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THE IMPACT OF FOLDING ON THE FORMATION OF INDUSTRIAL GAS CONTENT IN SANDSTONES UNDER THE CONDITIONS OF TOMASHEVSKYI DOMES

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Abstract. Given the significant depletion of classic oil and gas fields, which include the majority of hydrocarbon resources in Ukraine, the search for additional alternative deposits of energy carriers is important. The purpose of the work is to analyze the conditions of the industrial gas content in the sandstones of the Tomashevskyi anticlinal structures. On the example of these structures (Northern and Southern domes), the authors considered conditions for the formation of industrial gas content in sandstones of the coal-bearing strata. The research was carried out by constructing a map of local structures with the application of trend analysis. According to the hypsometric plan of the coal bed, an approximating surface of the 1st order – a plane – is constructed. Based on the deviation of the actual hypsometric marks of the coal bed from the corresponding marks of the approximating surface, a map of local structures was constructed by the interpolation method. Anticlinal folds are highlighted in the plan and their main parameters – amplitude and width – are defined. Based on these structural parameters, the bending coefficients of the domes under the research were calculated. Subsequently, calculations of the critical thickness for sandstones were performed. The main factor of the industrial gas content in the domed parts of the Tomashevskyi anticlinal structures is the processes of cracking which entailed the formation of improved filtration-capacity properties of sandstones in the section of the coal-bearing stratum. According to the calculated data, in sandstones with high-thickness, over the critical thickness (from 9.8 m to 17.0 m), accumulations of coal methane were formed under the impact of folded deformations with an effective thickness from 2.4 m to 14.9 m, in line with the actual data. Analysis of folding impact on the conditions of formation of the industrial gas content in sandstones under the conditions of Tomashevskyi domes proved the suitability of the method in predicting gas accumulations in local anticlinal structures for assessing the potential industrial gas content in ordinary 1st-order anticlinal structures. This method can be applied to search for gas deposits, both in positive structures of the 2nd-order (local), and 1st-order structures.

Keywords: hydrocarbons, coal-bearing strata, anticlinal structures, sandstones, gas accumulations.

1. Introduction

The growth of the country's economy is impossible without providing it with the necessary resource base, where an important role is played by the fuel and energy component, which is largely oriented towards traditional hydrocarbon energy raw materials – coal, oil, and gas. First of all, these issues concern traditional and non-traditional energy sources, among which coal mine methane (CMM) and coal abandoned methane (CAM) also occupy an important place. The relevance of these issues is confirmed by the fact that extraction and use of methane from coal mines is not only possible but also implemented on an industrial scale in many countries, in particular in Ukraine.

The coal-bearing strata of the Donets basin contain significant resources of methane for its production and usage as a valuable energy carrier. It is the main component of gases in the coal fields, with which the entire coal-bearing strata is practically saturated.

The peculiarity of the coal-bearing strata, in contrast to natural gas fields, is that methane is found in it mainly in a dispersed state and is weakly mobile or immobile. The low permeability values of rocks, which are, on average, hundredths and thousandths of a millidarcy, hinder the gas and water migration. And, as a consequence, they hinder the accumulation of gas in significant volumes in the form of deposits favorable for industrial development [1]. The decompression and cracking of rocks as a result of tectonic processes can contribute to the redistribution of water and gas in the coal rock massif and the concentration of free methane in the form of accumulations.

Thus, the process of cracking should be considered one of the leading natural factors in the formation of gas deposits in low-porosity coal-bearing strata. In cases where the bending deformations of the rock beds exceed the ultimate tensile deformations, they develop brittle rupture deformations leading to the occurrence of fracturing, changes in reservoir properties – increased permeability of cracked sandstone layers, and the formation of gas traps. The dimensions of the decompression zone and the intensity of cracking depend on the curvature of the bend and the deformation characteristics of the rock. The maximum permissible (critical) tensile deformations for sandstones are 0.003–0.004 [2].

