STRUCTURAL CONTROL OF CHANGES IN MINERALIZATION AND HYDROGEN INDEX OF MINE WATERS IN THE KRASNOARMIYSKA MONOCLINE ZONE

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ABSTRACT
In the context of mineral extraction, particularly coal, mine water has been found to typically exhibit higher mineralization levels in comparison to natural water bodies. The mineralization of mine water is influenced by a complex set of factors, including lithological, mining-technical, meteorological, and structural-tectonic. In contemporary research, there are divergent views regarding the tectonic factor influencing changes in the mineralization of underground or mine water. The objective of the present study is to ascertain the structural control of changes in mineralization and the hydrogen index of mine groundwater within the Krasnoarmiyska monocline zone of Donbas. The findings of the research indicate that the thrust faults of the near-meridional north-northeast extension generate conditions of water impermeability and function as screens in a hydrodynamic sense (impacting the isolation of hydrochemical indicators within a distinct tectonic block). Conversely, the presence of near-latitudinal north-north-east-trending faults, in conjunction with low-amplitude tectonic zones, engenders augmented filtration conditions for groundwater flow and inflow from deeper horizons. This phenomenon is accompanied by alterations in hydrochemical indicators within the vicinity of the fault zone. The distribution of the hydrogen index was found to be unaffected by structural-tectonic heterogeneities.

Introduction.

Under natural conditions, the total mineralization of groundwater varies significantly. Groundwater is categorized into four distinct groups based on the extent and nature of mineralization present. Freshwater has been found to contain mineralization levels of up to 1000 mg/dm³, while brackish water has been found to contain mineralization levels ranging from 1000 to 10000 mg/dm³. In the presence of elevated mineralization, water is categorized as either salty or brine. In the context of mineral extraction, particularly coal mining, mine water frequently exhibits higher mineralization levels in comparison to natural water bodies. The mineralization of mine water is influenced by a complex set of factors. The reasons for high mineralization are not only attributable to the interaction of water with rocks (rock composition) containing salts, sulphates, chlorides and other substances that increase water mineralization. The ingress of atmospheric precipitation and surface water into mine water, coal mining processes (e.g. drilling, blasting and rock transportation) also have a significant impact. A separate group consists of geological factors, namely: depth of occurrence (at great depths, water is under higher pressure and temperature, which promotes the dissolution of minerals and increases mineralization); the penetration of groundwater from other horizons (dissolved substances can change mineralization); low pH (acidity) can promote the dissolution of metals, which also affects mineralization; structural (tectonic) features of the coal massif.

In contemporary studies, the tectonic factor influencing changes in the mineralization of underground or mine waters has been considered in isolated studies. There is a plethora of divergent views regarding the impact of this factor. The authors of the studies [1] posit that the hydrogeochemistry of groundwater is determined by its planimetric location relative to rigid tectonic blocks and tectonic faults. In the course of the research project [2], the characteristic hydrochemical indicators of the groundwater in the Buchats-Kaniv aquifer complex were analyzed in order to establish a qualitative composition. This analysis also enabled the researchers to identify the relationship between these indicators and the neotectonic structure of the territory. It has been determined that increased mineralization is a characteristic indicator of the influence of deep

waters due to the tectonic structure, which is divided into blocks by disruptive faults. In [3], the influence of tectonics on the circulation of mineralizing fluids was studied in Upper Carboniferous sandstone sedimentary formations, using the example of the southern sector of Ebba (Nigeria). It was concluded that the structures facilitating the transport of fluids and salts include the main fault and secondary fractures due to control at the scale of the mining sector.

Concurrently, the authors of [4] concluded that the mineralization of mine waters in the Western Donbas, within the zone of active hydraulic connection of aquifers (Buchak-Kyiv and Kharkiv), ranges from 1.9 to 3.4 g/l, and in the zone where 'closed-type' coal seams are mined ranges from 3.8 to 21.0 g/l. Active hydraulic connection is confined to zones of deep faults. Tectonic disturbances, which are present throughout the complex of coal deposits, are impermeable. In essence, the deposits are comprised of closed horsts and grabens, which are largely isolated from one another in hydrodynamic terms. In [5], the authors argue that the zone of tectonically disturbed rocks is characterized by elastic hydrodynamic disturbances, comparable to an undisturbed, low-permeability rock mass. This argument is based on the determination of the filtration and capacitance properties of the tectonically disturbed zone. It is hypothesized that the mineralization of water in individual blocks of the carbon-containing massif will not be affected.

