Russian Geology and Geophysics © 2019, V.S. Sobolev IGM, Siberian Branch of the RAS
Vol. 60, No. 2, pp. 176–181, 2019 DOI:10.15372/RGG2019013 *Geologiya i Geofizika*

Geothermal Conditions and Petroleum Potential of the Tyumen and Malyshevka Formations of the West Siberian Basin

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Received 9 February 2018; accepted 1 March 2018

Abstract— The paper considers present-day rock temperature distribution in the top of the Tyumen and Malyshevka Formations throughout the West Siberian sedimentary basin. A temperature variations map based on earlier and newly obtained data has been compiled for regional hydrocarbon reservoir Yu_2. A forecast of the temperature variations in the Malyshevka Formation top has been made for the Arctic regions that have not been well studied with deep drilling. Analysis of hydrocarbon pools distribution within the Bathonian reservoir is presented.

Keywords: West Siberian sedimentary basin, present-day temperatures, Tyumen Formation, Malyshevka Formation, hydrocarbon accumulation, phase of accumulation

INTRODUCTION

Geothermal conditions are regarded as one of the most important factors having a significant effect on hydrocarbon formation, hydrocarbon phase state, hydrocarbon preservation, as well as the physical and chemical properties of hydrocarbons. It has been confirmed by multiple studies (Kontorovich et al., 1967, 1975; Zimin et al., 1967; Gurari et al., 1971; Kruglikov et al., 1985; Ermakov and Skorobogatov, 1986; Kurchikov and Stavitsky, 1987; Kurchikov, 1992, 2001; Magoon and Dow, 1994; Skorobogatov et al., 2003; Peters et al., 2005; Skorobogatov and Stroganov, 2006; Fomin, 2011; etc.).

Analysis of present-day temperatures in the Mesozoic–Cenozoic sediments for the top of particular stratigraphic units and depth slices has been performed since the mid of the 1960th both for the whole territory of West Siberia (Zimin et al., 1967, 1972; Kontorovich et al., 1975; Stavitsky et al., 1981; Kruglikov et al., 1985; Ermakov and Skorobogatov, 1986; Kurchikov and Stavitsky, 1987; Kurchikov, 1992; Ulmishek, 2003; etc.) and its regions (Ginsburg, 1971; Kurchkov, 1981; Skorobogatov et al., 2003; Skorobogatov and Stroganov, 2006; Skorobogatov and Soin, 2009; Skorobogatov and Soin, 2011; Novikov, 2011; etc.).

A regional 1:5 000 000 scale temperature map for the top of Lower–Middle Jurassic sediments was first published in the mid of the 1960th by Yu.G. Zimin, A.E. Kontorovich, and L.I. Shvydkova (1967). The dataset which the authors used for the investigation had included the measurements, obtained during the well-testing of the highly-productive intervals of Mesozoic sediments mainly in the territory of the Ob'–Irtysh interfluve. It should be noted that such territorial insularity was due to absence of the measurements for the northern part of West Siberia.

The last large geothermal generalizations for Lower–Middle Jurassic sediments for the territory of the whole West Siberia were made in the mid-1980s–beginning of the 1990s. The results of these studies were published in the monographs by V.I. Ermakov and V.A. Skorobogatov (1986), A.R. Kurchikov and B.P. Stavitsky (1987), A.R. Kurchikov (1992). By that time the amount of available geothermal data had significantly increased. The authors had clarified in details the requirements for raw data estimated the role of different geological processes and factors in the formation of the present-day temperature in a sedimentary cover.

Consirering the fact that in the Yamal-Nenets Autonomous Okrug drilling of the prospect wells that penetrated the Bathonian sediments started only in the second half of the 1980s (Kazanenkov, 2016), there, apparently, had not been enough factual material to draw detailed present-day temperature maps for this stratigraphic level in the territory of Russian northern and Arctic regions. This can be confirmed by the big number of possible' isotherms as in the maps by V.I. Ermakov and V.A. Skorobogatov (1986), as in those by A.R. Kurchikov and B.P. Stavitsky (1987).