The IGTM of the NAS of Ukraine has developed an analytical method for predictive assessment of the prospects of local anticlinal structures based on geological exploration data to search for zones of free methane accumulations in coal-bearing sediments [3, 4]. Local structures are second-order structures (structural protrusion, structural nose), which complicate the monoclinal occurrence of rocks and are distinguished by the deviation of the hypsometry of a bed from the approximating surface.

The application of the method enables a predictive assessment of the prospects of local anticlinal structures to search for free methane accumulations based on available geological and geophysical data. Unlike all other predictive methods, that is, direct field research, it is purely analytical and does not require additional search and exploration work (drilling and logging wells).

The methodology was successfully applied to search for free methane accumulations at several exploration sites and minefields of coal mines ("Butivska", named after O.F. Zasyadko, "Zakhidno-Donbaska" mines) [5, 6]. Finding the conditions for the formation of the gas content in sandstones of coal-bearing strata in real conditions of first-order folded structures (domes of anticlinal folds) is relevant given the proposed method. Such structures are the Tomashevskyi domes – Southern and Northern, which are located in the Popasniansk district of the Luhansk region and are located within the Lysychansk geological-industrial district of the Donets coal basin.

The purpose of the work is to analyze the conditions for the formation of industrial gas content in sandstones of the Tomashevskyi anticlinal structures.

The object of the research is the coal-bearing strata within the Tomashevskyi antic-lineal structures (Northern and Southern domes) in the Lysychansk geological-industrial district.

2. Methodos

The research was carried out by construction a map of local structures using trend analysis. According to the hypsometric plan of the coal bed, an approximating surface of the 1st-order – a plane – was constructed. Based on the deviation of the actual hypsometric marks of the coal bed from the corresponding marks of the approximating surface, a map of local structures was constructed using the interpolation method. Anticlinal folds were highlighted in the plan, and their main parameters – amplitude and width – were determined. On these parameters of structures, the bending coefficients of the researched domes were calculated. Subsequently, calculations of the critical thickness for sandstones were performed.

Geological structure of the research area. The geological structure of the Lysychansk geological-industrial district has been researched in sufficient detail [7–9]. According to the features of the tectonic structure, it is divided into two structural elements: 1) a strip of domed (brachyanticlinal) uplifts located between the Lisychansk and Severodonetsk thrusts; 2) the monoclinal slope of the northeastern wing in the Bakhmut depression. The strip of brachyanticlinal (dome) structures has a northwesterly strike and is disturbed by numerous tectonic structures of a fault and thrust nature. The greater part of the Lysychansk district is located to the southwest of the Lysychansk thrust and is confined to the area of the monoclinal northeastern wing in the Bakhmut depression [9].

Complexes of sedimentary rocks of the Paleozoic, Mesozoic, and Cenozoic eras were found in the geological structure of the Lysychansk district. On a large area, the sediments of suites of the Middle Carbon ($C_2^{3\text{-}7}$) come to the surface. Exactly to these formations, the industrial coal-bearing capacity is limited (up to 76 layers, of which 20 have working capacity). In general, the lithological composition of suites is dominated by sandstones and siltstones.

The Tomashevskyi area is structurally located at the junction of the Northern zone of block structures and the Northern zone of small-size folding of Donbas. In the northeast, the area is bounded by the Severodonetsk thrust. Lysychansk thrust extends in its central part, on the southern thrust, the boundary of the area coincides with the system of tectonic disturbances of the northwestern strike, including the Longitudinal fault. There are two brachyanticlinal (dome) structures (a fragment of the Lysychansk-Kremin system of echelon folds) between the Lysychansk and Severodonetsk thrusts, complicated by a system of tectonic disturbances (thrusts, faults). The southwestern part of the Tomashevskyi area is located within the monoclinal northeastern wing of the Bakhmut depression and is characterized by a relatively calm occurrence of rocks. The lithology and stratigraphy of the geological section are similar to the features of the geological structure in the Lysychansk district.

