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ABOUT PETROPHYSICAL CHARACTERISTICS AND OIL AND GAS BEARING CAPACITY OF RESERVOIR ROCKS IN DEEP LAYERS OF SOUTH CASPIAN BASIN (in the example of Umid&Babek structures)

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Аннотация. В статье говорится о наличии благоприятных условий для формирования месторождения углеводородов, аккумулируемых в глубоких пластах Южно-Каспийского бассейна, ниже предела пластической деформации на примере структур Умид-Бабек

Ключевые слова: глубинная миграция, коллекторские свойства, проходимость, пористость, геодинамическое напряжение, тектонически-активные разломы, термобарические условия и т.д.

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Annotation. The article states that there are favorable conditions for the formation of field by hydrocarbons accumulated in the deep layers in the South Caspian basin, below the PL in the example of Umid-Babek structures.

Keywords: Depth migration, collecting properties, permeability, porosity, geodynamic tension, tectonic active fracture zones, thermobaric conditions, etc.

In the capacity of richest hydrocarbon basin of the world, the Caspian region has become one of the activity centers, where oil and gas operations carried out in recent years. Our country has great and rich experience in the field of development of oil and gas potential of the Caspian basin. The basis of this is the fundamental scientific research undertaken and currently ongoing in the field of geology, geophysics of the Caspian basin and exploitation of the deposits and modern technologies created. All projects implemented in this direction are based on the geological model of the region [1, 2, 3]. The geological model forms the basis for carrying out relevant measures, applying exploitation, processing and transportation technology for geological model fundamental scientific research, assessment of hydrocarbon potential, search and exploration works, foreseeing and prevention of geological and ecological hazards.

The South Caspian basin has an exceptional place among the similar basins of the world for the complexity of its geological structure, richness of its hydrocarbon resources and geodynamic activity. It is enough to remind that in no other oil and gas basin of our planet, the thickness of sedimentary rock complex reach 24–26 kilometers like in the Caspian Sea. According to the hydrocarbon potential per sq. km, it is at a level comparable to the oil and gas regions of the Gulf of Mexico.

Exploration of oil and gas fields in the prospective structures in deep layers of the South Caspian basin is a very urgent problem and geological, geophysical and petrophysical researches widespread. From this standpoint, there emerged a necessity for the complex scientific analysis of the data obtained from deep layers in Azeri, Gunashli, Chirag, Shah Deniz, Umid, Babek and other areas.

The general gravimetric works in Umid structure, 40–45 km from the Bandovancape, located in the territory of Baku archipelago, in the Caspian Sea offshore area were carried out in 1951 and detailed works – in 1972 (Fig. 1). The geological formation of the structure was determined by the research conducted by seismic methods in 1953–1980, and deep exploration drilling was started in the field of Umid in 1981. Based on the data obtained, the petrophysical parameters of the sediments involved in the geological section of the field, the lithological composition of the rocks, oil and gas bearing capacity were clarified. Based on 2-dimensional (2D) seismic studies carried out in 1995–1999, the formation of Umid and Babek fields was determined.

In 2008–2012, the volume of seismic works in the direction of study of the tectonic framework of Pliocene sediments were increased and 103 km seismic profile was processed and interpreted on 16 profile in Umid-Babek field and relevant maps were elaborated. In 2012, 1300 sq. km 3-dimensional (3D) seismic exploration works were carried out by «Caspian Geophysical» LLC in the Babek-Umid field, and engineering-geological research works were performed on the upper part of the section required for conducting deep drilling works in Umid field. According to seismic and drilling data, the geological structure of the block was determined and as complicated with one high-amplitude longitudinal split toward the central vault axis of the upheaval and a few relatively low-amplitude cross splits around the vault (Fig. 2).

