Priority oil and gas exploration facilities in the north-east of the Predpatomsky trough

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Abstract. The article discusses the geological structure and prospects of oil and gas potential of the north-eastern part of the Predpatomsky regional trough. The features of the ratio of the structural plans of the upper and lower parts of the geological section due to thrust dislocations are indicated. It is assumed that deep drilling in the area of the Ulugur structure has not reached the target productive horizons in the autochthonous part of the section. Here, after clarifying the scope of seismic work, it is proposed to lay a exploratory well of greater depth. As another priority object for oil and gas, a potential zone of wedging of terrigenous deposits of the Vendian on the southwestern slope of the Suntar uplift is designated. The high prospects of the gas content of the upper part of the section, where gas deposits were established in newly discovered fields, were also noted. The results of direct geochemical testing of the Ulugur and Ergedzheysky license areas are presented, which allow localizing promising zones and areas of the studied territory.

1 Introduction

At present, the Betinchinskoye, Bysakhtakhskoye, Kaederginskoye, I.N. Kulbertinov, I.M. Menshikov, Otradinskoye and Khotogo-Murbayskoye gas and gas condensate fields have been discovered on the territory of the Yakut part of the Predpatomsky trough. Most of the fields have been discovered recently due to the intensification of geological exploration works in the region. The great interest of subsoil users in this territory is primarily due to the proximity to the main pipelines "Eastern Siberia – Pacific Ocean" and "Power of Siberia", as well as the relatively high potential of total hydrocarbon resources [1].

Within the territory under consideration, Sakhatransneftegaz JSC, represented by subsidiaries of Ulgurneftegaz LLC and GDK Lensk-Gaz LLC, owns two license areas: Ulugursky and Ergedzheysky. In 2018-2022, direct geochemical studies were carried out at the Ulugur and Ergedzhel license areas along the projected seismic profiles for preliminary identification of oil and gas prospective objects. VNIGRI JSC using standard methods of collecting and computer processing geological, geophysical and geochemical information carried out the work.

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2 Features of the geological structure

As part of the Predpatomsky regional trough, the Nyisko-Jerbinskaya and Berezovskaya depressions are distinguished, which are separated by the Urinsky anticlinorium.

The Nyisko-Jerbinskaya depression separates the Nepsko-Botuobinskaya anteclise from the folded structures of the Patom Upland, the depression is elongated in the north-easterly direction by 300 km, with an average width of about 120 km, its area is more than 40 thousand km².

The Berezovskaya Depression separates the Aldan anteclise from the structures of the Patom Upland and is an open structure opening towards the Kempendyai depression. The depression is elongated in the submeridional direction for 350 km with an average width of about 100 km. The area of the depression exceeds 36 thousand km².

It should be noted that in the existing tectonic maps, the conditional border between the Nyisko-Jerbinskaya and Berezovskaya depressions practically runs along the border between the Ulugur and Ergedzhey license areas (Figure 1).

The sedimentary cover within the studied territory has a thickness of 2000-7000 m and is represented by four structural and lithological complexes: Riphean, Betinchino-Seralakh (terrigenous), Byuksko-bilirsky (carbonate), Yureginsky-Metegersky (carbonate-halogens) and Verkholensk-Neryukteisk (carbonate).

![Fig. 1. Prospects of oil and gas potential of the Kulugursky and Ergedzheysky license areas. Symbols: 1 – isohyphses of the reflecting horizon of KV, 2 – discontinuous disturbances, 3 – hydrocarbon deposits, 4 – boundaries of superorder tectonic elements, 5 – boundaries of structures of the 1st order, 6 - wells, 7 – zones of development of thrust folds representing the main oil and gas exploration interest in the subsalt carbonate column (allochthon), 8 – zones of wedging of promising deposits in the south-west of the Suntar uplift. Designations: VLCHS – Vilyuchanskaya saddle, VS – Vilyuyskaya syncline, AA – Aldan anteclise, NDZH – Nyisko-Jerbinskaya depression, UL – Urinsky ledge, BD - Berezovskaya depression, SU – Suntar uplift, KD – Kempendyai depression.]

The main distinguishing feature of the Predpatomsky trough is the wide development of thrust dislocations dividing the section into autochthonous and allochthonous parts. Thrust dislocations have been reliably established within the Nyisko-Jerbinskaya depression [2]. The formation features of the Predpatomskyi trough include the appearance of Vendian salts in the Byuk formation (Torsal pack), as well as the fact that on the outer side the
terragenous vendian lies on a crystalline base, and in the inner part it is underlain by riphean formations.