Within the boundaries of the Lysychansk district, the Tomashevskyi brachyanticline, which is a component of the Lysychansk-Kremin system of folds, stands out. The length of the brachyanticline is about 12 km, the width is almost 3 km. The brachianticline is divided into two dome-shaped folds (domes): Tomashevskyi Northern and Tomashevskyi Southern. They are mainly folded of deposits of C_2^1–C_2^4 suites and have an asymmetric structure with steep north-northeast and low south-west wings. According to research data, disturbances of the thrust type are determined within the dome folds which are located along the Lysychansk thrust. According to [10], a diagonal tectonic disturbance is distinguished within the Tomashevskyi Southern dome. It crosses the upper part of the dome from north to south and is a zone of "rock extension". It is believed that under the conditions of the same dome, the Severodonetsk thrust is a screen that contributes to the accumulation of gases [9]. Thus, the main controlling disjunctive structure of the Tomashevskyi area is the Severodonetsk thrust, which submerges southwestward on the site and comes to the surface northeastward, beyond its boundaries.

The apophyses of this disjunctive structure from south to north are: the Longitudinal fault, the Lysychansk thrust, the apophysis of the Lysychansk thrust, and the Tomashevskyi thrust. The structure of Tomashevskyi domes themselves is complicated by: the Northern – Bezimennyi and Longitudinal faults; and the Southern-Central thrust.

The fields of "Tomashevskyi Pivnichna", "Tomashevskyi Pivdenna", Kapustin mine, Pryvilniansk, and Novodruzhevsk mines are within the Tomashevskyi area. The fields of the first two mines coincide with the position of the dome structures. Most of the mines are abandoned or idle.

Coal bed h_8, suite C_2^3 was mined by the idle mines "Tomashevskyi Pivnichna" and "Tomashevskyi Pivdenna".

According to data from mining operations [9], the distribution of gases in the coal-bearing strata is uneven. According to the degree of gas manifestation, the Tomashevskyi area can be divided into two parts: the zone of dome structures characterized by the increased gas content of coal sediments, and the monoclinal slope of the Bakhmut depression with moderate gas content. In the area of the dome structures, the layer surface of methane gases reaches from 0 m to 80 m, and the surface of the methane zone submerges in the southeast direction. Within the monoclinal slope, the methane zone is established from a absolute depth of -130 m and smoothly submerges in the northwest and northeast directions. Heavy hydrocarbons gravitate towards the zone of methane gases and appear at a depth of 100–200 m, below the upper boundary of the methane zone.

One can observe spatial and genetic connections between the gas content of beds and the nature of the geological structure: the conditions most favorable for the preservation of gases can exist in the presence of an uneroded anticlinal structure; they are less favorable for synclinal folds. In the mines in the Tomashevskyi area, during the mining of the coal bed h_8 in the center of the domes, methane gases were discovered already at a depth of 75 m, and at a depth of 235 m, the relative gas saturation of the workings reached 32–57 million m^3, and the development of the bed was accompanied by blow methane emission [10]. The impact of rupture tectonics on the distribution of natural gases manifests itself in different ways: in some cases, the disturbances are gas conductors, in other ones, they are screens that increase the gas saturation of the mine workings. Along the strike, the same disturbance can contribute to the degassing of the strata or the storage of gases.

According to [8], the total porosity of rocks in the region varies within the following limits: limestones – 3.6–4.4%, mudstones – 6.5–8.8%, siltstones – 6.4–8.7%, sandstones – 7, 8–21.9%. Respectively, the gas permeability varies within more significant limits – from 0.001–0.020 mD to 54–60 mD.

Based on the results [11], a characteristic feature of the field is the high gas content of the fractured and porous sandstone of great thickness, which lies at the bottom of the working coal bed and is separated from it by meter-thickness mudstone. This sandstone is the main source of methane in the mine. According to the Donbas classification, sandstone is indexed as H_5SH_6. According to the classification adopted in the gas industry, it belongs to the productive horizon B-3. This horizon gave gas influx to the Kremin and Lysychansk structures and is the main productive horizon and other fields of Northern Donbas [11].