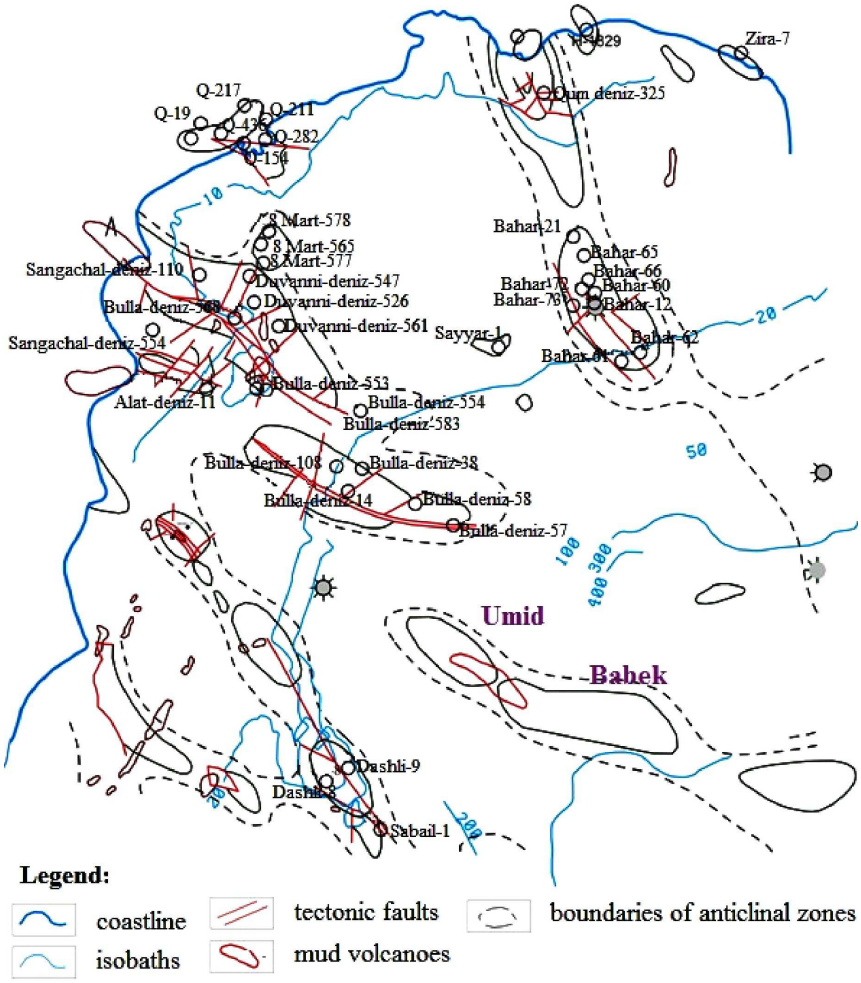

Figure 1 – Tectonic scheme of Umid-Babek block with surrounding structures and oil&gas fields

