MODELING STRUCTURAL-TECTONIC CHARACTERISTICS OF EASTERN FIELDS OF ABSHERON PENINSULA AND THE RISK OF TECTONIC IMPACT ON OIL-GAS BEARING

Namet Pashayev, Rufat Shahbazov, Firdus Karimzada
•
Azerbaijan State Oil and Industry University
namat.pashayev@mail.ru
rufetshaxbazov@gmail.com
firdus.karimzada@mail.ru

Absract

The morphostructural, genetic characteristics and oil-gas potential of local folds of the Buzovna-Mashtaga-Janub-2 anticlinal zone have been studied. These studies made it possible to predict promising oil and gas-bearing objects within individual local structures. This anticlinal zone is situated in the northeastern part of the Absheron Peninsula and consists of en-echelon local folds such as Buzovna–Mashtaga, Gala, Turkan, Zira, Janub and Janub-2. The presence of a regional left-lateral strike-slip fault between the Zira and Janub folds contributed to the displacement of the Janub and Janub-2 folds in the northeast direction and lead to the separation of these structures from studied anticlinal zone. However, they are a tectonic continuation of the anticlinal zone.

The level of dislocation of the studied folds decay in the northeast direction due to a decrease in the intensity of the cross buckle mechanism that forms these structures as they move away from the Greater Caucasus collision.

Due to the complexity of the oil and gas bearing structures under consideration with hemianticlines and taking into account that the latter, as a rule, transform into local folds with stratigraphic depth, they are promising objects for oil and gas prospecting and exploration. The natural reservoirs of the local folds under consideration are saturated with hydrocarbons in accordance with the principle of differential entrapment by S.P. Maksimova - V. Gassou.

Keywords: cross buckle mechanism, natural reservoirs, productive series suites, differential entrapment, Apsheron Peninsula

I. Introduction

The tectonic structure of the Apsheron oil and gas bearing region is characterized by the widespread development of infolded- disjunctive dislocations, injection structures and mud volcanism. There are as well as anticlinal zones, which are characterized by weak developed and buried folds. They are complicated by a small number of relatively low-amplitude faults and are mainly “closed” structures, such as the folds of the Buzovna–Mashtaga–Turkan–Zira–Janub-2 anticlinal zone [1,6].

The studied zone is located in the northeast of the Apsheron Peninsula, extends in a southeastern direction, and includes the local folds of Buzovna–Mashtaga, Gala, Turkan, Zira, Janub and Janub-2.

The Buzovna-Mashtaga fold has a complex structure, while consists by two-dome. The domes are separated from each other by a shallow saddle. In fact, the structure consists of a buried brachyanticlinal Buzovna fold and the Mashtaga structural uplift (Fig. 1) [2, 3].

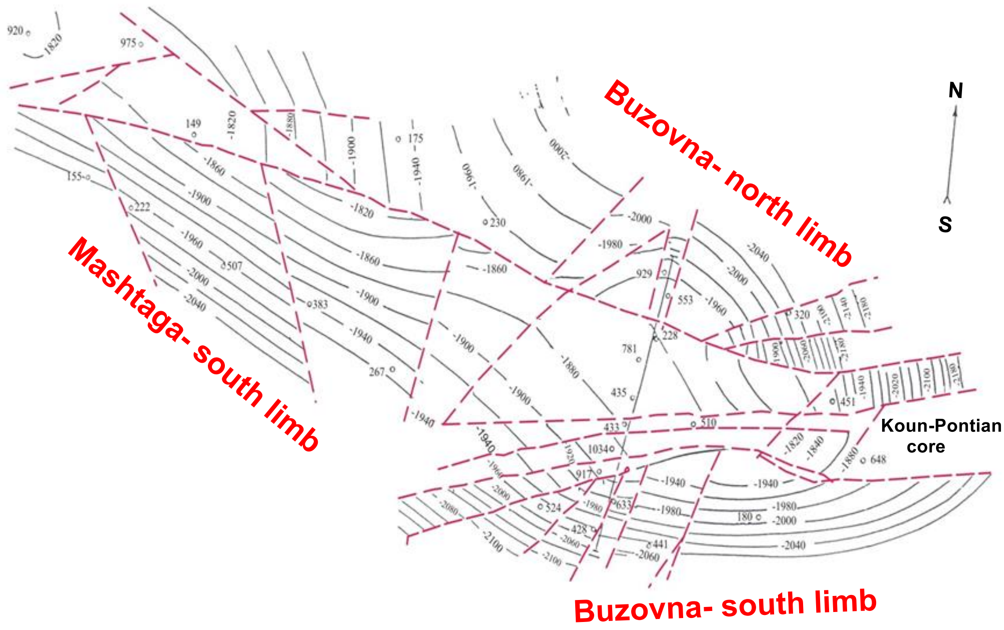

Figure 1:. *Buzovna–Mashtaga field. Structural map constructing by the roof of the PK suite*

