https://doi.org/10.33271/nvngu/2026-3/005

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STAGES OF FORMATION OF THE BEREZIVSKE GAS CONDENSATE FIELD STRUCTURE AND THE ROLE OF CON-SEDIMENTATION PROCESSES

Purpose. Establishing the stages of structure formation involving con-sedimentation processes at the Berezivske gas condensate field.

Methodology. Creation and analysis of a set of structural maps constructed using trend analysis for sediments of different ages. Information processing from published and archival geological literature.

Findings. The application of the authors' methodology for the distribution of local structures into con- and post-sedimentation categories using trend analysis allowed us to identify three stages in the development of the Berezivske gas-condensate field. The main folds of the field – the West Berezivska and East Berezivska anticlines – were formed during the Carboniferous. They were formed primarily through con-sedimental processes. Changes in the structural plan began in the Upper Carboniferous, including some modifications to the fold shapes and locations. The structural plan changed significantly during the Early Permian: The West Berezivska and East Berezivska anticlines did not manifest, and the local structures that formed were mainly post-sedimentation. In the Mesozoic, the structural plan changed again considerably. The main folds of the field practically did not manifest. Structural maps of Mesozoic horizons show several new local anticlines and synclines of mainly con-sedimentation origin. Therefore, during the development of the Berezivske gas-condensate field, periods with predominantly con-sedimentation folding occurred twice – in the Carboniferous and Mesozoic.

Originality. It has been established that the structure of the Berezivske gas condensate field formed in three stages: Carboniferous (formation of folds predominantly in a con-sedimentation manner); Early Permian (change in the structural plan, with no significant evidence of con-sedimentation origin for local structures); Mesozoic (second change in the structural plan, formation of new local anticlines and synclines predominantly in a con-sedimentation manner).

Practical value. The identified stages in the formation of folded structures provide a basis for analysing oil and gas potential in the central part of the near-axial zone of the Dnieper-Donets Depression.

Keywords: *local folding, con-sedimentation folds, post-sedimentation folds, trend analysis, oil and gas fields*

Received: 10 February 2026
Accepted: 08 April 2026
Available online: 27 June 2026

Introduction. The uneven distribution of energy resources and limited global energy supplies have made energy security one of the most critical issues facing every nation. Currently, a major challenge for Ukraine's national economy is energy security, particularly given its own hydrocarbon resources. Energy independence forms the foundation of the country's economic and political sovereignty. During the war and post-war period, this issue worsens and becomes a top priority [1].

To effectively achieve energy independence, many conditions must be met, in particular, the availability of its own resources and strategic reserves. Ukraine is included in the list of countries that have significant deposits of various types of energy resources (oil, natural gas, coal, peat, uranium, etc.). However, the level of provision of these resources, their extraction, and use are uneven, which in total does not currently provide the required level of energy security.

Currently, there are about 410 discovered gas, oil, and gas condensate fields, which, according to the State Scientific and Production Enterprise (SSPE) "Geoinform of Ukraine", are listed on the state register. They are concentrated in three oil and gas-bearing regions: The South – the South Crimean oil and gas province; the West – the Volyno-Podilska and Ciskarpattia Gas/Oil bearing provinces; the Carpathian oil-bearing region, the Transcarpathian gas-bearing region; the East –

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the Dnieper-Donetsk Depression (DDD) [1]. The largest hydrocarbon production occurs in Ukraine's Eastern region. The Western region ranks second. The Southern region is the least explored but the most promising.

The DDD represents the largest oil- and gas-bearing region in Ukraine, encompassing numerous hydrocarbon deposits of different genetic types. A considerable body of classical research has focused on the distribution of oil and gas structures according to the chronology of their formation. Among the most notable studies is the monograph by V. A. Vitenko and B.P. Kabyshev, "History of the Development of Oil and Gas Structures of the DDD" (1977), included in the series "Geology and Oil and Gas Potential of the Dnieper–Donets Depression," which was awarded the State Prize in 1991. In this work, the authors categorize the structures into ancient, archaic, mixed, and young groups based on the proportion of their Paleozoic-stage formation, corresponding to 100, 70, 30, and 0 %, respectively. These structures are also categorized as either con-sedimentation or post-sedimentation, with con-sedimentation structures being predominant. They are characterized by a decrease in suit thickness toward the uplift vaults. Similarly, an increase in the content of sandstones is observed. Therefore, the classical geotectonic method of facies and thickness measurements allows for dividing folds into con-sedimentation or post-sedimentation types for sufficiently large tectonic structures of the DDD.

Literature review. The genesis of folding is one of the fundamental aspects of petroleum geology because it influences the formation of traps, possible pathways of hydrocarbon migration, and the degree of preservation or loss of reserves. The character of folding – whether consedimentary, post-sedimentary, or transitional – significantly affects the development of oil and gas accumulations [3].