In view of the ambiguity of the conclusions of modern studies on the influence of structural-tectonic factors on changes in mine water mineralization, the aim of this study is to determine the structural control of changes in mineralization and the hydrogen index of mine groundwater within the Krasnoarmiyska monocline zone of Donbas.

Materials and methods of the study.

The work utilises materials from geochemical monitoring of mine water (average statistical indicators) in the mining fields of 16 coal mining enterprises across five coal seams that were being mined; and data on indicators in individual mine workings. The monitoring data was processed using mathematical interpolation in conditional coordinates with the use of modern software tools and digitization of cartographic information (individual mine fields and the Krasnoarmiyska monocline zone as a whole) to combine and visualize the obtained digital models.

Presentation of the main material.

The geological structure of the region is characterized by developed sedimentary rocks of the Middle and Upper Carboniferous periods, overlaid by younger sedimentary rocks (Cenozoic, Triassic, Jurassic), whose total thickness increases from south to north. Coal mining was carried out in the m_4^0, m_4, m_4^2, l_2^1, l_2^5, l_3, l_4, l_6, l_7^v, l_8, l_8^1, k_5, k_5^v, k_7, k_8 seams at various hypsometric horizons within different mines (Fig. 1). The deepest horizons of the deposit (-640 - -690 m) are characteristic of the Krasnoarmiyska, Tsentralna and Dimitrova mines (among those studied).

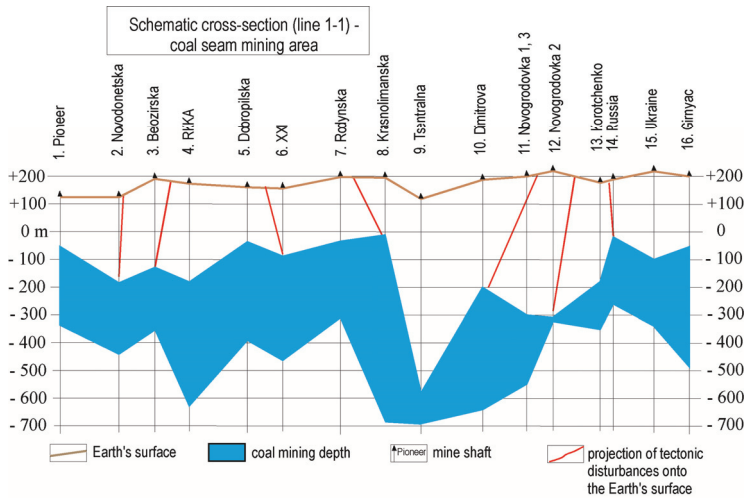

Fig. 1. Schematic cross-section of the Krasnoarmiyska monocline coal deposit development along line 1-1 (Fig. 2) with specified depths within the mine fields

The stratigraphic succession of coal deposits is characterized by alternating layers of coal, limestone, sandstone, argillite and siltstone, which vary in composition and thickness. The relatively calm stratification of the rocks is disrupted by tectonic faults (Fig. 2) of various orientations and morphologies [6].

