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Tectonic evolution of the Arctic onshore and offshore regions of the West Siberian petroleum province

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Abstract

The paper deals with the South Kara regional depression covering the southern part of the Kara Sea and presents a comparative analysis of the geologic structure of potential exploration targets in the offshore and onshore regions of the study area. Regional tectonic processes are considered, and the main stages of the formation of large tectonic elements are reconstructed. A comparison of the anticline traps in the onshore parts of the study area and offshore Kara Sea regions is made.

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Keywords: reflector; seismic sequence; tectonics; structure; trap

Introduction

The West Siberian petroleum province has been a focus of attention of many geologists and geophysicists since the late 1940s. As a result of a large exploration effort expended in this region and the discovery of more than 700 oil and gas fields, West Siberia has been a leading domestic oil and gas producing region for about one-half a century.

Systematic exploration in West Siberia started in the southern regions close to the largest populated locations and continued even more northerly. At present, one of the key research challenges facing Russian petroleum geologists and geophysicists is the study of the geologic framework of the Russian Arctic, including West Siberia and Kara shelf, considering their high potential for hydrocarbons (Bochkarev et al., 2010; Kazanenkov et al., 2014; Kontorovich et al., 2013).

This study aims at analyzing the geologic framework of the South Kara depression in the South Kara basin and providing a comparison of its hydrocarbon potential with that of the Arctic regions of continental West Siberia, including the Yamal Peninsula and the Gydan Peninsula. Mesozoic sediments extending over 530,000 km^2 cover an area of 348,000 km^2 offshore (excluding bay areas) and 182,000 km^2 onshore.

The overwhelming amount of seismic activity and deep drilling over the past decades resulted in numerus oil and gas discoveries both offshore and onshore. The fields discovered to date are Arkticheskoe, Antipayuta, Bovanenkovskoe, Kruzenshtern, Malyginskoe, North Tambeiskoe, Kharasaveiskoe, South Tambeiskoe, etc. in the northern part of the Yamal Peninsula and Geofizicheskoe, Gydanskoe, Salmanovskoe, Shtormovoe, etc. in the Gydan Peninisula (Ermilov et al., 2004).

Three discoveries were made in the Kara Sea. Rusanovskoe and Leningradskoe gas-condensate fields that are unique by their reserves were discovered in the Soviet era in 1989 and 1990, respectively. A large oil-gas-condensate discovery known as Pobeda was made in 2013 by Rosneft by drilling of the discovery well at the Universitetskaya structure located close to the Novaya Zemlya Archipelago (Fig. 1). The principal hydrocarbon reserves of the study area occur in fields with anticlinal closures, in Jurassic and Cretaceous sandstone reservoirs.

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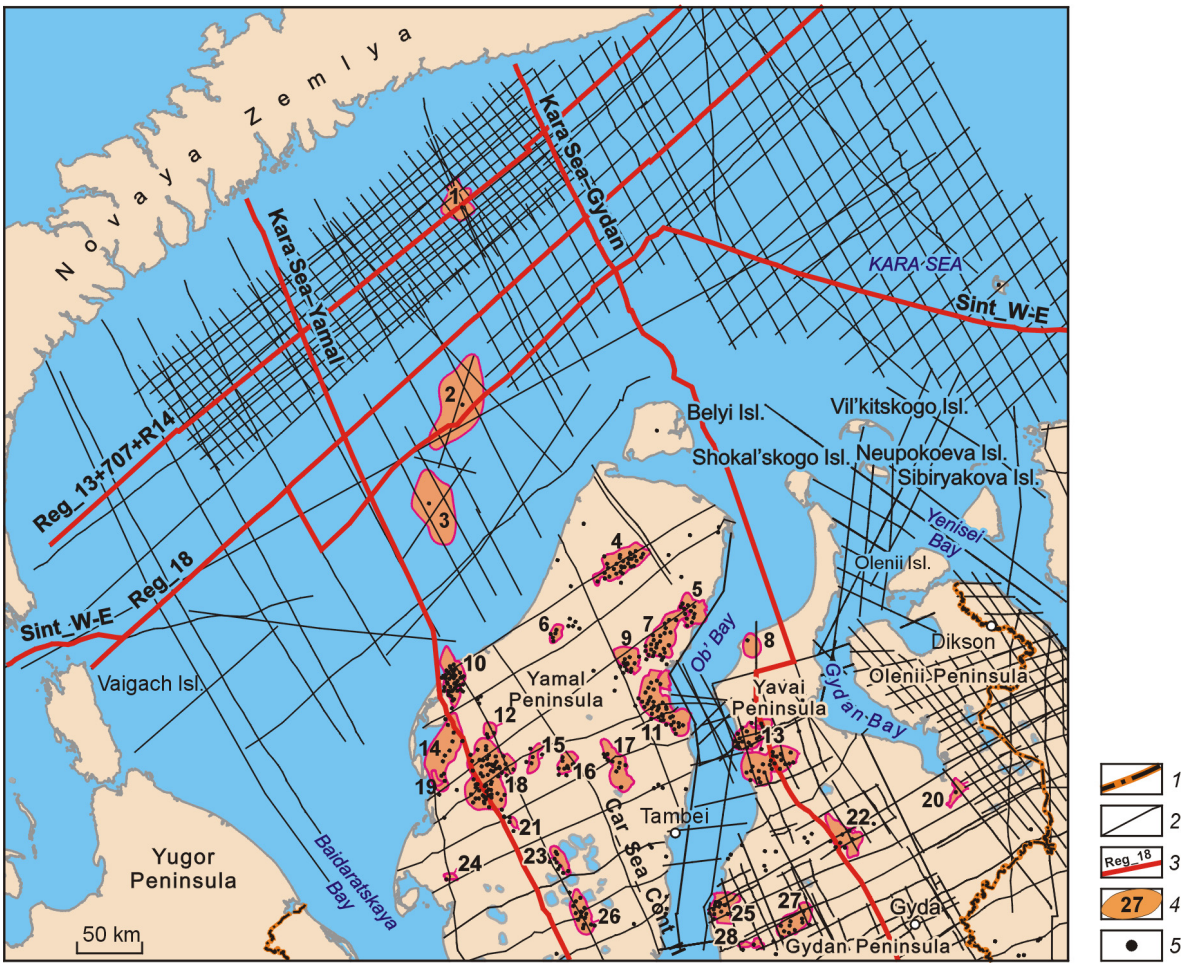

