 88(1), 17-24. http://doi.org/10.17721/1728-2713.88.03

[7] Козій Є.С. (2020). Хром у вугіллі пласта c_4^2 шахти «ім. М.І. Сташкова». Регіональні проблеми охорони довкілля. Матеріали Міжнародної наукової конференції молодих вчених. Одеса: ОДЕКУ, 2020. С. 80-85.

[8] Козій Є.С. (2020). Розподіл марганцю у вугільному пласті c_5 шахти «Благодатна». Матеріали Всеукраїнської наукової on-line конференції «Сучасні проблеми екології», Житомир: Житомирська політехніка. С. 86-87.

[9] Kozar M.A., Ishkov V.V., Kozii E.S., Strielnyk Yu.V. (2021). Toxic elements of mineral and organic composition of lower carbon coal Western Donbas. Geological science in independent Ukraine: Abstracts of Scientific Conference (Kyiv, September 8-9, 2021) / NAS of Ukraine, M.P. Semenenko Institute of Geochemistry, Mineralogy and Ore Formation. – Kyiv, pp.55-58.

[10] Ишков В.В., Козий Е.С. (2014). О распределении золы, серы, марганца в угле пласта c_4 шахты «Самарская» Павлоград-Петропавловского геолого-промышленного района. Збірник наукових праць НГУ. № 44, С. 178-186.

[11] Ишков В.В., Козий Е.С. (2013). Новые данные о распределении токсичных и потенциально токсичных элементов в угле пласта $c_6^н$ шахты «Терновская» Павлоград-Петропавловского геолого-промышленного района. Збірник наукових праць НГУ. № 41, С. 201-208.

[12] Ishkov V.V., Koziy E.S., Lozovoi A.L. (2013). Definite peculiarities of toxic and potentially toxic elements distribution in coal seams of Pavlograd-Petropavlovka region. Collection of scientific works of

GEOLOGY, MINERALOGY AND SOIL SCIENCE

NMU, no. 42, pp. 18-23.
[13] Kozii Ye.S. (2021). Arsenic, mercury, fluorine and beryllium in the c1 coal seam of the Blahodatna mine of Pavlohrad-Petropavlivka geological and industrial area of western Donbas. Geo-Technical Mechanics. no. 159. pp. 58-68. https://doi.org/10.15407/geotm2021.159.058
[14] Ишков В.В., Козий Е.С. (2013). О распределении токсичных и потенциально-токсичных элементов в угле пласта $c_6^н$ шахты «Терновская» Павлоград-Петропавловского геолого-промышленного района. Матеріали міжнародної конференції «Форум гірників». ДВНЗ «НГУ». Дніпро. С. 49-55.
[15] Ishkov V.V., Kozii Ye.S. (2022). Nickel distribution in the oils of the Dnipro-Donetsk basin. Сборник научных трудов III Международной научно-практической конференции «Современные тенденции геологоразведочной и нефтяной инженерии». Алматы. С. 161-166.
[16] Козій Є.С., Бордальова А.Ю. (2022). Аналіз розповсюдження ртуті у вугільному пласті $c_7^н$ поля шахти «Павлоградська» Дніпропетровської області. VII Міжнародний молодіжний конгрес. Сталий розвиток: захист навколишнього середовища. Енергоощадність. збалансоване природокористування. С. 53. https://doi.org/10.51500/7826-04-9
[17] Ishkov V.V., Koziy E.S. (2017). Distribution of toxic and potentially toxic elements in the coal of the layer $c_7^н$ of the "Pavlogradskaya" mine of Pavlogradsko-Petropavlovskiy geological and industrial district. Visnyk Of Taras Shevchenko National University Of Kyiv-Geology, 4(79), 59-66. https://doi.org/10.17721/1728-2713.79.09
[18] Mametova L.F., Mirek A., Kozii Ye.S. (2020). Pyritization of the Middle Carboniferous Sandstones of the Donbas. Mineral. Journ. (Ukraine). No. 42(2). pp. 14-19. https://doi.org/10.15407/mineraljournal.42.02.014
[19] Ishkov V., Kozii Ye. (2020). Distribution of mercury in coal seam $c_7^н$ of Pavlohradska mine field. Scientific Papers of DONNTU Series: "The Mining and Geology". No. 1(23)-2(24), pp. 26-33. https://doi.org/10.31474/2073-9575-2020-3(23)-4(24)-26-33
[20] Козий Е.С., Науменко Н.А., Кенжегалиева Ж.М., Музапарова А.Б. (2020). Прогноз зон повышенной трещиноватости в угольных пластах по содержанию ртути и мышьяка на примере пласта $c_8^в$ шахты «Днепровская» (Западный Донбасс). Сборник научных трудов международной научно-практической конференции «Современные тенденции геологоразведочной и нефтяной инженерии». Алматы. С. 140-144.
[21] Koziy E.S. (2017). Peculiarities of distribution of toxic and potentially toxic elements in the coal of the layer $c_{10}^в$ in the Stashkov mine of Pavlograd-Petropavlovsk geological and industrial district. Collection of scientific works "Geotechnical Mechanics". No. 132, pp. 157-172.
[22] Ishkov V.V., Koziy E.S. (2017). About peculiarities of distribution of toxic and potentially toxic elements in the coal of the layer $c_{10}^в$ of the Dneprovskaya mine of Pavlogradsko-Petropavlovskiy geological and industrial district of Donbass. Collection of scientific works