II. Method

The goals of the work are to study the morphostructural and genetic characteristics of development, level of complexity, oil and gas saturation of local folds in this anticlinal zone and identifying new promising objects. For this purpose, the study area was analyzed in the direction of Buzovna–Mashtaga–Turkan–Zira–Janub-2 anticlinal zone. The analysis was carried out in the Buzovna–Mashtaga, Gala, Turkan, Zira, Janub and Janub-2 structures. To identifying the

In the study area, models characterizing the problems of anticlinal zone were drawn up. The models are constructed by using of Surfer, Paint programs.

III. Discussion

The Buzovna fold is complicated by longitudinal fault through its axes, along which its northern limb slipped down.

Industrial accumulations of oil in the Buzovna-Mashtaga fold were discovered in the IV, V, VIII horizons of the Sabunchi, X horizon of the Balakhani, as well as in the PKC, PKS, KS and PK suites. Gas was obtained in the near-crest part of the southern limb of the Buzovna fold in horizon II of the Sabunchi suite.

The Gala field, located southeast of the Buzovna-Mashtaga fold, is confined to the same name and sharply asymmetrical brachyanticline. The fold is complicated along the Surakhani suite by 12 transverse faults, as a result of which the tectonic blocks have en-echelon position. In general, the fold is complicated by 13 normal faults (Fig. 2).

It is noteworthy that one normal type fault developed from the upper Miocene to the middle of the Sabunchi suite; its fault plane dips in the direction opposite to the dip of the fault planes that complicate the fold from the Balakhani suite to the top of the Apsheron stage inclusive. The latter mainly complicate the arch of the fold. In turn, 5 faults complicate the near-crest part of the northeastern limb of the fold from the upper half of the Sabunchi suite to the surface. The complexity of the fold crest by a network of faults almost exclusively in the upper part of the section indicates the development of tensile stresses there, not favorable to the preservation of more or less significant accumulations of hydrocarbons (see Fig. 2).

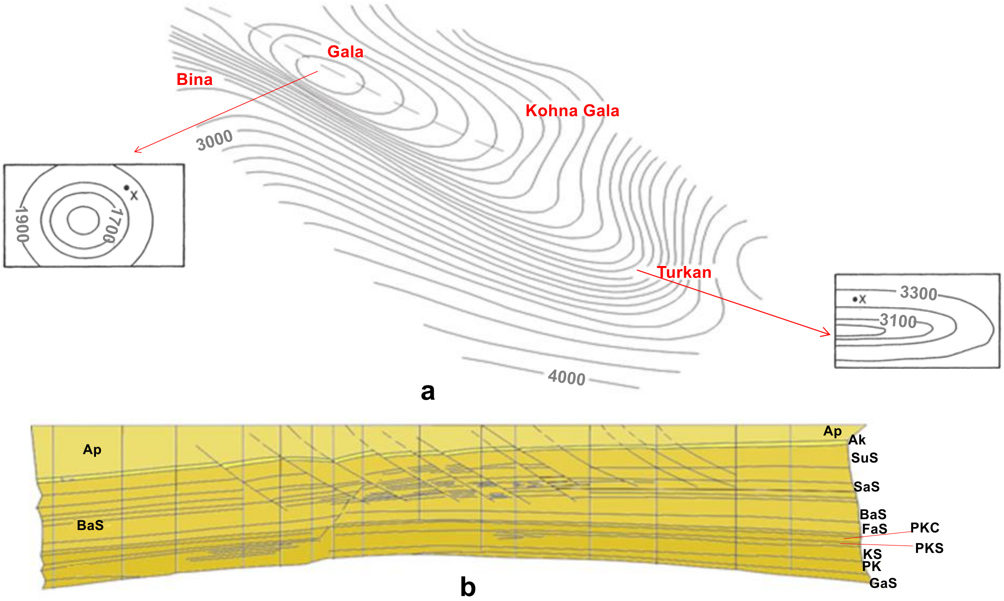

Figure 2: *Gala field: a- structural map along of the roof of the PKC suite; b- geological cross section profile I–I*

