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Role of Geological Structures Formation in the Development of Rock Fracturing

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***Abstract*—The article touches upon the issues of tectonic structure of the Terek-Sunzhensk oil and gas region. A brief description of the lithologic and stratigraphic characteristics of the Cretaceous sediments is given, the influence of the growth of structures in different geological time periods on changes in fracture density of various generation is analyzed.**

***Keywords*—structure; elevation; cracks; height of bend; oil and gas deposits**

I. Introduction

Oil and gas deposits found in the reservoirs of the Mesozoic complex within the Terek-Sunzhensky oil and gas region are related to the Upper Cretaceous, partly lower Cretaceous (alb, apt, Barrem, Valanginian) and Jurassic sediments (upper section).

The most studied Upper Cretaceous strata (up to 600 m) are composed of limestone with interlayer of clay and marl. The lime stones are intersected by surotostilolite seams, fractured and cavernous [2, 4]. The largest number of marl and clay interlayers is noted in the Dan, Campanian and Cenomanian layers [2, 5], which is clearly reflected in the geophysical diagrams with elevated gamma-ray logs, a decrease in electrical resistivity and lower indicators of gamma-ray neutron log (Fig. 1).

Here oil and gas deposits are mainly massive-arched and, rarely, massive-reservoir with lithological limitation of fracture development zones and are under high initial reservoir pressures (35-76 MPa) and temperatures (100-200 ° C).

The main deposits of hydrocarbons of the lower Cretaceous are concentrated in the Apt deposits. Oil inflows are obtained from II, III, IV sandy rocks and less often from V units. In the sediments of the Barrem, oil deposits were found in the Zamankulsky and Goryacheistochnensky fields. The deposits are confined to VI, VII and VIII units. In the Valanginian deposits, the oil potential is proven at the Zamankulsky and Malgobek-Voznesensky deposits.

The industrial oil content of the Upper Jurassic sediments is established on Zamanklsky area.

The deposits of the Lower Cretaceous and Upper Jurassic deposits belong to the massive-formation-vault type [3].

The main features of the tectonic structure of investigated deposits within the Terek-Sunzhensky oil and gas region, as shown by drilling data, generally repeat the structural plan of the Cenozoic sediments [4].

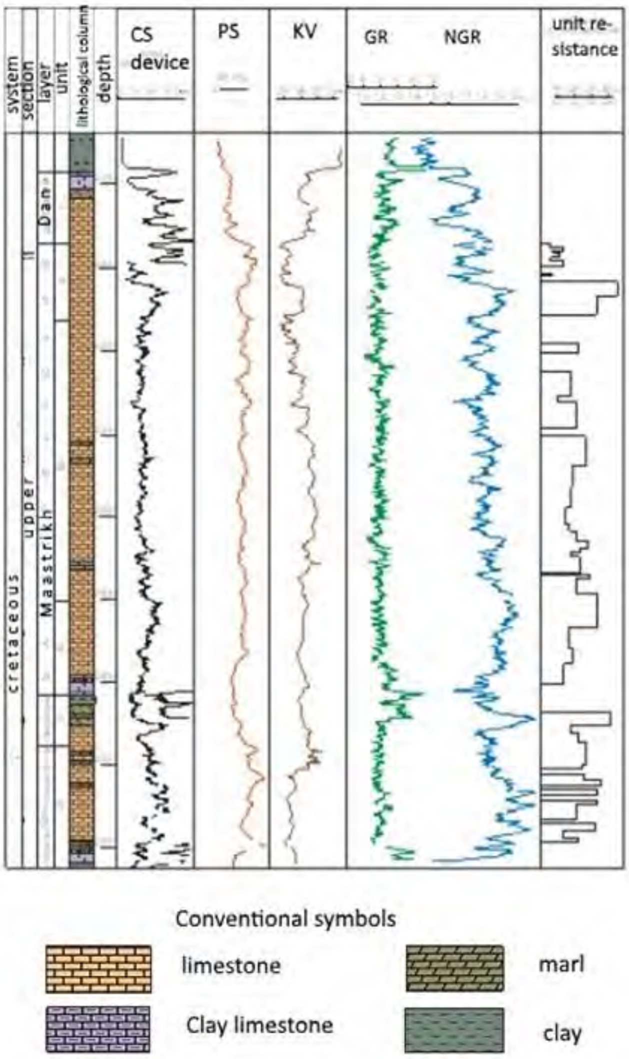

Fig. 1. Typical geological and geophysical section of the Upper Cretaceous sediments of the Terek-Sunzhensky oil region

