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History of anticlinal traps and oil and gas fields in Jurassic reservoirs in the northern West Siberian basin

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Abstract

The paper presents new paleotectonic data on the Bovanenkovo, Taz, and Gubkin dome-shaped uplifts and the Novyi Port, Urengoi, Kharampur, and Medvezh'e swells, with implications for the history of zone J_2 and the Jurassic reservoir as a whole. Most of the large uplifts originated in the Early–Middle Jurassic and completed their evolution in the early Late Cretaceous (latest Cenomanian), generally (Bovanenkovo, Novyi Port, Kharampur, and Taz) or to a large extent (Urengoi and Gubkin), except for the much younger Medvezh'e swell, which formed in the Paleogene–Quaternary interval. The conditions for oil storage and retention in anticlinal traps of Jurassic zones J_1 and J_2 were the most favorable between the middle Late Cretaceous and the Eocene, inclusive. Gas accumulation lasted for a much longer time, from the Late Jurassic to the Present, and was especially rapid in the Late Cretaceous–Paleogene.

Keywords: paleotectonic reconstructions; traps; oil; gas; reservoir history

Introduction

Although a wealth of data has been collected, the history of anticlinal traps and oil and gas accumulations they store remains poorly constrained, both for the West Siberian basin as a whole and for Jurassic reservoirs in its northern part. Furthermore, there is yet no agreement about approaches to solving the problem.

We report new paleotectonic data on the Bovanenkovo, Taz, and Gubkin dome-shaped uplifts and the Novyi Port, Urengoi, Kharampur, and Medvezh'e swells, with implications for the history of zone J_2 and the Jurassic reservoir as a whole.

Tectonic history of the West Siberian basin and formation of large uplifts in its north: existing views

There is controversy about the tectonic history of the West Siberian petroleum basin and large uplifts within its limits (Table 1), with the number of activity stages varying from four (Kontorovich, 2009) to ten (Rudkevich et al., 1970). Large uplifts in the basin either developed continuously since the Mesozoic or grew mainly by neotectonic activity (Bochkarev et al., 2013). Some structures were interpreted as inversional, e.g., the Middle Messoyakha horst (Agalakov et al., 2004). Neotectonics played a critical role in the history of most uplifts in the basin (Florensov et al., 1981; Gogonenkov and Timurziev, 2011) and most of their growth occurred during Cenozoic events (Gramberg et al., 2004).

The reported paleotectonic results show that the Bovanenkovo, Taz, Gubkin, Novyi Port, Urengoi, and Kharampur large uplifts in the northern West Siberian basin originated in the Early–Middle Jurassic and had completed their evolution by the early Late Cretaceous (latest Cenomanian), but the Medvezh'e swell formed in the Paleogene–Quaternary interval.

Methods and results

The tectonic history of the Novyi Port, Bovanenkovo, Urengoi, Medvezh'e, Kharampur, Gubkin, and Taz uplifts in the northern Wert Siberian basin was studied using structural mapping on the basis of sediment thicknesses. The method (called "isopach triangle") was suggested by A.Yu. Kara-

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Table 1. Tectonic history of the West Siberian basin and timing of uplift in its northern part: Existing views

