About the Influence of the Neotectonic Movements on the Placement of Oil and Gas Deposits in the Difficult Mining and Geological Conditions of the Nepa-Botuoba Anteclise

R F Sevostyanova¹, V S Sitnikov¹

¹Institute of Oil and Gas Problems of the Siberian Branch of the RAS, Petrovskogo st.2, Yakutsk, 677980, Russia

E-mail: rose_sevos@mail.ru

Abstract. The Nepa-Botuoba anteclise is one of the unique territories within the ancient Siberian platform. At present, after more than half a century of oil and gas exploration, the territory of the Nepa-Botuoba petroleum area under consideration, with a comparative assessment of the oil and gas potential of the sedimentary cover of the Lena-Tunguska petroleum province, which covers the predominant part of the Siberian platform, is unambiguously distinguished as one of the petroleum region richest in hydrocarbons raw materials. This article examines the neotectonics of the territory of the Nepa-Botuoba anteclise, provides information on the structure of the sedimentary cover. A brief description of the methodological approach is given, aimed at optimizing the methodology of oil and gas exploration in the conditions of the study area.

1. Introduction
The area under consideration, which includes a fragment of the marginal part of the Siberian platform and the adjacent sector of the Predatom depression and the Baikal-Patom mountain-fold area, is very promising in terms of oil and gas. Many oil and gas fields have been discovered here, large reserves of hydrocarbon raw materials have been explored and a reliable raw material base has been prepared for the further development of the oil and gas industry in the east of the country. In recent decades, the specified hydrocarbon resource base has been widely used for the implementation of federal oil and gas megaprojects, including those with the supply of oil and gas to the People's Republic of China across the Eastern Siberia - Pacific Ocean main oil pipeline and the Power of Siberia gas pipeline. At the same time, the percentage of development of predicted hydrocarbon resources in the south-west of the Republic of Sakha (Yakutia) does not exceed 40% on average. Forecasting and prospecting for oil and gas deposits that make up the remaining 60% of hydrocarbon resources at a sufficiently high level of geological and geophysical exploration of the area under consideration are associated with great difficulties, since the main possible targets for staging such works with justifying them according to traditional tectonic criteria are largely narrower searched [2]. Major discoveries didn’t take place. From the late 90s of the XX century to the present, only a number of small and medium fields have been identified in the immediate vicinity of the previously identified large oil and gas condensate...
fields such as Talakanskoye, Chayandinskoye, Srednebotuobinskoye and other large oil and gas condensate fields. It requires analysis of additional tectonic data. Among them, of undoubted interest are information about the neotectonic history and geological development of the territory under consideration, including within the boundaries of the main predicted objects.

For a sufficiently complete solution of urgent problems in the study of neotectonic conditions of oil and gas content, it is necessary to conduct a conditioned geomorphological analysis with subsequent interpretation of the results obtained in conjunction with data from medium-scale geological mapping, field seismic exploration, and deep drilling. For many promising territories, the indicated data integration according to the planned scheme is largely constrained by the lack of the necessary geomorphological materials of the appropriate level and scale.

2. Methods
In connection with the above, the assessment of the prevailing direction and amplitude of the latest movements of the study area was carried out using a simple integral smoothing of the modern relief based on the use of published small-scale maps of the latest tectonics of large regions.

This method, which is based on the idea of a possible direct expression of the structures of the platform cover in the relief of the day surface, has not found wide application in some areas in the search for oil and gas traps. A number of positive newest structures identified by this method turned out to be false, and individual structures identified in the sedimentary cover according to the data of geophysical work and deep drilling didn’t find an adequate expression on neotectonic maps. [7]. The decision of the question of whether it is possible to judge the structure of the sedimentary cover of the platform by the features of the relief in this region is not easy and ambiguous. Under the conditions of the multi-tiered sedimentary cover of the Siberian Platform, the degree of complexity of its structure and, in particular, the assessment of the coincidence of structural plans along the section, change in the space of sedimentary basins of different ages, depending on the manifestation of many factors. These include the degree of salinity of the section, the presence of manifestations of salt tectonics, the subordination of vertical and horizontal movements of endogenous and exogenous nature, the features of manifestation of platform magmatism, the conditions for the formation of karst, etc. The necessary prerequisites for a more or less reliable explanation and solution of the above problematic issues can be created by advanced zoning of the study area, taking into account the possible influence of the entire complex of the most informative factors.

It should be noted the geological peculiarity of a significant part of the Nepa-Botuoba anteclise, which has a typical platform appearance, which creates the necessary conditions for a significant proximity of the compared structures of the sedimentary cover and the latest structures of the geographic relief. In contrast to this territory, the sub-platform areas adjacent to it from the east-southeast are characterized by a more complex structure, primarily due to the presence in the upper part of the section of a superimposed complex of deposits in the form of a regular series of allochthonous plates [12].