GEOLOGY, MINERALOGY AND SOIL SCIENCE

"Geotechnical Mechanics". No. 133, pp. 213-227.

[23] Ишков В.В., Козий Е.С. (2021). Накопление Co и Mn на примере пласта c_5 Западного Донбасса как результат их миграции из кор выветривания Украинского кристаллического щита. Материалы XVI Международного совещания по геологии россыпей и месторождений кор выветривания «Россыпи и месторождения кор выветривания XXI века: задачи, проблемы, решения». С. 160-162.

[24] Козар М.А., Ішков В.В., Козій Є.С., Стрєльник Ю.В. (2021). Токсичні елементи мінеральної та органічної складової вугілля нижнього карбону Західного Донбасу. Геологічна наука в незалежній Україні: Збірник тез наукової конференції. – С. 55-58.

[25] Козій Є.С., Бордальова А.Ю. (2022). Аналіз розповсюдження ртуті у вугільному пласті $c_7^н$ поля шахти «Павлоградська» Дніпропетровської області. VII Міжнародний молодіжний конгрес. С. 53. https://doi.org/10.51500/7826-04-9

[26] Ishkov V.V., Kozii Ye.S., Chernobuk O.I., Lozovyi A.L. (2022). Results of dispersion and spatial analysis of the germanium distribution in coal seam $c_8^в$ of Zahidno-Donbaska mine field (Ukraine). Proceedings of the XXVIII International Scientific and Practical Conference. «Science and practice, actual problems, innovations», July 19 – 22, 2022, Milan, Italy, pp. 66-73. https://doi.org/10.46299/ISG.2022.1.28

[27] Козий Е.С. (2020). Анализ распространения бериллия и фтора в угольном пласте $c_8^н$ поля шахты «Днепровская» (Западный Донбасс). Сборник научных трудов международной научно-практической конференции «Современные тенденции геологоразведочной и нефтяной инженерии». Алматы. С. 17-22.

[28] Ішков В.В., Козій Є.С., Сливний С.О. (2021). Про розподіл германію у вугільному пласті $c_8^в$ поля шахти «Західно-Донбаська». Матеріали XIX Міжнародної конференції молодих вчених «Геотехнічні проблеми розробки родовищ». С. 27-32.

[29] Ishkov V.V., Kozii Ye.S., Chernobuk O.I., Pashchenko P.S., Lozovyi A.L. (2022). Results of correlation and regression analysis of germanium concentrations with thickness and ash content of coal seam $c_8^в$ of Dniprovska mine field (Ukraine). Proceedings of the XXIX International Scientific and Practical Conference «Trends in science and practice of today», July 26 – 29, 2022, Stockholm, Sweden, pp. 95-104. https://doi.org/10.46299/ISG.2022.1.29

[30] Ishkov V.V., Kozii Ye.S., Chernobuk O.I., Pashchenko P.S., Lozovyi A.L. (2022). Analysis of the spatial distribution of germanium in the coal seam $c_8^н$ of Dniprovska mine field (Ukraine) // The newest problems of science and ways to solve them. Proceedings of the XXX International Scientific and Practical Conference. Helsinki, Finland. 2022. pp. 11-15. DOI: 10.46299/ISG.2022.1.30

[31] Козій Є.С. (2020). Особенности прогноза устойчивости углевмещающих пород по комплексу геолого-геофизических методов. Сборник научных трудов II Международной научно-практической конференции «Современные тенденции геологоразведочной и нефтяной инженерии». Алматы.