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Giving these premises and taking into account the growing interest in the hydrocarbon potential of Bathonian sediments in West Siberia, it seems important to consider temperature distribution in the Yu_2 horizon, including the Arctic region and Kara Sea offshore that have no sufficient prospect-well coverage.

MATERIALS

For the last 30 years more than 500 new hydrocarbon accumulations have been discovered in the Bathonian sediments of West Siberian petroleum province, which comprises 70% of the total number of newly discovered accumulations. This number includes almost all the accumulations in J_2–J_4 reservoirs that were found in the south of the Tyumen Region during the Uvat project, and almost 80% of the accumulations discovered in the Yamalo-Nenets Autonomous Okrug.

The explorations have significantly increased the amount of available geothermal data for the sediments in question. Temperature measurements obtained during the well-testing of Bathonian reservoirs on the 569 blocks, as well as temperature logging on the 26 blocks are considered in this article. This was the basis for the sampling (~1200 values).

To analyze the collected data, we relied upon a modern structural map grid-scale model for the tops of the Tyumen and Malyshevka Formations that covered all the territory of the West Siberian sedimentary basin including the Yenisei–Khatanga Trough and the southern Kara Sea offshore.

METHODS

The temperature map for the Bathonian reservoir top was built based on a 3D model of the present-day temperature gradient of the West Siberian sedimentary basin that had been devised using the generalized data of temperature measurements in more than 6000 prospect wells (Kurchikov and Stavitsky, 1987; Kurchikov, 1992). The model is a map of deep heat flow and a series of temperature maps for the following depth slices: –500, –1000, –2000, –3000, –4000, –5000 m. The model is updated each time new data, including those mentioned above, or their interpretation become available. Formation temperature calculations in the top of permeable Bathonian sediments were performed using interpolation (and, partially, extrapolation) of temperature values for corresponding depth slices.

As a result, a unified grid-scale model covering the whole territory of the West Siberian sedimentary basin (WSB) including the southern Kara Sea offshore and the western part of the Yenisei–Khatanga Trough has been built. The map based on this model traces present-day temperature changes in the J_2 reservoir top and at the final stage has been corrected using the values of the composed sampling.

TEMPERATURE DISTRIBUTION IN THE TOP OF BATHONIAN SEDIMENTS

The temperature variations of the studied interval varies from 20–30 °C near the regional sediments pinch-outs along the basin's periphery to 110–120 °C in the zones of geothermal anomalies in the southern part of WSB (Krasnoleninsk, Salym, Nurol'ka-Koltogory depressions), and goes as high as 120–140 °C (and even higher) in the biggest depressions of its northern part (Nadym, Bol'shaya Kheta, Antipayuta–Tadebeyakha, and South Kara depressions). The variations allowed us to separate three big temperature zones, whose boundaries are determined by the structural geometry of the Tyumen and Malyshevka Formations top.

The first geothermal zone covers the area of External Belt's megamonocline (Kontorovich et al., 2001) that go along the basin's boundary and are characterized by a relatively low-temperature rate (from 20–30 to 80 °C, Fig. 1). Within this zone the top is gradually sinking from –600 m to –2300…–2500 m in the southern, eastern, and northern parts, and down to –2000 m in the western and southwestern parts.

The second (southern) and third (northern) geothermal zones cover the inner areas of the basin and, according to performed estimations, have different intervals of background temperatures. Regionally, the southern zone corresponds to the Middle Ob' Regional Bench (Kontorovich et al., 2001) where the regional background temperatures in the Tyumen Formation top at depths from –2000…–2500 m to –3100…–3250 m vary from 80 to 100 °C. The northern zone covers the area of the Yamal–Kara regional depression and the Krasnosel'kup monocline neighboring the depression from the east (Kontorovich et al., 2001). This zone is characterized by a temperature range from 90 to 110 °C. Within this territory the top of the Tyumen and Malyshevka Formations lies mostly below –3300 m, and at the depocenters of the biggest depressions the depth can reach –4500…–4600 m.