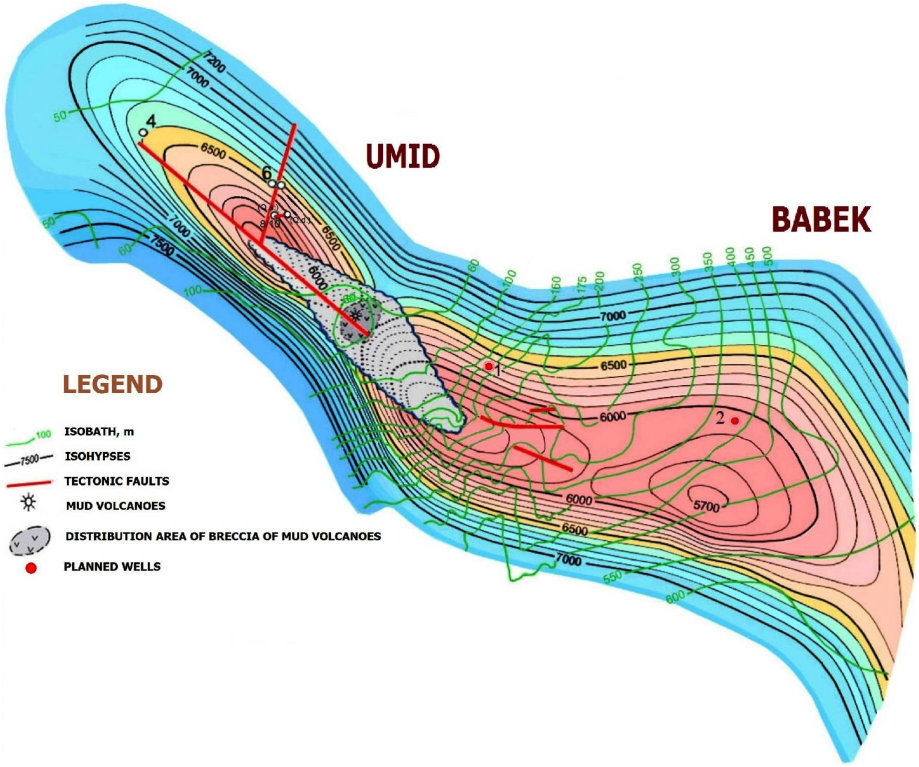

Figure 2 – Umid-Babek Perspective structures

In 2009 well № 8 with the design depth of 6.500 m was drilled in the north-east limb of Umid upheaval. The well encountered Zone V of the productive series (PS) within the range of 5.475–5.582 m, and Zone VII within the range of 5.923–6.006 m. The estimated specific resistivity (ESR) of Zones V and VII varies within the range of 10–12 and 30–32 ohm.m, respectively. WP curves are well-differentiated. When the bottom of the well was at 6.006 m, production casing was run into the well in order to perform testing in Zones V and VII; at the depth of 4.550 m gassing occurred in the well and the clay mortar flow was laid down. The clogging of the production casing was recorded and the well development was suspended for three years (Fig. 3).

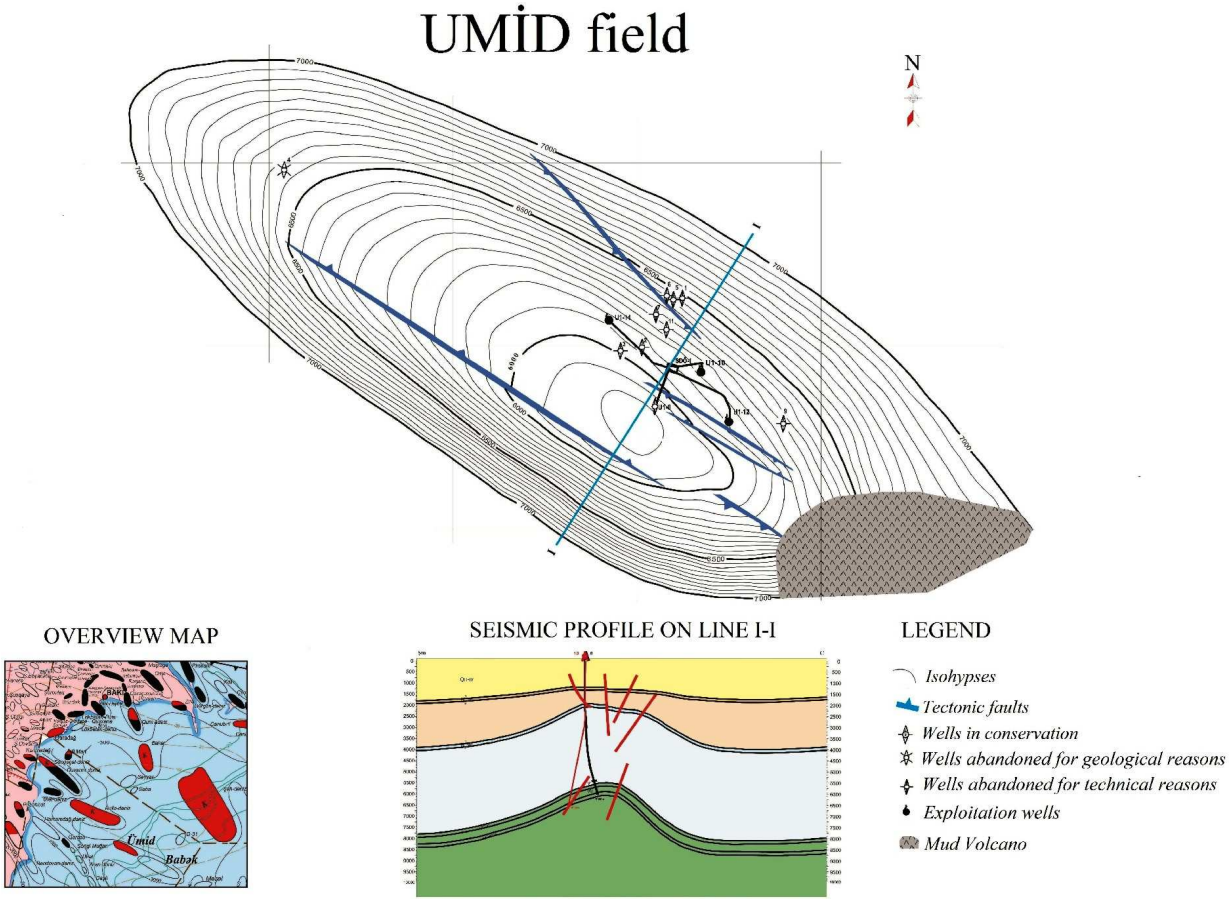

Figure 3 – Top boundary structural map of Zone VII of PS for Umid gascondensate field

The drilling of exploration well № 10 started on July 01, 2011 and was carried out up to a depth of 6.400 m. In the well Zone V was opened at 5.777–5.868 m and Zone VII at 6.248–6.364 m. Production casing was run until 6.400 m. On June 08, 2013 a sieve was opened in the well within the range of 6.356–6.336 m. The well started operation on Sept.19, 2012 and is currently operating.