Fig. 1. Schematic map of the Kara Sea–Yamal region. *1*, administrative boundaries; *2*, CDP reflection lines; *3*, seismic lines and sections discussed in the text; *4*, fields; *5*, wells. Fields: 1, Pobeda; 2, Rusanovskoe; 3, Leningradskoe; 4, Malyginskoe; 5, Tasiiskoe; 6, Syadorskoe; 7, North Tambeiskoe; 8, Shtormovoe; 9, West Tambeiskoe; 10, Kharasaveiskoe; 11, South Tambeiskoe; 12, North Bovanenkovskoe; 3, Salmanovskoe; 14, Kruzenshtern; 15, East Bovanenkovskoe; 16, Verkhnetiuteiskoe; 17, West Seyakhskoe; 18, Bovanenkovskoe; 19, South Kruzenshtern; 20, Ladertoiskoe; 21, Nerstinskoe; 22, Gydanskoe; 23, Neitinskoe; 24, Baidaratskoe; 25, Geofizicheskoe; 26, Arkticheskoe; 27, Soletskoe + Khanaveiskoe; 28, East Bugornoe.

Seismic and geological characterization

In the West Siberian petroleum province, the Paleozoic, Triassic, Jurassic, Neocomian (Berriasian–Lower Aptian) and Aptian–Albian–Cenomanian seismic megasequences (Kontorovich, 2009; Kontorovich et al., 2001, 2016), corresponding in their stratigraphic volume to the respective petroleum-bearing sedimentary megacomplexes (Kazarinov, 1958, 1963) have been traditionally recognized on seismic time sections. Areally extensive sequences of shales with anomalously low acoustic properties forming regional top seals of these megasequences can readily be tied to continuous and highly energetic reflectors that are be traced over much of the West Siberian basin (Table 1). The Turonian–Cenozoic megasequence forming the topmost part of the sedimentary fill comprises the Turonian–Maastrichtian and Cenozoic sedimentary complexes.

Analysis of seismic time sections and deep drilling data reveal that the overall structural style of Paleozoic and Mesozoic–Cenozoic sedimentary sections in the continental part of northern West Siberia and in the southern Kara Sea is similar. Since all seismic megasequences typical of West Siberia are widely developed on the Kara Sea shelf, this part of the study area represents the northern extension of the West Siberian basin.

Figure 2 shows seismic time sections along two regional profiles, each extending 890 km across the Yamal and Gydan Peninsulas and southern Kara Sea.

The Kara Sea–Yamal profile extends across the Tatrinov and West Matochkin uplifts in the Kara Sea, as well as the Kruzenshtern, Bovanenkovo, Middle Yamal, and Novoportovskoe uplifts located onshore.

The Kara Sea–Gydan profile extends across the Kropotkinskoe and Central Kara structures within the South Kara Sea regional depression, as well as the Salmanovskoe and Gydanskoe fields associated with the dome-shaped structures on the Gydan Peninisula.

The results of the integrated interpretation of well and seismic data were used to:

1. Create structure and isopach maps of the Mesozoic–Cenozoic seismic sequences at all stratigraphic levels. Since both

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