There are also zones of both higher and lower temperatures in the southern geothermal zone at the background of the average temperature values indicated above.

In the southwestern regions of West Siberia, the biggest zone of higher temperatures (>100 °C) is traced in the meridional direction from the northern part of the Nurol'ka depression to the northern part of the Koltogory depression. It embraces a number of territories where temperature rises higher than 110 °C. To the west from the Nurol'ka–Koltogory positive anomaly of the increased temperatures is observed in the Bakchar depression, the northern part of Ust'-Tym megadepression and Lar'yak depression. A zone of decreased temperatures (<80 °C) has been outlined in the northwestern part of the Parabel' megaswell, where in the Beloyarskaya area the measured temperature was 65 °C during the J_2 water-bearing layer well testing.

To the south, the temperatures above 100 °C have been detected on the limbs of the Mezhovsky and East Mezhovsky

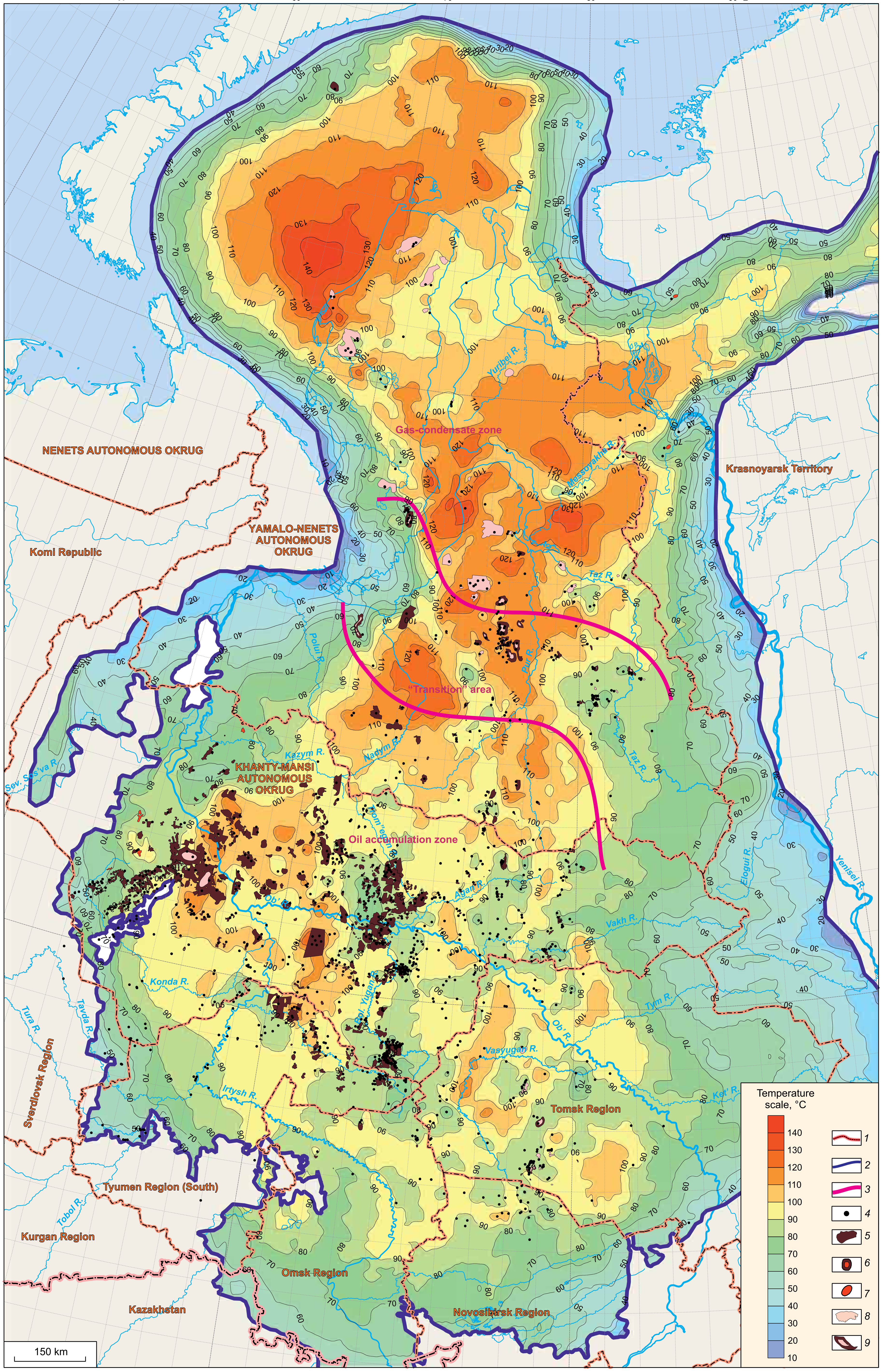

Fig. 1. Present-day temperature map for the top of the Tyumen and Malyshevka Formations. *1*, administrative boundaries; *2*, distribution limit of the Malyshevka sediments; *3*, boundaries of the 'transition' zone with different hydrocarbon phase states; *4*, temperature measurements for the Malyshevka Horizon. Hydrocarbon accumulation the J_2–J_4 layers: *5*, oil; *6*, oil and gas; *7*, gas; *8*, gas-condensate; *9*, oil and gas-condensate.

local elevations. This area is characterized by the absence of Jurassic sediments on the crest of the structures, pre-Jurassic rocks here are presented as granites and acid effusives which are overburden by Cretaceous deposits. It is the presence of the granite batholith that determines the increased temperatures in the structures. A certain decrease of the temperatures is observed in the Nadezhdinskaya, Verkhtarskaya, and Vostochnaya areas, where they reduce to 76 °C.

