History, current state and outlook for developing Mesozoic complex of Terek-Caspian downfold deposits

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Abstract. The article is devoted to the outlook for oil and gas potential of the Mesozoic complex of the Terek-Caspian downfold. The problem of oil and gas content of great depths has been of interest to scientists and specialists since ancient times. However, it became especially relevant in the second half of the 20th century. With the depletion of the Miocene deposits of the Tersko-Sunzhenskaya oil and gas region being exploited for a long time in the 50s of the 20th century, the question of preparing new hydrocarbon reserves through the development of deep-lying horizons of the Mesozoic has become acute. The main oil production in the Tersko-Sunzhensky oil and gas region has been associated with the Mesozoic complex, in particular the Cretaceous one, for more than 60 years. In the Upper Cretaceous deposits, more than twenty highly productive oil deposits associated with a carbonate reservoir represented by fractured limestones were discovered. Currently, many deposits of the Cretaceous complex are at the stage of depletion. This article briefly covers the development of the Mesozoic deposits. As well, it assesses the current state of the oil complex of the Chechen Republic. The short-term and long-term prospects of oil and gas content associated with Cretaceous and Upper Jurassic deposits have been assessed. For successful operation, it is necessary to have a unified oil and gas production system, whose components are oil production, geological exploration and scientific research. Specific recommendations were given for conducting geological exploration for oil and gas. The article substantiates the necessity of studying the regional structure of the territory under consideration using a complex of geophysical methods and parametric drilling, in particular, aimed at studying the nature of the structure and composition of the Upper Jurassic deposits and determining the location and depth of parametric wells. It is recommended to focus on a number of regional seismic profiles for the study area.

1. Introduction

Geophysical research (geophysical exploration) is being widely deployed on the territory of the Terek-Caspian downfold. In 1946-1948 the entire area was covered by magnetometric surveys, which resulted in a number of anomalies. Since 1947, seismic surveys using CDP seismic reflection method have been carried out. The research resulted in constructing a schematic structural map for the top of the Upper Cretaceous deposits for the first time. The obtained seismic data showed that low-amplitude structures, which significantly differ in morphology from the folds of the front ranges, can be...
developed in the flat part of the Mesozoic deposits. Exploration work was carried out at the same time. The results of drilling reference, prospecting and exploratory wells enabled to study the main features of the geological structure of the territory, to positively assess the oil and gas potential and contributed to a further increase in the volume of exploration for oil and gas more than 10 times. In general, the volume of deep drilling amounted to more than 3 million meters. The main volumes were concentrated in the Tersko-Sunzhenskaya fold zone. For the period from the end of 1946 to 1999, production (for Grozneft) amounted to more than 300 million tons and more than 25 oil deposits were discovered in chalk deposits within old and new areas. In accordance with the classification of fields by recoverable oil reserves, the fields of the Chechen Republic are distributed as follows: the large ones include Starogrozenskoye, Oktyabrskoye, Bragunskoye, Eldarovskoye; average ones are represented by Goyt-Kortovskoe, Pravoberezhnoe, Goryacheistochnenskoe, Severo-Bragunskoe, and the rest are small fields. Since 1957, the Upper Jurassic deposits have also been studied. Within Malgobek-Voznesenskaya (wells 864, 866, 876, 901, etc.), Karabulak-Achalukskaya (wells 47, 74, 107, 122, 153), Zamankulskaya (wells 46, 47, 58, 60, 61, 65), Datykhskaya (wells 12, 15) and other areas, more than 15 deep wells were drilled. As a result of drilling in the Upper Jurassic deposits, hydrocarbon deposits including one gas deposit in the subsalt deposits at the Datykh area were discovered [1]. This article focuses on the prospects for oil and gas potential associated with the Cretaceous and Upper Jurassic rock complexes.

2. General information about the geology and formation of hydrocarbon accumulations

The Terek-Caspian downfold is characterized by the presence of a thick sedimentary cover (up to 10-12 km). Mesozoic deposits are more than 4 km thick. Tectonically, the area under consideration covers the western part of the Terek-Caspian downfold. Terskaya and Sunzhenskaya anticlinal zones are in its center. The modern arrangement of the latter coincides with the suture zones dividing the mobile zones of the earth’s crust. The main oil and gas deposits are confined to them.

Geodynamic, hydrochemical and other data indicate that the process of formation and reformation of oil deposits in the Mesozoic complex is not completed and the current movements of the earth’s crust are actively influencing [2]. The latter is confirmed by the periodically observed reaction of production wells on the territory of the Terek-Caspian downfold to the seismic activity of the subsoil in 1912 and 1970.

