[PS]Thermobaric Conditions in Zones of Oil and Gas Accumulations of the Southern Oil- and Gas-Bearing Region of Ukraine*

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Abstract

The Southern oil- and gas-bearing region is one of the most promising of increasing quantities of recoverable hydrocarbon resources of the Ukraine. 39 fields were discovered in this region.

We have analyzed the distribution of geothermobaric parameters using data reached in the process of exploratory-prospecting work. In our opinion, optimum is the employment of the following geothermobaric parameters: the distribution of background temperatures at a depth of 2000 m (H_{2000m}), the distribution of expected values of temperatures at a depth of 5000 m (H_{5000m}), values of average geometrical gradients (G_a) at an interval of "neutral sphere" – maximum depth measurement of temperature in the borehole; of depths of occurrence of isothermal surface 423K (H_{423K}); of thermobaric coefficient ($K_t=T_{for}/P_{for}$) and the coefficient of hydrostatics ($K_{hyd}=P_{for}/P_{conv.hyd}$).

As an example we are giving the zonality of the distribution of the hydrocarbon deposits of the Black Sea-Crimean oil- and gas-bearing area. The temperature field at a level of 2000 m is rather differentiated. A zone of maximum heating occurs within the limits of the shelf and in the region of the Tarkhankut Peninsula. According to the distribution of G_a, two zones of different heating can be distinguished within the area: the area of high values (5.0-4.0 K/100m) which gravitates towards the Crimean Peninsula and the area of low values (about 3.0 K/100m) which stretches in the western direction to Predobrogea. An analysis of the distribution of H_{5000m} has allowed us to distinguish the highly heated (443-473K) eastern and lowly heated (403-443K) western zones. In the eastern part of the area, H_{423K} becomes changed from 4000 to 4500 m, in the western part: from 5000 to 6000 m. By thermobaric data one can distinguish three zones: the oil zone (T_{for} – 340-370 K; P_{for} – 15.0-30.0 MPa); the gas-condensate zone ($390>T_{for}>320K$; $36.0>P_{for}>16.5$ MPa) and the gas zone (T_{for}-291-425 K; P_{for} – 0.9-45.0 MPa). Abnormality of formational

pressures sufficiently influences the phase state of hydrocarbons in the seam. On the basis of K_{hyd} and K_t the zones are characterized: the oil zone – $1.2 > K_{hyd} > 0.9$; $21.7 > K_t > 12.3$ K/MPa with $2500 > H > 1770$ m; the gas-condensate one – $1.2 > K_{hyd} > 1.7$; $10.8 < K_t < 19.3$ K/MPa with $2910 > H > 1400$ m and the gas one – $0.9 < K_{hyd} < 1.8$; $143 > K_t > 9.84$ K/MPa with $4420 > H > 70$ m.

Revealed regularities of the distribution of the hydrocarbon deposits depending on initial formational temperatures and pressures, average geothermal gradient, thermobaric and hydrostatic coefficients confirm the relation between the geothermobaric regime of deposits and spatial position of the hydrocarbon deposits. Established regularities should be accounted while carrying out exploratory-prospecting work for oil and gas that will make it possible to conduct exploration and prospecting for new fields more effectively, including those at great depths.

THERMOBARIC CONDITIONS IN ZONES OF OIL AND GAS ACCUMULATIONS OF THE SOUTHERN OIL- AND GAS-BEARING REGION OF UKRAINE

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The Ukrainian part of the Black Sea water area is known to be one of the most promising region for the growth of hydrocarbon reserves in the Ukraine. According to data of geological-geophysical investigations, within the limits of the north-western part of the Black Sea shelf one can distinguish: Predobrogea oil- and gas-bearing region with Alibey and Zmiiny zones; Karkinit oil- and gas-bearing region with Bakal, Golytsyno, Mykhailivka and Gamburtsevo-Tarkhankut zones, Marginal and Lower Danube promising regions.

More than ten commercial and noncommercial gas and gas-condensate fields were discovered in the north-western part. Sandstones, limestones and marls of the Upper Cretaceous, Paleocene-Eocene and Upper Oligocene-Lower Miocene are known to be the reservoir rocks (Fig.1). The fields are multilayer (Golytsyno) and one-layer (Shtormove). The depth of occurrence of the productive horizons ranges from 500 to 2190 m.