GEOLOGY, MINERALOGY AND SOIL SCIENCE

С. 19-25.

[32] Kozar, M.A., Ishkov, V.V., Kozii, Ye.S., Pashchenko P.S. (2020). New data about the distribution of nickel, lead and chromium in the coal seams of the Donetsk- Makiivka geological and industrial district of the Donbas. Journ. Geol. Geograph. Geoecology. No. 29(4), pp. 722-730. http://doi: 10.15421/112065

[33] Козій Є.С. (2020). Марганець у вугільному пласті c_4^2 шахти «ім. М.І. Сташкова». Матеріали Всеукраїнської науково-практичної on-line конференції «Геотехнології гірництва та промислова екологія». Житомир. С. 228.

[34] Ishkov V.V., Kozii Ye.S. (2020). Peculiarities of lead distribution in coal seams of Donetsk-Makiivka geological and industrial area of Donbas. Tectonics and Stratigraphy. No. 47, pp. 77-90. https://doi.org/10.30836/igs.0375-7773.2020.216155

[35] Козій Є.С. (2020). Анализ распространения кобальта в угольном пласте c_1 поля шахты «Благодатная» (Западный Донбасс). Сборник научных трудов II Международной научно-практической конференции «Современные тенденции геологоразведочной и нефтяной инженерии». Алматы. С. 42-46.

[36] Ішков В.В., Козій Є.С., Кисельова М.Д., Стрєльник Ю.В. (2021). Про розподіл берилію у вугільному пласті k_5 ВП «Шахта «Капітальна» ДП «Мирноградвугілля». Міжнародна науково-практична конференція «Технології і процеси в гірництві та будівництві». ДонНТУ. – С.126-133.

[37] Ішков В.В., Козій Є.С. (2020). Особливості прогнозу стійкості вуглевміщуючих порід по комплексу геолого-геофізичних методів. Матеріали І Міжнародної наукової конференції «Сучасні проблеми гірничої геології та геоекології». С. 27-30.

[38] Kozii Ye. (2019). Classification of coal seams of the Krasnoarmiyskiy geological and industrial area of Donbas by the content of toxic and potentially toxic elements // Materials of the International Scientific & Practical Conference "Physical & Chemical Geotechnologies – 2019", Dnipro, P. 34-35.

[39] Ішков В.В., Козій Є.С., Стрєльник Ю.В. (2021). Результати досліджень розподілу кобальту у вугільному пласті k_5 поля ВП «шахта «Капітальна»». Збірник праць Всеукраїнської конференції «Від мінералогії і геогнозії до геохімії, петрології, геології та геофізики: фундаментальні і прикладні тренди XXI століття» (MinGeoIntegration XXI). С. 178-181.

[40] Козій Є.С. (2019). Розподіл нікелю, свинцю та хрому у вугільних пластах Донецько-Макіївського геолого-промислового району Донбасу. Матеріали VII Всеукраїнської науково-технічної конференції студентів, аспірантів та молодих вчених «Молодь, наука та інновації». Т.8 С. 4-5.

[41] Ішков В.В., Козій Є.С. (2019). Особливості розподілу токсичних і потенційно токсичних елементів в основних вугільних пластах по розрізу Красноармійського геолого-промислового району Донбасу. Матеріали міжнародної науково-технічної конференції «Проблеми

GEOLOGY, MINERALOGY AND SOIL SCIENCE

розвитку гірничо-промислових районів». С. 3 -14.

[42] Козій Є.С. (2020). Розподіл марганцю у вугільному пласті c_5 шахти «Благодатна». Матеріали Всеукраїнської наукової on-line конференції «Сучасні проблеми екології». Житомир. С. 86-87.

[43] Kozii Ye. (2020). Forecasting stability method of coal-containing rocks on the complex of geological and geophysical methods // Materials of the International Scientific & Practical Conference "Physical & Chemical Geotechnologies – 2020". Dnipro, P. 33-34.