3. Results and Discussions

Based on the data from geological exploration wells, a map of local structures for the researched area was constructed (Fig. 1). A local structure is part of a layer of sedimentary rocks of isometric shape in plan, which has absolute marks above or below the value of the approximating surface. The 1st-order polynomial trend model was used to calculate the approximating surface. Two anticlinal dome-type structures are highlighted on the obtained map – the Southern and the Northern. Both folds have a northwest strike and are subparallel to the Northern Donets thrust.

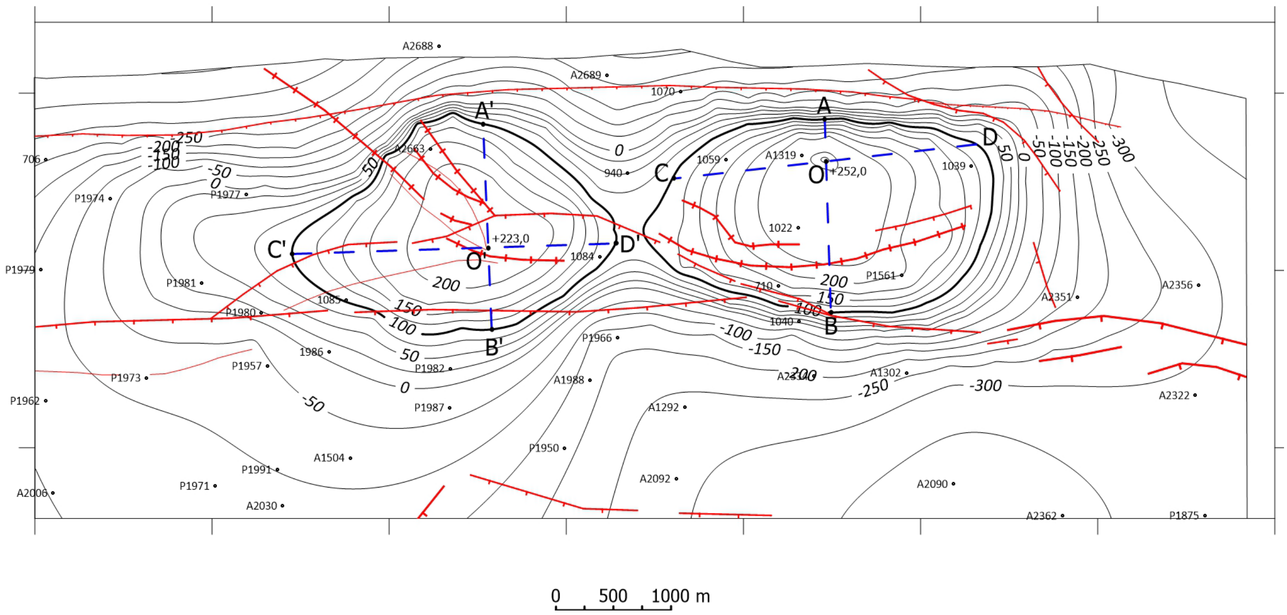

Figure 1 – The map of the local structures of the Tomashevskyi domes
(AB – width, CD – length of the dome)

The Tomashevskyi Southern dome is the dome-shaped uplift of the north-western strike with small rock dip angles (2–5°). The northeastern wing of the fold is cut off by the Severodonetsk thrust and has rock dip angles of up to 70°. On the southwestern wing of the fold, the dip angles are smaller (up to 20–30°). Like all the folds of the district, it is asymmetrical in cross-section.

The southern structure is located in the area of wells A1319, 1022, 1059, 1039 and has an elongated shape in the northwest direction. The length of the fold (within the isoline +100 m, forming a closed contour) is about 3 km, the width is 1.7 km. The highest height is 252.0 m, in the area of well A1319, closer to the eastern wing of the structure, which indicates its asymmetric cross-section.

The northern structure is located in the area of wells A2663, 1084, 1085. The shape of the dome is also elongated from the northwest to the southeast but is closer to isometric. The structure is complicated by two systems of disjunctive tectonic disturbances (northeast and northwest directions). The fold dimensions are 2.8 km by 2.3 km, the amplitude reaches 223.0 m.

