Some aspects of the placement of hydrocarbon accumulations within the Terek-Caspian trough

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Abstract. The article is devoted to the distribution of oil and gas accumulations within the Terek-Caspian trough. Various factors that determine the spatial distribution and formation of hydrocarbon deposits in the studied region (tectonically, stratigraphically) are considered. The distribution of total oil reserves by large stratigraphic complexes is given in tabular form. Information is given on hydrocarbon deposits depending on their confinement to certain structural forms and the phase state of the fluids. The prospects of opening new accumulations of oil and gas with a further increase in geological exploration for oil and gas are determined.

1. Introduction
Around the second half of the 20 century, widespread research has been conducted to study the patterns of distribution and conditions for the accumulation of oil and gas in the bowels of the earth. Long-term practice of exploration for oil and gas in many regions of the world has established verticalzonality in the distribution of hydrocarbon accumulations of different phase states and pronounced unevenness in the distribution of oil and gas in space. One of the main problems of oil and gas geology is the study of the spatial distribution of hydrocarbon accumulations and the conditions for their formation. In theoretical terms, this problem is associated with another no less important problem - the genesis of oil itself. On the practical side, research results in these areas allow us to ensure the development of rational areas for geological exploration for oil and gas and their high efficiency. The indicated studies should be carried out primarily in well-studied oil and gas areas, which include the Terek-Caspian oil and gas region.

2. Materials and methods
The research of this region was carried out in the following direction, collecting and analyzing the available actual and stock material on the geological structure of the region. Particular attention is paid to the poorly studied monoclinic and instrument zones of the Terek-Caspian Trough (TCT).
3. Results
The current structure of the TCT is determined by its position between the folded structure of the Greater Caucasus in the south and the Scythian plate in the north, which was formed mainly in the late Horogenic stage of geological development due to intense tectonic movements in the Predakchagyl folding phase [1].

TCT includes several structural elements of the second and third orders of anticlinal, synclinal zones, depressions, local structures, etc. [2]. Second-order tectonic elements include the Terskaya, Sunzhenskaya and Pereterechnaya anticlinal zones, the Montenegrin monocline, the Petropavlovskaya Depression and the Alkhanchurtskaya synclinal. Within each of the listed structural elements, separate local structures are distinguished: Eldarovskoye, Bragunskoye, Pravoberezhnoye, Chervlennoye, Starogroznenskoye, Oktyabrskoye, Khankalskoye, Benoyskoye, etc. In accordance with these elements of tectonic zoning, elements of the same name of oil and gas geological zoning, zones of oil and gas accumulation, oil and gas deposits and deposits are distinguished. The connection of local accumulations of oil and gas with anticlinal structures was established back in the second half of the 19th century. Russian and foreign researchers. The Anticlinal theory became widespread in the future [4].

Along with the tectonic factor, an important indicator determining the spatial distribution and formation of oil and gas deposits is the distribution of the main oil and gas complexes in the Mesozoic and Cenozoic. The main oil and gas complexes include Neogene, Paleogene-Cretaceous, Jurassic. In spatial terms, the boundaries of the industrial oil and gas potential of individual complexes do not coincide.

**Neogene complex.** Hydrocarbon deposits are established mainly in the central and partially in the northern part of the TCT, and are confined to sediments of the Sarmatian, Karagan, and Chokrak tiers. From the Upper Sarmatian sediments in the areas of Starogroznenskoye (Tashkala), Pravoberezhnoye, Chervlennoe. Oil, oil and gas and purely gas deposits associated with terrigenous reservoirs are confined to the Karagansky layer. The Chokrak beds of sandstone are confined to a greater extent to oil deposits. In total, more than 120 hydrocarbon deposits were discovered in the Miocene deposits at Malgobek-Voznesenskaya, Goryacheistochnenskaya, Bragunskaya, Starogroznenskaya, Oktyabrskaya, Gudermesskaya and other. Middle Miocene oil and gas deposits associated with traps of a reservoir-arch, lithologically and tectonically ecological.