[44] Ishkov V.V., Kozii Ye.S., Strelnyk Yu.V. (2021). Research results of cobalt distribution in coal seam k_5 of "Kapitalna" mine field. Збірник праць Всеукраїнської конференції «Від мінералогії і геогнозії до геохімії, петрології, геології та геофізики: фундаментальні і прикладні тренди XXI століття» (MinGeoIntegration XXI), 28-30 вересня 2021року. С. 178-181.

[45] Ішков В.В., Козій Є.С., Завгородня В.О., Стрєльник Ю.В. (2021). Перші дані про розподіл кобальту у вугільному пласті k_5 поля ВП «Шахта «Капітальна». Міжнародна науково-практична конференція «Технології і процеси в гірництві та будівництві». ДонНТУ. – С.55-64.

[46] Ishkov V.V., Kozii Ye.S. (2020). Some features of beryllium distribution in the k_5 coal seam of the "Kapitalna" mine of the Krasnoarmiiskyi geological and industrial district of Donbas. Odesa National University Herald. Geography and Geology. Vol. 25. No. 1(36), pp. 214-227. https://doi.org/10.18524/2303-9914.2020.1(36).205180

[47] Ішков В.В., Козій Є.С. (2020). Зольність вугільного пласта k_5 шахти «Капітальна». Матеріали міжнародної науково-практичної конференції «Технології і процеси в гірництві та будівництві». ДонНТУ. – С.87-91.

[48] Ishkov V.V., Kozii Ye.S. (2021). Distribution of arsene and mercury in the coal seam k_5 of the Kapitalna mine, Donbas. Mineralogical Journal. No. 43(4), pp. 73-86. https://doi.org/10.15407/mineraljournal.43.04.073

[49] Ішков В.В., Козій Є.С., Капшученко Є.О., Стрєльник Ю.В. (2021). Попередні дані про особливості розповсюдження нікелю у вугільному пласті k_5 поля ВП «Шахта «Капітальна». Міжнародна науково-практична конференція «Технології і процеси в гірництві та будівництві». ДонНТУ. – С.21-31.

[50] Єрофєєв А.М., Ішков В.В., Козій Є.С. (2021). Особливості впливу основних геолого-технологічних показників нафтових родовищ України на вміст ванадію. Матеріали II Міжнародної наукової конференції «Сучасні проблеми гірничої геології та геоекології». С. 115-120.

[51] Kozii Ye. (2020). Coal height of coal seam k_5 of "Kapitalna" mine. Proceedings of the "Widening Our Horizons": International Forum for Students and Young Researchers, pp. 399-401.

[52] Широков О.З., Сафронов І.Л., Ішков В.В., Козій Є.С. (2020). Основи методики прогнозу стійкості вуглевміщуючих порід по комплексу геолого-геофізичних методів. Матеріали III міжнародної науково-практичної конференції «Проблеми розвитку гірничо-промислових