The zone's eastern parts are characterized by a sequence of linear regions extended in the meridional direction with increased and decreased temperatures that are related to the depressions and elevations in the relief of the Tyumen Formation. The reduced temperatures have been registered in the J_2 layer within the New Agan and Tagrin local structures (72–76 °C) complicating the eastern part of the Var'egan–Tagrin bench within the Koshil'skaya and Severovakhskaya areas (70–75 °C) in the northern part of the Aleksandrov arch, and to the north of it within the Upper Kolik'egan structure (76–77 °C). In the Koltogory–Urengoi regional megatrench separating the Var'egan–Tagrin bench and Alexandrov arch the temperatures increase up to 90 °C and higher.

In the central parts of the southern zone, the low-temperature areas (70–80 °C) in the top of the J_2 layer are oil-saturated reservoirs on the northeastern slope of the Upper Dem'yanka megaswell and Surgut arch. This fact for different stratigraphic levels has been noted multiple times by different authors (Zimin et al., 1967; Kontorovich et al., 1975; Kruglikov et al., 1985; Ermakov and Skorobogatov, 1986; Kurchikov and Stavitsky, 1987; Kurchikov, 1992). For example, the temperatures in the central part of the Surgut arch, and in the Yuzhno-Surgutskoe, Sokinskoe, Saigatinskoe, Bystrinskoe, Yaunlorskoe, Novobystrinskoe, Vachimskoe fields, and in the northern part of the Vostochno-Surgutskoe field the temperature of J_2 does not exceed 80 °C. As the Tyumen Formation top is sinking slowly in the directions of the troughs and depressions, surrounding the crest of structure the temperatures are gradually increasing to 85–90 °C (Fig. 1).

In the territory of the Nizhnevartovsk arch sediments overheat has been registered in the western part of the Tyumen Formation top, where in some areas (Yur'evskaya, Bylinskaya, Orekhovskaya, and Ermakovskaya) the formation temperatures exceed 100 °C. In the eastern part of the structure crest the temperatures vary within the range of 80–85 °C. At the same time, the Chernaya Gora structure has the lowest temperature for this territory equal to 78 °C.