Reference	Tectonic history models
(Rudkevich, 1969; Rudkevich et al., 1970, 1976)	Three cycles in Jurassic–Neogene tectonic supercycle: Jurassic, Cretaceous–Early Oligocene, and Middle Oligocene–Anthropogene. Subcycles: Early–Middle Jurassic rapid subsidence and uplift and Late Jurassic relatively slow subsidence within Jurassic cycle; Neocomian, Aptian–Cenomanian, Turonian–Danian, and Paleocene–Early Oligocene within Cretaceous–Early Oligocene cycle; Middle–Late Oligocene, Neogene (without Late Pliocene), and Late Pliocene–Anthropogene within Middle Oligocene–Anthropogene cycle.
(Florensov et al., 1981)	Total amount of neotectonic (post-Oligocene) uplift in the Yamal oil and gas province no higher than 100–200 m.
(Bochkarev et al., 1983)	With regard to uncompensated deposition, Early Jurassic uplift, which was inherited in many structures, actually lasted for a part of Late Jurassic and throughout Neocomian. Rate of uplift slowed down from Middle Jurassic to Early Cretaceous, inclusive, rather than having ceased completely in the Late Jurassic, as it was previously suggested. Many uplifts underwent most of their growth in Early Cretaceous, Aptian–Albian–Cenomanian, and Cenozoic times.
(Bochkarev et al., 2013)	Four main events in tectonic history of Yamal–Gydan region and its surroundings: Late Triassic–Early Jurassic, Middle–Late Jurassic, Neocomian and Cenomanian–Cenozoic. Three regional zones of monoclines within Triassic–Early Jurassic stage; growth of small 100 m uplifts in western zone (Novyi Port and Tambei fields); steep tilted monocline in zone of North Kamennyi Mys and several northern structures; origin and evolution of East Tambei and Geophysical uplifts and North Parus swell in eastern zone. Inherited structural framework during Middle–Late Jurassic event, no growth. Most rapid growth of Novyi Port, Geofizicheskoye, Aderpayuta, Tambei, and West Messoyakha uplifts during Neocomian event. Notable structural changes and repeated changes in geometry and height of Novyi Port swell and other uplifts during Cenomanian–Cenozoic event.
(Agalakov et al., 2004)	Greatest subsidence relative to Paleozoic surface in place of Middle Messoyakha swell in latest Triassic, which confirms its inversion origin.
(Kontorovich, 2009)	Four main tectonic events in history of West Siberian basin and structures within its limits: Jurassic, Berriasian–Aptian, Albian–Turonian, and Cenozoic.
(Cherdantsev et al., 2013)	Heights of Bovanenkovo, Kharasavei, Yamburg, Novyi Port, and Aivasedopur uplifts within 150–200 m relative to Cenomanian top by the end of Eocene Serov deposition. Height of Mevezh'e uplift 70 m prior to neotectonic stage and 195 m at present. Most rapid neotectonic growth of Novyi Port uplift (57% height increase). Messoyakha horst consists mainly of blocks with different tectonic histories which were brought together into a single structure by Miocene tectonic activity.
(Timurziev, 2014)	Siberian low ridges and Messoyakha horst originated and evolved in Pliocene–Quaternary.

vashkina and E.N. Permyakov from the Russian Research Institute of Oil and Gas Geology (VNIGNI) in 1951 and was described in detail by Mashkovich (1970) and Neiman (1974). Note that the available data provide slightly different time limits of the reconstructed intervals (see below).

Novyi Port swell is located in the west of the study region, in the southern part of the larger South Yamal swell (Kontorovich et al., 2001). It is a 65 km long and 25 km wide NW structure, with two peaks, rising 350 m above the top surface of the Kiterbyut Formation. The swell has about the same size and elevation relative to the Laida Formation top, with a slightly higher northern peak (350 m). The elevations above the tops of the Malyshevka, Tanopcha, and Kuznetsovo Formations are, respectively, 430, 200, and 200 m (Fig. 1, 2*D*).

We consider the swell history with respect to the Kiterbyut top surface. A small rise, about 25 m, formed in the southwestern part of the swell early during the Laida deposition (latest Aalenian, 170 Ma) (Fig. 3); moderate uplift began also in the north but remained quite low (60 m) through the end of the Malyshevka deposition (middle Late Bathonian, 161 Ma). During the Tanopcha deposition (latest Aptian, 108 Ma), the swell approached its present geometry, and the southern and northern local highs merged into a single structure rising for 300 m. The swell approached its present shape and height (330 m) in the end of the Kuznetsovo deposition (middle Early Coniacian, 87.5 Ma).

Thus, the Novyi Port swell is a typical syndepositional structure which existed already in the Laida time (latest Aalenian, 170 Ma) and had almost formed in the late Kuznetsovo time in the middle early Coniacian, at 87.5 Ma), when it grew for 94% of its present height. The swell completed its evolution apparently in the end of the Late Cretaceous (Pervukhina, 2006, 2010). It means that neotectonic activity did not contribute much to the rise of the Novyi Port swell, contrary to the view that it would be responsible for 57% of the swell growth (Cherdantsev et al., 2013).

Bovanenkovo dome-shaped uplift located in the western part of the area, like the Novyi Port swell, is a closed structure in the center of the larger Nurma swell. It is restricted to the southern half of the swell where it is 260 m high relative to the Kiterbyut Formation top (Fig. 2*E*) and is higher (350 m) and larger relative to the Laida Formation surface. In the northern half of the Nurma swell, there is a low uplift, which merges with other uplifts into a single uplift rising 550 m above the top of the Malyshevka Formation. The uplift is broader and slightly lower (500 m) with respect to the