Con-sedimentary folding develops simultaneously with sediment deposition as a result of uneven crustal movements. Such structures are commonly associated with reef buildups, lenticular sedimentary bodies, and stratigraphic traps that may function as hydrocarbon reservoirs [4, 5]. The early formation of local anticlinal uplifts promotes the primary accumulation of hydrocarbons, while facies pinch-outs and lithological barriers often contribute to the sealing and preservation of deposits [5, 6]. Con-sedimentary structural systems are typically characteristic of foredeep basins, passive continental margins, and intraplatform depressions [7]. A representative example is the West Siberian petroleum province, where a large number of hydrocarbon fields are related to con-sedimentary tectonic structures [8].

Post-sedimentation folding forms after sedimentation completes, under the impact of regional tectonic movements [6, 9]. It can damage or alter primary traps, leading to secondary hydrocarbon migration. It creates new anticlinal traps and fault structures, which can be favourable for oil and gas accumulation [10]. Zones of increased fracturing can develop, which can play a dual role [4, 6].

The issue of establishing the stages of structure formation in the central part of the Dnieper-Donetsk depression has been repeatedly examined in the works by domestic researchers [11, 12]. Many publications have emphasized the rift nature of the depression [13, 14], the role [15] of the Hercynian and Alpine tectonic phases [16], the characteristics of salt dome tectonics [17, 18], and the influence of tectonic movements on the development of anticlinal structures [14]. Considerable focus has been given to studying the deep structure [19], rupture anomalies, and the morphology of folded forms in Carboniferous, Permian, and Mesozoic sediments [20].

Meanwhile, most research has viewed the structural development of local uplifts primarily from the perspective of post-sedimentation tectonics. At the same time, the role of con-sedimentation processes in fold formation has often been assessed only in a fragmentary or indirect manner. Issues regarding spatiotemporal changes in the structural plan of individual fields, specifically the relationship between con-sedimentation and post-sedimentation deformations in sediments of different ages, remain insufficiently systematized.

A notable area within the central part of the Dnieper-Donetsk depression is occupied by the Berezivske gas condensate field, situated in the middle of the depression's axial zone. The complex tectonic structure of this region, resulting from its multi-stage geological development, necessitates a detailed investigation of the patterns of local structure formation that control hydrocarbon traps. It is known that local folds influence the redistribution of gases [25]. Gas redistribution and the type of cover depend on the specific type of local fold and the extent of catagenetic transformations of the rocks.

In the Dnieper-Donetsk depression, there are many local folds, and, as noted in [2], applying the method of facies and thicknesses here needs clarification and improvement. This is because of the small size and amplitude of the folds, minor fluctuations in thicknesses, and often the inability to track facies changes over small distances.

The Berezivske gas condensate field is characterised by changes in structural morphology throughout the section from the Carboniferous to the Mesozoic, indicating a multi-stage process of its formation. However, a comprehensive model that combines structural map analysis across different stratigraphic levels with a quantitative assessment of con-sedimentation processes has not yet been proposed. Existing data from archival and published sources require generalisation using modern structural analysis approaches, particularly trend-analysis methods that enable the differentiation of the regional component and local deviations.

Unsolved aspects of the problem. As part of the study presented in [2], a methodological approach was developed to classify local oil and gas field structures into con-sedimentary and post-sedimentary types. The proposed technique integrates capacity-based methods with trend and correlation analyses, allowing for a more reliable identification of the stages of structural formation and their subsequent evolution. The obtained results demonstrate the significant role of tectonic activity in controlling hydrocarbon migration and accumulation during particular phases of geological development.

Establishing the patterns of local structure formation within the Berezivske gas condensate field led to the conclusion that during the Upper Serpukhovian period, these structures were formed via con-sedimentation processes [2].

Therefore, an urgent scientific issue is to establish the stages in the formation of the Berezivske gas con-

densate field's structure, including determining the role of con-sedimentation processes in the evolution of local anticlinal and synclinal structures. Solving this problem is crucial for understanding the evolution of the tectonic structure in the central part of the Dnieper-Donets depression, as well as for predicting oil and gas potential and guiding future geological exploration.

Prospects for further development in this area include enhancing the authors' existing methodology [2]. Additionally, to confirm and clarify the conclusions reached for the Upper Serpukhovian stage, it is advisable to expand the research to other horizons of the Berezivske field. This will help clarify models of hydrocarbon deposit formation, optimize geological exploration, and improve the utilization of the region's resource potential.

Purpose. The purpose of the article is to establish the history of the formation of the structure of the Berezivske gas condensate field and the role of con-sedimentation processes in this. Objectives include dividing local folds into post- and con-sedimentation, and establishing the stages in the field's structural formation.

Methodology. The authors' method for dividing folded structures into con-sedimentation and post-sedimentation [2] was employed in this research. The methodology is based on the following: at the initial stage – on a detailed analysis of the structure and thickness of horizons of different ages; at the second stage – on a detailed analysis of local structures, deviations in horizon thickness from the trend, hypsometric change trends, and thicknesses of horizons of different ages. Joint analysis of maps of various parameters allows us to determine the relative age of local structures (con- or post-sedimentation). For each researched horizon, a set of the following maps was created: hypsometry, horizon depth change trend, local structures, isopach maps, trend of thickness variation over the area, and local deviations of thicknesses from the trend. These map sets were constructed for 10 rock horizons within the Berezivske gas condensate field. Specifically, these horizons include: Serpukhovian stage (C_1s) of the Lower Carboniferous; Bashkirian (C_2b) and Moscovian stages (C_2m) of the Middle Carboniferous; Upper Carboniferous (C_3); Kartamyska (P_1kt), Mykytivska (P_1nk), and Slovianska (P_1sl) of the Lower Permian; Triassic system (T); Jurassic system (J); and Cretaceous system (K). A total of 60 maps were constructed and analysed across the field area.

