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**Myroslav PALYUK, Volodymyr SHLAPINSKY,
Albert MEDVEDEV, Bohdan RIZUN, Myroslav TERNAVSKY**

# PROBLEMATIC ASPECTS OF THE FORMATION OF THE UKRAINIAN SEGMENT OF THE CARPATHIANS

In the paper a model of the formation of the folded-covering-block structure of the Carpathians at a time interval that envelops Late-Hercynian and Alpine events is substantiated. Moreover, this concerns the Outer Carpathians, but the whole Carpathians arch was characterized without going into details, a critical estimate is expressed for application of such terms as terrains, accretion prism, suture, subduction and Transcarpathian fault. It is shown that formation of the Carpathians occurred through several stages under the influence of different-directed, manly horizontal, movements, as a result of which was destruction of early formed Hercynian continental crust, laying of geosynclinals troughs, formation and further transformation of the basement of the Flysch Carpathians, its collision with Eurasian continental edge, underling of the latter under flysh complex. After completion of these processes mainly vertical movements took place that lineally formed the structure of the Carpathians as folded-covering-block one. As a result of the last event (Pliocene-Pleistocene), a differential development of intensive fracturing occurred with the influx of hydrocarbons and filling traps formed up.

*Keywords*: formation of the Carpathians, terrains, accretion prism, Transcarpathian fault, crocodile tectonics, Other Carpathians, folded-covering-block structure.

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**Yuri KHOKHA, Oleksandr LYUBCHAK, Myroslava YAKOVENKO**

## THERMODYNAMICS OF TYPE II KEROGEN TRANSFORMATION

The article reviews the chemical structure of type II kerogen. The changes that occur with the structure of type II kerogen as it passes through the stages of catagenesis from immature to post-mature are evaluated. Structural models of type II kerogen at different stages of catagenesis are presented: both obtained empirically after studying the structure by physical and chemical methods and the results of modelling by molecular dynamics method.

Methods of equilibrium thermodynamics are used to calculate the composition of the kerogen–gas system for crust sections in the range of 1–20 km with a heat flux of 40 to 100 mW/m$^2$. The composition of kerogen/fluid geochemical system is calculated using the E. T. Jaynes formalism. It boils down to determining the optimal distribution of 5 elements (C, H, O, N, S) among the 44 additive constituents of the solid phase (i. e., type II kerogen) and other individual components that are included in the system ($CO_2$, $H_2O$, $H_2S$, $NH_3$, $CH_4$, $C_2H_6$, $C_3H_8$, *i*-$C_4H_{10}$, *n*-$C_4H_{10}$, *i*-$C_5H_{12}$, *neo*-$C_5H_{12}$, *n*-$C_5H_{12}$).

Comparison with the experiments showed that the results of the calculations do not contradict the experiments, with study the structure and changes in type II kerogen with increasing degree of catagenesis. In the analysis of changes in the concentrations of water, carbon dioxide and hydrogen sulfide, it is founded that kerogen could be not only a donor of atoms for gas components, but also their acceptor in contact with a high-energy fluid stream. It is shown that the determination of sulfur-containing atomic groups of kerogen by thermodynamic modelling yields gives more reliable results than molecular dynamics methods.

Established is that the concept of "methane-graphite death", which takes place in the state of thermodynamic equilibrium in the transformation of organic matter, is erroneous. The calculation shows that the composition of the kerogen–gas system, in addition to methane and carbon, includes solid-phase heteroatom groups, various additive components of aromatic structures and gases, both organic and inorganic. The distribution of elements between the additive components of kerogen and gases in this system controls the pressure and temperature in a complex way. The nature of changes in hydrocarbon gas concentrations in equilibrium with type II kerogen indicates the presence of an "oil window" in low-warmed zones within 2–4 km depths.

*Keywords*: type II kerogen, catagenesis, "oil window", equilibrium thermodynamics, Jaynes formalism.