GEOLOGY, MINERALOGY AND SOIL SCIENCE

районів». Покровськ. С. 16-24.
[53] Kozii Ye. Chromium in the coal seams of the Chervonoarmiiskyi geological and industrial area of Donbas. Proceedings of the "Widening Our Horizons": Intern. Forum for Students and Young Researchers, 2021, pp. 453-455.
[54] Ішков В.В., Козій Є.С., Киричок В.О., Стрєльник Ю.В. (2021). Перші відомості про розподіл свинцю у вугільному пласті k_5 поля ВП «Шахта «Капітальна». Міжнародна науково-практична конференція «Технології і процеси в гірництві та будівництві». ДонНТУ. – С.76-86.
[55] Ishkov V. V., Kozii Ye. S., Chernobuk O. I., Kozar M. A., Dreshpak O. S., Pashchenko P. S., Vladyk D. V. (2022). Relationship of germany content with the thickness of the coal seam $c_8^н$ of the "Dniprovska" mine field. The 15 th International scientific and practical conference "Modern scientific research: achievements, innovations and development prospects" (August 14-16, 2022) MDPC Publishing, Berlin, Germany. pp 189-197.
[56] Козій Є.С. (2020). Про розподіл ванадію у вугіллі пласта $c_{10}^в$ шахти «Дніпровська». Матеріали Всеукраїнської науково-практичної конференції студентів, аспірантів та молодих учених «Перспективи розвитку гірничої справи та раціонального використання природних ресурсів». Житомир. С. 8-12.
[57] Ishkov V.V., Kozii Ye.S. (2019). Analysis of the distribution of chrome and mercury in the main coals of the Krasnoarmiiskyi geological and industrial area. Tectonics and Stratigraphy. No. 46, pp. 96-104. https://doi.org/10.30836/igs.0375-7773.2019.208881
[58] Ishkov V.V., Kozii Ye.S., Kozar M.A., Dreshpak O.S, Chechel P.O. (2022). Condition and prospects of the Ingichke deposit (Republic of Uzbekistan). The XXVII International Scientific and Practical Conference «Multidisciplinary academic notes. Theory, methodology and practice», July 12 – 15, 2022, Prague, Czech Republic, pp. 96-104. https://doi.org/10.46299/ISG.2022.1.27
[59] Козій Є.С. (2020). Хром у вугіллі пласта c_4^2 шахти «ім. М.І. Сташкова». Матеріали Міжнародної наукової конференції молодих вчених «Регіональні проблеми охорони довкілля». Одеса: ОДЕКУ. С. 80-85.
[60] Ішков В.В., Козій Є.С., Владик Д.В., Зіньковський А.С. (2020). Про вміст берилію в вугільному пласті $c_8^в$ поля шахти «Західно-Донбаська». Матеріали ІІІ міжнародної науково-практичної конференції «Проблеми розвитку гірничо-промислових районів». Покровськ. С. 31-34.
[61] Єрофеєв А.М., Козій Є.С. (2021). Результати кластерного аналізу родовищ нафти Дніпровсько-Донецької западини за вмістом ванадію. Матеріали IX Всеукраїнської науково-технічної конференції «Молодь, наука та інновації». С. 338-339.
[62] Yerofieiev, A.M., Ishkov, V.V., Kozii, Ye.S. (2021). Influence of main geological and technical indicators of Kachalivskyi, Kulychykhinskyi, Matlakhovskyi, Malosorochynskyi and Sofiivskyi deposits on vanadium content in the oil. International Scientific&Technical Conference «Ukrainian Mining Forum».

GEOLOGY, MINERALOGY AND SOIL SCIENCE

pp. 177-185.

[63] Ішков В.В., Козій Є.С. (2020). Зольність вугільного пласта k_5 шахти «Капітальна». Матеріали міжнародної науково-практичної конференції «Технології і процеси в гірництві та будівництві». ДонНТУ. С.87-91.

[64] Ishkov, V.V., Kozar, M.A., Kozii, Ye.S., Bartashevskiy, S.Ye. (2022). Nickel in oil deposits of the Dnipro-Donetsk depression (Ukraine). Problems of science and practice, tasks and ways to solve them. Proceedings of the XXVI International Scientific and Practical Conference. Helsinki, Finland, pp. 25-26. https://doi.org/10.46299/ISG.2022.1.26

[65] Єрофєєв А.М., Ішков В.В., Козій Є.С. (2021). Особливості впливу геолого-технологічних показників деяких родовищ на вміст ванадію у нафті. Матеріали VIII Всеукраїнської науково-практичної конференції студентів, аспірантів та молодих вчених «Перспективи розвитку гірничої справи та раціонального використання природних ресурсів». С. 43-46.

[66] Ishkov V., Kozii Y., Chernobuk O., Lozovyi A., Diachkov P. (2022). Results data of the regression and correlation analysis of the concentration of germanium with thickness and ashity in the coal seam $c_8^н$ of the Dniprovska mine. The XXXIII International Scientific and Practical Conference «Trends in the development of science in the modern world», August 23 – 26, 2022, Graz, Austria. pp 115-124.

[67] Ішков В.В., Козій Є.С., Максимович А. С., Мартиненко Ю. В., Мельник М.В. (2020). Особливості у розподілу сірки загальної по площі вугільного пласту $c_7^н$ поля шахти «Павлоградська». Матеріали XVIII конференції молодих вчених «Геотехнічні проблеми розробки родовищ». Дніпро. С. 83-86.