In turn, the concentration of hydrocarbon accumulations mainly in the lower section of the Productive series (PS–N $_2{}^1$) is associated with the absence of faults on the crest of the fold, penetrating below the upper half of the Balakhani suite (see Fig. 2). As a result, the lower half of the latter apparently plays the role of a seal for hydrocarbon accumulations in the underlying horizons. The above facts indicate the formation of this fold mainly due to the mechanism of transverse bending [4].

The southeastern periclinal of the fold is strongly elongated along strike due to the development of the Kohna Gala and Turkan structural uplifts in its near-crest zone (see Fig. 2). As a result, the arch of the Gala uplift based on Apsheron deposits is located 3...4 km to the northwest. A characteristic feature of these uplifts is that the dip angles of the layers along the limbs increase with depth. This fact indicates the syndepositional development of the fold. It can be noted that on its southeastern plunge, where the structural uplifts of Kohna Gala and Turkan are located, buried uplifts are developed below the PS, i.e., the fold along the underlying PS deposits is three-arched (see Fig. 2). Structurally, there is a discrepancy between the structure of the upper part of the PS and the structure of its lower section. Another feature of the fold is the complexity of transverse faults, the amplitude of which in the crest of the fold is 50...60 m, closer to the northwestern pericline it decreases to 20...30 m, while on the southeastern plunge to 10...15 m [2]. At the same time, the amplitudes of the faults decrease towards the limbs of the fold and with stratigraphic depth completely attenuate in the upper parts of the Balakhani suite (see Fig. 2, b), which indicates their juvenile age.

The morphology of the Gala uplift changes with depth. Thus, along the roof of the PK suite, the ratio of its width to length is 1:3, while along the Apsheron-Aghjagil deposits it is 1:2. For deposits lying below the PS, the displacement amplitude of faults is 600...700 m, but for the PS it reaches 1200 m [3]. Within the Gala uplift, the main part of the horizons and suites of PS is oil-bearing. In its southeastern pericline there is a structural complication of the Turkan (see Fig. 2), its constituent layers lie at an angle of 5^0. Between the Gala and Turkan areas, the sediments of the Apsheron-Aghjagil stage mainly lie horizontally. Well drilled here

No. 3 (4377 m) showed the presence of oil in the PK suite. Subsequently, wells drilled into this suite No. 1216, 1217 yielded oil only in the second object (GaS_2).

The Zira fold is located southeast of the Turkan structure. Here, the deposits of the upper section of the PS have undergone very weak dislocation, and the lower section manifests itself as a dome-shaped buried uplift. The fold is complicated by two faults with an amplitude of 50 m with a lowered central block (Fig. 3a,b) [2, 3].

