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THE DEVELOPMENT OF IDEAS ABOUT THE STRUCTURE AND OIL AND GAS POTENTIAL OF NEPA-BOTUOBA ANTECLISE AND ADJACENT PART OF PREDPATOMSKII TROUGH

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We considered various alternatives for tectonic zoning of the southwestern territories of The Republic of Sakha (Yakutia). Since 1975, the northern part of the Nepa-Botuoba anteclise has been considered the structure controlling the oil and gas bearing area of the same name. The Nepa-Botuoba oil and gas region is one of the unique territories of the ancient Siberian platform. Its hydrocarbon potential is only partially explored. Analysis of the evolution of ideas about the structure of the Nepa-Botuoba anteclise shows that as new data about its deep structure appear, the reserves of oil and gas increase almost synchronously. Currently, almost the entire resource base of the republic's oil and gas industry is concentrated here.

Key words: anteclise; trough; tectonics; oil; gas; Cambrian; Vendian; Riphean

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Geological and tectonic characteristics. The area under study is located in the marginal part of the Siberian platform, where the Baikal-Patom folded system is adjacent. Information on the composition and structure of the sedimentary cover is obtained here from geological surveys, core drilling, widely used in the diamonds prospecting and exploration, data from numerous deep oil and gas wells, as well as from complex geophysical studies, mainly seismic exploration. The age of rocks varies from Riphean to Jurassic, inclusively. In most cases, the platform cover section is represented by Vendian and Cambrian sediments [3].

In terms of tectonics, the territory under consideration is located in close proximity to the three largest depression structures of the Siberian platform: Vilyui hemisyneclise, Tunguska syneclise and Predpatomskii regional trough [12]. An extensive area (850 × 250 km) of the relatively uplifted crystalline basement extends in a direction close to the northeast from the Lena River upstream to the Vilyui-Markha interfluve [9].

History of the study. In 1952, in the southeastern part of the Tunguska syneclise, D.A.Tugolesov noted the buried Lower Paleozoic Katanga anteclise, bounded from the south by the Angaro-Lena trough. Almost simultaneously (in 1952), K.R.Chepikov discovered an extensive buried uplift separating the Tunguska syneclise from the Angaro-Lena trough. It was called Angaro-Vilyuy uplift and stretched from the Angara River to the middle reaches of the Vilyui River. Later on, the boundaries of this uplift were extended on the tectonic maps of V.T.Mordovskiy, V.G.Vasilyev, I.P.Karasev, et al., which were constructed using geological survey materials, deep drilling and geophysical survey data.

In 1959, P.E.Offman, while studying tectonics and volcanism of the central part of the Siberian platform, identified the Nepa residual anteclise, which, in his opinion, is limited from the southeast by the inherited Early Paleozoic syneclises (Upper Lena and Nuya), and from the west and north, by the Vanavar and Markhinsky imposed syneclises, respectively.

The geological structure of the considered platform margin is to some extent related to the specifics of this region formation, in particular, its significant distortion with the repeated uplift of the Baikal-Patom highland. This ultimately led to a different understanding of the tectonics of the platform area under study and to the discovery (especially in the 1960s and 1970s) of various tectonic elements, including the monocline, the terrace-like steps, the ledge, the structural bench, the homocline, the syneclise edge, part of the marginal trough, and hemianteclise.

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Despite significant differences in the tectonic schemes used by many researchers, when studying the given territory, there was an almost general agreement in the presence of the largest positive structure here. Over the years, it was revealed: Nepa residual anteclise (P.E.Ooffman, 1959); a significant part of the Angaro-Olenek anteclise (V.G.Vasiliev, N.V.Chersky, 1964); Angaro-Peleduy anteclise (I.P.Karasev, 1966); Angaro-Lena hemianteclise (M.M.Mandelbaum, 1969); Middle Siberian anteclise (D.A.Tugolesov, 1970); Angarsk anteclise (S.L.Arutyunov, 1973); Angaro-Lena anteclise (A.P.Korpachev, T.N.Spizharsky et al., 1973); Katango-Botuobinsky anteclise (S.A.Knyazev, V.P.Trunov, 1973); Nepa-Botuoba anteclise (A.E.Kontorovich, N.V.Melnikov, V.S.Staroseltsev et al., 1975) [6].

With the joint development of a program of geological exploration for oil and gas in the Eastern Siberia and The Republic of Sakha (Yakutia) by scientific and industrial organizations, it was possible to substantiate this large superorder structure for the first time [9] and define it as Nepa-Botuoba anteclise [6].

The tectonic position of the investigated territory, which is currently regarded as the northern part of the Nepa-Botuoba anteclise, was previously interpreted in different ways. At the same time, the circumstance which made the unambiguous interpretation much more difficult was the position of this part of the platform at the junction of the largest depressions (Vilyui and Tunguska).