Results. The Berezivske gas condensate field (Kharkiv region, Bohodukhiv district) was chosen as the research object. Tectonically, the field is part of the Kotelevskyi-Berezivskyi structural swell located in the central area of the Dnieper-Donetsk depression's axial zone. The Berezivske-Kotelevskyi swell has several domes, including the Stepove, East-Berezivske, West-Berezivske, Kotelevskyi, Ukrainian, and others. The Berezivske field is linked to two domes: East-Berezivske and West-Berezivske. These domes are asymmetrical brachianticlines extending northwest. The domes within the isogypsum at – 4,575 m (the top horizon C-5) measure 3.3 × 1.5 km with an 85 m amplitude, and 3.7 × 2.2 km with a 140 m amplitude, respectively. Several tectonic fractures occurred at the Berezivske field. The primary ones are longitudinal normal faults. Fault I has an amplitude of up to 150 m. Fault III has an amplitude of up to 140 m and is a splay of Fault I. The faults die out within Triassic rocks. A series of transverse small-displacement faults is also present.

Within the Berezivske field, Paleozoic, Mesozoic, and Cenozoic sediments have been exposed by wells.

The Carboniferous System (C) consists of the Lower (C_1), Middle (C_2), and Upper (C_3) series. The lower section includes sediments from the Tournai (C_1t), Viseu (C_1v), and Serpukhovian stages (C_1s). The total thickness of the Lower Carboniferous is nearly 1,700 meters. The rocks from the Lower Carboniferous, listed from bottom to top, include: interbedded mudstones and sandstones with thin limestone layers; a thick limestone layer overlain by sandstones; alternating layers of sandstones, siltstones, and mudstones with limestone layers; a mudstone layer with siltstones, and less often, sandstones and limestones; and a rhythmic sequence of interbedded sandstones, siltstones, mudstones, and less frequently, limestones. In the sediments of the Upper Serpukhovian sub-stage (C_1s_2), several sandstone horizons are identified, including the C-5 horizon, where the main gas faults in the field are confined.

The middle Carboniferous section (C_2) includes sediments from the Bashkirian stage (C_2b) and the Moscovian stage (C_2m). The total thickness of the Middle Carboniferous exceeds 1,200 meters. The rocks of the Middle Carboniferous, from bottom to top, consist of interbedded siltstones, mudstones, and sandstones with layers of limestone and coal; thick sandstone horizons interbedded with mudstones; and thin layers of limestone.

The upper Carboniferous (C_3) section contains sediments from the Kasimovian (C_3k) and Gzhelian (C_3g) stages. The total thickness of the Upper Carboniferous is up to 700 meters. Rocks from this period are characterized by interlayered thick sandstones, siltstones, mudstones, and sometimes dolomitized limestones.

The Permian system (P) is characterized by sediments from three suites within the lower section (P_1): Kartamyskyi (P_1kt), Mykytivskyi (P_1nk), and Slovianskyi (P_1sl). The thickness of Permian sediments can reach up to 930 meters. From bottom to top, the rocks of the Permian system mainly consist of red-coloured clays, siltstones, and sandstone interlayers, interbedded anhydrites, limestones, dolomites, and clays containing rock salt interlayers.

The Triassic system (T) is represented by sediments of four suites, specifically Shebelynska, Korenivka, Serebrianska, and Protopivska. The total thickness of Triassic sediments reaches up to 930 meters. The rocks of the Triassic system are arranged from bottom to top as follows: a sandy-clayey stratum, a sandy stratum, a sandy-carbonate stratum, and a clayey stratum.

The Jurassic system (J) is represented by sediments of two series: Middle (J_2) and Upper (J_3). The total thickness of Jurassic sediments exceeds 600 meters. From bottom to top, the rocks of the Jurassic system include: clays, sandstones, sands with interlayers of limestone, and siltstones.

The Cretaceous system (K) is represented by sediments of two series: Lower (K_1) and Upper (K_2). The total thickness of the Cretaceous rocks is nearly 900 meters. From bottom to top, the succession consists of interbedded sands, sandstones, and clays, followed by white writing chalk with marl interlayers.

The Paleogene (*P*), Neogene (*N*), and Quaternary (*Q*) systems have a combined thickness of over 300 meters. The rocks are represented by sands, sandstones, marls, clays, loess-like loams, soil, and topsoil.

Several gas-bearing strata have been identified in the section: Upper Serpukhovian, Upper Visean, Lower Visean, and Tournaisian. Reservoir beds are represented by sandstones.

The rocks of the Berezivske field have been penetrated by dozens of both exploration and production wells, enabling the construction of reliable maps of structures and isopachs.