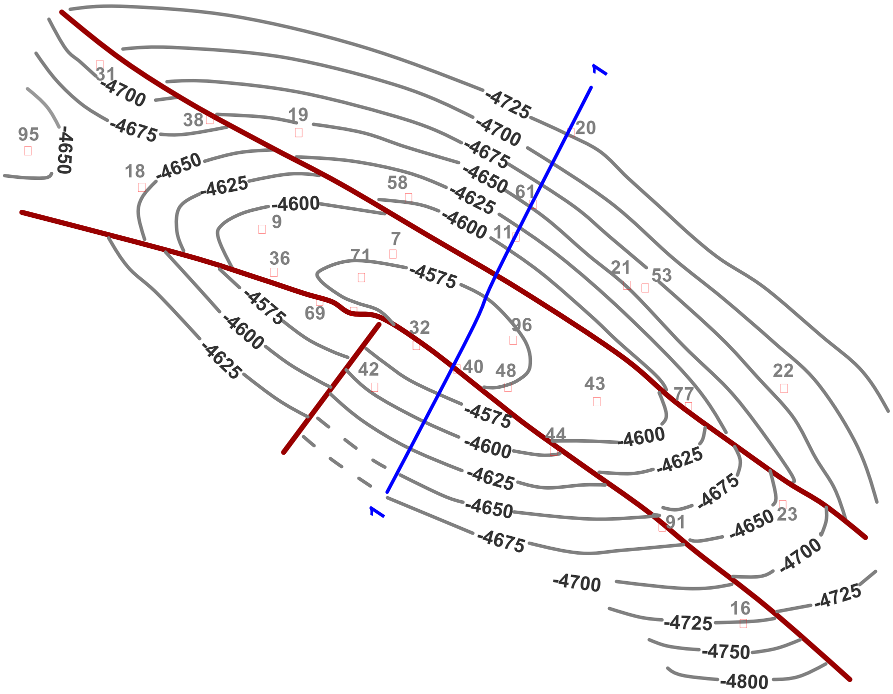

Figure 3a: *Zira field: structural map*

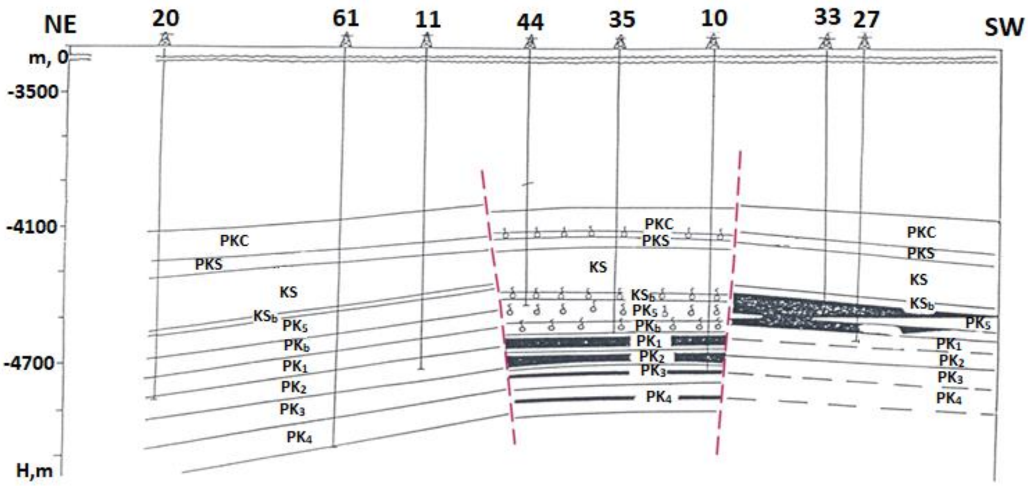

Figure 3b: *Zira field: structural map and geological profile along line I–I*

Based on the profile section, we can say that these fractures played an important role in the distribution of oil and gas over the area and section of the field (see Fig. 3b).

The study of the structures of Zira, Janub, Janub-2 showed that they have a single mode of development and common morphogenetic features. The Zira structure along the top of the PS is also a buried asymmetrical short brachyform fold. Along the roof of the Gala suite, the south limb of the fold lies at an angle of 8...10°, and the north – 3...4°. The Zira field has an oil rim and is gas-condensate-bearing [4].

The Janub structure is a poorly developed buried fold in southeast direction, which flattens upward along the section; as a result, it is very weakly expressed along the top of the Apsheron stage. Along the roof of the Pre-Kirmaki suite, its southwest limb dip at an angle of 6°, and the northeast one – 8° (Fig. 4).

