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Analysis of the Effectiveness of Geological Exploration Using Hydrocarbon Raw Materials within Terek-Caspian Trough

Daukaev A.A.
Department of Geology, Geophysics and Geoecology CRI of the RAS
Department of Applied Geology, GSNTU
Department of Physical geography and landscape science CSU
Grozny, Russia
daykaev@mai.ru

Gatsaeva L.S.
Department of Geology, Geophysics and Geoecology CRI of the RAS
Grozny, Russia
gls69@yandex.ru

Bachaeva T.Kh.
Department of Geology, Geophysics and Geoecology CRI of the RAS
Grozny, Russia
bachaeva@bk.ru

Gatsaeva S.S.-A.
Department of Applied Geophysics and Geoinformatics GSNTU
Grozny, Russia
sveta_gacaeva@mail.ru

Abubakarova E.A.
Department of Geology, Geophysics and Geoecology CRI of the RAS
Department of Applied Geophysics and Geoinformatics

Khamsurkaev Kh.I.
Department of Railway Safety GSNTU
Grozny, Russia
hhi67@mail.ru

Usmanov A.Kh.
AS of the CR
Grozny, Russia
bachaeva@bk.ru

Aidamirova Z.G.
Department of Applied Geology GSNTU
Grozny, Russia
lizi_68@list.ru

***Abstract* – The article analyzes information on oil and gas deposits obtained by seismic exploration, geological and geophysical data compilation and reinterpretation for the western part of the Terek-Caspian trough. The tabulated data on morphological parameters (linear dimensions, amplitudes) of local structures have been collected for several years. Differences in the efficiency of geological exploration were identified (geological features of the structure, topography, deep and surface seismic and geological features). The causes of low efficiency of geological exploration in some areas (complexity of the structure, seismic conditions, a reduced size of geological objects and disregard of the disjunctive block structure) were identified. Recommendations for geological prospecting and exploration of oil and gas deposits were provided.**

Keywords – local structures; Terek-Caspian trough; oil and gas potential; geological structure; geological exploration; Montenegro monocline.

I. INTRODUCTION

Eastern Ciscaucasia is divided into two parts, significantly differing from each other in geomorphological features, tectonics and history of geological development. It consists of a flat part corresponding to the platform slope of the Ciscaucasian troughs, and the mountain and piedmont parts corresponding to the eastern part of the northern slope of the Greater Caucasus mega-anticlinorium. Due to the fact that these territories belong to different tectonic structures, the methods for studying their structures and efficiency of geological, in particular seismic, exploration, differed significantly. The exploration of Mesozoic deposits, in particular Upper Cretaceous, began in the beginning of the 1950s by the integrated southern geological expedition (ISGE) and other organizations.

II. METHODS AND MATERIALS

The historical, scientific and analytical approaches were used. The research was carried out on the basis of published works.

III. RESULTS

In 1958, deep exploration drilling began on the Mesozoic sediments and in the Benoiskaya area, where in well No. 32 when testing foraminiferous + upper cretaceous sediments industrial gas inflows with condensate were obtained. In some other areas of the Montenegrin zone, the study of Cenozoic deposits (Karagan-Chokrak, Maikop) was continued by drilling exploratory wells in order to search for various types of oil and gas deposits (structural, non-structural, combined). Until the 1970s, gravimetric and seismic studies were carried out in the Black Mountains. In the 1970s and 1980s, within the zone under consideration, drilling and seismic exploration works were carried out. As a result, a number of promising objects were found in the Upper Cretaceous sediments (uplifts of the North Bragun, Mineral, North Mineral, North Dzhalkinsky, Khankal , Lesnoye, Ilinskoe, South-Khayankortovskoe, Terek, Rodnikovoye, Sayasanovskoye, Severo-Sayasanovskoye, Severo-Benoyskoye, Zandakskoye, Nozhai-Yurtovskoe, Severo-Nozhai-Yurtovskoe, etc.). At the first seven objects, deposits of oil and gas were discovered. One of the parameters characterizing the effectiveness of exploratory drilling is the success rate which is 0.3 for this area. Deep drilling (parametric and prospecting) was carried out [1, 3].

Thus, in 1992, in the dome of the North Nozhay-Yurt area, parametric well No. 1 with a design depth of 5300 m. was created. It was not brought to the design depth and it revealed only Maikop sediments at a depth of 4067 m. According to preliminary results of the correlation of well sections along the roof of the lower Maikop deposits, anticlinal inflection was established. Prospects for hydrocarbon deposits within this structure are promising.