The Carboniferous System (*C*), Lower Series (C_1). The structure of the Lower Carboniferous will be examined using the example of the Upper Serpukhovian Substage (C_1s_2). It features interbedding of sandstones, siltstones, mudstones, and limestones. The sandstones are layered and light grey. Several sandstone horizons are identified, with the C-5 horizon being over 80 meters thick and the most productive at the field. In the article [2], a structural map, a map of the approximating surface, a map of local structures of the first order, an isopach map, a map of the first-order trend of thickness, and a map showing the deviation of thickness from the approximating value are provided for this sub-stage. The depth of the base of the Upper Serpukhovian sub-stage ranges from minus 4,800 to minus 4,500 meters. This map highlights the West Berezivska (wells 31, 100, 106 in the central part of the fold) and East Berezivska (wells 113, 115) anticlines. The map of the approximating surface shows an increase in the regional depth background moving eastward. The local structure map reveals the anticlines bounded by a zero isoline, with a clear division into anti- and synclines. The local amplitude of the West Berezivska anticline is 120 meters, while that of the East Berezivska anticline is 100 meters.

The isopach map shows changes in the thickness of the C_1s_2 horizon (from 490 to 260 m). The trend map of the C_1s_2 horizon thickness reveals a regional increase in thickness toward the southeast. The map showing deviations of the thickness from the approximating plane displays areas with values above and below the trend. It demonstrates that areas with negative deviations correspond to zones of local anticlines, while areas with positive deviations align with zones of local synclines. This is a significant indication of the con-sedimentation formation of these structures in the Lower Carboniferous.

Carboniferous system (*C*), Middle Series (C_2). The structure of the Middle Carboniferous is illustrated by the example of the Bashkirian stage (C_2b) and the Moscovian stage (C_2). Middle Carboniferous rocks lie intermittently on the rocks of the Lower Carboniferous.

Bashkirian stage (C_2b). For the sediments of this stage, a structural map, an approximating surface map, a map of local first-order structures, an isopach map, a first-order power trend map, and a map of power deviations from the approximating value were created. The sediments of this stage consist primarily of interbedded sandstones, siltstones, and mudstones, with limestones and coal, which overall form a greyish terrigenous strata.

The depth at the base of the Bashkirian stage ranges from minus 4,400 to minus 4,200 meters. The structural map highlights the West-Berezivska and East-Berezivska anticlines. The map of the approximating surface indicates a general increase in the regional depth background, mainly toward the east. On the local structures map (Fig. 1), the anticlines are bounded by the zero isoline. Overall, the fold contours resemble those of the Lower Carboniferous, though some eastward displacement of the local structure maxima is observed. For instance, in the East Berezivska local fold, the central area includes wells 50 and 204. The local amplitude of the West Berezivska anticline reaches up to 100 meters, while the East Berezivska anticline reaches up to 60 meters.

The isopach map displays areal variations in the thickness of the C_2b horizon (ranging from 490 to nearly 700 meters). The thickness trend map for the C_2b horizon indicates a regional increase in thickness toward the southwest. The thickness deviation map from the approximated value (Fig. 2) highlights areas with thick-

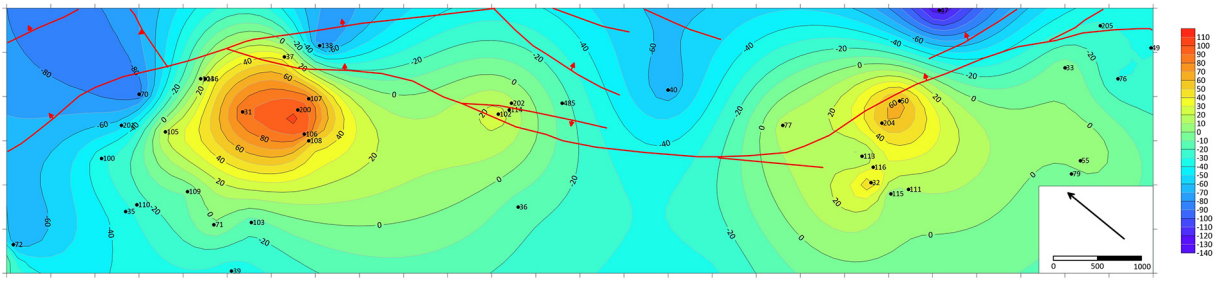

Fig. 1. Map of the first-order local structures for the C_2b horizon, Berezivske field

