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# The oil and gas potential of the north of the Siberian platform and adjacent shelf

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Abstract. The objective of this article is an estimation of the oil and gas potential of the north of the Siberian platform and adjacent shelf. The Siberian platform is characterized by a large concentration of oil and gas resources in the southern and central parts of the platform. The main oil and gas province of the Siberian Platform is the Leno-Tungus oil and gas province. The oilbearing strata in the Lena-Tungus oil and gas province are confined to the Riphean, Vendian, Lower-Middle Cambrian deposits, in which large oil and gas fields are discovered. In modern contours the Siberian platform in the north and north-west is fringed by the Yenisei-Khatanga regional trough. In the east, the Yenisei-Khatanga regional trough is connected with the Anabar-Lena trough, framing the north-eastern part of the Siberian platform. Analysis of the available geological and geophysical materials shows a fairly high potential of the Anabar-Lena and Yenisei-Khatanga troughs for the discovery of large hydrocarbon fields. The basic understanding of the geologic-tectonic structure and petroleum potential of the northern part of the Siberian Platform and the adjacent shelf of the Arctic zone are currently based on seismic data by the method of the common depth point (CDP), tied to the existing deep search and parametric wells. Representations of the deep structure and oil and gas potential of specific areas, the allocation of targeted promising oil and gas horizons can change dramatically as the depth of seismic acquisition of the method of the common depth point increases and the software for processing and interpreting seismic data is improved. The localized oil and gas resources of the north of the Siberian platform and adjacent shelf are 41017,3, subsequently, 27582,3 - onshore and offshore - 13435 MMT (million tons) of oil equivalent.

#### 1. Introduction

The objective of this article is an estimation of the oil and gas potential of the north of the Siberian platform and adjacent shelf. Investments in the development of Arctic infrastructure are constantly growing and have already reached 10 percent of all investments in the Russian Federation. Ensuring the energy needs of the Arctic regions through the discovery and development of large oil and gas fields in the Siberian platform's edge zones is becoming a key task. The Siberian platform is characterized by a high concentration of oil and gas resources. Analysis of the available geological and geophysical materials shows a fairly high potential of the Yenisei-Khatanga and Anabar-Lena troughs for the



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discovery of large hydrocarbon fields [1-4]. Representations of the deep structure and oil and gas potential of specific areas, the allocation of targeted promising oil and gas horizons can change dramatically as the depth of seismic acquisition of the method of the common depth point increases and the software for processing and interpreting seismic data is improved.

#### 2. The resource base and development potential of the Arctic zone of the Siberian Platform

The report is devoted to the seismological characteristics of the sedimentary cover section, estimates of the resource base and development potential of the Arctic zone of the Siberian Platform. The interest of oil and gas companies in the Arctic region of the Earth is quite high. Currently, the Siberian Platform is the third region of Russia after Western Siberia and the Ural-Volga region with a large concentration of oil and gas resources on land. The Arctic part of the Siberian Platform is located mainly in the Lena-Tunguska oil and gas province, as well as the West Siberian and Khatanga-Vilyu provinces. The generation of hydrocarbons took place for a long time. The intensive phase of the realization of dispersed organic matter can be attributed to the late Riphean. Riphean-Mesozoic deposits are widely developed in the marginal parts in the north and northeast of the Siberian Platform.

The main ideas on the geological and tectonic structure and oil and gas potential of the Arctic zone of the Siberian Platform are based on seismic data tied to drilled deep parametric and exploratory wells. The system of rifts in the Arctic zone of the Siberian Platform is presented at Figure 1. The figure shows the epicenters of earthquakes of the Laptev sea shelf for the period from 1964 to 1996: 1-3 - earthquakes of different magnitude (M1> 6; M2 = 5-5.9; M3 = 4-4.9); 4 - earthquakes registered after 1991; 5 - tensile stress and compression stresses (the length of the arrow is proportional to the cosine of the angle of inclination to the horizon); 6-continental slope; 7 - plate boundaries (a - confident, b - assumed); 8 - the main fault zones; 9 - faults.



Figure 1. The system of rifts in the Arctic zone of the Siberian Platform.

The formation of the Arctic Ocean basin occurred in the Late Paleozoic-Mesozoic time. In the Arctic Ocean, the mid-Oceanic Gakkel ridge separates the North American and Eurasian lithospheric plates, tectonic activation in the Cretaceous period led to the formation of the Laptev Sea Plate. When spreading

lithospheric plates in the process of lowering the blocks of the parent lithospheric plate along the fault system, an edge system is created, which is further transformed into an edge deflection. The edge systems are characterized by intensive sedimentation with the formation of sedimentary strata of high capacity. The presence of sedimentary material from the mother plate and high heat flow creates favorable conditions for oil and gas formation. According to paleotectonic analysis, the Turukhan-Norilsk, Yenisei-Khatanga, Anabar-Lena and Verkhoyan regional systems are distinguished in the north of the Siberian Platform. The above-mentioned regional systems were formed at the pre-Paleozoic stage of development of the northern part of the Siberian platform. The Yenisei-Khatanga and Turukhan-Norilsk regional systems were formed in the Riphean-Precambrian. A large block of the northwestern part of the Siberian Platform broke off and descended along the Main Yenisei Fault in the Lower Paleozoic - Precambrian. As the results of magnetometry studies show, the western border of the ancient Siberian platform probably runs along the valley of the Taz River, at a distance of 250-300 km from the Yenisei River.