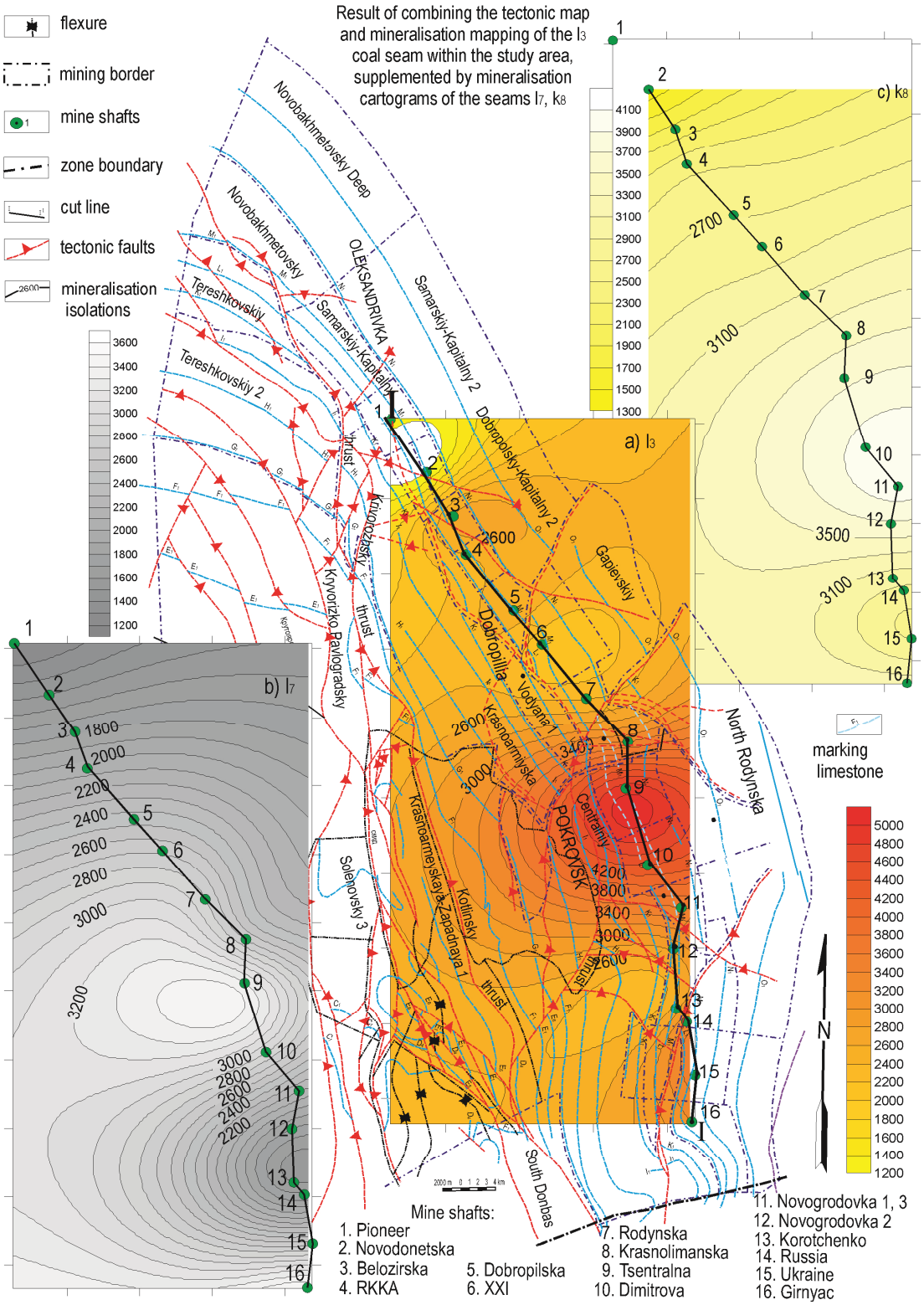

Fig. 2. Fragment of a tectonic map of the study area with the results of the assessment of mineralization indicators in isolines for different strata (a, b, c) and pH indicator (d)

The first group of faults is morphologically represented by thrust faults of a near-meridional north-northeast extension (Samarskyi, Krasnoarmeyskyi, Mertsalivskyi, northern part of Dobropilskyi) and diagonal north-eastern orientation (Selidovskyi, Tsentralnyi, southern part of Dobropilskyi, series of Novo-Iverskyi faults). The second consists of numerous subparallel disjunctives of a thrust morphology with a near-latitudinal north-north-west extension (Krasnonolymanskyi, Hlybokoiarskyi, Karpivskyi, Hrushevskyi, Fedorivskyi, Samoilovskyi, Hnilushynskyi) and diagonal north-eastern orientation fault 5, fault 'B'.