The analysis of geological sections makes it possible to divide the sedimentary cover into two parts: allochthonous and autochthonous levels with a sliding boundary between them. The faults dividing the floors are gently sloping, and near the day surface they are steeply sloping. At a depth of about 1000 m, approximately on the border of the Cambrian and Vendian, the planes of these faults take a horizontal position [9].

3. Structure of sedimentary cover
The study area covers the interfluve of the Peleduy-Nyuya-Ulakhan Botuobiya-Vilyui rivers, where many hydrocarbon deposits have been identified and explored (Talakanskoye, Chayandinskoye, Tympuchikanskoye, Verkhnechonskoye, Srednebotuobinskoye, Taas-Yuryakhskoye, etc.) areas form
a vast megazone of oil and gas accumulation [14, 15, 18]. Within the Nepa-Botuoba antecline, where the rocks are poorly dislocated and a predominantly autochthonous stage is developed on the day surface, structures of the 1st order are distinguished in the near-arch part: the Nepa-Peleduy arch and the Mirninsky ledge [1, 3, 5]. On their uplifted parts, and also often beyond the boundaries of large uplifts, many structures of a higher order have been identified according to CDP-2D seismic and deep drilling data. Currently known oil and gas deposits are associated with anticlinal and non-anticlinal traps of various sizes. In the least studied parts of the study area, the presence of similar traps of hydrocarbon raw materials is predicted with varying degrees of validity. In the light of the latest scientific concepts, the necessary geological prerequisites for the continuous development of deposits of various sizes are due to the established and, to a certain extent, studied block tectonics of the lower part of the sedimentary cover [4, 6, 11].

North of the Vilyui River in the 80s of the XX century, the Syuldyukarsky ledge was preliminarily identified, which a little later, according to the results of additional geological exploration (seismic exploration, deep drilling), was not confirmed and was no longer taken into account on the tectonic zoning schemes [8].

Carbonate deposits of the Lower, Middle and Upper Cambrian, Lower Ordovician, Lower Jurassic, Neogene and Quaternary deposits come to the surface within the territory under consideration and in the immediate vicinity of it [19, 20].

4. Neotectonic structure

In the neotectonic structure of the considered territory of the south-west of Yakutia, two zones differing in structure are distinguished. The first of them, significantly predominant in size, belongs to the Nepa-Peleduy arch, the second belongs to the zone of the Predatomsky neotectonic folds. Numerous local breaks of various morphogenetic types were established in both zones. Large faults cross both zones.

The Nepa-Peleduy vault in the part under consideration is characterized by a rather complex structure. Its surface is dominated by synclines, vast in areal sizes and relatively narrow anticlines. Large positive recent structures (Chayandinskaya, Homesh, Kyrakhskaya, etc.) are less developed. On the ground surface within the Nepa-Peleduy arch, structures of the autochthonous complex are distinguished, their amplitude increases down the section. In neotectonic terms, all of them are expressed by very shallow structures. Their amplitude fades towards the surface.

One of the largest positive structures in this area is the Homesh ledge. [10, 18]. Outcrops of Cambrian deposits are found on the ground surface in its most elevated part, and rocks of the Ordovician and Lower Jurassic age are found on the slopes. The dimensions of the ledge are 40*30 km, its amplitude in relation to the adjacent depressions is about 100 m. In the lower part of the section, it corresponds to the structure that controls the Verkhnechonskoje field on the border of Yakutia and the Irkutsk region. The Chayandinskoe ledge is distinguished in the southern and eastern parts of the Nepa-Peleduy arch. It is a gentle structural level with an amplitude in relation to its own peripheral parts of no more than 50 m, and in relation to adjacent depressions it reaches 200 m. Its dimensions are 80 * 40 km. In relation to the structures of the autochthonous complex of the sedimentary cover, this ledge is a direct relief form. It is located above the northeastern, central and other parts of the unique Chayandinskoye field.

The newest depressions in the studied area of the Nepa-Peleduy arch are characterized by an inverted relief. They are often expressed by positive relief forms, representing the remnants of the Paleogene leveling surface [18]. These are conservative forms, lagging behind in uplifting from adjacent positive newest structures.
5. Conclusions

1. Comparison of topographic data on the structure of the modern geographic relief of the territory under consideration with geological and geophysical information on the tectonic structure of the multi-storey sedimentary cover in different parts of its section shows a significant similarity of the compared indicators in the conditions of the Siberian platform and the absence of such in the neighboring territories, conditionally attributed to the Predpatom regional trough. In the latter case, distinct traces of horizontal movement of individual parts of the section in the northwest direction were established, which is regarded as a consequence of the probable manifestation of giant paleoslides associated with the presence in the sedimentary cover of a number of plastic salt-bearing strata of the Cambrian and Vendian age and the unstable state of the sedimentary section at different stages of its geological development.

