Journal of Petroleum Science and Engineering 154 (2017) 91–99

Contents lists available at ScienceDirect

Journal of Petroleum Science and Engineering

journal homepage: www.elsevier.com/locate/petrol

Distinct features of crude oils from Nyurol'ka Depression (Southeast of Western Siberia)

Diana Saltymakova[a,*], Nataly Krasnoyarova[b], Olga Serebrennikova[b]

[a] University of Manitoba, Centre for Earth Observation Science, Winnipeg MB, Canada R3T 2N2
[b] Institute of Petroleum Chemistry Siberian branch of the Russian Academy of Sciences, Akademichesky Avenue, 4, 634021 Tomsk, Russia

ARTICLE INFO

Keywords:
Biomarkers
West Siberia
Nyurol'ka Depression
Aryl isoprenoids
Jurassic oil
Paleozoic oils
Domanik horizon
Timano-Pechorskaya
Volga-Uralskaya

ABSTRACT

Aryl isoprenoids detected in Nyurol'ka Depression oils are unique biomarkers of photic zone anoxia (PZA) and they could be a key for the oil nature determination. In this study, the composition of the oils from four adjacent territories was investigated in order to characterize the PZA features within Nyurol'ka Depression. Samples were analyzed using the gas chromatography-mass spectrometry, the gas-liquid chromatography, and spectrophotometry.

To characterize the PZA recorded in the Paleozoic oils from Nyurol'ka Depression they were compared with the Paleozoic oils from Volga-Uralskaya and Timano-Pechorskaya oil and gas provinces. Despite the fact that aryl isoprenoids were identified in the Paleozoic samples from the three studied territories, Nyurol'ka Depression oils demonstrate individual composition. The differences lie in the distribution of isoprenoid alkanes, alkylcyclohexanes, steranes, hopanes, aryl isoprenoids, triaromatic hydrocarbons, dibenzothiophenes and biphenyls relative abundance. The biomarker composition indicates a less stable PZA in the sedimentary basin in Nyurol'ka Depression, as well as a greater degree of thermal maturity.

Jurassic oils from Nyurol'ka Depression were compared with the Jurassic oils from Koltogorskiy rift, which is an adjacent territory to the area under study. Unlike the oils from the Koltogorskiy rift, the Jurassic oils of Nyurol'ka Depression are characterized by the presence of aryl isoprenoids and absence of nickel porphyrins. The combination of aforementioned features could be caused by the presence of a PZA in Nyurol'ka Depression and its absence on the territory of Koltogorskiy rift.

It is concluded that the presence of the PZA affected the biomarker composition and could be an indicator of one or similar sources for most of the Paleozoic and Jurassic oils in Nyurol'ka Depression.

1. Introduction

Nyurol'ka Depression is a unique object of great interest. It is located in the South Eastern part of the West Siberian Plain in the area between the rivers Ob and Irtysh. Significant reserves of hydrocarbons are confined to this area; however, their origin is still controversial. The source rock for the most part of the West Siberian oil and gas province is the Upper Jurassic Bazhenov Formation (Kontorovich et al., 1997; Goncharov et al., 2015; Kozlova et al., 2015) while Paleozoic rocks within Nyurol'ka Depression could also be a source for oil trapped in Paleozoic deposits (Gaidukova and Kudryashova, 2012). The chemical composition and the distribution of individual groups of hydrocarbons (HC) and heterocyclic organic compounds of oils the can give important information about the possible source of these oils.

According to studies, the main feature of Nyurol'ka Depression oils is the presence of aryl isoprenoids (Chirkova et al., 2014, 2017). Aryl isoprenoids derived from aromatic carotenoids isorenieraten and ß-isorenieraten (Hartgers et al., 1994; Brocks and Schaeffer, 2008), which were produced by green sulfur bacteria *Chlorobiaceae* (Summons and Powell, 1987), and their presence indicates photic zone anoxia (PZA) in the sedimentary basin (Koopmans et al., 1996). These compounds have never been detected before in other Western Siberian oils (Krasnoyarova et al., 2015) and could be a clue to the oil origin.