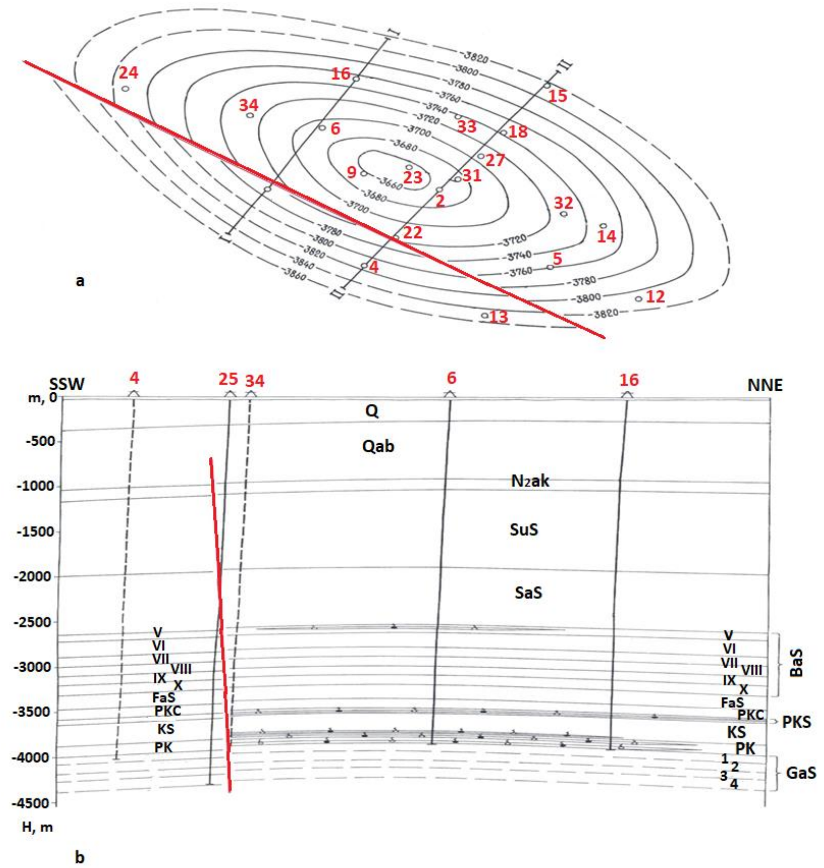

Figure 4: *Janub field: a – structural map by the roof of the PK suite of PS; b –geological cross-section on profile line II–II*

Unlike Zira field, the Janub field in the PS deposits are gas and gas-condensate-bearing.

The Janub-2 fold is located next to southeast of the Janub structure and extends in the same direction. It flattens towards the top of the Aghjagil stage (Fig. 5) and is a gently sloping buried shortened brachyanticline with dimensions of 3.0x1.5 km. With stratigraphic depth, the fold acquires a more distinct form, the dip angles of the limbs increase, and it is more clearly expressed by the bottom of the PS. Based on well data, a transverse fault divides the fold into a downdip northwest and an uplifted southeast blocks. Janub-2 is a gas condensate field, the prospects of which are associated with the lower part of the PS and underlying sediments [4,10].

The Zira, Janub, and Janub-2 uplifts are buried and oil and gas bearing, and are also weakly complicated by disjunctive dislocations, which gives reason to predict the presence of productive objects in the underlying PS strata. The lack complexity with disjunctive dislocations of these folds or its absence also gives reason to predict the likelihood of the formation of gas and gas-condensate accumulations in them.

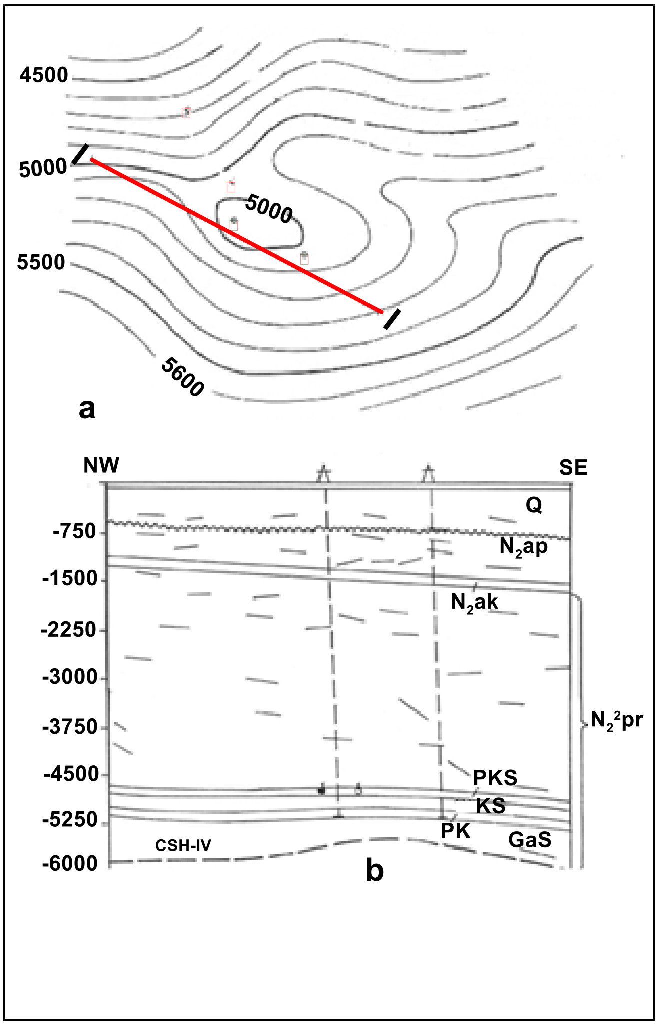

Figure 5: *Janub-2 field: a – structural map by the top of the PK suite of PS; b – seismic geological profile on line I–I*