**Upper Cretaceous complex.** The boundaries of the industrial petroleum potential of the Upper Cretaceous are spread over the entire territory, i.e. Upper Cretaceous is regionally oil and gas bearing. The limestones of the Upper Cretaceous complex are confined mainly to single-phase oil deposits. On the Gudermesskoy, Ilyinskoy, Severo-Dzhalkinsky, Mesketinsky and Khankalsky areas, transitional deposits with a high gas factor are established, and on one Benoyskoy area - an oil and gas condensate deposit. Deposits in the Upper Cretaceous sediments related to the stratum-vaulted and massive-vaulted types are in the conditions of high pressure and high reservoir temperatures [5].

**In the Lower Cretaceous complex.** oil and gas deposits were discovered in the Aptian tier, and single deposits in the Albian, Barrem, Goteriv, and Valanginian tiers. Oil deposits of a transitional type and one gas deposit (Khankalskaya) are confined to the second sandy layer of the Aptian tier. Deposits were discovered in the Barremian tier within the two deposits of Goryacheistochnenskaya and Datykhskaya. The Tersko-Sunzhenskoye oil and gas region is characterized by the complex structure of the vast majority of oil and gas fields, a significant variety of types of hydrocarbon accumulations. Many of the fields have a number of productive horizons. The available data indicate that the hydrocarbon accumulations are not of the same type, confined to different tiers of the Mesozoic sediments. The deposits of the Tersko-Sunzhenskoye oil and gas region, within which oil and gas condensate deposits were found in the Mesozoic complex until 1972 year, are classified according to the well-known classifications of I O Broad, N A Eremenko (1957, 1960), N A. Eremenko (1968) to a group of deposits associated with anticlinal and brachianticular folds or to a class of deposits of a structural type A A Bakirov (1968).
The largest reserves include hydrocarbon deposits confined to high-amplitude, linearly elongated anticlines formed by the Eocene and Upper Cretaceous layers: oil and gas condensate Malgobek-Voznesenskoye, oil Eldarovskoye, Khayan-Kortovskoye, Goryacheistochenskoye, (Yastrebunskoye), Bragunskoye, Gudermesskoye, Karabulak-Achalukukskoye, Starogroznskoye, Octoberskoye. Most of the deposits in the Cretaceous deposits of these deposits are classified as arched, complicated by tectonic fractures. The above folds are confined to oil deposits with an external and internal oil contour of various types. The structures of smaller sizes and amplitudes of the brachianticline type are predominantly associated with massive waterfowl (the Montenegro monocline, the Petropavlovsk Depression and instrument zones).

Smaller reserves belong to deposits confined to the brachianticlines or low-amplitude folds (oil Akhlovskoye, Zamankulskoye, etc., oil and gas condensate Benoyskoye). Some of them, for example, Akhlovskoye, could be considered as original satellites of nearby large deposits. The exploration of a floating oil reservoir in the Upper Cretaceous sediments on Harbizhinskoy Square — on the structural bridge between the western parts of Terskaya and Sunzhenskaya anticlinal zones.

The revealed structural confinement of hydrocarbon accumulations in the Mesozoic sediments testifies to the crucial role of the structural tectonic factor as controlling the placement of deposits in the region. At the same time, the confinement of certain types of deposits to certain structural forms is noted [6]. There are structures of a smaller size and local large sizes (structures of the "third" order) and warehouse smaller sizes and brachyanticlines (structures of the "fourth" order). Oil deposits with external and internal oil contours are confined to third-order structures, and only waterfowl deposits to fourth-order structures. Almost all of the identified deposits in the Mesozoic deposits of the considered area turned out to be mainly oil, with rare exceptions gas (Khankalskaya) and oil and gas condensate (Benoyskoy). On Benoevskaya Square, an oil and gas condensate deposit confined to the Upper Cretaceous and Eocene sediments. Under the gas-bearing part is a low-power oil-bearing part.