II. Methods and Materials

The studies on tectonics of this region are reflected in the works [1, 8–12, 15]. The Terek-Sunzhensky dislocation zone consists of the Sunzhensky and Terek subzones and the synclinal deflections separating them. In their turn, the subzones include several lines of anticlinal uplifts. Three such lines are distinguished in the Sunzhensky subzone. The first one (Southern) consists of Zamankulsky, Karabulak-Achaluksky, Sernovodsky uplifts; the second one consists of the forecast of the North-Karabulaksky, North-Sernovodsky, Severo-Zakanovsky, Andreevsky, Oktyabrsky, Sayasanovsky and Zandaksky uplifts; the third line (Northern) includes Starogroznensky, North-Starogroznensky, Nozhay-Yurtovsky and Granichny uplifts.

In the Terek subzone, three lines of folds are also distinguished. On the first line (Southern) the uplifts of Novo-Ivanovo-Arak-Dalatoreksky, Akhlovsky, Malgobek-Gorsky, Khayan-Kortovsky, Eldarovsky, Goryacheistochnensky, Petropavlovsky, Western, Eastern-and Southern-Gudermessky areas are distinguished. On the second line, the Northern Malgobeksky, Northerb Eldarovsky, Northern Mineral, Mineral, Vinogradny, Bragunsky, Koshkeldinsky uplifts are distinguished. On the third (Northern) Pravoberezhny, Northern-Bragunsky, Pridorozhny, Northern-Koshkeldinsky uplifts are distinguished. All of them have a strike corresponding to the general strike of the zone. The arches of the uplifts are, as a rule, wide, the wings of which are steep and complicated by longitudinal fractures. The fractures have the character of faults and thrusts. Their amplitudes sometimes reach several kilometers.

In addition, a significant number of fractures of the type of uplifts and thrusts of diagonal orientation along the arches and pegs of many of the above mentioned uplifts were revealed.

All the above-mentioned uplifts can be “divided” into two groups: the first one consists of large folds and the second one consists of accompanying structures (“satellites”) belonging to the buried ones (the structures are distinguished under the Neogene-Oligocene complex of rocks).

Thus, the first group includes Zamankulsky, Karabulak-Achaluksky, Starogroznensky, Oktyabrsky (Sunzhensky subzone) Arach-Dalatareksky, Ahlovsky, Malgobek-Gorsky, Eldarovsky, Khayan-Kortovsky, Bragunsky, Western and Eastern Gudermessky (Terek subzones) folds, traced throughout the studied section, with known deviations in the planned position of their arches. Usually, the Cretaceous vaults are shifted to the South, and the Neogene folds are complicated by additional smaller structures.

The second group (“satellite” structures) includes the North Zamankulsky, Northern Karabulaksky, Northern Sernovodsky, Andreevsky (Sunzhensky subzone), Northern Malgobeksky, Northern Eldarovsky, Mineral, Northern Mineral, Vinogradny, Northern Bragunsky, Koshkeldinsky (Terek subzone) uplift.

Within the Terek-Sunzhensky zone of deflections, three subzones of synclinal deflections are distinguished: the Southern subzone (Beslanovsky and Sunzhensky deflections); the middle subzone separating the Sunzhensky and Terek subzones (Akbashsky, Alkhanchurtovsky and Petropavlovsky deflections); the Northern subzone (Predterechny deflection). The subzones have a common Caucasian strike and are located along the lines of the Argunsky deep fault in the Chernogorsky and Benoisk-Eldarovsky areas in the Terek-Sunzhensky zone. To the West of these faults, diagonally oriented uplifts of Kharbizhinsky (between the Sunzhensky and Terek subzones) and the Nazrano-Yandyrsky wedge (to the south of the Sunzhensky subzones) stand out along the Suret-Akhlovsky fault against the background of large synclines.