In 1948, during the diamond prospecting, G.H. Feinstein discovered a large uplift among the Permian, Triassic and Jurassic deposits. This uplift extends in the northeast direction for almost 400 km from the upper course of the Chona River trough the Ulakhan Botuobiya River to the Vilyuy River, and called it the Cambrian-Silurian bar. In further studies, this uplift was mentioned under different names, including Botuobinsky, Syuldyukarsky, and Malo-Botuobinsky bar [4].

The tectonic affiliation of the territory under study to the Siberian Platform was also considered ambiguous. Some researchers included it in the composition of the large structural elements listed above, others regarded it as an independent saddle-type structure. The position between the two large syneclises, the fold axis incurvity and the absence of distinct periclinal closing contributed to the latter point of view being the most common.

For the first time, given territory was assigned to structures of this type on a tectonic map of the Siberian Platform, compiled in 1963 at VNIGRI under the editorship of Yu.A.Pritula. Here, it was a saddle-shaped arc between adjacent syneclise and anteclise. Later, within tectonic zoning of The Republic of Sakha (Yakutia), K.Mokshantsev et al. named this saddle Botuobinskaya [11] and considered it as a large intermediate or residual structure that separates the Vilyui and Tunguska syneclise, as well as the Anabar anteclise and the Nepa buried uplift. At the same time, within the axial part of the saddle, a large Chono-Syuldyukarsky bar, complicating its structure, was found.

In the form of a narrow bridge between the indicated syneclises, the Botuobinskaya saddle was also shown on the duty tectonic map of the sediment cover of the Siberian platform, compiled in 1968 under the editorship of A.A.Trofimuk, Yu.A.Pritula, K.A.Savinsky [2].

Recently, the areas previously referred to the Botuobinskaya saddle have been included in the newly revealed Nepa-Botuoba anteclise and occupy its northern part.

Results and discussion. New data obtained as a result of a geophysical survey and deep drilling confirm the presence of a large positive structure in the area under study. The size, structure, and geological history (formation features and duration) allow us to consider this structure as an anteclise. In particular, the latter is one of the evidence of the unfoundedness of combining this uplift with Anabar anteclise into a single superorder structure of the Angara-Olenek anteclise type (V.G.Vasiliev, N.V.Chersky, 1964). A rather extensive Sugdzherskay saddle was revealed by the Late Precambrian - Early Paleozoic sediments in the area between the Anabar and Nepa-Botuoba anteclises, in the basin of the Markhi River, i.e. far north of the previously determined Botuobinskaya saddle.

According to the available geological and geophysical data, the absolute elevations of the crystalline basement surface within the Nepa-Botuoba anteclise are recorded in the interval from –

1.2 km in its central part to –2.5 km on the contouring isohypse. The structure of the northern and central parts of this superorder structure is complicated by a number of large structures of the first order (Mirnynsky ledge, Nepa-Peleduy arch).

The geological structure of the Predpatomskii regional trough, adjacent to the Nepa-Botuoba anteclise from the southeast, is complicated by the presence of longitudinal and transverse zoning. The longitudinal zoning is characterized by the presence within the trough of the outer (near-platform), inner (near-axial) and near-folded zones, differing in the degree of their structure complexity, which is substantially increased to the south-east. The transverse zoning of the trough consists in the alternation of the Nyuya-Dzherbinskaya and Verhne-Lenskaya depressions and the separating Peleduy transverse uplift. The structure of the Predpatomskii regional trough is complicated by a significant number of local structures in the upper part of the section according to the geological survey and case studies [3].

Within the study area of the Nepa-Botuoba anteclise in the structure of the sedimentary cover, along with the plicate structural elements of various orders, the complex of geological and geophysical methods revealed the presence of block structures separated by large faults [7]. They are mapped mainly according to geophysical data on the surface of the Archean crystalline basement and in the bottoms of the sedimentary cover. The existence of faults is confirmed by numerous dislocations and fractured zones, which complicate the structure of local uplifts [2, 14].

As new geological and geophysical data on the regional structure of large prospective areas, as well as more detailed information on the structure of the discovered fields and potentially oil and gas bearing areas, were gained, the above views were periodically substantially refined (see figure).

So, in the mid-70s of the XX century, A.B. Kogan (VNIGRI), interpreting the gravitomagnetic data on the south-western fragment of the eastern part of the Siberian platform using the developed NSFF method (normalized summation and frequency filtering of statistical data), concluded the presence in the geological history of this platform of processes pushing its foundation to the south-east under the sedimentary cover of the Predpatomskii trough for more than 100 km [5].