The western and northern parts of the breakaway block of the ancient platform experienced deep immersion in the Jurassic-Cretaceous time, and then they became part of the base of the Epigercine West Siberian Plate and the Yenisei–Khatanga trough adjacent to it. The rest of the Epiarchean platform was named the Siberian Platform and is located east of the Yenisei River. The Yenisei-Khatanga regional trough was formed as an independent structure, and it borders the north western edge of the modern Siberian platform. In the slowly expanding Yenisei-Khatanga regional trough, intensive accumulation of Paleozoic-Mesozoic sedimentary deposits with a thickness of 8 km in the east to 15 km in the west occurs [1]. The Yenisei-Khatanga regional system stretches from southwest to northeast in the northern part of the Siberian Platform. Its length is slightly more than 1000 km, the average width is 250 km. The Yenisei-Khatanga regional system borders the Yenisei Paleo monocline in the south, and the Anabar paleo trough in the east. On the basis of paleotectonic analysis there are the Yenisei-Khatanga deflection and the foredeep systems formed at the pre-Paleozoic stage of development of the northern part of the Siberian platform such as:

- 1. The Turuhano-Norilsk;
- 2. The Yenisei-Khatanga;
- 3. The Anabar-Lena and 5
- 4. The Verhoian.

The Yenisei-Khatanga oil and gas bearing region includes the territory of the Yenisei-Khatanga regional trough, the Yenisei Bay, the western part of the Anabar-Khatanga saddle of the northern margin of the modern Siberian platform. In the Jurassic period, there was a transition from the filling of grabens and depressions to the formation of a continuous sedimentary cover. The marine basin of the western part of the Yenisei-Khatanga regional trough occupies the entire southern and southeastern part of the modern Laptev Sea area and closes with the marine basin of the West Siberian Plate to the west 60 km from the modern valley of the Yenisei River at the latitude of Vankor area. These deposits are overlain by a clay-siltstone stratum of Upper Jurassic rocks. The surface of the crystalline basement in the western part of the Yenisei-Khatanga regional trough is submerged 14-16 km from the level of the world ocean. The depression is filled with Jurassic and Cretaceous sediments up to 6-7 km thick, which quietly lie on the Paleozoic-Triassic folded complex with a capacity of more than 6 km, lying on the Precambrian folded foundation.

At the beginning of the Late Jurassic epoch, the West Siberian plate acquired modern outlines. In the east of the West Siberian Plate, in the Yenisei-Khatanga regional trough and the modern Yenisei Bay, a single marine sedimentation basin was formed. The sedimentary complex is composed of sediments of marine and coastal-marine facies and includes sedimentary deposits of the Upper Jurassic, Lower and Upper Cretaceous. The figure shows stratified regional frame profile: submeridional Region 4 (Figure 2), from which it can be seen that the depth of the foundation in the central part of the depression exceeds 12 km [1-2]. The sediments of the Valangin-Cenomanian age are characterized by a strong predominantly sandy stratum. In the eastern part of the Yenisei-Khatanga regional trough, intense

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deflection occurred in the Triassic. The thickness of the Triassic deposits is 1.5 - 2.5 km. Triassic deposits are an independent structural floor above the foundation, which is composed of dislocated rocks of the Middle and Upper Paleozoic.



Figure 2. The stratified regional frame profile of submeridional Region 4.

The structural plan of the Mesozoic complex of the Yenisei-Khatanga regional trough inherits the structural plan of the Upper Paleozoic-Lower Mesozoic complex, but acquires a more plicative character. The total capacity of the Jurassic and Chalk is about 2.5 - 3.5 km. Jurassic and Cretaceous deposits lie horizontally, but in some areas, they are dislocated. In the western part of the Yenisei-Khatanga regional trough (the eastern part of the Pur-Taz oil and gas bearing region, cretaceous deposits are oil-bearing. Permian deposits are oil-bearing in the eastern part of the Yenisei-Khatanga regional trough (Yenisei-Khatanga oil and gas bearing region) and the western part of the Anabaro-Khatanga saddle. Nine seismostratigraphic complexes are traced in the Yenisei Bay. The initial total resources in the Yenisei-Khatanga regional system amount to 14,878.3 million tons of oil equivalent.