The well № 12 was drilled to 6.309 m (until the upper part of Zone VII of PS); the production casing was run into the well and cemented. In 2014, testing operations were carried out in Zone VII and the well started operation with the high daily production of gas condensate. Currently, both wells produce 750–800 thousand m^3 of gas and 100–110 tones of condensate daily [8].

During the analysis, the results of well logging data (WLD) of a drilled well at the field were compared with geological & geophysical data obtained at the neighboring fields Shah Deniz, Nakhichevan, Alat-Deniz, Zafar-Mashal and Bulla-Deniz fields.

Although the depth of the research was more than 5.000 m, vertical seismic profiling (VSP) works were conducted in the range of up to 2.400 m in one of the 12 wells drilled in the field – the well № 7. Oil, gas and condensate fields are associated with Zones V, VII and Zone VIII of the PS in Umid field. Presence of gas, gas-condensate fields such as Bulla-Deniz, Shah Deniz and Baharenables to highly assess the structure in terms of the oil and gas bearing capacity.

The complications in the data of the seismic research carried out in Umid field and deep layers of geological sections built, in the edges of the mud volcanoes and outer parts of the structure decrease compared to the upper layers. There emerged favorable conditions for migration of hydrocarbons and the structure for the possibility of the formation of gas and gas condensate fields are considered prospective in terms of oil and gas bearing capacity (Fig. 4).