The main parameters of the researched structures in terms of width (AB) and length (CD), within individual isolines (+100, +125, +150, +175), are given in Table 1–2. As one can see, the calculated bending coefficients are quite significant. The bending coefficients of the southern structure are 0.052–0.088 in width and 0.043–0.056 in length. The bending coefficients of the northern structure are 0.038 – 0.069 and 0.028 – 0.044, respectively. The calculated critical thickness of the sandstones for the southern structure is within 9.8–14.0 m (in width) and 20.8–24.2 m (in length). Within the northern dome, it is respectively – 12.8 – 17.0 and 30.2 – 32.3.

Table 1 – Parameters of the Tomashevskyi Southern dome

Dimensions of the structure, m				The bending coefficient of the structure, dimensionless		Critical thickness of sandstones, m	
Isoline	Height	Width	Length	By width	By length	By width	By length
+100	152,0	1730	2715	0.088	0.056	9.8	24.2
+125	127,0	1650	2400	0.077	0.053	10.7	22.7
+150	102,0	1550	2100	0.066	0.049	11.8	21.6
+175	77,0	1470	1790	0.052	0.043	14.0	20.8

Table 2. – Parameters of the Tomashevskyi Northern dome

Dimensions of the structure, m				The bending coefficient of the structure, dimensionless		Critical thickness of sandstones, m	
Isoline	Height	Width	Length	By width	By length	By width	By length
+100	123.0	1775	2820	0.069	0.044	12.8	32.3
+125	98.0	1650	2445	0.059	0.040	13.9	30.5
+150	73.0	1490	2100	0.049	0.035	15.2	30.2
+175	48.0	1280	1745	0.038	0.028	17.0	31.7

Thus, the obtained data regarding the bendings of the structures and the calculated values of the critical thickness of the sandstones testify to the significant impact of folding on the state of the coal rock massif in their domed parts, namely, its significant decompression due to fracturing. Under the condition of the presence of an appropriate fluid seal, this indicates the potentiality for the formation of gas deposits during the formation of fractured zones in domes. The presence of gas accumulations is confirmed by the results of geological exploration and mining works in the researched area.

According to [11], the first active gas manifistation in coal exploration wells was recorded in 1947, when a gas-water fountain (well K1087) with the debit of gas about

10–15 thousand m^3/day erupted from the sandstone underlying the bed h_8. A similar fountain occurred during the drilling of the control well in the Tomashevskyi Southern dome (well A1293) in 1955.

The most complete information about the gas content of the coal strata was obtained during the operation of the “Tomashivskyi Pivdenna” mine. The mine was put into operation in 1960 and closed in 1978. The coal bed h_8 was mined at depths of 240–400 m [10]. Rocks containing coal beds (limestones, sandstones) were the main source of methane inflow into mine workings. The emergence of methane was recorded at a depth of only 75 m, in the center of the dome. At a mining depth of 235 m, the mine was classified as a supercategory due to the high volume of gas in its workings, which amounted to 32–57 m^3/t d.p. (ton of daily production). The main source of gas inflow into the mine workings, including in the form of blowers, was the sandstone H_5SH_6, which lies in the coal bottom h_8. In particular, when mining the domed part of the structure from this sandstone, more than 25 blowers with a maximum debit of gas-of 10.5 thousand m^3/day were documented [8].

To ensure reliable working conditions in the fields of Tomashevskyi mines, a large number of methane-degassing wells were drilled from the surface at different times. Man-made degassing of rocks was carried out through the mining workings as the main source of methane inflow. The use of degassing ensured a decrease in gas inflow into workings from 32–27 m^3/t to 15 m^3/t. At the same time, the total gas emissions for the period from 1955 to 1964 amounted to 61.3 million m^3, and from 1965 to 1972–92.2 million m^3, with an average volume of methane emission of 118 m^3 per ton of coal. It is estimated that during these seven years (1965–1972), five–six times more methane was released into the mine workings and the degassing network than could be contained in the coal of the mined-out bed [10]. In addition, significant degassing work was carried out during the construction of the mine. To reduce gas emission into and around the ventilation shaft, six degassing wells were drilled from the surface, revealing the sandstone near bed h_8. The debit of methane of these wells reached 72 thousand m^3/day. For 11 years, more than 24 million m^3 of gas was emitted from wells [11].