With this regard, the researchers K.A. Anikiev, M.F. Dvali, V.F. Lipetskiy et al. stated that the abnormally high formation pressure is due to the periodic breakthrough of high-pressure fluid flows from the depths into the water-oil-bearing horizons. In this case, the main ways of vertical migration of fluids can be both old deep faults and newly formed natural hydraulic fracturing of formations [3–5].

3. Current state of Chechen oil complex resource base

Table 1 shows data on the state of oil and gas reserves and resources. Depletion of proven oil reserves is 97%, and gas reserves – about 50%. Currently, the Upper and Lower Cretaceous deposits are in commercial development. The main deposits of the Cretaceous complex including the Starogrozenskoye and Oktyabrsky deposits are located in the area of high water pressure and are characterized by abnormal pressures, hydrochemical anomalies (condensation waters, etc.), which explains the mechanism of their formation due to the predominantly vertical migration of fluids from bottom to top. A number of researchers prefer the subduction mechanism referring to the formation of large deposits of Tersko-Sunzhenskoye oil and gas region from the standpoint of the geodynamic concept of oil and gas formation [6; 9]. Despite a fairly high degree of development, the Upper Cretaceous complex of deposits within the Tersko-Sunzhenskoye oil and gas region is characterized by significant oil and gas resources. In accordance with an expert assessment of the potential raw material resources of hydrocarbon in Chechen Republic, the Upper Cretaceous complex accounts for more than half of the total raw materials on the balance sheet of OAO Groznoftegaz.
During Mesozoic deposits development, up to 220 million tons oil have been extracted, which is more than 85% of the initial recoverable reserves of the corresponding deposits and 63% of all produced oil within the Chechen Republic. Most of the oil produced is associated with the Sunzhenskaya anticlinal zone. The Terskaya and Priterechnaya anticlinal zones are in the second and third places in terms of oil produced from the Cretaceous deposits, respectively. In the rest of the tectonic zones, oil has been produced to date in insignificant quantities.

As of 01.01.2020, the degree of exploration of the initial total oil resources in the Chechen Republic is 80%, the degree of depletion of the drilled reserves is 96.9%. The Terskaya anticlinal zone is characterized by the largest residual reserves of industrial categories. The Sunzhenskaya, Priterechnaya and Petropavlovskaya tectonic zones are distinguished by approximately the same residual reserves of category A+B+C₁. The largest reserves of category C₂ are recorded for deposits within the Petropavlovskaya depression (Fig. 1).

Figure 1. Distribution of residual oil reserves of industrial categories by tectonic zones

The development of the majority of the Cretaceous oil and gas deposits of the Terskaya and Sunzhenskaya anticlinal zones is more than 80%. The current state of the oil complex can be characterized as unstable. In a short time, from 2000 to 2005, the annual oil production was raised from almost zero to 2500 thousand tons.