Of particular interest are steeply dipping faults of a north-northwest orientation (Mertsalivskyi and Hlybokoyarskyi thrust), with an azimuth of 330-350°, which have a large zone of fragmentation, are often replaced by sandstone and, in essence, represented by thrusting [7]. Against the general background of fault formation, low-amplitude tectonics are developed quite locally, concentrated in tectonic zones oriented coaxially with medium-amplitude faults of various morphologies, and located in the volumes of thrust or scale-like thrust packages, the boundaries of which are served by northeast-oriented faults. The deposits are broken into horsts and grabens from north to south, which are additionally disturbed by tectonic zones of low-amplitude disturbance. It is obvious that the tectonic structure of the Pioneer mine, which has a large number of thrusts, differs from the tectonic structure of the Krasnolymanska mine, where they are practically absent (except for the Tsentralnyi thrust one). That is, the geodynamic situation of fracture formation changed from north to south, which, in our opinion, could have affected the mineralization indicators and geochemical diversity of the mine water composition.

Processing of geochemical monitoring data for mine waters (average mineralization indicators) within the mining fields of 16 coal mining enterprises in coal seams l_3, l_7 and k_8 using mathematical interpolation with modern software tools made it possible to create maps of the distribution of mineralization indicators in plan (Fig. 2, a, b, c). Visualization of the latter allows us to conclude that mine groundwater is brackish, with mineralization varying from 1400 to almost 5000 mg/dm³. However, the maximum salt content values (3000–5000 mg/dm³) are characteristic of the area between the Rodynska and Novogrodivska 2 mines (layers l_3 and k_8) or the area between the Rodynska and Dimitrova mines (layer l_7), i.e. they coincide spatially. At first glance, everything seems quite logical: the greatest depth of coal mining causes an increase in the indicator. A sufficiently high mineralization index is recorded locally within the l_3 seam of the Belozirska, RKKA and Dobropilska mines (2500-3200 mg/dm³), where the mining depth reaches -630 m. However, in other seams, no increase in mineralization is recorded in this area, including in seam k_8, which is located lower in terms of hypsometry. Another location with an increase in the mineralization index is located within seam k_8 – between the Korotchenko and Hirnyak mines (3100-3500 mg/dm³). The aforementioned halo of elevated indicators within the k_8 seam, in the area of the l_7 seam, has the opposite effect (a decrease in values to 1200 mg/dm³), although the depth of reserve extraction does not differ significantly. Moreover, in the area of the RKKA mine (extraction mark – -620 m), no increase in the mineralization index values for the k_8 and l_7 strata is recorded. Analysis of the results obtained suggests that the near-meridional north-northeast-trending thrusts create conditions of impermeability and act as screens in hydrodynamic terms. At the same time, near-latitudinal north-north-east-trending faults, together with low-amplitude tectonic zones, on the contrary, create increased filtration conditions for the flow of groundwater and inflow from deeper horizons.

The assessment of the hydrogen index (Fig. 2, d) for the l_3 stratum showed that the waters of the Dimitrova, Novogrodivska 1, 2, and 3 mines, with mineralization indices of 2600-3600 mg/dm³, are acidic (pH less than 6.5). Acidic mine waters usually have increased mineralization, although the highest mineralization index is related to another area. However, acidic mine waters are also present and are formed in workings (mainly in old ones) as a result of the oxidation of sulphur sulphides (in the form of pyrite) under the action of water and oxygen in the air [8]. This is true because the mines listed have not been mining coal for many years. Most of the analyzed area has a pH of 6.5-8.8 and is characterized as brackish with increased mineralization [9]. No influence of tectonic heterogeneities on the distribution of the hydrogen index (pH) was found.

Conclusion.

The results of the research suggest that the near-meridional north-northeast-trending thrusts create conditions of impermeability and act as screens in hydrodynamic terms (affecting the isolation of

hydrochemical indicators in a separate tectonic block). At the same time, near-latitudinal north-north-east-trending faults, together with low-amplitude tectonic zones, on the contrary, create increased filtration conditions for the flow of groundwater and inflow from deeper horizons (affecting changes in hydrochemical indicators around the fault zone). No influence of structural-tectonic heterogeneities on the distribution of the hydrogen index was found. The research results can be used in the assessment and forecasting of geochemical indicators of mine and underground waters when their use is necessary.

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