After the liquidation of the mine, the methane emission continued for a long time from it. Exploration works [9] established that a technogenic reservoir with an average thickness of 170 m was formed over the mined-out space due to the shift of rocks. Gas can enter the mined-out space from underlying horizons. Gas constantly migrates into the atmosphere due to open tectonic disturbances and fracture zones, which were additionally formed due to the fall of the massif.

According to [9], as of 2011, about 18 wells were drilled in the fields of the "Tomashevskyi Pivnichna" and "Tomashevskyi Pivdenna" mines. Part of the wells was drilled to degas the minefields (wells 3k, 1083, 1097, 1420 at the "Tomashevskyi Pivnichna" minefield; wells 1d, 1d, 1k, 11k, 3335 at the "Tomashevskyi Pivdenna" minefield). Other wells were laid to obtain productive inflows of gases. On the field of the "Tomashevskyi Pivnichna" mine, inflows of gas with water were obtained in wells 7k and 8k; on the field "Tomashevskyi Pivdenna" gas and water manifestations are found in well No. 3345; well No. 3335a is operated as a gas production facility.

The presence of productive horizons in the lower part of the structure was found by exploratory wells for gas during the last works within the researched area. Four wells were drilled within the Tomashevskyi Southern dome. Three of them (A3535, A3335a, A3335b) are located within the same site at a distance of 50–60 m from each other. The wells were drilled to gradually study the gas content of the Middle and Lower Carboniferous sections. The complex geophysical works carried out in the wells and the research of productive horizons in an open hole (with a bed tester), as well as in the column, made it possible to identify new gas-saturated layers. The gas content surface within the structure is estimated to be 500–550 m vertically, which stratigraphically corresponds to the sediments of the suits C_2^3, C_2^2, C_2^1 [11].

In the wells located near the apical zones of folds, gas emission, often in the form of outbursts, was recorded from fairly shallow depths. Thus, in particular in well A-1319 (see Fig. 1), the release of gas bubbles was observed at the intersection of sandstone at a depth of only 41 m, at a depth of 63 m there was abundant gas release with pressure at the wellhead, and at a depth of 108 m gas together with water, it fountained under pressure to a height of up to 10 m above the surface [11]. Numerous gas manifestations at depths of 100–300 m were observed in other wells, and debits ranged from 40–70 m^3/day to 3000–3600 m^3/day. According to the same data [11], gas manifestations from deeper horizons are even more torrential, with emissions of gas and water up to a height of 20–30 m, with pressures of 6.0–7.0 MPa, close to hydrostatic ones.

In general, based on the drilled exploration wells within the Tomashevskyi southern dome, the industrial gas content was established in the following sandy horizons: H_5SH_6, H_4SH_5, H_3SH_4, G_4SH_1, G_3SG_4, G_1SG_2, $F_2SH_2^1$, and reserves (categories C_1 and C_2) and resources of gas (category C_3) were calculated [8, 11]. The parameters of the open porosity coefficients and gas saturation used for the calculation are given in Table 3. The open porosity coefficient varies from 10.4% to 12.5%, and the gas saturation coefficient is 0.40–0.70. The values of the effective thickness of the productive beds, obtained from the data of the well research, are quite significant – from 8.2 m to 14.9 m, except for the bed H_4SH_5, the effective thickness of which is equal to 2.4 m (Table 3).

Table 3 – Characteristics of gas-saturated sandstones for calculating gas reserves on Tomashevskyi area [11]

Bed index	Effective thickness, m	Open porosity coefficient, %	Gas saturation coefficient, dimensionless
H_5SH_6	13.2	10.5	0.40
H_4SH_5	2.4	10.4	0.70
H_3SH_4	14.1	10.6	0.50
G_4SH_1	5.7	10.5	0.65
G_3SG_4	14.9	10.5	0.50
G_1SG_2	8.2	12.5	0.53
$F_2SH_2^1$	9.0	11.3	0.45

Thus, the actual data on the industrial gas content of the coal-bearing strata at Tomashevskyi area confirms the data concerning the conditions for the formation of gas accumulations in thick sandstones of anticlinal structures. In sandstones, the thickness of which exceeds the calculated critical thickness, an effective thickness with improved filtration capacity properties was formed and contains methane deposits in significant volumes, suitable for use.