Nozhay-Yurt Area. In 1989, well No 2 with a design depth of 5,000 m was created in the roof of the structure. At a depth of 4,689 m (absolute mark minus 4,156 m.), the well opened the top of the Cretaceous with discrepancies from seismic survey data of 200 m. When testing the objects, weak damped gas inflows from the roof of the Upper Cretaceous were obtained. The negative results of drilling are due to the lack of reservoirs with favorable reservoir-filtration properties. When drilling this well, an oil-impregnated core was lifted from the sandy formation. It's early to stop assessing prospects for the oil and gas potential of this area. In the 1990s and early 2000s, the oil and gas exploration stopped. Since 2000, research institutes began to carry out thematic studies on synthesis and reinterpretation of seismic materials and drilling data. Since 2009, seismic exploration was renewed within the promising areas and deposits in the territory of the Chechen Republic, including the Benoy zone. Based on the materials of these works, it turned out that this trough is represented by a complex-built tectonic element in the form of two skibs (northern and southern) limited by thrusts. In 1929, according to N.S. Shatski, the Benoy zone was viewed as a continuation of the Terek-Sunzhen folded zone.

Based on the results of later works, some researchers note that the Benoy anticline is a sub-thrust structure formed by the advancing of the Cretaceous stratum from the south in the zone of the Planiduk ridge, where a large thrust was noted in the eastern part of the Varandi anticline [9]. In the north, it joins the Terek-Sunzhen folded zone. Based on the results of these works, new oil and gas objects in the Upper Cretaceous sediments - Vostochno-Pravoberezhny, Tolstoy-Yurtovsky, Rasvetny, Kirovsky, Dolinniy, Krasnostnepnovsky, Zapadno-Khankalsky - were identified. They are Aldynsky, Chernorechensky, Prirazlomny, West Mineral, West Mesketinsky, South Nozhaiyurt, East Nozhayurt, South Sayasanovsky, Rucheyny, South Arkabash, Burtunai deposits. The latter are local structures of the block-anticline type with linear dimensions of the long axis varying from 8 to 23 km, the short axis varying from 1.2 to 3.4 km and an amplitude varying from 150 to 450 m [1, 3, 6].

Thus, in the history of geological exploration, several stages can be distinguished. At the first stage (from the end of the 19th century to the beginning of the 1950s), geological studies were carried out to study the structure of tertiary deposits and their oil and gas content. The sections of the tertiary deposits were studied along the mountain rivers. A number of surface oil outlets were found. Two of them are nature monuments of the Chechen Republic. At the second stage (the 1950–60s), exploration works discovered oil and gas deposits of the foraminifero-upper cretaceous sediments (Benoy). At the third stage (1970–80s), using deep drilling, seismic prospecting, and aero magnetic exploration, the folded-block structure of the Cretaceous sediment complex in the Black Mountains region was identified. Promising geological objects in the form of local structures and block anticlines were identified. In Novolak, a gas condensate reservoir was discovered; in Mesketinskaya, an oil deposit in the Upper Cretaceous sediments was discovered.

The prospecting and exploration method was based on the "anticline theory". A simple undisturbed structure of the anticline and discovery of oil and gas deposits in the roof part were assumed. Therefore, the first wells were drilled in this part of the structure. In case of negative results, the structure was not considered promising. This technique was applied throughout the North Caucasus and beyond. In general, in the Terek-Sunzhen oil and gas region (TSOGR), the main direction of exploration was the Upper Cretaceous. The experience of studying the Upper Cretaceous local uplifts showed the complex nature of their structure, despite their apparent simplicity, as evidenced from the above-described results of seismic exploration and generalization of geological and geophysical materials. On the basis of the results of seismic prospecting and drilling, several zones differing in the degree of disturbance of local structures can be distinguished TSOGR. The Zarechnaya tectonic zone is characterized by proliferation of platform-type structures, while the western part (Zamankul and other structures) is characterized by proliferation of weakly disturbed structures. In the central part of the Terek-Sunzhen folded zone, high amplitude folds are strongly disturbed by fractures, within which there is a high fracture of the Upper Cretaceous sediments. Accordingly, within their limits, highly productive deposits of oil were discovered. The eastern and southeastern parts are characterized by strongly disturbed

structures such as block anticlines. Their amplitude rarely exceeds 300-400 m. Structural and tectonic factors play the same role [2].