IV. Results

Thus, it should be noted that along the Buzovna–Mashtaga–Turkan–Janub-2 anticlinal zone, according to the strike of folds from northwest to southeast, as the breakdown of structures by disjunctive dislocations decreases, so phase changes in the accumulation occur. Thus, hydrocarbon accumulations phase changes from oil in the Buzovna-Mashtaga fold to gas condensate and gas phase in the Janub, Janub-2 areas [1].

As can be seen, the degree of complexity of local folds by faults plays a significant role in phase fluid saturation. In this case, regional axis-longitudinal faults can be pathways for the vertical migration of hydrocarbons during the formation of their accumulations or destruction and reformation, and can also serve as a screen on the path of their migration [1].

In other words, any disjunctive can periodically play the role of a screen or conductive. This can also occur in cases where deposits with different hydrodynamic regimes are developed in blocks shielded by a fault. In this case, if a high reservoir pressure gradient occurs between adjacent deposits being developed, it can disrupt the screening role of the fault, which must be taken into account when developing adjacent deposits screened by the same fault.

In the Apsheron oil and gas bearing region, regional axial and transverse disjunctive dislocations play a significant role in the formation, preservation, destruction and reformation of hydrocarbon accumulations. In this area, transverse faults are mostly local and developed mainly in the upper part of the section, and axis-longitudinal faults are mostly regional with deeper penetration and are mostly not components of deep faults. As noted earlier, the Buzovna–Mashtaga field is complicated by 19 transverse and radial faults. Such a large number of them within one fold is obviously associated with upward squeezing of rheologically active clays of the Kovundag-Maykop series (Fig. 6) [2].

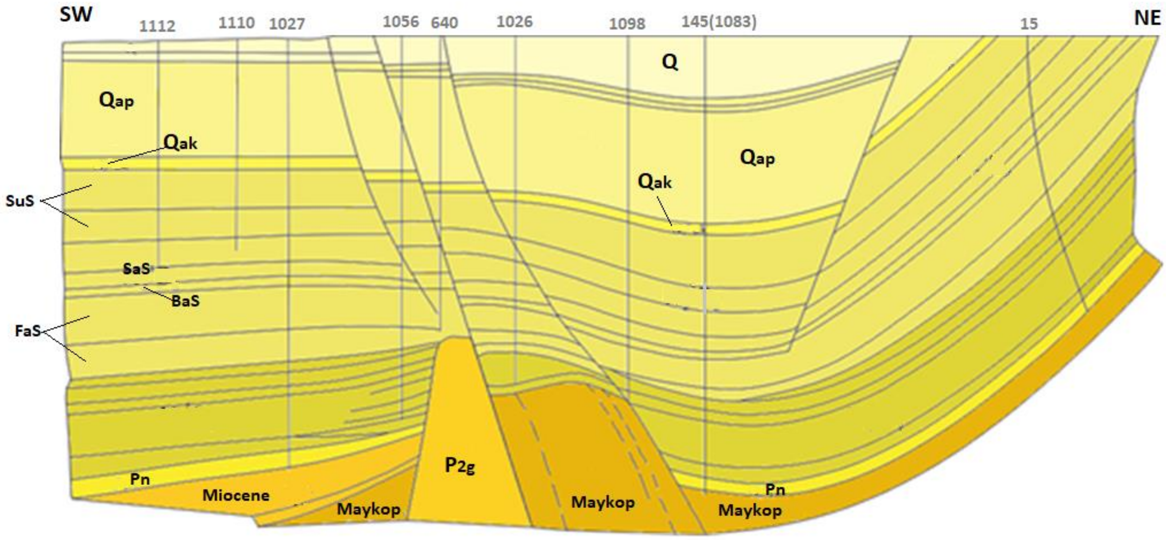

Figure 6: *Geological profile of the Buzovna–Mashtaga field*

As a result, the overlying and more competent rocks of the Pre-Kirmaki, Kirmaki and Post-Kirmaki suites of the lower stage of the PS were subjected to ductile deformations when they were bent and tensile stresses arose in them. The normal faults complicating both limbs of the Buzovna-Mashtaga fold also contributed to the formation of the graben due to the occurrence of tensile stresses. The formation or reformation of hydrocarbon accumulations due to a dense network of normal faults indicates their time-varying role as a conductor and screen, as well as the high probability of the existence of hydrocarbon accumulations in deep-lying rock strata.