According to the relation of local uplifts and deep faults in the territory of fold deflection zone the following uplifts are distinguished: upon-fracture (Zamankulsky, Karabulak-Achaluksky, Sernovodsky, Starogroznensky, Oktyabrsky, Arak-Dalatareksky, Ahlovsky, Malgobek-Gorsky, Eldarovsky, Khayan-Kortovsky, Goryacheistochnensky, Bragunsky, the

Western - and Eastern Gudermessky, Datykhsky, Benoysky), characterized by a large steepness of the wings and the presence of longitudinal and diagonal violations such as faults and thrusts; near fracture (Northern Malgobeksky, Northern Mineral and Mineral), characterized by a steep Southern wing and the presence of faults; inter fracture (Khankalsky, Northern-Bragunsky, Andreevsky), which have wide arches and flat wings.

Simultaneously with the formation of the structural plan, according to works [13, 14], a reservoir was formed in the investigated sediments. Tectonic movements, accompanied by the redistribution of stress fields, contributed to the intensive formation of fracturing. With the decay of tectonic movements, the "healing" of cracks occurred. According to some researchers [6, 7], the formation of cracks is associated with phases of tectogenesis and is cyclical in nature. According to the results of paleostructural analysis, the growth of most of the structures of the Terek-Sunzhensky oil and gas region, which was laid in the Cretaceous time, continued in the Paleogene, Neogene and Anthropogenic time [14]. It was observed especially intensively during the Oligocene, Middle Miocene, and Pliocene-Anthropogenic periods. The structures were fully formed in the Pliocene-Anthropogenic periods.

In order to determine the influence of the formation of structures on fracturing over all local uplifts, weighted average values of the bulk density of three generations of cracks (mineral, effective, styllolites) and the percentage of each of them were calculated. Then there were changes in the heights of the bend of the layers for each geological period as a percentage of the maximum heights which now have folds, taking into account faults. The comparison of the percentage of cracks of various generations with a change in the height of the bend of the layers in geological time intervals showed that the density of stylolite seams does not correlate with the change in the height of the bend of the layers. The relations of the content of mineral cracks with the increment of the height of the bend of the layers formed in the period from the Maikop to the Meotic period (Fig. 2 a), and the content of effective cracks with the increment of the height of the bend of the layers formed in the time interval from the Meotic to modern time (Fig. 2 b) are noted. This fact indicates that effective cracks arose during the Pliocene and post-Pliocene time, and they provided filtration of hydrocarbons.

III. Conclusion

The analysis of the change in the volume density of fractures of various generations from the modern height of the uplifts shows that the number of stylolites depends little on its height (Fig. 2 a). This is explained by the fact that styllolites were formed in the initial stage of diagenesis, when the Upper Cretaceous structures were low-amplitude.

The graph of the dependence of the bulk density of mineral and effective fractures on the maximum bending of the layers (Fig. 2 b) shows that with increasing values of the bending of the layers, the total density of effective fractures increases and the proportion of mineral fractures decreases.

According to the authors the increase in the density of effective fractures which under the conditions of the Terek-Sunzhensky oil and gas region play the main role in the creation of useful capacity, as well as during the migration of liquids and gas, confirms the statement that the formation of fracture is reasoned by the processes of structure formation.

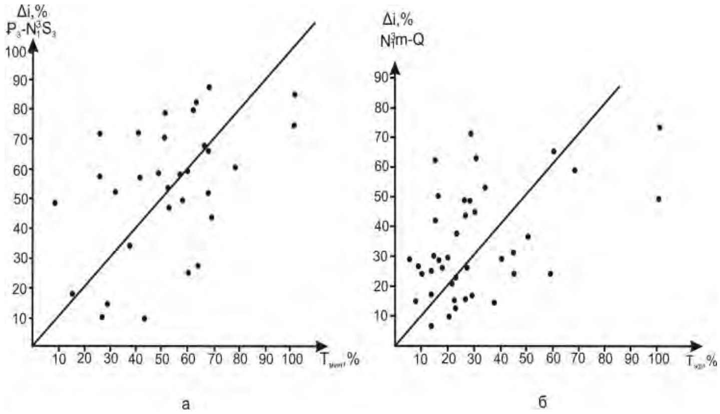

Fig. 2. The comparison of volume density of mineral (T_{min}) and effective (T_{ef}) fractures with the change of the height of the bend of the layers

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