IV. CONCLUSION

Thus, the southern folded zone in contrast to the platform one, is characterized by proliferation of dislocated local structures. The rupture-block structure could contribute to destruction of deposits in the arched parts and their concentration in the wing and periclinal parts in complex-shielded traps [4]. Evidence of the possibility of discovering a deposit in the arch part of the structure is the zone of destruction of Upper Cretaceous rocks with improved capacitive properties within the wing part of the Chervlen area. Despite the long history of geological exploration, the deep geological structure of this area is understudied (single wells opened Jurassic and lower sediments, and seismic prospecting is hard carry out due to complex surface seismic conditions). The results of comparison of morphological parameters for local structures obtained in different years showed a significant difference between them (Table 1). Analysis of the data on geological exploration of oil and gas in Upper Cretaceous sediments showed significant differences in their temporal and spatial efficiency rates. The efficiency rate began to decline with an increase in oil and gas reserves in the second half of the 1970s (the beginning of the 1970s is characterized by maximum efficiency of geological exploration). In spatial terms, the southern part of Eastern Ciscaucasia is characterized by lower efficiency compared to the northern platform. A decrease in the efficiency rate in time is due to the complex structure and reduced size of prospecting geological objects. In spatial terms, it is due to complex surface and deep seismic geological conditions. The reason for the low efficiency of geological exploration (the success rate is less than 0.3) is the search for structures in the main well drilled in the fornix without taking into account its discontinuous block structure [5, 7]. Thus, the Upper Cretaceous sediment complex has a significant resource potential. It is necessary to carry out seismic exploration works using modern advanced technologies. The method of geological exploration should be based on “constantly refining ideas about typical models of the structure of oil deposits. Therefore, improvement of this technique should begin with typification of open deposits and accurate prediction of the types of traps” [8, 10]. Selection of priority geological objects and location of the first wells should be based on a set of criteria taking into account a discontinuous block structure. After obtaining the results for the first exploratory wells, additional seismic exploration and re-interpretation of geological and geophysical materials are required. Taking into account insufficient knowledge of individual zones, this area can be considered as one of the most promising for exploration in order to study the geological structure and replenish the resource base of the oil and gas industry of the Chechen Republic. For further research on the deep structure, correlation of the structural plans of the Cretaceous and lower sediments, oil and gas potential, it is necessary to continue geological exploration using aerial methods, seismic exploration and deep drilling.

TABLE I. COMPARISON OF MORPHOLOGICAL PARAMETERS OF GEOLOGICAL OBJECTS DETERMINED FOR DIFFERENT YEARS

No	**Name of zones and structures**	**Trailing isohypsum, m**			**Linear dimensions, km**			**Amplitude, m**			**Note**
		1987	***2006***	***2012***	***1987***	***2006***	***2012***	***1987***	***2006***	***2012***	
Montenegrin monocline											
1	North-Nozhay-Yurtovskaya	4400	4200	4200	16.0x2.0	12.x2.5	12.9x2.3	100	300		Anticline
2	Nozhay-Yurtovskaya	4250	4200	4200	20.0x2.0	9.5x2.6	11.2x2.2	100	250	250	Anticline
3	Zandakskaya	3800	3600	-	10.1x3.0	-	15.5x2.3	200	-	450	Block anticline
4	Sayasanovskaya	3000	3200		18.0x2.5	10x2	15 x 1.5	300		250	Block anticline
5	Belorechenskaya	4400	4600	4400 4800	10.0x3.5	12x2	8.0x1.713.5 x3.0	200	250	400 450	Anticlinal fold of two blocks
6	South Khayankortovskaya	5300	5300	-	13.3x2.0	16.3x2.4	-	200	550	-	The structural plan has not been changed
7	North Benoyskaya		1900	-		12.4x2.3	23x2.5		350	550	
8	North Khankalskaya	5600	5400	-	17.2x2.0	9.2x2.3	-	150	350	-	
9	Priterechnaya	5500	5400	-	9.5x2.0	12.5x2.3	-	300	500	-	
10	Rodnikovaya	5300 5400	5700	-	10.0x2.0 9.0x2.5	13.5x2.1	-	150 20	250	-	
11	Suvorovskaya	5400	5100	-	17.0x2.3	11.6x2.5	-	300	280	-	

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