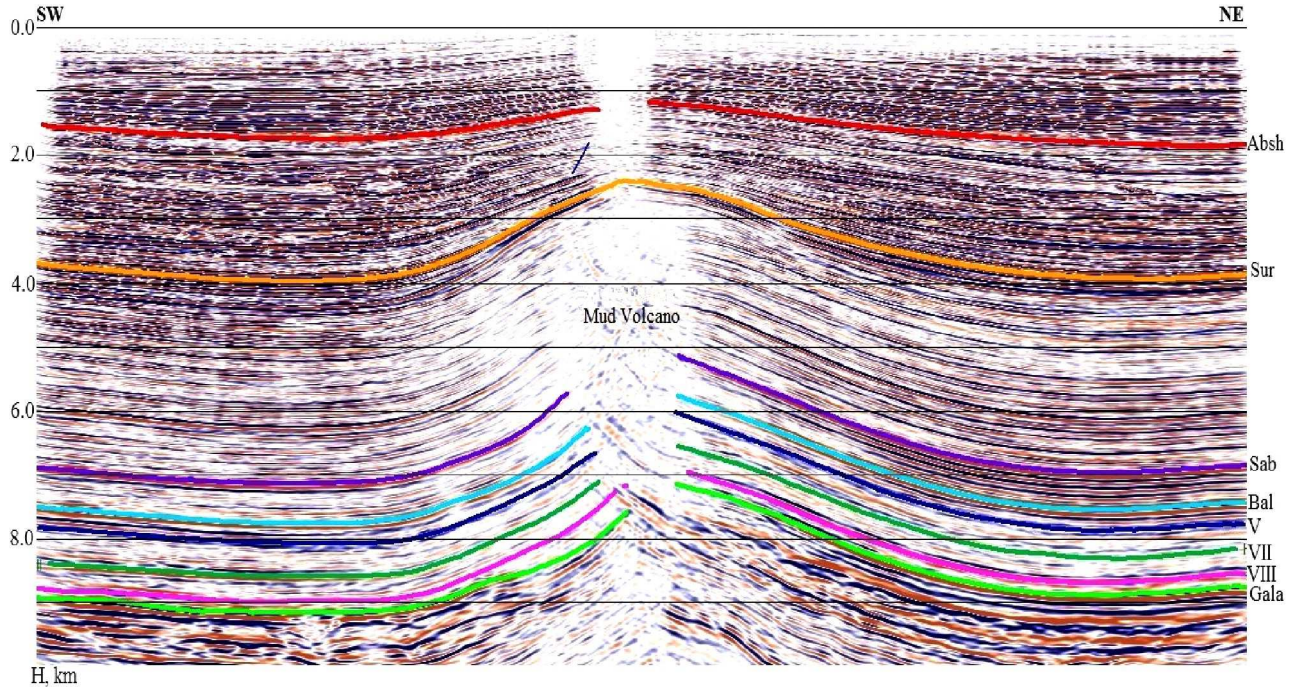

Figure 4 – Dynamic depth crossline 3340 in the Umid field

The amorphous mud mass created by the mud volcano located in the SW of Umid structure has a characteristic geometric shape and the fractures observed around it decline in deep layers (Fig. 5). The coverage of the mud volcano in the upper layers has been widened due to geodynamic tension occurred in the field. The shape of the structure in the deep layers does not change that much and the anticlinal form in the layers maintains its properties [5, 6]. It is clear from the model of geological section that there is a favorable condition for the diffusion of the liquid-gas clay solution to the environment by tectonic fractures (mostly vertical and close to it).

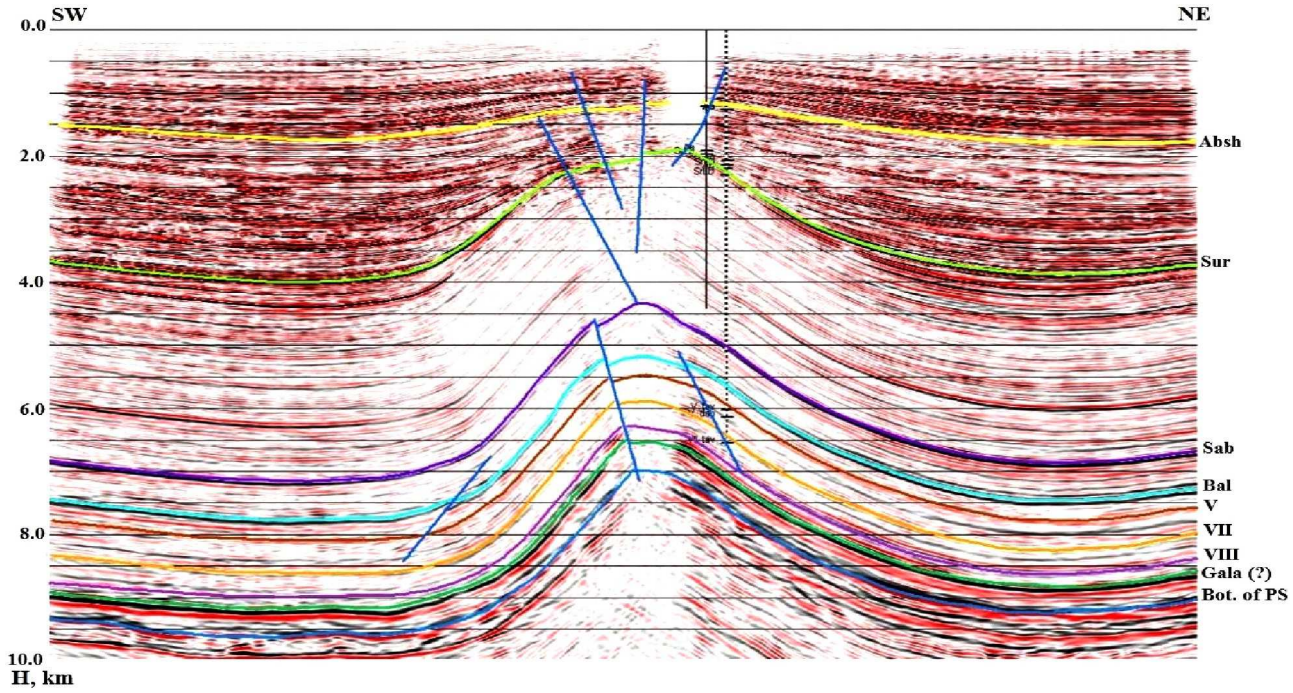

Figure 5 – Dynamic depth crossline 3060 in the Umid field

According to the WLD of the wells drilled in the field, non-observation of Abnormal High Formation Pressure (AHFP) and high ratio of clay bearing capacity of the layers identified based on WLD in the range shown are associated with the free diffusion of the gas fractions to the environment.

In the geological sections, the slope angle of the horizons in the arch and its surrounding parts in the structure within the sedimentary complex between the heel of the PS and the surface of the Cretaceous sediments is reduced from 30–35 °C to 10 °C degree towards the synclinal in the surrounding part of the arch in the SW wing and from 20–250 to 10 °C degree in the NE wing of the structure. Sharp reductions are observed from 43° to 10° degree of the slope angle of the layers beginning from the surrounding part of the arch in SW wing towards the NW wing of the structure. This tendency is disrupted in the NE of the field and here, the slope angles of the layers are 10–300. In the west of the field, the depth of layers is considerably reduced. Conversely, the depth of the layers in the well region № 12 is relatively small compared to the depth of the ones in the SW wing. The slope angles of the layers in the surrounding part of the southern wing of the structure increase to 450 [7].