Among various disjunctive dislocations within the Nepa-Botuoba anteclise, thrusts also play a certain role. The intensity of the thrusts, including the amplitude and size of the horizontal displacement, naturally reduces in the north-west direction. During the seismic CDP-2D survey, the presence of a thrust with a horizontal displacement of up to 15 km was first recorded in 1986 in the joint area of the northern part of the Predpatomskii regional trough and the Nepa-Botuoba anteclise. Yakut researchers V.G.Serzhenkov, V.S.Sitnikov, and N.A.Arzhakov developed a two-level thrust tectonics model of the sedimentary cover of the western part of the Predpatomskii trough [1, 8] based on the analysis of past seismic data and interpretation of geological data with new seismic materials.

Conclusions. Until the end of the 80s of the 20th century, the exploration and seismic prospecting of anticline traps, with further detailed study and bringing them to the category of «prepared for the deep exploration drilling», prevailed in the strategy of geological exploration for oil and gas in Soviet Russia. Even taking into account the potentially high oil and gas content in almost all reservoir beds in the Early Vendian strata section, the effectiveness of oil and gas exploration on the considered area of the Siberian platform was low. Many anticlinal structures were put out from prospecting after the first wells drilling because of the negative results. Siberian scientists, together with oil and gas prospectors from industrial organizations, have compiled ample material and optimized the methods of oil and gas exploration. The developed methodology made it possible to predict and find hydrocarbon deposits mainly in Vendian terrigenous sediments in various traps types, including variously screened non-anticlinal traps. Geological exploration was carried out on the territory of the Nepa-Botuoba anteclise and near it, including the areas, where exploration, focused on especially anticlinal traps did not produce positive results. The new methodology, applied on the given territory, led to the discovery of new large gas and oil deposits, which are mostly located in non-anticlinal traps [13].

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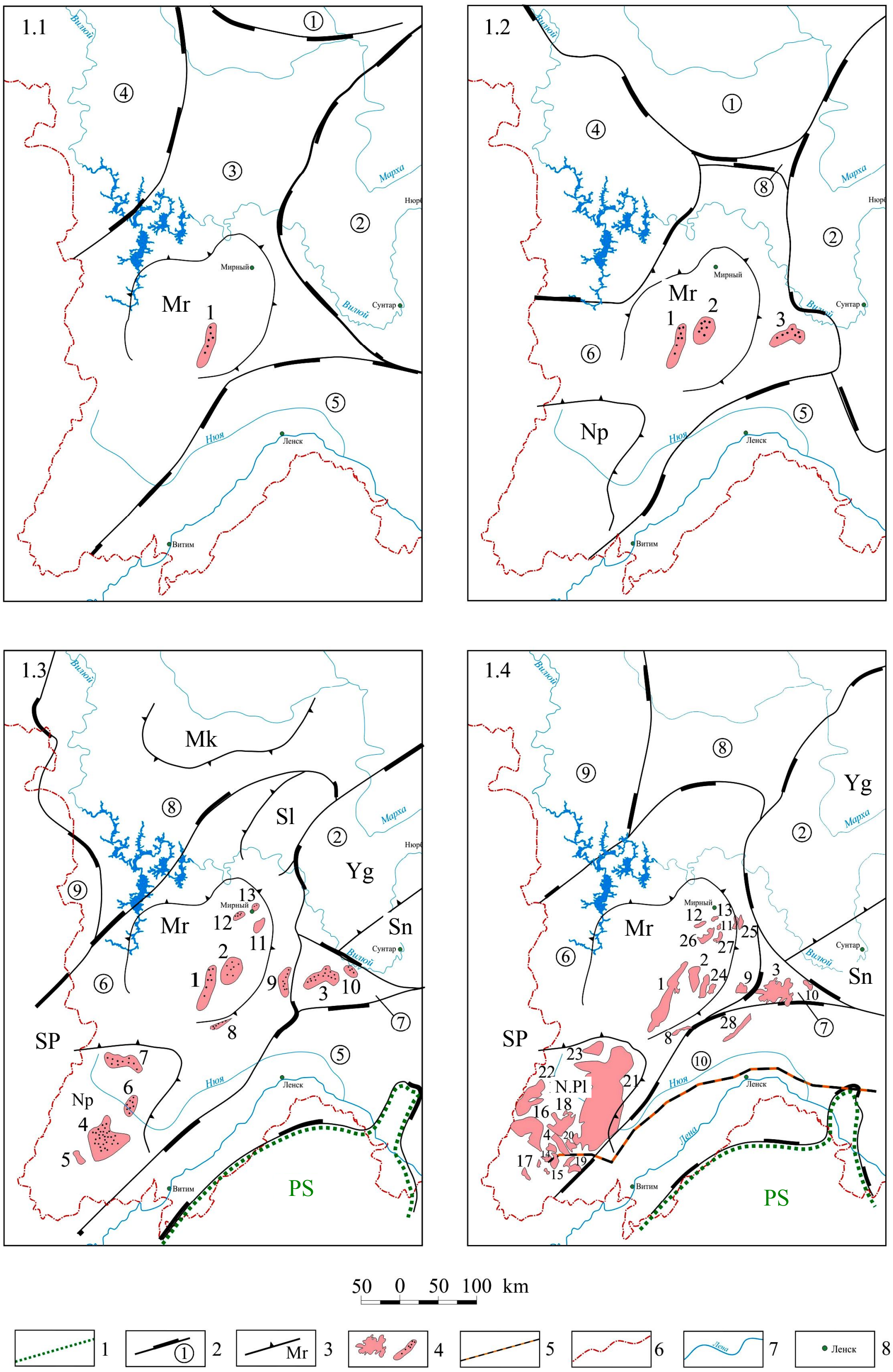