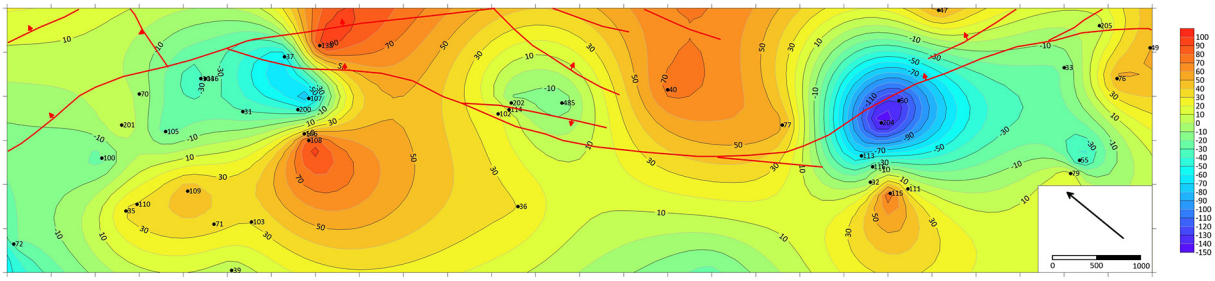

Fig. 2. Thickness deviation map from the approximated value for the C_2b horizon, Berezivske field

nesses above and below the trend line. It is clear that regions with negative deviations correspond to zones of local anticlines, while areas with positive deviations align with zones of local synclines. This provides significant evidence of the con-sedimentation processes that formed these structures during the Bashkirian period of the Middle Carboniferous (C_2b).

Carboniferous system (C), Middle Serries (C_2), Moscovian Stage (C_2m). The sediments of a stage are mainly interbedded mudstones, siltstones, and limestones with thick sandstone beds.

Structural and isopach maps were constructed for the sediments of this stage, as well as four derived maps: a map of the approximating surface, a map of the first-order local structures, a first-order trend map of thickness, and a map of thickness deviation from the approximating value. The base of the Moscovian Stage occurs at depths ranging from –3,800 to –3,550 m. The structural map shows the West-Berezivska and East-Berezivska anticlines. The approximating surface map shows an increase in the regional depth background, mainly in the northeast direction. On the map of local structures, the anticlines are limited by a zero isoline. In general, the contours of the folds are similar to the structures of the Bashkirian Stage (C_2b), but a westward shift of the maximum of the East-Berezivska local structure is noted (wells 77, 115). The local amplitude in the Moscovian Stage sediments of the West-Berezivska anticline is up to 100 m, and in the East-Berezivska anticline is over 60 m.

The isopach map shows areal variations in the thickness of the C_2m horizon, ranging from nearly 300 to over 500 meters. The trend map of the C_2m horizon thickness indicates a regional increase in thickness toward the southwest. The map of thickness deviation from the approximate value highlights areas with thickness above or below the trend. It is clear that areas with negative thickness deviations belong to zones of local anticlines, while areas with positive deviations coincide with zones of local synclines. This is a significant indication of the con-sedimentation formation of these structures during the Moscovian age of the Middle Carboniferous (C_2m).

Carboniferous System (C), Upper Series (C_3).

Let us examine the structure of the upper Carboniferous series, using the Kasimovian (C_3k) and Gzhelian stages (C_3g) as examples. The Upper Carboniferous stratum is primarily composed of thick, predominantly grey, quartz and quartzofeldspathic sandstones. They are interbedded with siltstone, mudstone, and dolomitized limestone layers. They rest on the Middle Carboniferous sediments with a slight unconformity. A structural map, an approximating surface map, a first-order local structure map, an isopach map, a first-order thickness trend map, and a map of thickness deviations from the approximating value were constructed for the sediments of this series. The Upper Carboniferous base lies between minus 3,350 and minus 3,130 m. On the structural map, the West-Berezivska and East-Berezivska anticlines appear in slightly altered forms. The approximating surface map shows an increase in the regional background of depth, primarily in a northeasterly direction. The map of local structures (Fig. 3) depicts anticlines bounded by a zero isoline. Some changes in the shapes and displacements of the maxima of local structures toward the east are observed compared to the Middle Carboniferous structures. For example, the northern part (well 77) has the form of a local syncline for the East-Berezivska local fold. The local amplitude of the West-Berezivska anticline exceeds 100 meters, while the East-Berezivska anticline exceeds 40 meters.

The isopach map shows areal variations in the thickness of the C_3 horizon (from 380 to 700 m). The C_3 horizon thickness trend map shows a regional increase in thickness in a southwesterly direction. The thickness deviation map from the approximate value (Fig. 4) shows areas with thickness deviations above and below the trend. Areas with negative thickness deviations predominantly belong to zones of local anticlines, while areas with positive deviations coincide with zones of local synclines. This is a significant indication of the con-sedimentation formation of these structures during the Moscovian age of the Upper Carboniferous (C_3).

Permian system (P). The sediments unconformably overlie Upper Carboniferous rocks. In the upper part, they are represented mainly by chemogenic rocks (anhydrites, dolomites, limestones, rock salt layers). In the lower part of the section, they are represented mainly by terrigenous rocks (clays, siltstones). Three suites are distinguished in the system: Kartamyska (P_1kt), Mykytivska (P_1nk), and Slovianska (P_1sl). For each of these suites, a structural map, an approximating surface map, a map of first-order local structures, an isopach map, a first-order thickness trend map, and a thickness deviation map from the approximating value (a total of 18 maps for the Permian deposits) were constructed.