To solve theoretical and applied problems of oil and gas geology and geophysics of the study region the necessity arises to study the distribution of the geothermobaric parameters in detail using new data obtained in the course of prospecting and re-interpretation of material published earlier. In the course of the study of the spatial distribution of temperatures and their connection with conditions of the hydrocarbon occurrence the using of the following geothermobaric parameters was established to be the most optimal: the distribution of the background temperatures at levels of the same name (for the given region at a depth of 2000 and 5000 m); values of average geometrical gradients at an interval of a "neutral layer" maximal depth of the temperature measurement in the borehole; depths of occurrence of the isometric surface of 423 K (150°C); the thermobaric coefficient and the coefficient of hydrostatics.

We have used data of geothermobaric measurements for 22 deep boreholes, 112 measurements of the temperature while testing the probable productive horizons and 72 thermograms being read during carrying out geophysical investigations of a borehole. It has made it possible to determine a geothermobaric regime of the shelf zone of the north-western part of the Black Sea.

Figure 2A shows the graph of the vertical distribution of the hydrocarbon deposits depending on values of initial formational temperatures and pressures. One can distinguish two zones. The upper one, gaseous, with parameters: T_{for} becomes changed from 290 to 320 K; P_{for} from 4.5 to 13 MPa. The lower one is gas-condensate and is characterized by T_{for} > 315 K when P_{for} > 13 MPa. The anomality of formational pressures influences essentially the phase state of hydrocarbons in the seam. In the graph of the distribution of the hydrocarbon deposits depending on the coefficient of hydrostatics and the depth of occurrence (Fig.2B) one can distinguish two zones. The upper one, gaseous, is characterized by such parameters: K_h becomes changed from 1.1 to 1.3 when depths of occurrence of the cover of productive horizons (H) in deposits of the Upper Paleogene and Lower Neogene are from 400 to 1000 m. The exception is the gas deposit of the Odesa gas field in sediments of the Middle Paleogene which is due to anomalous formational pressure (K_h = 1.78) when H is 400 m. The lower part is gas-condensate: K_h > 1.2 when H > 1000 m in deposits of the Lower Paleogene. The distribution of the hydrocarbon deposits depending upon the thermobaric coefficient ($K_{therm} = T_{for}/P_{for}$) and the depth of occurrence is shown in Figure 2C. The upper zone is gaseous: H reaches the depth of about 1000 m, K_{therm} becomes changed from 25 to 70. The lower zone is gas-condensate one: H > 1000 m becomes changed from 10 to 25.

The Karkinit oil an gas-bearing region within the limits of which, by the way, the majority of the hydrocarbon deposits were discovered, is considered to be the most provided with factual material. Temperature value at a depth of 2000 m becomes normally decreased from the east (Tarkhankut peninsula) to the west and becomes changed from 100 to 65° C (zone of the Odesa abyssal fracture). It should be noted that the maximum heated zone (80-100°C) which is clearly connected with the temperature distribution at the land depth of the Tarkhankut peninsula is distinguished by isotherm of 80°C. Isotherm of 75°C represents a boundary of the lesser heated region of the shelf which gravitates towards Predobrogea trough. In this region the temperature value ranges from 75 to 60°C. A considerable area of the distribution of the lowest temperatures (60°C) was determined. According to geophysical investigations, the regional abyssal fractures are weakly distinguished in the temperature field that is due to insufficient amount of factual material.

Taking into consideration that conducted extrapolation was rather distant (from 3000 to 5000 m) and due to insufficient data on deep geological-geophysical structure (lithological composition of rocks, their conductivity, value of the heat flow and other) the boundary of the distribution of geothermal parameters in the study territory is somewhat washed out and is not clearly fixed by the Odesa deep fracture, but nevertheless one can distinguish high-heated (170-200°C) eastern and low-heated (130-170°C) western zone of the shelf.