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**Viacheslav LUKINOV, Kostiantyn BEZRUCHKO,**
**Mykhailo MATROFAILO, Liubov KUZNETSOVA**

## TO THE QUESTION OF OUTBURST HAZARD PREDICTION OF COAL BEDS AT THE LVIV-VOLYN BASIN

Sudden coal and gas outbursts in coal mines are one of the most harmful and at the same time, dangerous gas-dynamic phenomena faced when coal producting. The sudden coal and gas outbursts is the evanescent destruction of the bottom-hole area in the coal bed, which develops from the bottom into the depth of a massif, and the crushed coal with gas is thrown to a long distance from the bottom into the mine, destroying everything in its way, creating the conditions for explosion and fire breaking-out. Sudden outbursts lead to significant material losses for the recovery from an accident and in some cases injuries and human losses. The problem of reliable prediction, prevention, and control of sudden coal and gas outbursts at coal mines remains extremely urgent, due to the constant increase in the depth of mining operations. The analysis of the experience of predicting and preventing the outburst hazard in coal beds of Donets and Lviv-Volyn coal basins is analyzed. At Donbas mines since 1906, there have been more than 7.5 thousand sudden outbursts. Although mining had now reached considerable depths (from 300 to 600 m), the emergence of coal and gas outbursts have not been recorded. The purpose of the research is to determine the depth of the possible emergence of sudden coal and gas outbursts in the LVB, with regard to the peculiarities of the geological structure of the coal-bearing strata in the Lviv-Volyn coal basin.

The comparative possible depth estimation in the manifestation of the outburst hazard of the coal beds in the LVB is given. It is calculated according to the normative technique and performed according to the formulas obtained by the statistical analysis for the actual position of the minimum depth of coal and gas outbursts at the Donbas mines. The absence of sudden coal and gas outbursts at LVB mines on the coal beds, which are hazardous according to the prediction data, is performed according to the methods regulated by the normative documents and compiled by the experience of studying the outbursts in Donbas, is explained by the differences in the geological structure of the LVB, the main of which is the presence of thick mass of covering deposits and a significantly greater depth of the methane gas zone. The application of the empirical formulas prediction, which includes the methane gas zone depth index, allows us to account for these differences and it is much more reliable to determine the possible depths of sudden outbursts for LVB, which, all other things being equal, should be greater than in the Donbas. In particular, according to the performed calculations, the outburst hazard situation at the "Stepova" mine is predicted at depths of more than 700 m. As prediction indices for the calculations, values of methane gas zone depths of 450 m were adopted, and the minimum value of volatile-matter yield was 33.3%.

This approach can be proposed for predicting the coal and gas outbursts hazard in other Lviv-Volyn basin mines. To determine the predicted depth of the possible emergence

of sudden coal and gas outbursts, it is advisable to take into account the depth of the methane gas zone in the prediction calculations.

*Keywords*: Lviv-Volyn coal basin, coal beds, sudden outburst, zone of methane gases, prediction of outburst hazard.

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**Andriy POBEREZHSKY, Iryna BUCHYNSKA,**
**Olena SHEVCHUK, Taras MUKAN**

# MINING COMPLEX OF THE LVIV-VOLYN COAL BASIN AND ITS IMPACT ON THE ECOSYSTEM OF THE REGION

The influence of exploitation and abandonment of coal mines of the mining complex of Lviv-Volyn coal basin on the ecosystem of the region is considered. The main ecological problems of the territory are analyzed. It is established that the high technogenic pollution of the Chervonograd geological and industrial region is facilitated by the inflow of highly polluted drainage waters from the mine heaps and rock waste heaps of the Chervonograd Central Mining Plant into soils, surface, ground and underground waters. The negative impact of the heaps is caused by the high level of fault tectonics and fracturing of the bedrocks, the flat surface of the area. The influence of technogenic objects on the atmospheric air quality is analyzed. The main causes of the atmospheric air pollution are stationary sources of pollution.

Technogenic objects have a significant impact on the quality of the the atmospheric air. The main role in the structure of pollutants belongs to sulphur anhydrite, carbon and nitrogen oxides, dust and soot. The amount of pollutant emissions into the atmospheric air from stationary sources of pollution for Chervonograd and Sokal districts has been analyzed according to the data of the Main Statistics Office in Lviv region.

To prevent further deterioration of the ecological situation, it is recommended to form flat heaps, their reclamation and landscaping with the obligatory covering of the surface with a layer of neutral rocks, to keep measures to prevent burning of heaps. To stabilize the situation and to prevent further contamination of soil, surface and underground waters, the stable network of observations on the state of the geological environment, systematic geological and environmental monitoring should be carried out.