Euxinia is an anoxic state when H_2S is enriched in the water column and penetrates into the photic zone to establish PZA, which is a common phenomenon in Earth's history (Naeher and Grice, 2015). The closest territories where the presence of aryl isoprenoids was reported prior are Volga-Uralskaya (VUOGP) (Fig. 1A) and Timano-Pechorskaya oil and gas provinces (TPOGP) (Bushnev, 2009; Ostroukhov et al., 2015). The source rock for the oils containing aryl isoprenoids was Domanik horizon (D_3 Frasnian), which is a regional source kitchen for a number of oil fields (Neruchev et al., 1986; Kayukova et al., 2016).

The Domanik horizon genesis is well understood and the revealing of the main similarities and differences between the composition of

* Corresponding author.
E-mail addresses: chirkovadiana@gmail.com (D. Saltymakova), natalex@ipc.tsc.ru (N. Krasnoyarova), ovs49@yahoo.com (O. Serebrennikova).

http://dx.doi.org/10.1016/j.petrol.2017.04.017
Received 12 April 2016; Received in revised form 18 March 2017; Accepted 13 April 2017
Available online 15 April 2017

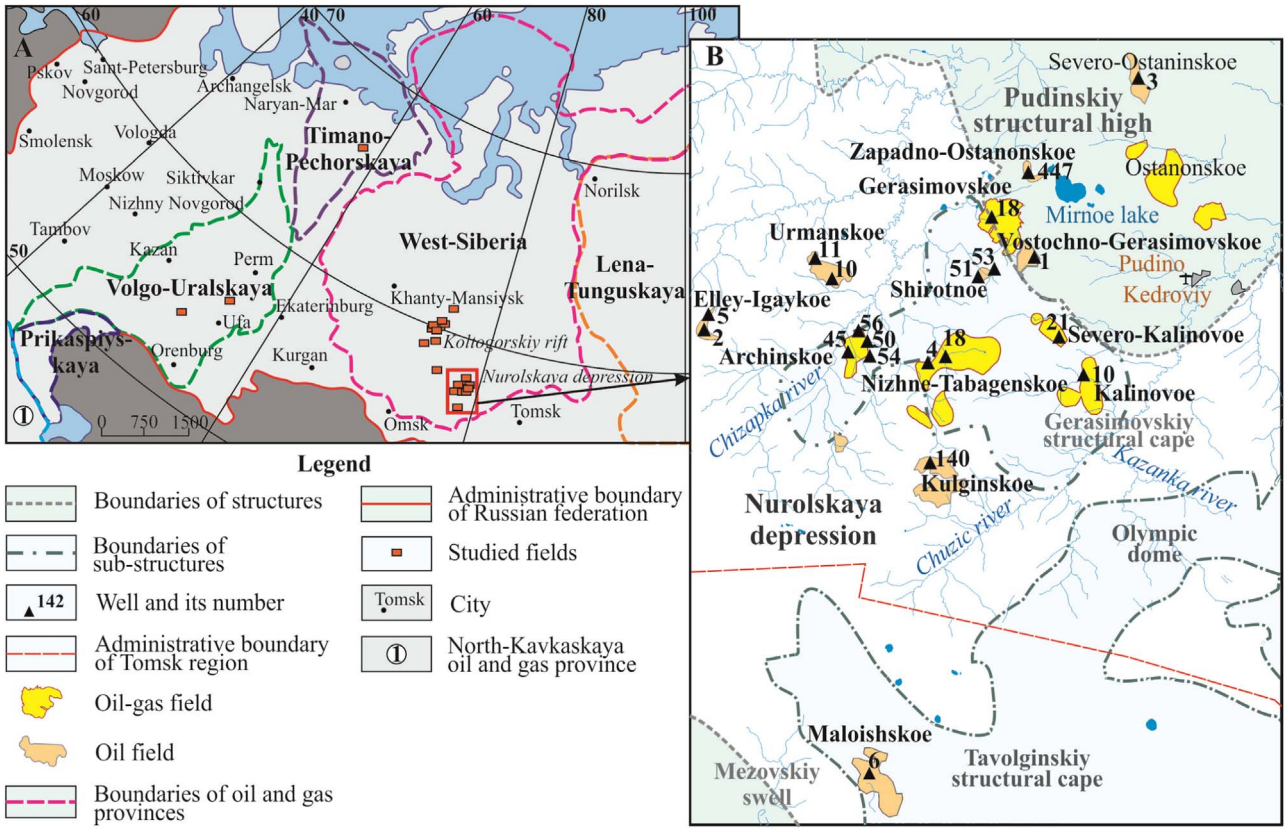

Fig. 1. Map showing A – West Siberian, Volgo-Uralskaya and Timano-Pechorskaya oil and gas provinces and the oil fields under study; B – locations of oil samples within Nurolskaya depression.

Paleozoic oils from Nyurol'ka Depression and oils from eastern regions of the European part of Russia can be used to determine the source of organic matter (OM).

Similarly, the comparison of Jurassic oils from Nyurol'ka basin with Jurassic oils from the adjacent negative structure may also serve the same purpose.

2. Geological settings

2.1. Geological features of Domanik deposits

Domanik horizon, it is the main source rock in the territory of VUOGP and TPOGP which was formed in the last half of Frasnian age in the late Devonian period (Kayukova et al., 2016).

Domanik horizon composed of dark gray, almost black limestones with a high bitumen content interbedded with the same color marl and clay siliceous shales and cherts (Gatovskii et al., 2016). The rock accumulation occurred in the epicontinental marine basin under normal salinity in warm humid climate. Here the sediments rich in OM formed under reducing geochemical conditions in the absence or slow flow of the bottom waters (Neruchev et al., 1986) with the presence of PZA (Bushnev, 2009; Ostroukhov et al., 2015). High bitumen content in the Domanik deposits resulted from the plankton growth, algae, and continental OM (Kayukova et al., 2016). Late Frasnian age deposits were accumulated under unstable conditions in the offshore shallow water and there numerous organogenic constructions were formed (House et al., 2000).