4. Conclusions

The main factor of the industrial gas content in the domed parts of the Tomashevskyi anticlinal structures is the processes of cracking, which caused the formation of improved filtration-capacity properties of sandstones in the section of the coal-bearing strata.

According to the calculation data, in sandstones with a large thickness, over the critical thickness (from 9.8 m to 17.0 m), accumulations of coal methane were formed under the impact of folding deformations with an effective thickness from 2.4 m to 14.9 m, in line with the actual data.

The analysis of the folding impact on the conditions for the formation of the industrial gas content of sandstones in terms of Tomashevskyi domes proved the suitability of the methodology for predicting gas accumulations in local anticlinal structures for the assessment of the potential industrial gas content in ordinary 1st-order anticlinal structures. This methodology can be applied to searching for gas deposits, both in positive structures of the 2nd-order (local) and 1st-order structures.

REFERENCES

1. Lukinov, V. V. (2007), “Mining and geological conditions for the formation of free methane accumulations in coal deposits”, *Naukovyi visnyk Natsionalnoho hirnychoho universytetu*, vol. 4, pp. 55–59.

2. Iofis, M. A. and Shmelyov, A.I. (1985), *Inzhenernaya geomehanika pri podzemnyh razrabotkah* [Geomechanics engineering in underground mining], Nedra, Moscow, USSR.

3. Ukraine Ministry of Coal Industry (2005), 10.1.05411357.004:2005. Skupchennya vilnogo metanu u neporushenomu vugleporodnomu masivi. Metodika prognozuvannya zon ta viznachennya yih parametriv: Normatyvnyy dokument Minvuhlepromu Ukraïny. Standart [10.1.05411357.004:2005. Accumulation of free methane in an undisturbed carbon deposit. Methodology for predicting zones and determining their parameters: Regulatory Document Coal Industry of Ukraine. Standard], Ukraine Ministry of Coal Industry, Kiev, Ukraine.

4. Bulat, A.F., Lukinov, V.V. and Bezruchko, K.A. (2017), Umovi utvorennya gazovih pastok v kam'yanovugilnih vidkladennyah [Conditions of gas traps forming in carboniferous sediments], Naukova Dumka, Kyiv, Ukrainian.

5. Bezruchko, K., Prykhodchenko, O. and Tokar, L. (2014), “Prognozis for free methane traps of structural and tectonic type in Donbas”, in Bondarenko, V., Kovalevs'ka, I. and Ganushevych, K. (ed.), *Progressive Technologies of Coal Coalbad Methane and Ores Mining*, *Taylor & Francis Group*, London, pp. 267–271. https://www.taylorfrancis.com/chapters/edit/10.1201/b17547-47/prognosis-free-methane-traps-structural-tectonic-type-donbas-bezruchko-prykhodchenko-tokar

6. Bezruchko, K., Prykhodchenko, O., Kargapolov A. and Urazka, M. (2016), “Terms of forming of the combined gas traps on Western Donbas territory”, *Geologiya i geohimiya goryuchih kopalin*, vol. 1–2 (168–169), pp. 26–37.

7. Kuznecov, I.A., Lapushin, V.V. and Levenshtejn, M.L. (1963), *Geologiya mestorozhdenij uglya i goryuchih slancev SSSR. Ugolnye bassejny i mestorozhdeniya YUga evropejskoj chasti SSSR* [Geology of coal and combustible shales deposits of the USSR. Coal basins and deposits of the Southern European part of the USSR], in Levenshtejn, M.L. (ed.), Gos. nauchn.-tekhn. izd-vo lit. po geol. i ohrane nedr, Moscow, USSR.