In the western part of the Tersky anticline zone within the Malgobek-Voznesensky-Ali-Yurtovsky zone, as well as at the Starogroznsensky deposits, from Valanginian limestones (the bottom of the carbonate stratum) in several wells received gas inflows with condensate. All these deposits, although confined to structural protrusions of tectonic origin, are heterogeneous and belong to groups of reservoir, massive and transitional varieties. The formation-vaulted ones include oil deposits of the VII and IX sand formations of the Barrem tier of the Zamankulsky deposit and the Goteriv tier of the Datykhskoye area. All of them are poorly studied. The massive group includes oil and gas condensate deposits of several varieties.

In the past, with insufficient knowledge of the variety of types of deposits, some researchers developing the classification of hydrocarbon accumulations considered one of the essential signs of massive deposits to be the presence of only one external contour of oil content. The results of studying the features of oil deposits in various regions of the world over time showed not the universality of this feature, even for deposits with powerful productive strata. In some cases, within large structural protrusions, the reservoir is productive over the entire thickness of the reservoir in the vault. The oil reservoir in this case has an external and internal oil contour [7]. These are exactly the oil deposits in the Upper Cretaceous deposits of Malgobek-Voznesenskaya, Khayan-Kortovsky, Eldarovskaya, Bragunskaya, Oktyabrskaya, Karabulak-Achalukskaya and Starogroznsenskaya areas.

A number of explored massive oil deposits, including waterfowl, in the Upper Cretaceous deposits of the considered area revealed a non-horizontal (bent) water-oil contact. This very important circumstance indicates the insolvency of another formal classification requirement put forward by some compilers of the classification of the requirement that massive deposits have the formal requirement that massive deposits have only horizontal oil-water contact. Among the massive deposits are oil deposits in the Upper Cretaceous deposits of the Zamankulsky, Malgobek-Voznesensky, Khayan-Kortovsky, Karabulak-Achalukskoye deposits and the oil deposit in the Valanginian deposits of the Zamankulsky deposit.

Within the Terskaya and Sunzhensky anticlinal zones, the so-called massive reservoir oil deposits were identified, confined to the Alb-Aptian layers of the Malgobek-Voznesensky, Khayan-Kortovsky,
Karabulak-Achaluksky deposits. Each of these deposits is confined to a series of hydrodynamically interconnected sand-siltstone beds, as is proved by numerous interval tests, hydrodynamic studies of wells and other relevant geological data.

A massive reservoir oil deposit may be also present in the Alb-Aptian deposits of the Akhlovskoye field, located west of the well-known Malgobek-Voznesenskaya gas-oil-bearing area. At the Akhlovskoye field, the oil content of the Alb-Aptian strata was established at several intervals. In the years 1971-75, Exploration work was not yet completed and the data available by that time did not allow a conclusion on the nature of the oil-water contact. The classification of the main types of hydrocarbon accumulations in the Mesozoic sediments of the Tersko-Sunzhenskoye oil and gas region is given in the attached table.

**Table 1.** Table of distribution of total oil reserves by stratigraphic units in the western part of Terek-Caspian trough (as of 01.01.2018)

| Second order structural elements (zones) | Oil distribution by stratigraphic complexes | Total initial recoverable oil reserves, thousand tons |
|------------------------------------------|-------------------------------------------|-----------------------------------------------------|
|                                          | Neogene | Paleogene-Upper Cretaceous | Lower Cretaceous |                                                     |
| Priterechnaya                           | 1103    | 14628                       | 97              | 15828                                               |
| Terskaya                                | 3473    | 113772                      | 6467            | 123712                                              |
| Sunzhenskaya                            | 120340  | 52066                       | 14289           | 186695                                              |
| Petropavlovskaya                        | 0       | 1700                        | 0               | 1700                                                |
| Montenegrin                             | 0       | 895                         | 0               | 895                                                 |
| Monocline                               |         |                             |                 |                                                     |