4. Prospects for Mesozoic deposits development

Cretaceous sedimentary complex. This complex includes the Lower Cretaceous and Upper Cretaceous deposits. The Lower Cretaceous deposits are widely developed within the western part of the Terek-Caspian downfold and accessed to their full thickness by a significant number of wells. The Lower Cretaceous section is represented by a thick stratum of terrigenous rocks with the exception of the Valanginian stage composed of carbonate rocks. The thickness of the Lower Cretaceous varies widely, reaching 1,700 m in the area of the Beslanovskaya depression. On the northern slopes of the Chemorskaya monocline and the platform side of the Terek-Caspian downfold, regional pinching out of the Lower Cretaceous deposits occurs. The Lower Cretaceous complex is represented by all stages of the generally accepted stratigraphic scale and 12 formations of the local scale. Oil and gas content is mainly associated with the Barremian (Goryacheistochnenskaya and Zamankulskaya areas) and Albian-Aptian deposits (Braguny, Goryacheistochnenskaya, Khayan-Kort, Eldarovo, Starogroznskaya, Oktyabrskaya, Malgobek-Voznesenskaya, Akhlovo, Karabulak-Achal areas). According to a number of individual specialists of the central and eastern parts of the Terek-Caspian downfold, where high-amplitude strongly dislocated structures, which high-rate Upper cretaceous deposits are confined to, are developed and characterized by a high degree of traps filling (the height of the deposit exceeds the thickness of the Upper Cretaceous strata), it is possible to predict deposits in the Lower Cretaceous deposits. The supposed facies replacement of the Upper Jurassic gypsum-anhydrite sequence is a favorable factor for hydrocarbons upward migration here. Massive hydrocarbon deposits have already been discovered under the Albian clay cover. The deposits were
formed due to an excessive amount of hydrocarbons. The Upper Cretaceous deposits were accessed by a significant number of wells within the anticlinal zones, and they were studied by separate wells (Benoi square, Datykh square, etc.) and in natural outcrops in the Black Mountains zone [7]. The Upper Cretaceous complex is represented by all layers. In lithological terms, they are represented by various types of limestones, with interlayers of clays and marls. There are no clear boundaries between individual layers. According to GIS, the boundaries of the top and bottom of the Upper Cretaceous are clearly marked. The total thickness of the Upper Cretaceous complex of deposits is 200-500 m. The thickness of the Upper Cretaceous sedimentary complex increases from west to east from 2,200 m to 5,000 m within anticlinal zones and up to 7,000 m in synclinal zones. The Upper Cretaceous sedimentary complex is characterized by regional oil and gas content. Oil and gas deposits have been found practically in all structural-tectonic zones of the Terek-Caspian downfold (Terskaya, Sunzhenskaya anticlinal zones, Benoiskaya dislocation zone, Petropavlovskaya and Alkhanchurtkaya synclinal zones), as well as in buried structures of near-edge zones. The thickness of individual deposits reaches more than 1,000 m. By now, hydrocarbon deposits associated mainly with complex-screened (structural-disjunctive) traps characterized by the fissured-cavernous reservoir type have been found in the Cretaceous complex of deposits. Further prospects for the discovery of new oil and gas accumulations in the Upper Cretaceous deposits are also associated with the traps of this type. In particular, this is evidenced by some results of geophysical studies and comprehensive reinterpretation of geological and geophysical materials presented further [8]. Of practical interest are also zones of rocks destruction found in the cross-section of the Upper Cretaceous and identified within individual structures (Chervlennaya, etc.) based on the results of detailed seismic surveys. The Shelkovskaya zone with small-amplitude faults, structural terraces, and protrusions in its southern part is of interest in terms of searching for complex-screened traps. In the northern part of this area, there is a wipeout zone identified with the ruptured zone.

_Effective Jurassic subsalt sedimentary complex._ In a number of regions of the world (Russia, the USA, North Africa, etc.), the high oil and gas potential of subsalt complexes of sedimentary deposits confined to various stratigraphic units has been proven. The Upper Jurassic subsalt sediments are a strategic reserve for replenishing the hydrocarbon resource base in the Chechen Republic. To date, the industrial oil and gas content of these sediments within the Eastern Ciscaucasia has been proven by the production of hydrocarbon inflows in Datykhskaya, Maryinskaya and other areas. According to many researchers, the resource potential of these deposits is highly estimated. The most promising areas for identifying new hydrocarbon deposits in terms of a combination of factors are the western parts of the Sunzhenskaya anticlinal zone and the Chernogorskaya monocline.

5. _Conclusion_

Thus, the territory under consideration is characterized by certain prospects for developing the hydrocarbon resource potential. The Upper Cretaceous will remain the focus area of geological exploration in the near future. The seismic exploration carried out in the late 1980s – early 1990s, as well as generalization and comprehensive reinterpretation of accumulated geological and geophysical materials in the Upper Cretaceous deposits revealed about 30 promising small oil and gas objects. Prospecting and exploration work for oil and gas in the Cretaceous deposits should be focused on the search for oil and gas deposits within the limits established in the Upper Cretaceous deposits of new and previously identified geological objects, as well as in unopened horizons of deposits and search for new oil and gas promising geological objects in the Meso-Cenozoic deposits of both structural and non-structural types. Long-term prospects for oil and gas content can be associated with the development of the Upper Jurassic subsalt deposits. It is necessary to study the regional structure of the considered territory using a complex of geophysical methods and parametric drilling, in particular, in order to study the nature of the structure, composition of the Upper Jurassic deposits and determine the location and depth of parametric wells. It is recommended to focus on two regional seismic profiles along the lines Dattykh-Burunnaya and Vedeno-Kargalinskaya. Conducting sufficient geological exploration at a faster pace, as well as targeted research and development work
simultaneously with oil and gas production in the region under consideration will significantly increase the resource base of the oil and gas industry.

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