8. Anciferov, A.V., Golubev, A.A., Kanin, V.A., Tirkel, M.G., Zadara, G.Z., Uziyuk, V.I., Anciferov, V.A. and Suyarko, V.G. (2009), *Gazonosnost i resursy metana ugolnyh bassejnov Ukrainy. Tom 2. Uglegazovye i gazovye mestorozhdeniya Severo-Vostochnogo Donbassa, okrain Bolshogo Donbassa, DDV i Lvovsko-Volynskogo bassejna* [Gas content and methane resources of coal basins of Ukraine. Vol. 2. Coal gas and gas fields of the North-Eastern Donbass, the outskirts of the Greater Donbass, the DDV and the Lviv-Volyn basin], Veber, Donetsk, Ukraine.

9. Bagrij, I.D., Gozhik, P.F., Pochtarenko, V.I., Aksom S.D., Dubosarskij, V.R., Mamishev, I.Ye., Kizlat, A.M. and Palij, V.M. (2011), *Prognozuvannya geodinamichnih zon ta perspektivnih plosh dlya vidobutku shahtnogo metanu vugilnih rodovish Donbasu* [Forecasting of Geodynamic zones and promising areas for mine methane extraction of coal deposits of Donbass], Foliant, Kyiv, Ukraine.

10. Monogarova,Yu.J., Monogarov, I.I. and Mantoshko, Ya.S. (2009), "Features of the main directions of degassing operations on Tomashevsky square of the Lisichansky geological and industrial district of Donbass", *Geolog Ukrayini*, vol. 3, pp. 161–164.

11. Pavlov, S. D. (2005), *Puti osvoeniya gazov ugolnyh mestorozhdenij* [Ways to develop coal field gases], Kolorit, Kharkiv, Ukraine.

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ВПЛИВ СКЛАДЧАСТОСТІ НА ФОРМУВАННЯ ПРОМИСЛОВОЇ ГАЗОНОСНОСТІ ПІСКОВИКІВ В УМОВАХ ТОМАШЕВСЬКИХ СКЛЕПІНЬ

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Анотація. З огляду на значне виснаження класичних родовищ нафти і газу, до яких належить більшість вуглеводневих ресурсів України, актуальним є пошук додаткових альтернативних покладів енергоносіїв. Метою роботи є аналіз умов промислової газоносності пісковиків Томашевських антиклінальних структур. На прикладі цих структур (Північне та Південне склепіння) розглянуті умови формування промислової газоносності пісковиків вугленосної товщі. Дослідження здійснювалися шляхом побудови карти локальних структур із застосуванням тренд аналізу. За гіпсометричним планом вугільного пласта побудована апроксимуюча поверхня 1-го порядку – площина. За відхиленням фактичних гіпсометричних позначок вугільного пласта від відповідних позначок апроксимуючої поверхні методом інтерполяції побудована карта локальних структур. В плані виділені антиклінальні складки та визначені її головні параметри – амплітуда та ширина. За цими параметрами структур виконані розрахунки коефіцієнтів вигину досліджуваних склепінь. Згодом виконані розрахунки критичної товщини для пісковиків. Головним чинником промислової газоносності у склепінних частинах Томашевських антиклінальних структур є процеси тріщиноутворення, які спричинили формування покращених фільтраційно-ємнісних властивостей пісковиків в розрізі вугленосної товщі. У пісковиках з великою потужністю, понад критичну товщину (від 9.8 до 17.0 м) за розрахунковими даними, під впливом складчастих деформацій були сформовані скупчення вугільного метану з ефективною товщиною, за фактичними даними, від 2.4 до 14,9 м. Аналіз впливу складчастості на умови формування промислової газоносності пісковиків в умовах Томашевських склепінь засвідчив придатність методики прогнозування газових скупчень у локальних антиклінальних структурах, для оцінки потенційної промислової газоносності в звичайних антиклінальних структурах 1-го порядку. Ця методика може бути застосована для пошуку газових покладів, як у позитивних структурах 2-го порядку (локальних), так і структурах першого порядку.

Ключові слова: вуглеводні, вугленосна товща, антиклінальні структури, пісковики, газові скупчення.