The existence of two different-heated zones occurred within the limits of the study territory was completely confirmed: a zone of high values of the geothermal gradient (3.5 4.0 C/100 m) which gravitates towards the Crimean peninsula and a zone of its lower values (3.0°C/100 m) that is characteristic of the Predobrogean trough. There seems to be an impression that according to data of seismic survey the tracing of the Odesa abyssal fracture was made not quite successfully. After its crossing the longitudinal deep tectonic dislocation (Golitsyno) it changes sharply its rectilineal direction and deviates in a north-easterly direction, approximately as much as 15-20 km.

According to determined spatial zonality of the hydrocarbon distribution in a sedimentary cover one should connect the prospects of oil presence in the shelf of the Black Sea with Predobrogea oil- and gas-bearing region, especially with the Zmiiny zone.

To estimate a phase state of hydrocarbons of the study area we have compiled the map of depths of occurrence of the isotherm surface of 150°C (Fig.3). For the eastern part of the shelf (boundary the Odesa abyssal fracture) the depth of occurrence of the isotherm surface becomes changed from 4000 m (Crimea) to 4500 m (Odesa fracture). In the north-western part: from 5000 m (Odesa fracture) to 6000 m (the region of the Zmiiny peninsula).

Thus, oil deposits may be discovered at a depth of about 6000 m within the limits of the Marginal perspective region, Alibey and Zmiiny zones. The discovery of the oil fields in the Karkinit oil- and gas-bearing region is improbable. This is due to thermobaric conditions, geochemical transformations and the processes of heat-mass-transfer at an interval basement-"the Earth's surface".

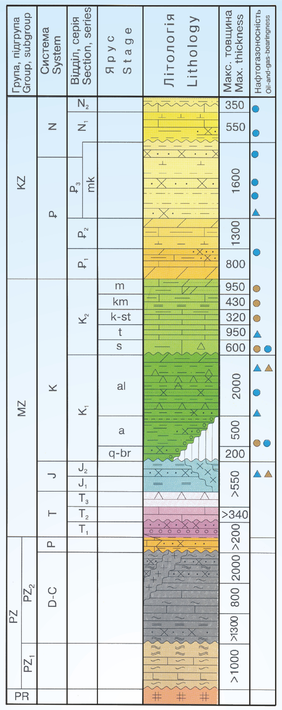

Fig. 1. LITHOLOGICAL-STRATIGRAPHICAL SECTIONS OF BLACK-SEA-CRIMEAN AREA

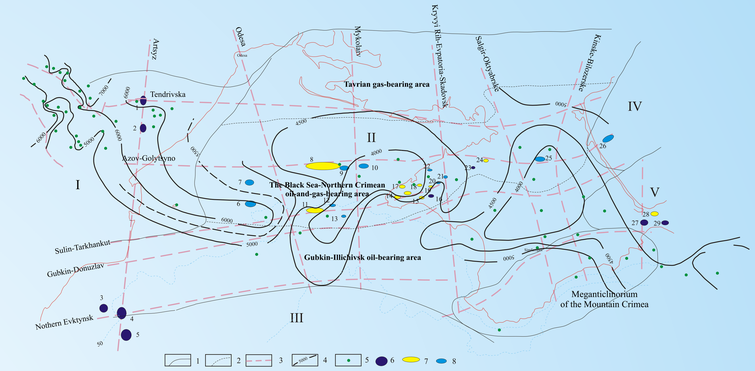

Fig. 3. SCHEME OF THE DISTRIBUTION OF DEPTHS OF OCCURRENCE OF THE ISOTHERMAL SURFACE 150 °C (m)

Boundaries: 1– of oil- and gas-bearing areas; 2 – of oil- and gas-bearing regions; 3 – dislocations with a break of continuity, 4 – isohypses of isothermal surface 150 °C. 5 – monitoring points. Fields: 6 – oil; 7 – gas-condensate; 8 – gas. Oil-gas-geological zoning: I –Predobrogean oil- and gas-bearing area; II – Black Sea-Crimean gas- and oil-bearing region; III – Chornomorske perspective region; IV – Azov-Berezan gas-bearing region; V – Indol-Kuban oil- and gas-bearing region. Discovered fields: 1 – Eastern Sarata; 2 – Zhovty Yar; 3 – Synoe (Romania); 4 – Levada (Romania); 5 – Doina (Romania); 6 – Odesa; 7 – Bezimenna; 8 – Golytsyno; 9 – Southern Golytsyno; 10 – Shmidt; 11 – Shtormove; 12 – Arkhangelske; 13 – Crimean; 14 – Olenivka; 15 – Western Oktyabrske; 16 – Oktyabrske; 17 – Chornomorske; 8 – Karlavka; 19 – Glibivka; 20 – Kirovske;21–Zadorne; 22 – Yaryl gach; 23 – Serebryanka; 24 – Tetyanivka; 25 – Dzhankoy; 26 – Strilkove; 27 – Vladyslavivka; 28 – Southern Syvash; 29 – Moshkarivka