From the above, we can conclude that within the territory under consideration, accumulations of hydrocarbons are formed due to stepwise migration. Using the example of the studied anticlinal zone with a chain-like position of local folds and with the main south-southeast–north-northwest direction of fluid migration, i.e., in general along the updip of layers, the differential entrapment of hydrocarbons according to the principle of S.P. Maksimova – V. Gassou is clearly observed [5,7]. Thus, at the southeast end of the zone, in the traps of the Janub, Janub-2 folds, accumulation of gas and gas condensate is found, further along the updip of layers in the Zira fold - gas-gas-condensate-oil, and in the local folds Turkan-Gala-Buzovna-Mashtaga oil deposits were formed (Fig. 7). The presence of gas accumulations in the Aghjagil and Apsheron stages of the Gala and Buzovna-Mashtaga fields may be of a technogenic nature.

The Apsheron oil and gas region is characterized by the destruction and reformation of oil and gas deposits due to the complication of folds by a network of faults and mud volcanism. In the Apsheron, Lower Kura, Shemakhi-Gobustan oil and gas bearing regions, in most cases, mud volcanoes, complicating local uplifts, are located in the zones of intersection of regional axial-longitudinal faults with transverse ones [9]. However, the absence of mud volcanoes in local fold of the Buzovna–Mashtaga–Zira–Janub-2 anticlinal zone is obviously associated with insufficient energy of rheologically active clays of the sedimentary section due to their low mass and absence or very weak development of compressive stresses here. Thus, within the considered anticlinal zone, the Kovundag-Maykop series with a total thickness of about 500...600 m is lithologically represented by clays and shales. An equally important reason for the underdevelopment of local folds in the anticlinal zone under consideration, i.e., their buried nature, is associated with the absence of compressive stresses within this territory [8]. For example, within the Apsheron-Balkan structural megasaddle, complicated mainly by elongated brachy- and linear folds, as well as different-scale and different-type disjunctives, including transverse strike-slip faults, mud volcanism is widely developed. The nature of the latter is associated with the subduction nature of the structural megasaddle.

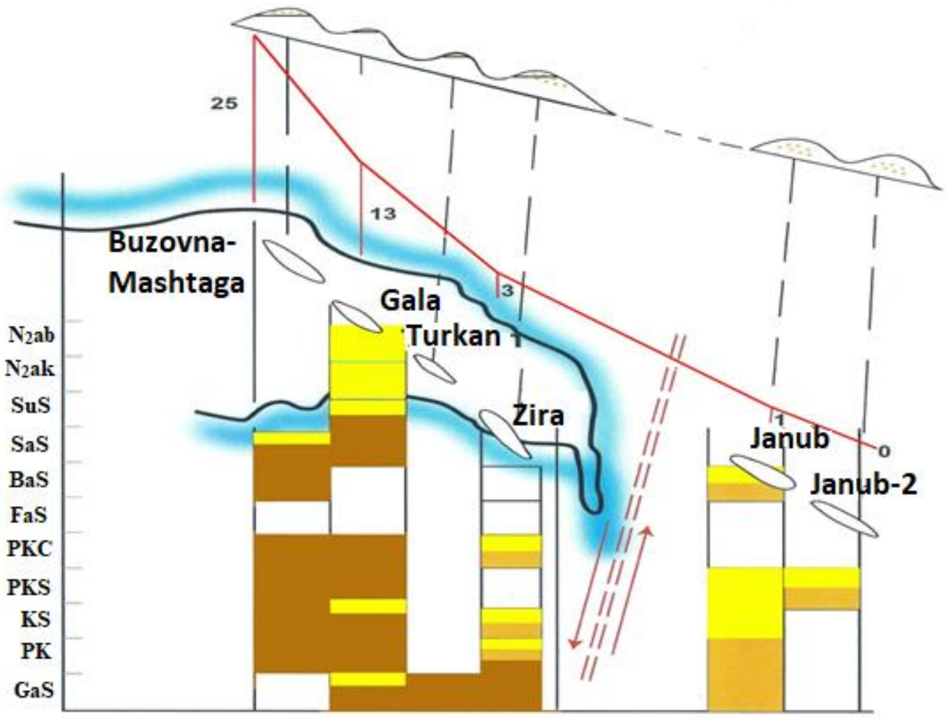

Figure 7: *The nature of oil and gas saturation and the level of dislocation of local folds of the anticlinal zone Buzovna–Mashtaga–Zira–Janub-2*