Tectonic zoning of the south-west of Yakutia in different periods of oil and gas prospecting: 1.1 – 1970; 1.2 – 1975; 1.3 – 1988; 1.4 – 2016 (according to the data of the North Yakutia Oil & Gas Exploratory Expedition, Murbay Geophysical Expedition, «Yakutneftegazrazvedka» Trust, «Lenaneftegasgeologia» Production Geological Association, «Yakutskgeofizika» Trust, JSC «SNIIGGiMS», with authors clarifications)

1 – the boundary between the Siberian Platform (SP) and the Patom fold system (PS); 2 – the boundaries of the superorder structural elements of the sedimentary cover (anteclise, syneclise, trough, saddle): ① – Anabar anteclise, ② – Vilyui syneclise, ③ – Botuobinskaya saddle, ④ – Tunguska syneclises, ⑤ – Predbaikalskii marginal trough ⑥ – Nepa-Botuoba anteclise, ⑦ – Viluchanskaya saddle, ⑧ – Sugdzherskay saddle, ⑨ – Kureyskaya syneclise, ⑩ – Predpatomskii regional trough; 3 – the boundary of the structural elements of the first order: Mr – Mirninskiy ledge, Np – Nepskiy arch, N.Pl – Nepa-Peleduy arch, Sl – Syuldyukarskiy ledge, Mk – Morkokinskiy ledge, Yg – Ygyattinsky depression, Sn – Suntarsky arch; 4 – oil and gas fields; 5 – a fragment of the Eastern Siberia – Pacific Ocean trunk pipeline; 6 – the border of The Republic of Sakha (Yakutia); 7 – large rivers; 8 – the main settlements.

Oil and gas deposits: 1 – Srednebotuobinskoe, 2 – Tas-Yuryakhskoe, 3 – Verkhnevilyuchanskoe, 4 – Talakanskoe, 5 – Taranskoe, 6 – Nizhne-Khamakinskoye, 7 – Ozernoye, 8 – Khotogo-Murbayskoye, 9 – Iktekhskoye, 10 – Vilyuisko-Dzherbinskoe, 11 – Severo-Nelbinskoe, 12 – Machchobinskoe, 13 – Irelyaskoe, 14 – Alinskoe, 15 – Vostochno-Alinskoe, 16 – Verhnepeleduyskoye, 17 – Peleduyskoye, 18 – Severo-Talakanskoe, 19 – Yuzhno-Talakanskoe, 20 – Vostochno-Talakanskoe, 21 – Chayandinskoye, 22 – Tympuchikanskoe, 23 – Bukskoe, 24 – Bes-Yuryakhskoe, 25 – Stanakhskoe, 26 – Mirninskoe, 27 – Nelbinskoe, 28 – Otradninskoe

The updated methodological approaches based on the high specific density of oil and gas potential allowed to reveal a unique area of oil and gas accumulation within the Nepa-Botuoba anteclise [2, 10]. To date, more than 20 hydrocarbon deposits have been identified here, including the Chayandinskoye oil, gas and condensate field, with gigantic gas reserves (see figure). Discovered and predicted deposits are confined, as a rule, to relatively elevated blocks in the bottoms of the sedimentary cover; to various tectonic faults; as well as to non-anticlinal traps, in the formation of which an important role was played jointly by lithological and tectonic factors.

The fields indicated in the figure contain 4/5 gas reserves and all oil reserves with C_1 and C_2 categories within the Republic of Sakha (Yakutia) and are recorded in the State Register of Mineral Reserves of Russian Federation. At the same time, the coefficient of development of inferred resources here does not exceed 0.3, which indicates the presence of significant reserves for the further raw hydrocarbon base upgrade.

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