In the western part of the southern geothermal zone where the average temperatures exceed 90 °C, there is with ring-like area whose temperatures go over 100 °C. Its contours embrace two positive anomalies located in the Krasnoleninsk and Salym petroleum districts. These anomalies characterized by pre-Jurassic, Upper Jurassic, Lower Cretaceous, Cenomanian tops as well as by different depth slices have been described in (Kontorovich et al., 1975; Kurchikov, 1981, 1992; Kruglikov et al., 1985; Nesterov et al., 1988) and other publications. However, the variations of present-day temperatures excluding the Krasnoleninskoe and Salymskoe fields have been discussed only in (Ermakov and Skorobogatov, 1986). The new materials that have recently become available have made it possible to specify the characteristics of these high-temperature anomalies.

In the Salym area, the high-temperature zone is limited by a closing isotherm of 105 °C that goes in the meridional direction from the Severo-Dem'yanskaya area in the south to Yuzhno-Sakhalinskaya area in the north. The rock temperature in the J_2-reservoir top exceeds 115 °C. The central part of this anomaly is characterized by maximum temperatures varying from 124 to 130 °C.

In the Krasnoleninsk area, the high-temperature zone is closed by a 105 °C isotherm. This zone embraces (from the south to the north) Severo-Molodezhnoe, Srednenazymskoe, Rogozhnikovskoe, Severo-Nazymskoe, Tsentral'noe fields, and the eastern part of Krasnoleninsk field. The maximum formation temperatures have been registered in the rocks of the Krasnoleninskoe field (116–120 °C). In the other fields, they change from 106 to 110 °C.

In the southern parts of the northern geothermal zone areas of high and lower temperatures change one another in the direction from the west to the east (Fig. 1). The maxima here correlate with the Nadym megadepression (>120 °C) and Middle Pur trench (>110 °C), while the minima—with the most elevated parts of the Northern arch and Vyngapur swell (85–90 °C). Relatively low temperatures (74–80 °C) in the J_2 layer have been registered in the eastern part of this area in the wells of Chernichnaya, Ust'-Chasel'skaya, Verkhnechasel'skaya and Yuzhno-Chasel'skaya areas.

In the northern regions of the Nadym–Pur interfluve to the east of the Taz Bay as the Tyumen Formation goes deeper, the rock temperatures increase, so almost everywhere there the temperatures exceed 110 °C, and there are areas with >120 °C and >130 °C. High temperatures were registered during J_2 formation tests in the Padinskaya (122 °C), Yuzhno-Pestsovaya (132 °C) and Yuzhno-Parusovaya (139 °C) areas. Certain decrease of rock temperatures in the Tyumen Formation top was noted in the Urengoiskoe and Pestsovoe fields.

To the north lies a linear zone of reduced temperatures corresponding to the Messoyakha ridge. As the Bathonian deposits deepen from the east to the west, the temperature gradually increases from the Nizhnekhetskaya area (25 °C) to the Parusovaya area (113 °C).

In the southern parts of the Gydan Peninsula, there is a wide zone with the temperatures above 100 °C. It can be traced to the east up to the bank of the Yenisei River, and to west—up to the southeastern regions of the Yamal Peninsula. In the tectonic context, the most part of this zone belongs to the Antipayuta–Tadebeyakha syneclise and the western part of the Agapa–Yenisei trench in whose big depressions the sediments temperature may reach 120 °C and more, while in the northern part of the Gydan Peninsula the rock temperatures of the Malyshevka Formation top remain similar to the background ones. According to V.A. Skorobogatov and L.V. Stroganova (2006) formation tests of the J_2 layer in the Stormovaya area gave the temperature of 97 °C.