The section between allochthon and autochthon runs along the lower breakdown (detachment), which rises stepwise stratigraphically and hypsometrically from the inner parts of the highlands to the front of the fold-thrust belt. In the Predpatomskiy trough, the detachment passes through the saline deposits of the Torsal pack. As the Torsal pack wedges out, it passes to the saline deposits of the Lower Cambrian.

In the Nyisko-Jerbinskaya depression, autochthonous and allochthonous structural complexes are characterized by a pronounced mismatch of structural plans due to the complication of the upper part of the section by contrasting fold-thrust dislocations. 

Allochthon is characterized by the development of linear fold-thrust dislocations mainly of the north-eastern strike, separated by synclines with undisturbed internal structure. The number and width of dislocated areas increase from the platform towards the Baikal Highland [3]. Along the section, the disruption of the sedimentary cover abnormally increases in the saline part. At the same time, there is a simplification of structural forms down the section due to the earlier formation of the upper covers and their involvement in subsequent deformations.

Thrust dislocations are also assumed in the Berezovskaya Depression. In the 80s, a number of parametric and exploratory deep wells were drilled on the identified positive structures in the southern part of the depression [4]. Unfortunately, the work carried out was not crowned with the discovery of new accumulations of hydrocarbons, only minor direct signs of oil and gas potential were recorded and separate well-permeable formations were identified. Subsequently, after conducting detailed seismic surveys, it turned out that at the level of the design Vendian-Lower Cambrian productive horizons, the positive structures installed in the upper part were not detected. It was assumed that the discrepancy of structural plans is also due to thrust dislocations [5].

Thus, for both depressions, the main problem of mapping promising structures is the mismatch between the structural plans of the lower and upper parts of the section. The structures identified within the Predpatomsky trough have predominantly narrow linearly extended shapes that coincide in strike with the general strike of the depressions.

3 Prospects of oil and gas potential

Traditionally, the main prospects for the oil and gas potential of the though are associated with unaffected thrust dislocations of part of the section – autochthonous deposits. The structure of the autochthon in the Nyisko-Jerbinskaya depression along the reflecting horizon of the KV (the roof of the terrigenous vendian) is characterized by a fairly calm monocline immersion of rocks in a south-southeasterly direction with a slope gradient of 15-20 m/km and only in the extreme northeast the slope of the rocks gradually shifts to the southwest. The monocline slope is complicated by rare local uplifts, structural noses and bays.

In the autochthonous part, the prospects of oil and gas potential are associated with terrigenous-carbonate deposits of the Vendian. Thus, oil inflows (4.65 m³/day) were obtained from the Kharistan productive horizon at the Betinchinsky oil field. At the Hotogo-Murbai gas field, industrial inflows (up to 143.2 thousand m³/day) were obtained from the terrigenous Botuobinsky productive horizon of the Vendian. At the Verkhnevilyuchansky oil and gas condensate field, which is large in terms of gas and oil reserves, productive horizons are also confined to the terrigenous Vendian (Vilyuchansky and Kharystansky productive horizons) and carbonate Vendian-Lower Cambrian (Yuryakhsky productive horizon) complexes.
Within the studied territory, high prospects are associated with the Bysakhtakh productive horizon. Industrial gas inflows from the Bysakhtakh horizon were obtained at the Bysakhtakh and I.N. Kulbertinov gas condensate fields. The gas flow rate ranged from 18.1 to 984.8 thousand m$^3$/day at the Bysakhtakhskoye field and 79.3 thousand m$^3$/day in the well 1-P of the I.N. Kulbertinov field. Although, the established porosity of the Bysakhtakh horizon in the deposits is low (5-7%), good permeability is provided due to the intense fracturing of high-siliceous rocks [6].

A fairly large deposit of the Otradninsky GCM is confined to the Telgespitskaya carbonate thicket of the Vendian. Here, the flow rates from the Telgespit horizon after hydrochloric acid treatment of the bottom-hole zone reached 1070 thousand m$^3$/day (sq. No. 314-2). Gas deposits in the Telgespit horizon in the studied region are also found in the newly discovered fields of I.M. Menshikov and I.N. Kulbertinov.

The northeastern part of the Ulugur license area and the adjacent northern part of the Ergedzhey license area are of the greatest interest. Moskvitin I.E. [7] based on the study of deep drilling materials on the Verkhnevilyuchanskaya, Vilyuysko-Djerbinskaya, Buyaginskaya and Sheinskaya areas, established a consistent increase in the capacity of the terrigenous part of the Vendian section, composed mainly of sandstones on the outskirts of the Suntar uplift. Here, lithological traps composed of well-sorted granular Vendian reservoirs are predicted.