The surface of the sediments lying under the PS in Umid field and the general structural plan in the PS sediments change in lower layers, and certain differences are observed in structural maps drawn on different horizons.

In the structural map on the surface of the sediments lying under the PL, Umid structure and the synclinals, which separate it from the neighbouring structures, are reflected. Umid structure is in the form of asymmetric anticlinal in the direction of north-west-south-east expressed in 7.000–7.900 m horizontals. The width of the structure is 3.5–4.0 km and is monitored at the distance of 19 km. It is reflected to the north-east wing with 7.000–8.700 m horizontals and lies at an angle of 16–24°. The south-west wing, shown with the 7.000–8.500 m horizontals, lies below the vertical angle (26–45°). The south-west wing of Umid structure descends to the south and joins to the synclinal separating it from Dashli-Aran structures. The deepest place of the synclinal is surrounded by the 9.600 m horizontal. The north-eastern wing of Umid structure passes to the Kichikdagh-Umid synclinal separating it from Bulla-Deniz structure. The aforesaid synclinal consists of two undulations. The western undulation is closed by 9.350–9.250 m horizontals, while eastern undulation was reflected in the research area by 9.500–9.250 m horizontals.

Zone VII (analogue of Pereriv suite) of the PS for the field is of particular importance in terms of oil and gas prospects.

Dynamic features of the seismic record were studied with well data and it was noted that the reservoir rocks of the PS were mainly composed of lentil-shaped sands of delta origin, aleurolites and sandstones.

According to regional correlations, the hydrocarbon saturation ratio is at 0.20 for Umid field, as in the fields located on the anticlinal line of Sangachal – Duvanny-Deniz – Khare-Zira Island – Babek. In other words, closed horizontal at 6.000 m is determined. According to the data obtained from the wells № 12 and 14, the minimum oil saturation thickness is 2 m, according to the data of regional correlation and wells drilled in Umid field, the average effective oil saturation thickness is 23 m, according to the geophysical research data of the wells № 4 and 6,2 m, the maximum effective oil saturation thickness is 35 m.

The total effective thicknesses, gas saturation percentage, porosity, layer pressure, temperature and other geological parameters of Zones V and VII which are gas and gas condensate objects of the main industrial significance in Umid field, are determined as a result of complex research works conducted in the wells drilled. It should be noted that the pressure, temperature, and other parameters of the layers are determined analogically to the data obtained from the wells drilled in Bulla-Deniz field.

In Zone V, the average effective thickness was 23.0 m, gas saturation – 76 %, porosity – 18 %, formation pressure – 80 MPa, temperature – 100 °C, density of gas – 0.680 kg/m^3, density of condensate 815 kg/m^3. As a result of the research conducted, the average effective thickness in Zone VII was determined 37.4 m, gas saturation – 77 %, porosity – 18 %, formation pressure – 100 MPa, temperature – 110 °C, density of gas – 0.680 kg/m^3 and density of condensate – 815 kg/m^3.

The mud volcano played a role on the gas saturation intervals of the geological section using the properties of the interval velocity cube drawn in the process of seismic data obtained, in the formation of gas field, as well as in the formation of screen in the periclinal of the SE of the structure and conditions established for the formation of fields [1].

The analysis of new data gives reasons to conclude the followings.

CONCLUSION

The article states that there are favorable conditions for the formation of field by hydrocarbons accumulated in the deep layers in the South Caspian basin, below the PL in the example of Umid-Babek structures. As a result of the geological evaluation, the surface of the sediments lying under Umid structure, the tectonic formation and dimensions on the different horizons of the PL are clarified, it is shown that the structure is complicated mainly by longitudinal large amplitude fractures and diametrical small amplitude fractures, the expansion area of mud volcano located in the south-eastern periclinal of the structure is reflected in maps and profiles. It is noted that there is a favorable petrophysical and lithological positive condition suitable to the wells drilled at the deep layers of Umid structure, in the fields of Shah Deniz, Bulla-Deniz and Alat-Deniz. The comparison of the data on the sections of the wells drilled in the surrounding areas and new drilled wells in Umid field gives reason to say that there are prospective objects in the deep layers.

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