In the Yamal Peninsula present-day rock temperatures in Bathonian sediments are varying in a wide range from 60–68 °C in the Novoportovskaya area to 120–125 °C—in the Kharasaveiskaya area. In general, it corresponds to the background values of 90–110 °C, while the increased values (115–120 °C) are observed along the northwestern coast of the peninsula in the area of 50–70 km in width. The high rock temperatures of the Malyshevka Formation top have been confirmed with actual measurements during well-tests of gas-condensate reservoirs on the Kharasaveiskaya area (120–123.5 °C).

In the territory of the southern Kara Sea a wide high-temperature zone with the maximum temperatures are expected in the South Kara depression where the Malyshevka Formation top lies at the depth of –4200…–4500 m. At the average geothermal gradient equal to 3.72 °C/100 m (Kazanenkov et al., 2014) structural mapping allows us to conclude that in the megadepression's deepest part the rock temperatures of the J_2 layer may reach 150 °C and more.

It is necessary to point out that the Bathonian deposits of the South Kara depression embody the biggest high-temperature zone in WSB, whose southern part includes Kharasaveiskoe and Krusensternskoe fields. The presence of such a positive geothermal anomaly in the vicinity of the fields has also been noted by V.A. Skorobogatov et al. (Skorobogatov et al., 2003; Skorobogatov and Stroganov, 2006; Skorobogatov and Soin, 2009).

THERMAL REGIME AND PHASE OF THE J_2–J_4 BATHONIAN ACCUMULATIONS

The performed geothermal mapping reflecting geothermal condition changes in the tops of the Tyumen and Malyshevka Formations has enabled to determine the lateral zoning of the localization of reservoirs with different phase states in the J_2–J_4 layers of West Siberian petroleum province. This what makes this study unique, because no one before has tried to investigate the interrelation between the physical and chemical properties of hydrocarbons and the sediments temperatures of the Bathonian stratigraphic interval within the whole territory of West Siberia.

Let's remember that within West Siberia there is no other regional reservoir with such a big oil and gas bearing area as the Bathonian one (Kazanenkov, 2016). This fact is determined by a favorable sequential combination of paleographic environments for the time of source rocks deposition, formation of the permeable reservoir network and seal rocks, and by the further geological history of WSB (Kontorovich et al., 2013).

Hydrocarbon reservoirs in the permeable complex of Bathonian sediments are found almost in every oil-and-gas bearing area of the province: from the north to the south—from the Pobeda field discovered in the Prinovozemelskoe offshore of the Kara Sea to the Kazanskoe field in the south of the Vasyugan petroleum region; and from the west to the east — from the Iusskoe and Kotyl'inskoe fields in the southwest of Ural region to the Chernichnoe and Termokarstovoe fields in the east of the Pur–Taz petroleum region and the Khabeiskoe field in the Yenisei–Khatanga petroleum region.

For the time being the Bathonian deposits embody reservoirs in the following state: oil, gas-condensate, oil and gas-condensate, oil-and-gas and gas.

Considering the total number of hydrocarbon accumulations discovered in the J_2–J_4 layers, those in oil phase state definitely prevail, their majority being concentrated in the southern geothermal zone. About 75% of the oil accumulations are placed with the temperature range from 80 to 100 °C at the depth from –2500 m to –3000 m. As the reservoir top's depth decreases, and so its temperature, the number of deposits reduces, which is the common pattern typical for all petroleum basins worldwide.

The oil extracted from the J_2–J_4 layers of West Siberia is characterized by reduced density, reduced sulfur and resins content, and raised paraffin content that raised together with the rock temperature (Kazanenkov, 2018).

For instance, the heaviest (0.871–0.895 g/cm^3), high-paraffin (1.7–5.53%), sulfur (0.55–1.8%) and high-sulfur (1.82–2.16%), resin (5.28–14.62%) and high-resin (15.32–21.6%) oils with low gas content (<50 m^3/t) have been found in the deposits localized in a meridional zone with the rock temperatures of the Tyumen Formation top from 70 to 90 °C that extends from the Upper Dem'yanka megaswell to the South Nadym monocline. This zone embraces two geothermal anomalies with reduced temperatures relative to the background ones and is limited by the Surgut arch and the northeastern part of the Upper Dem'yanka megaswell described above.