In the allochthonous part of the section, the zones of thrust development are also of some interest. Various structures and dislocated structures can be found in these zones (Figure 1). The development of fractured cavernous carbonate reservoirs in the Uspun and Kudulakh formations, as well as Telgespit, Yuryakh and Osin horizons is expected here. According to the existing ideas, the formation of significant hydrocarbon deposits in carbonate rocks of the Upper Precambrian and Cambrian is possible only in the case of the following sequence of processes: formation of a fault zone with feathering cracks → circulation of aggressive solutions through them with the formation of secondary fractured-cavernous reservoirs → vertical migration and accumulation of hydrocarbons in the formed secondary reservoir [8].

The presence of a sufficiently powerful Riphean sedimentary cover in the inner part of the Predatomskiy trough and the established pre-Vendian wide denudation of the Riphean tops [9] cause mainly gas saturation of the section.

To localize the most promising zones of the sites under consideration, direct geochemical studies were carried out along the projected seismic profiles.

The main results of the lithogasogeochemical testing of the Ulugur and Ergedzheysky license areas are as follows:

- Contrast anomalies in sorbed gases and bitumens of near-surface deposits.
- Predominantly the "migration" composition of hydrocarbon gases, high contents of the epigenetic coefficient, indicate the migratory nature of the latter.

Figure 2 shows the resulting scheme of hydrocarbon saturation prospects of the study area according to geochemical studies.

The concordant prostration of individual isolated narrow elongated geochemical anomalies with the general prostrations of the Nyusko-Djerbinskaya and Berezovskaya depressions may indicate that they are confined to allochthonous structures. Larger and isometric anomalies rather owe their origin to structures in the autochthonous part of the section.

In this regard, from the perspective of oil and gas potential, the Ulugur structure remains very interesting (Figures 1 and 2). Taking into account the actual faces at 2800 and 3106 m, apparently, the wells drilled within its limits did not reach autochthonous deposits. It is recommended here, after carrying out a small amount of clarifying seismic exploration of the MOGT-3D modification, to lay a search well with a design depth of 3600 m.
favorable location of well No. 289-1 in the specified structure, consider the possibility of deepening it.

Fig. 2. Prospective zones based on the results of direct geochemical testing. Symbols: 1 – hydro system, 2 – ES-PO oil pipeline, 3 – Power of Siberia gas pipeline 4 - wells, 5 – hydrocarbon deposits, 6 – Specially protected natural territories, 7 – boundaries of superorder tectonic elements, 8 – boundaries of structures of the 1st order, 9 – zones of wedging of prospective deposits on south-west of the Suntar uplift, 10 – promising zones based on the results of direct geochemical testing, 11 – recommended areas for the preparation and staging of deep drilling. Designations: VIS – Vilyuchanskaya saddle, NJV – Nuisko-Djerbin depression, SP – Suntar uplift, KV – Kempendyai depression. UV – Urinsky ledge, BV – Berezovskaya depression.rospects of oil and gas potential of the Kulugursky and Ergedzheysky license areas.

There are 2 geochemical anomalies in the selected wedging zone of promising deposits in the south-west of the Suntar uplift (Figure 2). Here it is recommended to conduct seismic surveys of the MOGT-2D modification in order to outline potential wedging structures of lithological traps with elements of tectonic shielding in terrigenous Venda deposits for further deep drilling. Thus, geological exploration on the southwestern slope of the Suntar uplift is of priority importance for both license areas.

In the remaining areas of the Ulugur and Ergeza license areas, certain prospects for oil and gas content may be associated with the upper part of the section. At the newly discovered gas-condensate fields (Kederginskoye, Mukhtinskoye), located to the east of the territory under consideration, commercial deposits are established in the Tolbachanskiy, Olekminskiy, Charskaya and Icherskaya formations.

Apparently, these deposits were formed during reformation of large deposits from the lower to the upper floors in the course of ongoing tectonic processes. This type of oil and gas accumulation requires additional case studies for a more accurate prediction.
4 Conclusion

In recent years, large-scale geological exploration for the search and exploration of oil and gas fields has been unfolding within the Predpatomsky regional trough. The discovery of new deposits, including oil, at new stratigraphic levels expands the range of search tasks and prospects for the oil and gas potential of the region.

The available geological, geophysical and geochemical information allows us to speak about the presence of oil and gas potential in the northeastern part of the Ulugur license area and the adjacent northern part of the Ergedzhey license area, as well as in the Ulugur structure located in the central part of the Ulugur site.

In order to successfully solve the tasks of forecasting zones of oil and gas saturation of the subsurface, it is necessary to consolidate all available updated geological and geophysical information within the framework of case studies.

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