Permian System (P). Kartamyska Suite (P_1kt). The depth of the Permian System base ranges from –2,800 to –2,570 meters. On the structural map, the West-Berezivska and East-Berezivska anticlines are barely visible compared to the Carboniferous sediments. The approximating surface map shows an increase in the regional depth background, primarily in a northeasterly direction. The local structure map (Fig. 5) reveals significant changes in the nature of local structures, particularly in the eastern and central parts of the field. Specifically, in areas with Car-

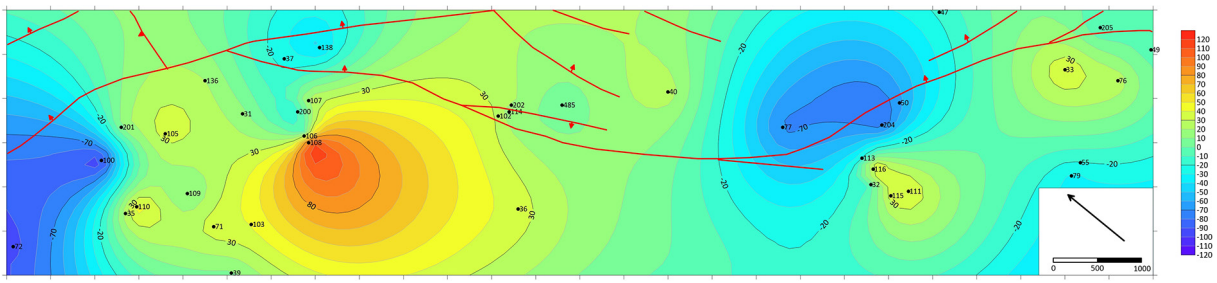

Fig. 3. Map of first-order local structures at the Berezivske field along the C_3 horizon

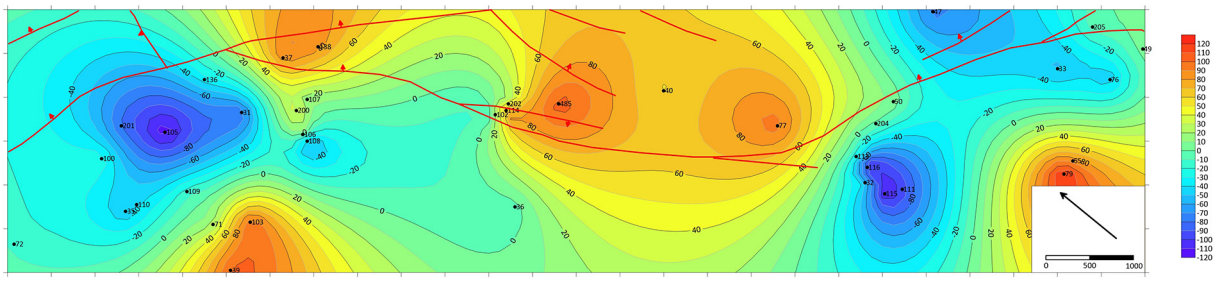

Fig. 4. Map of thickness deviations from the approximate value of the Berezivske field along the C_3 horizon

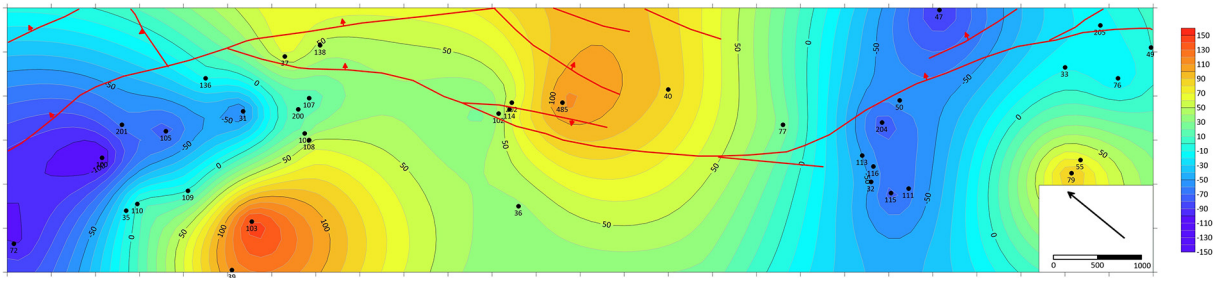

Fig. 5. Map of first-order local structures at the Berezivske field along the horizon (P_1kt)

boniferous local anticlines, local synclinal forms are identified (well 115), and conversely, in areas with local synclines, local anticlines are present (well 185). The West-Berezivska local anticline is shifted southwest (well 103).

The isopach map shows variations in the area of the horizon thickness (P_1kt), ranging from 40 to 240 m. The horizon thickness trend map (P_1kt) indicates a regional increase in thickness towards the northeast. The thickness deviation map from the approximate value (Fig. 6) highlights areas with deviations above and below the trend. No significant signs of con-sedimentation folding in local structures during the Early Permian (P_1kt) are observed. Analysis of maps showing local structures and thickness deviations from the trend for the Mykytivska suite (P_1nk) and the Sloviansk suite (P_1sl) generally revealed similarities to the sediments of the Kartamyska suite (P_1kt). That is, in the sediments from the Early Permian period, the West-Berezivska and East-Berezivska folds are barely evident. No significant signs of con-sedimentation origin are recorded for local structures.