Some of the hydrocarbon accumulations found in the Mesozoic sediments have not yet been classified because exploration has not yet been completed, or there was no data on the position and characteristics of the oil-water contact. So, for example, due to the incomplete solution of the reconnaissance tasks, until 1971 the positions of the oil-water contact in the Upper Cretaceous deposits of the Eldarovskaya, Yastrebina, Bragunskaya, Gudermes, Oktyabrskaya, Starogrozensky areas were not completely established or very approximately determined. Among the massive deposits of the oil and gas region under consideration, one can distinguish subtypes of deposits with stratigraphically coeval reservoirs. The last subtype includes deposits, apparently with a common (single) Upper Cretaceous and Eocene reservoir: oil - in the Eldarovskaya, Yastrebina, Bragunskaya, Oktyabrskaya (probably still at Gudermes, Starogrozensky) areas, gas condensate with a low-oil oil-bearing part - on the Ben [8].

A small oil reservoir was discovered in the Upper Jurassic carbonate deposits of Zamankulskaya area, which can be classified as a massive waterfowl, with an estimated partial tectonically shielded. On the whole, within the region, within the studied Mesozoic stratigraphic range, in those fields where two or more deposits are found, there is a definite tendency to oil relief as the depths increase. In this case, the regularity of the increase in gas saturation of oils carried out in “SevKavNIPIneft” V.F. Kondratiev, the total range of gas factors of the Tersky zone is 70-760 m³/t saturation pressure - 115-385 kg/cm², volumetric factors 1.25-4.36. In the Sunzhensky zone, similar ranges for gas factors are 30–1080 m³/t, saturation pressures 40–390 kg/cm², and volumetric factors 1.12–4.04.

The deficit of saturation pressure decreases markedly with depth (for example, at the Zamankulskoye field, where the established interval of oil and gas content is three times the most significant in the stratigraphic section, from the Upper Cretaceous to the Jurassic deposits inclusive). In the Mesozoic sediments of the Tersko-Sunzhenskoye oil and gas region, in addition to oil deposits, the first gas condensate deposits were also made - in the Upper Cretaceous and Eocene layers in the Benoevsky Square, in the Valanginian layer - on the Malgobek-Voznesensky Square (it is also within some preliminary gas condensate accumulation in the Upper Jurassic deposits is possible). These facts,
as well as the peculiarities of changing the thermodynamic conditions along the section, suggest the probability of discovering new gas condensate (gas) deposits as they open deeper than the underlying horizons.

The variety of these types of hydrocarbon accumulations is apparently associated with certain features of their insufficiently studied genesis [9]. It is possible that over time, other varieties of hydrocarbon accumulations will be found in the Mesozoic complex of the considered area, because the study of the oil and gas potential of these deposits is far from complete.

4. Conclusion

Based on the foregoing, some conclusions can be drawn that can be used in predicting the discovery of new oil and gas fields and deposits, planning and selecting directions for exploration for oil and gas in the area. The most important factor controlling the location of oil and gas accumulation zones and local hydrocarbon accumulations is tectonic. The main zones of oil and gas accumulation and deposits are usually confined to supra-fault anticlinal zones (Tersky, Sunzhensky) consisting of rock-shaped separate anticlines, expressed practically throughout the section. Accordingly, the latter are characterized by the largest stratigraphic range of oil and gas potential. In the instrument zones of the anticlinorium, in the synclinal zones and the Montenegrin monocline, buried oil and gas structures in the Mesozoic deposits are developed [10].

The Upper Cretaceous complex is characterized by regional oil and gas potential. The purely oil deposits of this complex are established in all structural tectonic zones, with the exception of the Benoysky dislocation zone. In the Lower Cretaceous, both pure oil (Aptian) and single gas deposits are discovered. To date, in the Upper Jurassic subsalt complex, one gas deposit has been established within the Datykh area. Accordingly, the discovery of similar deposits in other areas of the Montenegrin zone [11] is forecasted in this complex.