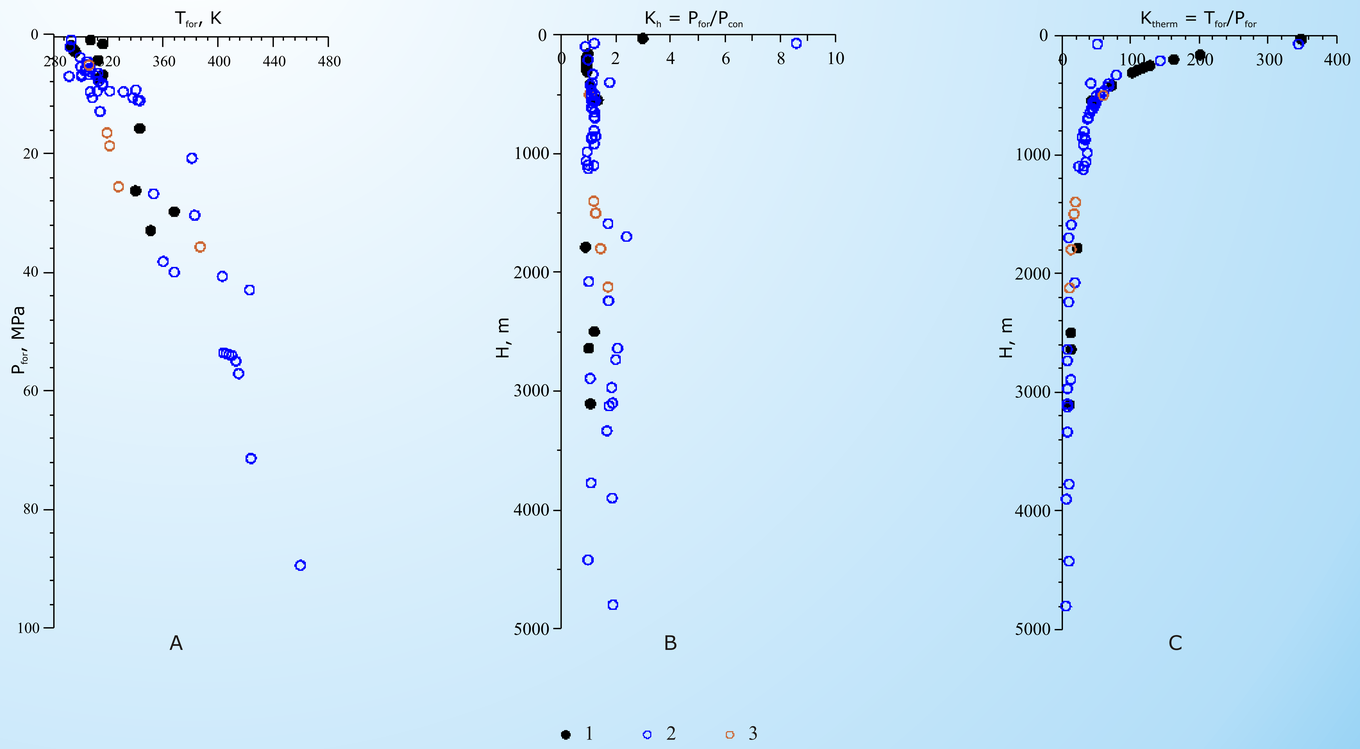

Fig.2. DISTRIBUTION OF THE HYDROCARBON DEPOSITS DEPENDING UPON:

A – initial formational temperatures and pressures; B – coefficient of hydrostatics and a depth of occurrence; C – thermobaric coefficient and a depth of occurrence

Hydrocarbon deposits: 1– oil; 2 – gas; 3 – gas-condensate