The Triassic system (T). Triassic rocks are deposited with erosion on rocks of Lower Permian age. They initiate sediments of the second structural stage in the field. Four suites are distinguished within the Triassic formation – Shebelynska, Korenivska, Serebrianska, and Protopivska. The rock types include sandy-clayey, sandy, sandy-carbonate, and clayey rocks. A structural map, an approximating surface map, a first-order local structure map, an isopach map, a first-order thickness trend map, and a map of thickness deviations from the approximating value were constructed for the Triassic system. The base of the Triassic system is mainly found at depths between −2,200 m and −2,500 m. No closed folds are visible on the structural map. The base of the horizon has an undulating structure. The approximating surface map shows an increase in the regional depth background, primarily in a northeasterly direction. The local structures map (Fig. 7) reveals several local anticlines and synclines, with the largest being a local anticline reaching up to 140 m in amplitude (located between wells 102 and 103), which transitions into a local syncline with an amplitude of up to 60 m (from wells 47 to 115). The structural layout of the Triassic horizon differs from that of the Carboniferous horizons, where the main features are the West-Berezivska and East-Berezivska anticlines.

The isopach map shows areal variations in the thickness of the T horizon ranging from 620 to over 900 meters. The trend map of the T horizon thickness reveals a regional increase toward the northeast. The deviation map from the approximate values (Fig. 8) indicates areas with thicknesses above and below the trend. Two such areas are identified: one with increased thickness up to 120 meters located from wells 102 to 103, and the other with decreased thickness up to 60 meters (from wells 47 to 115). This means that the anticlinal area is characterized by reduced sediment thickness, while the synclinal area has increased thickness. Moreover, the amplitudes of local folds closely correlate with variations

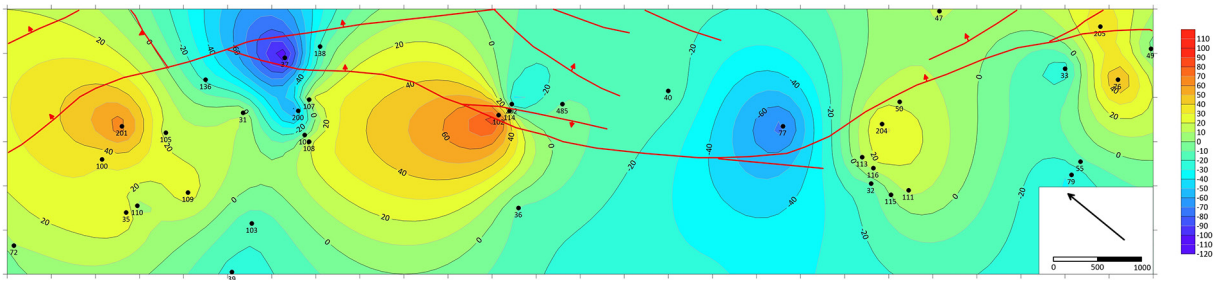

Fig. 6. Map of thickness deviations from the approximate value of the Berezivske field along the horizon (P_1kt)

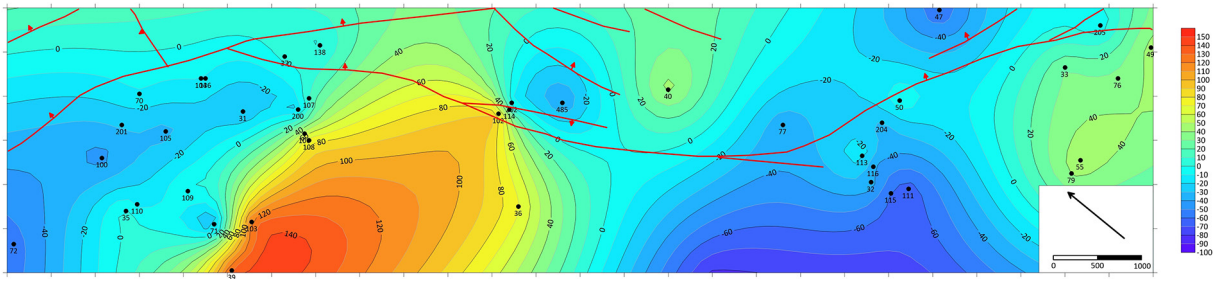

Fig. 7. Map of first-order local structures at the Berezivske field along the T horizon

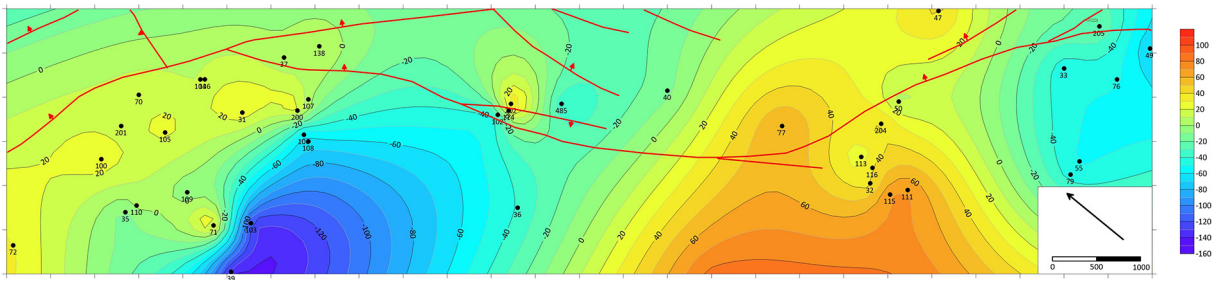

Fig. 8. Map of thickness deviations from the normalized value for the Berezivske field along the T horizon

in sediment thickness, which is a significant sign of the con-sedimentation formation of these local structures during the Triassic period (*T*).