The Anabar-Lena regional system covers the Anabar Shield from the north and east, and includes the Anabar-Khatanga saddle and Anabar trough. The sedimentary cover is represented by Lower Riphean-Middle Paleozoic terrigenous-carbonate and Upper Paleozoic-Mesozoic terrigenous deposits. Within its borders, the Anabar-Khatanga and Anabar-Lena oil and gas regions are distinguished. The Anabar-Khatanga oil and gas bearing region includes the territory of the Mesozoic Anabar-Khatanga saddle or Khatanga depression along the Riphean-Paleozoic deposits and the Khatanga Bay, which are part of the Anabar-Lena regional system. The territory of the Khatanga depression is a peripheral part of the salt accumulation area in the Anabar-Lena trough and the modern water area of the Laptev Sea. In the west of the Anabar-Khatanga saddle, salt stocks of the Middle Devonian are developed. The central part is composed of Permian-Mesozoic-Cenozoic mainly terrigenous complex with a capacity of up to 10 km. Deposits of the Lower-Middle Paleozoic and Precambrian, characteristic of the northern slope of the Anabar massif of the Siberian Platform, were found on the sides of the deflections at the base of the section.

The sedimentary strata of the complexes are represented by various limestones, dolomites and marls with layers of shales, mudstones and intrusive rocks. The oil content of the Permian terrigenous strata spread over an area of 4,500 km2 in the Anabar-Khatanga interfluve has been reliably established. The porosity of Permian deposits in some areas reaches 20%, permeability - up to 500 mD. The oils of this area have different composition and properties. Their specific gravity is in the range from 0.76 to 0.985 g/cm3. The explored structures lie at depths up to 2000 m. In the Anabar-Khatanga interfluve, six small deposits/deposits of hydrocarbons were discovered. Numerous oil occurrences are recorded throughout the exposed interval of the section - from the Precambrian to the Lower Cretaceous inclusive. In the Khatanga Bay, rocks of the subsalt complex, as well as lower carboniferous carbonate and Lower Permian terrigenous deposits are of the greatest interest. An exploratory well drilled in 2017-2018 from

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the shore of the Khara-Tumus peninsula revealed the presence of oil in the Khatanga Bay in the range of 2305-2363 m.

The Anabar-Lena oil and gas bearing region covers the territory of the Anabar-Lena trough and the adjacent shelf of the Laptev Sea. The Anabar-Lena trough continues to the east the southern band of the bends of the Yenisei-Khatanga marginal zone. From the north, it is bounded by the Olenek folded system fading to the west, extending from the Lena Delta to the Khatanga Bay along the coast of the Laptev Sea. Table 1 presents the distribution of hydrocarbon resources (geological)/categories and Oil and Gas foredeep regions of the Siberian platform on 01.2021 year. In general, the localized resources are 41017,3, subsequently, 27582,3 - onshore and offshore - 13435 MMT (million tons) of oil equivalent.

Oil and gas bearing areas	Reserves Resources					
	$\begin{array}{c} ABC_1 + C_2, \\ MMT \text{ in} \\ units \text{ oe} \end{array}$	D <sub>1</sub> , MMT in units oe	D <sub>2</sub> , MMT in units oe	D <sub>1</sub> +D <sub>2</sub> , MMT in units oe	Ambiguous category, MMT in units oe	Total, MMT in units oe
Yenisei-Khatanga -	425,3	5538	7597	13135		13560,3
onsnore Yenisei-Khatanga - offshore					1318	1318
Anabar-Khatanga - onshore		5807	1969	7776		7776
Anabar-Khatanga - offshore				2117		2117
Anabar-Lena - onshore		1801	636	2437		2437
Anabar-Lena - offshore			384	384	3116	3500
Laptev Sea perspective					6500	6500
Pre-Verkhoyn	1		952			953
Vilyuy	471	1216	1169	2385		2856
Total	881,6	14362	12707	28643	10934	41017,3

Table 1. Localized hydrocarbon resources by category in the North of Eastern Siberia according to [1
23], in units of oil equivalent (oe).

# 3. Conclusions

The current state of development of the Arctic zone of the Siberian Platform is characterized by the presence of the following risks and challenges:

- the lack of technologies for prospecting, exploration and development of offshore hydrocarbon fields in arctic conditions and
- high energy intensity of hydrocarbon production and low labor productivity [15, 24, 25].

At the beginning of March 2020, four special zones were approved with a preferential tax regime for the development of Arctic hydrocarbon resources to the north: a) the Arctic Circle, b) 70 degrees north latitude and c) 67 degrees north latitude, and d) south 69 degrees north latitude. The development of hydrocarbon resources in the marginal zones should be carried out using nature-saving technologies created by the RAS institutes, such as supercomputing teramodeling of oil and gas provinces, robotic drilling of wells without complications, creating well digital twins, building digital unmanned fields, quantum fiber transmission of Big field data and contactless monitoring of accident-free operation of pipelines in real time. The logic of the development of the Arctic infrastructure (Prirazlomnoye field, Yamal LNG, Northern Sea Route and Northern Latitudinal Railway) strongly dictates the need to accelerate the environmental development of hydrocarbon resources.

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1201 (2021) 012076

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