*Keywords*: Lviv-Volyn basin, mining complex, waste heaps, soils, underground waters, atmosphere.

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**Oleksandr PRYKHODKO, Ihor HRYTSYK,**
**Ihor KUROVETS, Svitlana MELNYCHUK**

# VERTICAL THERMOBARIC ZONING OF HYDROCARBON DEPOSITS OF THE EASTERN OIL- AND GAS-BEARING REGION OF UKRAINE

For the predictive appraisal of the perspective exploratory territories as well as prediction of separate producing horizons of prospecting and exploration areas for oil and gas it is necessary to establish the regularities of distribution of already explored deposits of hydrocarbons with structural-tectonic construction, lithological-stratigraphic features, hydrogeological and geothermobaric conditions of oil- and gas-bearing region taken into account.

Interconnection between geothermobaric parameters and the phase state of hydrocarbons in the vertical section should be an important factor for the solution of the posed task.

Within the limits of the Eastern oil- and gas-bearing area of Ukraine, the spatial zoning is established in the location of gas, oil and gas-condensate deposits. As a whole, the distribution of temperatures and pressures at different depths, average geothermal gradients, gradients of the lithological-stratigraphical horizons of the same name (sustained both as to the area and thickness) are closely connected with the deep geological structure of the studied region (area) and confirm the existing notions of the role of tectonic, lithological-stratigraphic and hydrogeological factors in the formation of the thermal regime of sedimentary basins.

Vertical zoning of the distribution of hydrocarbon deposits of oil- and gas-bearing horizons was developed according to geothermobaric parameters of the north-western part of the Dnieper-Donets Depression and 8 areas from 15 ones of the Eastern oil- and gas-bearing region, namely: Monastyryshche-Sofiivka and Talalaivka-Rybalske oil- and gas-bearing areas, Glynsk-Solokha gas- and oil-bearing area, Ryabukhyne-Northern Golubivka and Mashivka-Shebelynka gas-bearing areas, Rudenky-Proletarske oil- and gas-bearing region, Krasna Rika gas-bearing area and also oil- and gas-bearing area of the Northern edge.

Revealed regularities of the distribution of formation temperatures, pressures, geothermal and thermobaric coefficients with peculiarities of the tectonic structure of the Dnieper-Donets graben taken into account will make it possible to solve theoretical problems connected with hydrocarbon migration, the formation and preservation of deposits in more well-founded way that will make it possible to conduct prospecting for new fields at great depths within the studied territory more effectively,

*Keywords*: thermobaric parameters, initial formation temperatures, initial formation pressures, thermobaric coefficient, hydrostatic pressure, hydrostatics coefficient, producing horizon, oil- and gas-bearing complex, phase state of hydrocarbons, exploratory-prospecting works, oil, gas and gas-condensate deposits.

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**Oleksiy BARTASHCHUK**

## COLLISION DEFORMATIONS OF THE DNIEPER-DONETS DEPRESSION
### Article 1. Tectonics of the articulation zone with the Donets folding structure

The article is the first part of a trilogy devoted to the study of post-rift deformations of the riftogenic structure of the Dnieper-Donets paleorift. The mechanisms of collision warping of the horizons of the sedimentary cover of the southeastern part of the Dnieper-Donets depression are considered.

According to the previous mapping data, the tectonic deformations of the sedimentary cover were controlled by systems of faults of the north, north-west, and south-east vergence. The lattices of tectonites of the Hercynian, Lamaric, and Attic generations determine the specific "cross-thrust" structure of pushing. Overthrusts and linear folding of three generations permeate the sedimentary sequence of the transition zone from east to west for hundreds of kilometers within the eastern part of Izyumsky paleorift segment.

The analytical base of the research was the materials of geological mapping of the zone of the junction of the depression with the Donets fold structure. Using field definitions of the tectonite vergency of the Hercynian, Laramide and Attic phases of tectogenesis, the original method of reconstruction of tectonic deformation fields and tectonophysics analysis of structures, collision deformations of the sedimentary cover of the south-eastern part of the Dnieper-Donets paleorift are studied.