2.2. Geological features of Nyurol'ka Depression in case of Archinskoe field

Archinskoye field (Fig. 2) contains oil gas condensate reserves and it is located on the south-western slope of Nyurol'ka Depression. Commercial oil and gas deposits associated with deposits of three stratigraphic complexes Middle Devonian, early-middle and late Jurassic.

The major oil and gas reserves (81%) concentrate in the cross section of the first complex associated with M layer – the weathering crust of Paleozoic sediments and the basement carbonates. M layer made up of biogenic limestone shoal facies (Gritchina et al., 2016). The reservoir consists of several hydrodynamically isolated productive lens which is controlled by fault seal and confined to hydrothermal alteration zones of organic limestones (Abrosimova and Rizkova, 1997).

Early-middle and late Jurassic commercial HCs are located in Toarcian, Bajocian/ Aalenian, and Oxfordian sediments. The reservoirs composed of sandstones.

3. Samples and lithology of reservoirs

Four oil samples were selected from the Permian-Carboniferous carbonates in TPOGP (Table 1) on the Usinskoye field and eight samples from VUOGP were obtained from the middle Carboniferous carbonates of the Zapadno-Leninogorskaya, Kiyazlinskaya, Abdrachmanovskaya fields. 10 Nyurol'ka oils from Paleozoic deposits (Fig. 1B) described in Chirkova et al. (2017) was used for comparison with VUOGP and TPOGP samples. Paleozoic sediments (2818 – 3850 m) presented by dolomites, limestones and carbonates and the weathering crust (w.c.) is bauxite deposit (2970 – 3081 m). The oil sample of Urmanskoe field well 11 was collected from the interval, which contains Pz and J_1 rocks.

Koltogorskiy rift Jurassic oils samples were described in Belitskaya et al., 2008; Belitskaya and Serebrennikova (2009) and used in the study for identifying the characteristic features of Nyurol'ka Depression Jurassic oils (Chirkova et al., 2017). Jurassic reservoirs within Nyurol'ka Depression oil (2488 – 3026 m) are usually argillaceous