The differential peculiarity of the positive geothermal anomaly in the Krasnoleninsk district is presence of very light oils (0.801–0.829 g/cm^3) with low sulfur content (0.08–0.52%) and high gas factor (120–253 m^3/t). The paraffin content in such oils varies from 2.05 to 5.8%, and that of resin and asphaltenes—from 1.12 to 7.41%.

Unlike the Krasnoleninsk district, the high-temperature zone of the Salym field embraces reservoirs with light and mid-density oils. While the light (0.830–0.846 g/cm^3) and resin (5.13–5.28%) oils are concentrated in the southern part of the anomaly (Severo-Dem'yanskoe, Gusenichnoe, and Verkhnesalymskoe fields), in the central part of the anomaly (Salym field) the oil density from the J_2 layer increases to 0.860 g/cm^3. The peculiarity of the oils from this anomaly has been low sulfur content (0.2–0.51%).

In general, the reservoirs of the southern geothermal zone, whose background temperatures vary from 80 to 100 °C contain mostly light and mid-density oils with the gas factor up to 100 m^3/t. Their sulfur content qualifies them as sulfur oils (0.64–1.74%) and the paraffin content—as paraffin ones (1.7–4.3%). Their resin and asphaltenes contents vary within 5.24–13.26% qualifying them as resin oil.

As the sediment temperature rises to the north from the southern geothermal zone it leads to further improvement of qualitative oil characteristics. For example, in the southern regions of the northern geothermal zone the reservoirs contain very light oils, whose densities do not exceed 0.825 g/cm^3 (Pal'nikovskoe, Paisyatskoe, Verkhnepurpeiskoe, Novogodnee, Ety-Purovskoe, Stakhanovskoe, and other fields). There oils are characterized by high paraffin (0.98–7.2%) and low sulfur (0.02–0.23%) and resin contents. Their distinctive property has been their significant gas saturation varying from 200 up to 500 m^3/t.

Further to the north, in the Nadym–Pur and central areas of the Pur–Taz interfluve the Bathonian sediments, together with oil reservoirs (Lenzitskoe, Zapadno-Medvezh'e, Yubileinoe, Berogovoe, Verkhnechasel'skoe, and other fields), contain deposits with mixed composition of hydrocarbons such as oil- and gas-condensate (Urengoiskoe, Severo-Komsomol'skoe, Chernichnoe, and other fields); gas-condensate (Ukrainsko-Yubileinoe, Novochasel'skoe, Fakhirovskoe, and other fields) and oil-and-gas (Vostochno-Medvezh'e field) reservoirs. At the same time, it has been noted that in the west (Nadym–Pur interfluve) the rock temperature by 20–25 °C higher than those in the east (central regions of the Pur–Taz interfluve) where they do not exceed 90 °C.

The physical and chemical properties of the oil from the reservoirs of the J_2–J_4 'transitional' zone characterize it as extra light—from 0.770 (Yuzhno-Khadyr'yakhinskoe field) to 0.822 g/cm^3 (Kynskoe field) and low-resin—from 0.34% (Zapadno-Medvezh'e field) to 2.4% (Verkhnechacel'skoe field). In terms of paraffin content, it is classified as the paraffin (2.56–5.42%) and high-paraffin (6.32–21.62%) kind. Based on the paraffin content one can distinguish several areas of reservoir concentration. The oils high in paraffin are concentrated in sediments with the temperatures varying from 80 to 90 °C that are located in the eastern part of the zone.

Within the transition zone, the gas factor mostly varies from 200 to 300 m^3/t. A relatively increased gas content has been observed in the Urengoi (340 m^3/t) accumulations, where the temperature of the J_2 layer varies from 110 to 120 °C. In the western part of the zone, where the rock temperatures decrease to 70–80 °C, the oil gas factor reduces accordingly. For instance, in the Novoportovskoe, Yarudeiskoe, and Lenzitskoe fields it varies within the range of 110–120 m^3/t.