Analysis of maps showing local structures and thickness deviations from the trend for Jurassic sediments (*J*) and Cretaceous sediments (*K*) generally indicates that they are similar to Triassic sediments (*T*). The base of the horizon has an undulating structure. The West-Berezivska and East-Berezivska anticlines are barely visible. On the maps of local structures for horizons *J* and *K*, several local anticlines and synclines are observed, likely caused by con-sedimentation processes.

Thus, studying the history of structural formation using the updated trend analysis methodology yielded the following results. For the section of the Berezivske gas condensate field (Kotelevsko-Berezivska structural swell in the central part of the axial zone of the Dnieper-Donetsk depression), three stages of sedimentary strata formation and folding are identified.

Stage 1 – Carboniferous (C). The West-Berezivska and East-Berezivska anticlines were mainly formed by con-sedimentation. In the Upper Carboniferous, a change in the structural plan begins. These anticlines appear in slightly altered forms, with a shift of the maxima of local structures toward the east and with reduced amplitude.

Stage 2 – Early Permian (P_1). A change in the structural plan occurred. The West-Berezivska and East-Berezivska folds were not manifested within the Early Permian deposits. No significant evidence of a con-sedimentation origin was recorded for the identified local structures.

Stage 3 – Mesozoic (T, J, K). A second change in the structural plan occurred. The base of the horizon has an undulating structure. The West-Berezivska and East-Berezivska anticlines did not manifest. On the maps of local structures of horizons *T*, *J*, and *K*, several local anticlines and synclines of mainly con-sedimentation origin are identified.

That is, in the history of the development of the Berezivske gas condensate field, there have been two periods with significant development of con-sedimentation folding – the Carboniferous (which experienced the greatest intensity of con-sedimentation folding) and the Mesozoic.

Conclusions. By applying the updated method for distinguishing local structures into con-sedimentation and post-sedimentation, the history of the structural formation of the Berezivske gas condensate field was analysed. Three stages of structural plan changes were identified, and it was demonstrated that periods with significant development of con-sedimentation folding occurred twice – during the Carboniferous (which experienced the highest intensity of con-sedimentation folding) and the Mesozoic.

Prospects for further development involve refining the methodology by incorporating statistical indicators and expanding the scope of research to other fields.

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Етапи формування структури Березівського газоконденсатного родовища й роль конседиментаційних процесів

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Мета. Встановлення етапів формування структур Березівського газоконденсатного родовища за участі конседиментаційних процесів.

Методика. Створення й аналіз комплексу структурних карт, побудованих із застосуванням тренданалізу для різновікових відкладів. Опрацювання інформації, опублікованої у фондовій геологічній літературі.

Результати. Застосування авторської методики розподілу локальних структур на кон- і постседиментаційні з використанням тренданалізу дозволило виявити три етапи формування ділянки Березівського газоконденсатного родовища. Під час карбону були сформовані головні складки родовища – Західно-Березівська та Східно-Березівська антикліналі. Вони утворювалися переважно конседиментаційно. Переміни структурного плану розпочались у верхньому карбоні – деяка зміна форм і розташування складок. Під час ранньої перми суттєво змінився структурний план. Західно-Березівська та Східно-Березівська антикліналі не проявилися. Сформовані локальні структури є переважно постседиментаційними. Під час мезозою структурний план знову суттєво змінився. Головні складки родовища практично не проявились. На картах локальних структур горизонтів мезозою відмічається декілька нових локальних антикліналей і синкліналей переважно конседиментаційого походження. Таким чином, під час розвитку Березівского газоконденсатного родовища періоди із переважаючим розвитком конседиментаційної складчастості відбувались двічі – у карбоні й мезозої.

Наукова новизна. Встановлено, що формування структури Березівського газоконденсатного родовища відбулось у три етапи: карбоновий (формування складок переважно конседиментаційним шляхом); ранньопермський (зміна структурного плану, для локальних структур суттєвих ознак конседиментаційного походження не зафіксовано); мезозойський (друга зміна структурного плану, формування нових локальних антикліналей і синкліналей суттєво конседиментаційним шляхом.

Практична значимість. Встановлені етапи формування складчастих структур є основою для аналізу нафтогазоносності для центральній частині приосьової зони Дніпровсько-Донецької западини.

Ключові слова: *локальна складчастість, конседиментаційні складки, постседиментаційні складки, тренданаліз, нафтогазові родовища*