2. A comprehensive analysis indicates that under the conditions of widespread development in the territory of Western Yakutia of deposits of the Lower Jurassic sedimentary complex, unconformably overlapping the underlying formations of the Early Paleozoic age, which are in varying degrees of denudation, depending on the degree of activity of each specific local area or an extended zone of their distribution. In these cases, manifestations of positive recent tectonic movements are clearly identified by outcrops to the day surface in the place of eroded Lower Jurassic sandstones of dense carbonate rocks of the Cambrian age. With a certain degree of conventionality, such a methodological approach can be used in the geological conditions of the Nepa-Botuobinskaya anticline as an additional criterion confirming the presence of an increased hydrocarbon potential here. As an example, when the obtaining of reliable results of the first prospecting works was restrained by unreasonable ignoring of the above data, we can cite the relevant information on the history of the study of the Srednebotuobinskaya and the Taas-Yuryakhskaya anticlinal structures adjacent to it from the east, identified in the late 1960s. In particular, as the study and preparation for setting up deep exploratory drilling at the first of them, the preliminary views on the assessment of hydrocarbon reserves controlled by this trap, based on the materials of drilling and testing of the first exploratory wells, dramatically and repeatedly changed [13, 17]. So, after the completion of the drilling of the first well, laid at the northern end of the Srednebotuobinskaya brachyanticlone, according to seismic data and testing of promising sections in an open wellbore using a pipe formation tester, industrial gas flow (over 300 thousand m$^3$/day) was obtained from the basal layers of sedimentary cover, after the 20th descent of the formation tester (with a plan of 5). In well No. 2, located according to seismic data in the most elevated dome of the structure, an inflow of formation water was obtained. The question arose about the possible futility of the structure. Later it turned out that in fact the indicated well is located on the immersion of the western slope of the vast Srednebotuobinskaya petroleum trap. There were many problems after drilling the next well No. 4. At first, gas inflow was obtained from the main Botuobinsky horizon in the open wellbore, later, during testing in the casing this interval was mistakenly characterized as «dry object» [16].

6. References

[1] Anciferov A S, Bakin V E, Vorobev V N et al 1981 Petroleum Geology of the Siberian Platform (Moscow: Nedra Publishing House) p 420
[2] Berzin A G, Arhipova T A 2010 J. Bulletin of the Yakut State University 2 pp 28-33
[3] Zamaraev S M 1966 Geophysical research and the problem of oil and gas content in the south of the Siberian platform (Moscow: Gostoptehizdat) pp 128-193
[4] Kleshev K A, Sheyn V S 2004 J. Geology and geophysics 1 pp 23-40
[5] Kontorovich V A, Belyaev S Y, Kontorovich A E 2004 J. Geology, geophysics and development of oil and gas fields 1 pp 47-58
[6] Kontorovich A E et al 2010 *J. Geology and geophysics* **51** pp 7-17
[7] Mikulenko K I, Timirshin K V 1997 *J. Domestic geology* **6** pp 24-28
[8] Mokshancev K B et al 1975 *Tectonics of Yakutia* ed Y N Trushkova (Novosibirsk: Nauka Publishing House) p 200
[9] Molotkov N K 1983 Methodological issues and main results of neotectonic studies of the Nepa-Botuoba region (Novosibirsk: Nauka) pp 111-119
[10] Nikolaev N I 1962 Neotectonics and its expression in the structure and relief of the territory of the USSR (Moscow: GNTIGON) p 392
[11] Protopopov Y H 1993 Tectonic complexes of the platform cover (Yakutsk: YSC SB RAS Publishing House) p 40
[12] Safronov A F 1987 Author's abstract of doctoral dissertation *History of oil and gas formation and oil and gas accumulation in the marginal systems of the north of the Pacific belt* (Moscow: Moscow State University) p 36
[13] Safronov A F 2004 *The history of the development of sedimentary-rock basins in the east of the Siberian platform* (Yakutsk: YSC SB RAS Publishing House) p 79-91
[14] Serezhenkov V G, Sitnikov V S, Arzhakov N A 1996 *J. Oil and gas geology* **9** pp 4-10
[15] Sitnikov V S, Zhernovskiy V P 2012 *J. Bulletin of the State Committee for Geology of the Republic of Sakha (Yakutia)* **1** pp 107-115
[16] Sitnikov V S, Burova I A, Kushmar I A et al 2014 Geology and oil and gas potential of the south-west of Yakutia: realities and prospect (St. Petersburg: FSUE «VNIGRI») p 436
[17] Sitnikov V S, Kashireev V A and Mikulenko K I 2002 J. Russian Arctic pp 347-353
[18] Sitnikov V S and Spektor V B 1998 Geophysical research in Yakutia (Yakutsk: Yakut State University press) pp 21-31
[19] Shemin G G 2007 Geology and oil and gas potential of the central regions of the Siberian platform (Novosibirsk: SB RAS Publishing House) p 467
[20] Shibina T D, Kushmar I A, Klyarovskyaya A V 2011 *J. Petroleum Geology - Theoretical and Applied Studies* **6** pp 1-17