[68] Ішков В.В., Козій Є.С. (2020). Аналіз розповсюдження берилію у вугільному пласті k_5 шахти «Капітальна» Червоноармійського геолого-промислового району. Всеукраїнська конференція «Від Мінералогії і Геогнозії до Геохімії, Петрології, Геології та Геофізики: фундаментальні і прикладні тренди XXI століття». С. 182-187.

[69] Yerofieiev, A.M., Ishkov, V.V., Kozii, Ye.S., Bartashevskiy, S.Ye. (2021). Research of clusterization methods of oil deposits in the Dnipro-Donetsk depression with the purpose of creating their classification by metal content (on the vanadium example). Scientific Papers of Donntu Series: "The Mining and Geology". pp. 83-93. https://doi.org/10.31474/2073-9575-2021-1(25)-2(26)-83-93

[70] Широков О.З., Сафронов І.Л., Ішков В.В., Козій Є.С. (2020). Основи методики прогнозу стійкості вуглевміщуючих порід по комплексу геолого-геофізичних методів. Матеріали XVIII конференції молодих вчених «Геотехнічні проблеми розробки родовищ». Дніпро. С. 70-75.

[71] Ishkov V.V., Kozii Ye.S., Dreshpak O.S, Berezniak O.O., Chechel P.O., Pashchenko P.S. (2022). The main results of mineralogical and petrographic studies of limestones from Novoselytske deposit (Ukraine). Scientific Collection «InterConf»: Proceedings of the 1 st International Scientific and Practical Conference «Recent Advances in Global Science». Vilnius, Lithuania: Vaiga. pp 195-206.

GEOLOGY, MINERALOGY AND SOIL SCIENCE

[72] Козій Є.С., Бордальова А.Ю. (2022). Особливості розповсюдження ртуті у вугіллі пласта $c_8^н$ поля шахти «Благодатна» Дніпропетровської області. Матеріали регіональної науково-практичної конференції «Ґрунтові води». С. 34-35.

[73] Ishkov V.V., Kozii Ye.S., Kozar, M.A. (2021). Peculiarities of vanadium geochemistry in oils from the deposites of the Eastern oil and gas-bearing region of Ukraine. Geo-Technical Mechanics. no 161. https://doi.org/10.15407/geotm2020.161

[74] Kozii Ye.S., Ishkov V.V. Nickel content in the oils of the Dnipro-Donetsk basin. (2022). Theoretical and Applied issues of Agricultural Sciences: book of proceeding of the International Scientific and Advanced Conference. Dnipro. Two Part. pp. 296-299.

[75] Ішков В.В., Козій Є.С., Владик Д.В., Зіньковський А.С. Основні закономірності мінливості потужності вугільного пласта $c_7^н$ поля шахти «Павлоградська». Матеріали XVIII конференції молодих вчених «Геотехнічні проблеми розробки родовищ». Дніпро. 2020. С. 54-57.

[76] Ishkov V.V., Kozii Ye.S. (2022). Nickel distribution in the oils of the Dnipro-Donetsk basin. Сборник научных трудов III Международной научно-практической конференции «Современные тенденции геологоразведочной и нефтяной инженерии», 14-15 апреля 2022 года, г. Алматы. С. 161-166.

[77] Ішков В.В., Козій Є.С., Найден К. В., Сливний С. О. (2020). Особливості вмісту миш'яку у вугільному пласті $c_7^н$ поля шахти «Павлоградська». Матеріали XVIII конференції молодих вчених «Геотехнічні проблеми розробки родовищ». Дніпро. 2020. С. 79-82.

[78] Yerofieiev A.M., Ishkov V.V., Kozii Ye.S., Bartashevskiy S.Ye. (2021). Geochemical features of nickel in the oils of the Dnipro-Donetsk basin. Collection of scientific works "Geotechnical Mechanics". No. 160, pp. 17-30. https://doi.org/10.15407/geotm2021.160.017

[79] Ishkov V.V., Kozii Ye.S., Chernobuk O.I., Kozar M.A., Pashchenko P.S., Diachkov P.A., Vladyk D.V. (2022). Manifestation of the phenomenon of coal enrichment with germanium of low-powered areas of the seams of the Dniprovska mine (Ukraine) and the «Zylbermints law». Scientific Collection «InterConf» International Scientific and Practical Conference «Science in the Environment of Rapid Changes». Brussels, Belgium: De Boeck, pp 225-226.