V. Conclusions

1. Buried folds Janub, Janub-2, according to morphogenetic, structural-tectonic characteristics, spatial orientation and nature of oil and gas saturation, are a structural-tectonic continuation of the Buzovna–Mashtaga–Turkan–Zira anticlinal zone, which developed mainly due to the cross-buckle mechanism.
2. The level of dislocation of local folds of the Buzovna–Mashtaga–Turkan–Janub-2 anticlinal zone weakens in the southeast direction due to distance from the Greater Caucasus collision.
3. Buried local uplifts of the studied anticline zone, expressed as hemianticlines in the overlying rock strata, are promising for oil and gas.
4. Fluid saturation of the reservoirs of natural traps of the studied anticlinal zone occurred according to the principle of differential trapping clearly expressed here by S.P. Maksimova – V. Gassou in the direction of the regional updip of layers and depending on the level of their complexity with disjunctive dislocations.

Reference

[1] Mukhtarova, Kh.Z., Nasibova, G. J., (2022). The role of studying tectonic factors in reducing the risks of ineffective exploration and exploration and determining oil and gas perspectivity southern part of Absheron archipelago. // "Reliability: Theory and Applications" (RT&A), Special Issue № 3 (66) Volume 17, January 133-137 p. DOI : https://doi.org/10.24412/1932-2321-2022-366-133-137 .

[2] Gahramanov, G.N., Mukhtarova, Kh.Z., Shpyrko, S.G., Nasibova, G. J. (2021). Technique of paleotectonic backstripping and assessment of hydrocarbon potential in anticline traps (South Caspian Basin). EAGE, Geoinformatics, 11-14 May, Kiyiv, https://eage.in.ua/?page_id=1526.

[3] Narimanov, N.R., Mukhtarova, Kh.Z., Nasibova, G. J. (2022). The mechanism of formation and prospects of non-structural traps in the South Caspian megadepression. // Journal of Geology, Geography and Geoecology, Ukr., Dnipro, 2022, 31 (3), p. 529-538.

[4] Mukhtarova, Kh.Z., Nasibova, G. J. Prospects of oil and gas potential of the sedimentary strata of the South Caspian Basin based on paleotectonic and geodynamic criteria. // Journal of Geology, Geography and Geoecology, Ukr., Dnipro 2023, 32 (1), p.153-163 DOI https://doi.org/10.15421/112315

[5] Ganbarova, Sh.A. (2024). Course lecture notes of "Prospecting and exploration of oil and gas fields". Baku, 115 p.

[6] Mukhtarova, Kh.Z., Nasibova, G. J. Geodynamic regime and prospects for oil and gas potential South Caspian Basin. // Journal of Geology, Geography and Geoecology, Ukr., Dnipro 2023, 32 (3), p.550-559; DOI https://doi.org/10.15421/112349

[7] Mehtiyev, Sh.F. Selected works. (2010). Baku, 474 p.

[8] Mukhtarova, Kh.Z., Nasibova, G.J., Ganbarova, Sh.A., Zeynalova, S.A., Ismailova, M.M. (2023). The influence of compressive stresses on folding in the Middle Kura depression and the Turkmen shelf. // Journal of Geology, Geography and Geoecology, Dnipro, 32 (2), p. 352-359; doi:10.15421/112332.

[9] Nasibova, G. J., Ismayilzadeh, E. A., Ganbarova, Sh.A., Ismayilova, M. M. (2023). Oil and gas prospects of tectonic crashing zones of the Kura intermountain depression. // "Reliability: Theory and Applications" RT&A, Special Issue No 5 (75) Volume 18, November, DOI: https://doi.org/10.24412/1932-2321-2023-575-313-322.

[10] Xalilova L., Seidov V. Evolution of hydrocarbon deposits in the South Caspian Basin. // Geophysics, 2023, 45(3), p. 126-134. https://doi.org/10.24028/gj.v45i3.282420.