The content of stable condensate in the gas caps of oil-and-gas-condensate reservoirs of the transition zone changes from 110.6 to 387 g/m^3. Similar values of condensate concentration have been obtained from gas-condensate deposits (130–392 g/m^3). It has been noted that the sediments temperatures in the oil and gas-condensate reservoirs are 10–15 °C higher than in gas-condensate ones.

To the north of the transition zone, Bathonian sediments mainly contain gas-condensate reservoirs, whose stable condensate content varies from 100 to 450 g/m^3. The reservoirs have been found within a wide range of rock temperatures: the lowest of them measured in the Maloyamalskoe field (70–80 °C), and the highest exceeding 130 °C in the Yuzhno-Pestsovoe field. Most of the reservoirs are concentrated within the temperature range from 90 to 130 °C at the depth from –3000 m to –4050 m.

Thus, a conclusion can be made that in the northern geothermal zone at the background of increasing sediments temperatures from the south to the north, one can clearly observe a zoning in the location of hydrocarbon accumulations with different phase states from oil to gas-condensate.

Within the boundaries of the low-temperature zone of the External Belt, some local elevations also contain some oil (Shaim, Serginsk, and Universitetskii petroleum districts) and gas deposits (Shaim, Serginsk petroleum districts and the western part of the Yenisei–Khatanga petroleum region).

In most of the accumulations in question, the rock temperatures do not exceed the value of 70 °C. The minimum rock temperatures (<50 °C) have been registered in the deposits of the Iusskoe and Kotyl'inskoe fields of the Shaim petroleum district at the depth of –1295…–1305 m and –1351…–1378 m, respectively.

CONCLUSIONS

The new geothermal data for oil-and-gas bearing layers (J_2–J_4) has made it possible to specify present-day temperature distribution in the top of the Tyumen and Malyshevka Formations and widen the existing geothermal maps to the poorly studied arctic areas of WSB.

In general, the territories of WSB demonstrate good correlation in the configuration of isolines for similar temperatures, and Bathonian top structure depths, so the present-day temperature map makes it possible to divide the area into three big zones.

The first, low-temperature (from 20–30 to 80 °C) zone cover the area of the External Belt and goes along the basin's margins. The second (southern) and third (northern) geothermal zones cover the inner areas of the basin and have different background temperature intervals. In the southern zone, the regional background temperatures vary from 80 to 100 °C in the Tyumen Formation's top. In the northern zone, the background temperatures change from 90 to 110 °C.

In the southern zone, at the background of these temperatures, one can observe both positive (Krasnoleninsk, Salym, Nurol'ka, and Bakchar) and negative (Surgut and Tailak–South Dem'yanka) geothermal anomalies. In the northern zone, high-temperature anomalies correlate with the mega-depressions with the South Kara depression to be the biggest of them.

Analysis of present-day rock temperature distribution in the top of the Tyumen and Malyshevka Formations and oil and gas bearing capacity for the whole territory of WBS has made it possible to verify Bathonian play boundaries for different hydrocarbon accumulations.

The temperature increasing from the south to the north within the inner regions of the basin allows us to identify three zones as of oil accumulation, transition (containing oil, oil and gas-condensate, and gas-condensate reservoirs), and mostly gas-condensate zone covering the northern and arctic areas of the basin. All the pure gas-bearing accumulation found in the Bathonian formations are located in the low-temperature region of the External Belt.

For the Bathonian reservoir a clear correlation has been demonstrated between the present-day temperatures in the top of the Tyumen and Malyshevka Formations and the physical and chemical properties of the oils from the J_2–J_4 layers. Increasing temperatures lead to reduced oil density, sulfur, resin and asphaltenes content, and increase in paraffin content and gas factor values.

The presented research results allow one to predict the phase of hydrocarbon accumulation in Bathonian sediments based on the geothermal conditions, firstly, in the poorly studied areas of West Siberian oil and gas province.

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Editorial responsibility: V.A. Kontorovich