The tectonophysical analysis of tectonites of different ages indicates that together they control the cover-thrust and folded deformations of the riftogenic structure. Overthrusts and linear reverse-folding of three generations form the West-Donetsk integumentary-folding region, within which a segment of the same name tectonic thrust is distinguished. By pushing the system of repeatedly deformed, crushed into folds of geomass

sedimentary rocks on weakly deployed syneclise deposits, the riftogenic structure of the south-eastern part of the basin is completely destroyed. The structural-tectonic framework of the allochthone, pushed from the side of the Donets structure, is composed of dynamically conjugated lattices of Hercynian, Laramide, and Attic tectonites. They control the echelon backstage of linear reverse-folds, tectonic plate-covers of transverse extrusion of sedimentary geomass from axial to airborne zones and folded covers of longitudinal thrust from the south-east.

The riftogenic structure of the transition zone between the Dnieper-Donets basin and the Donets folded structure was completely destroyed by deformations of three generations of platform activation. The dynamically coupled tectonite lattice, the overlays, and the folded zones of the Hercynian, Laramide, and Attic generations jointly form the West-Donets fold-fold region within its boundaries. The main tectonic element of the area is the eponymous subregional tectonic thrust segment. The central structural zone is Veliko-Kamyshevakhskaya, Novotroitskaya, Druzhkovsko-Konstantinovskaya and Main anticlines. The central zone divides the body of the segment into two tectonic regions according to the tectonic style and intensity of deformation of the sedimentary sequence. The northern part is occupied by the Luhansk-Kamyshevakhsky region of the rocky-layered linear folding of the thrust, and the southern part is the Kalmius-Toretsky region of scaly tectonic covers.

*Keywords*: tectonite frame, thrust cover, uplift folded zones, tectonic wedging segment, cover-folded region.

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**Ivanna KOLODIY, Halyna MEDVID**

# FORECAST ESTIMATION OF OIL AND GAS RESERVES OF LOWER CRETACEOUS SEDIMENTS IN KARKINIT-NORTHERN CRIMEAN DEEP (by gas-hydrogeochemical indicators)

Distribution features of formation waters in Karkinit-Northern Crimean deep were studied; the conditions of chemical composition origin of formation waters have been studied as well.

The regional features for the distribution of formation waters and the conditions of their chemical composition forming of the Lower Cretaceous complex are established.

The formation waters are salty or saline and commonly have low metamorphism intensity.

The formation waters of the Lower Cretaceous complex are salt with often a low degree of metamorphosis.

The values of the variation coefficients of five principal components (mineralization, (Na + K), chlorine (Cl), bromine (Br), and the water sampling depths) are estimated to range from 28.73 to 57.14 %, which indicates insignificant variability each of these indicators; this characteristic does not depend on the type of water and place of sampling.

The seven objects of the correlation such as mineralization, chlorine, calcium, ammonium, bromine, sulfates and hydrocarbonates are closely associated with each other.

The land waters are commonly of calcium chloride (Cl.Ca) or hydrocarbonate natrium (Hyd.Car.Na) type, whereas in the water area all variety of formation waters has been recognized. Formation waters of Late Cretaceous shelf complex as well as formation waters at Tarkhankut peninsula have close relation between chemical components, low variations in the composition of macro- and micro-components. Therefore, the formation waters of these regions could be formed in quite similar conditions.

The characteristic features of the shelf formation waters are high sulfate content, despite the fact that waters complex occurs at great depths.

At the same time, a decrease in the metamorphism intensity is observed as well as an increase in the Cl/Br ratio up to 1000 or more, caused by low bromine content. It is apparent that such characteristic can be the result of extrusion of water at the late stages of clay rocks dehydration. Paleoinfiltration processes in Lower Cretaceous complex may be considered as an alternative explanation.

High gas saturation in the waters of the folded basin bed has been recognized at Golytsyno area and at the Tarkhankut peninsula (Melova, Oktyabrska, Berezivska and Western Oktyabrska areas). This allows us to predict the prospects of the Lower Cretaceous sediments of the Karkinit-Northern Crimean deep.

*Keywords*: Karkinit-Northern Crimean deep, Lower Cretaceous aquiferous complex, hydrogeochemical conditions, sedimentary waters, dissolved gases.

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*PAVLYUK Myroslav, MAYEVSKY Borys, KUROVETS Serhiy*. The Department of Geology and Exploration for Oil and Gas Fields is 75 years old