In spatial terms, the western and central parts of the TCT are predominantly oil-bearing regions, while the gas ones are the eastern parts. In general, the described patterns in the location of hydrocarbon accumulations in space and along the section are an important factor that must be taken into account when conducting geological exploration for oil and gas. The involvement in the exploration and exploration of deeper Mesozoic horizons will make it possible to establish new, possibly highly productive oil and gas deposits. According to some researchers, the vertical-step migration of fluids from bottom to top along deep faults is of great importance in the formation and placement of hydrocarbon deposits [12].

References

[1] Sidorov V A 1989 Modern geodynamics and oil and gas potential (Moskow: Nauka)
[2] Letavin A I, Orel V E., Chernyshev S M and others 1987 Tectonics and oil and gas potential of the North Caucasus (Moskow: Nauka)
[3] Friedemann B Benedetto M Di Fuchs T Lampe C and Sciamanna S 2009 Integrating structural geology and petroleum systems modeling – A pilot project from Bolivia’s fold and thrust belt (Marine and Petroleum Geology vol 26) pp 573-579
[4] Daukaev A A 2009 Regulations in placing oil and gas clusters in section of sedimentary case and in space (In the collection: Collection of scientific papers Integrated Research Institute of the Russian Academy of Sciences vol 2) (Moscow) pp 226-231
[5] Kerimov I A, Aksenov E M, Antonov V A and others 2016 Mineral resources resources of the Chechen republic Collective monograph (Grozny: AN CR)
[6] Hantschel T and Kauerauf A I 2009 Fundamentals of Basin and Petroleum Systems Modeling (Berlin: Springer)
[7] Di Primio R and Horsfield B 2006 From petroleum-type organofacies to hydrocarbon phase prediction (AAPG bulletin vol 90) pp 1031-1058
[8] Kornilov Yu V, Burlakov I A and Bogush I A 2013 Some aspects of the oil and gas potential of the Upper Cretaceous sediments of the Eastern Ciscaucasia (Oil industry of the Chechen
Republic: state, problems and priority directions of development. Materials of the All-Russian Scientific and Practical Conference) (Grozny: AN CHR) pp 90-97

[9] Timurziev A I 2017 Geodynamic aspects of oil and gas zoning of primary mantle hydrocarbon systems, global patterns and prospects of oil and gas potential of the bowels of the North Caucasus Collective monograph (Current problems of geology, geophysics and geocology of the North Caucasus vol 7 Part 1) (Moskow: IHNHT named after S I Vavilova RAS) pp 221-235

[10] Shtun S Yu, Savina Yu A, Dotsenko V V, Stepanov A N and Yaroshenko A A 2017 On the formation of oil and gas accumulation zones in superdeep horizons of the Middle Caspian oil and gas basin. Terek-Caspian marginal deflection Collective monograph (Current problems of geology, geophysics and geocology of the North Caucasus vol 7 Part 1) (Moskow: IHNHT named after S I Vavilova RAS) pp 263-274

[11] Kozub A P, Nemtsov I N and Nemtsov N I 2019 Prospects for the oil and gas potential of the deeply submerged horizons of the Terek-Caspian trough (Modern problems of geology, geophysics and geocology of the North Caucasus vol 9) (Moskow: IHNHT named after S I Vavilova RAS) pp 258-266

[12] Sianisyan E S, Prozorova G N, Pogorelskaya S V and Sianisyan S E 2013 Renewable hydrocarbon resources of the Mesozoic-Cenozoic reservoirs of the Terek-Caspian trough (Oil industry of the Chechen Republic: state, problems and priority areas of development. Materials of the All-Russian Scientific and Practical Conference) (Grozny: AN CHR) pp 98-117