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Problems of the geology and petroleum potential of the Arctic (in lieu of a preface)

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For many years in the 20th century, Russian has been and continues to be a world leader in geology, exploration and mining activities in the Arctic, and in the past decades over the Russian Arctic continental shelf. The Russian Arctic sector and the shelves of the Arctic seas hold a unique and massive resources base, including oil and gas, diamonds and base and rare-earth metals, phosphates, gold, PGE ores, and other mineral reserves. The knowledge of the geology of the Arctic sector of our planet is the key for solving many global geological problems. Thus it becomes clear that studies of the geology and mineral deposits of the Arctic are seen as a research priority of the geological institutions of the Russian Academy of Sciences and its Siberian Branch in particular. The most important results are published on a regular basis in the issues of *Russian Geology and Geophysics*/*Geologiya i Geofizika*.

The first Special Issue of *Russian Geology and Geophysics/Geologiya i Geofizika* (Vol. 51, No. 1) “Problems of the Geology and Petroleum Potential of the Arctic” was published in 2010. The papers presented in the first issue covered a broad range of problems related to the geology of the Arctic, including hydrocarbon (Section 1) and other mineral resources (Section 2) potential, exploration and mining technologies. The issue contained articles of scientists from different institutes, including six that were affiliated with the Siberian Branch of RAS and eleven institutes of the Russian Academy of Sciences and non-academic industry-based organizations and universities. Many papers had authors from 5 or 6 institutions.

This Special Issue of Russian Geology and Geophysics “Problems of the Geology and Petroleum Potential of the Arctic” we have invited contributions mostly from the Institute of Petroleum Geology and Geophysics, Siberian Branch of the Russian Academy of Sciences, which provided an overview of the most recent results and development that have been realized by the institute in Russia’s sector of the Arctic. This issue comprises the following sections:

1. Phanerozoic stratigraphy, lithology and paleogeography (4 articles).
2. Tectonics and magmatism (5 articles).
3. Problems of oil and gas geology, organic geochemistry (5 articles).

The volume begins with the paper, which presents the paleogeographic reconstruction of the West Siberian basin during the Jurassic using the extensive data sets on geology, geophysics, paleontology, lithology, and geochemistry collected over the years in the region (Kontorovich et al., 2013). Special emphasis was given to the Arctic part of the basin, including the southern portions of the Kara Sea, Ob, Taz, and Yenisei bays. The authors discuss cyclic sedimentation, which affected petroleum systems in the basin, including the formation of regional seals, source and reservoir rocks. The paper discusses a variety of depositional environments in relation to organic carbon accumulation in different stratigraphic units and the biochemical composition of organic matter. This is the first attempt to provide a paleogeographic reconstruction for rock complexes having wide areal distribution and age range using the data on the geochemistry of autochthonous hydrocarbon biomarkers in sedimentary rocks. The paper also considers paleogeographic implications for the hydrocarbon potential of this unique basin.

The other three papers in this section contain new data on the Devonian, Triassic, and Jurassic–Cretaceous stratigraphy of the Laptev Sea and New Siberian Islands, the new prospective Arctic regions of northern Central Siberia (Konstantinov et al., 2013; Nikitenko et al., 2013; Yazikov et al., 2013).

The section “Tectonics and magmatism” begins with the paper by Vernikovsky, Dobretsov, Metelkin, et al. (2013) “Concerning tectonics and the tectonic evolution of the Arctic”, which addresses the present-day tectonic structure of Russia’s Arctic, based on new field observations and interpretation of geophysical and paleomagnetic data. Of particular interest may be the first seismic tomographic model of the

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entire Arctic presented in the paper by Jakovlev et al. (2012), as well as a number of paleotectonic reconstructions, which provide a deeper insight into the geologic history of the Arctic region from the Neoproterozoic (950 Myr) through the Permian (255 Myr). The authors revise and revive the ideas of Zonenshain and Natapov (1987) about the ancient Arctida continent.

As a natural continuation of the paper by Vernikovsky et al. (2013), the work by Koulakov et al. (2013) presents the results of plate reconstructions in the Arctic region for the Permian through the present from integrated geophysical, including seismic tomography and geological studies. The authors suggest that southwestward subduction of crust of the Anyui (Proto-Arctic) Ocean in the Jurassic–Early Cretaceous was the key driving force of the Mesozoic tectonic history of the region. This subduction zone was reconstructed in the South Anyui suture extending from Alaska to the Lena Delta, as suggested by the data of Sokolov et al. (Sokolov et al., 2009, 2010) and relics of the subducted oceanic plate reconstructed by the above-mentioned seismic tomographic model at depths of 400–600 km (Jakovlev et al., 2012). As a result of subduction, the Arctida plate (including Svalbrad, Kara, Lomonosov–Mendeleev range blocks) drifted south- and southeastward and rotated clockwise during the opening of the Canadian basin. The Eurasian basin opened at 55–0 Ma after cessation of the Anyui subduction at 115–120 Ma and plate rearrangement as a result of rotations of Eurasian and North American plates and continued rifting that opened the North Atlantic.

The results summarized in the papers by Vernikovsky et al. and Koulakov et al. will help unravel the nature, geologic history and hydrocarbon potential of the Arctic sedimentary basins. However, the authors admit that some of their reconstructions are quite speculative, assuming a large number of the "blank" areas and the deficit of data.

The third paper in this section (Dobretsov, Vernikovsky, et al., 2013) offers a consideration of Mesozoic–Cenozoic magmatism in the central and eastern Arctic with particular attention to plume magmatism (from the Triassic traps on the Siberian Platform and beneath the West Siberian basin to flood basalt magmatism in Greenland at 60–30 Ma) and the onset of mantle plume magmatism at 0–27 Ma in the eastern Arctic, including the De Long Islands, Alaska and Chukchi Peninsulas. A comparison of MORB-type, plume- and subduction-related magmatism liked with the successive opening of three oceanic basins (Anyui, Canadian, and Eurasian) distinguished seven stages in the geodynamic evolution of the Arctic over the last 250 Myr, which were described in detail in plate reconstructions of Koulakov et al. (2013). It should be noted that the analysis of Mesozoic–Cenozoic magmatism and reconstruction of the geodynamic evolution of the central and eastern Arctic proposed by Dobretsov et al. may provide important information regarding the thermal structure of the lithosphere in the Arctic regions during the Mesozoic and Cenozoic and thus can be used to evaluate the hydrocarbon potential in basins with widespread basalt magmatism.

The papers by Vernikovsky et al. (2013), Kulakov et al. (2013), Dobretsov, Vernikovsky, et al. (2013) nicely complement the recently published article by Laverov et al. (2013) and provide a basis for Russia's claim on extended continental shelf beyond its exclusive economic zone. Pivotal to this claim is the origin of the Lomonosov and Mendeleev Ridges forming part of the hypothetical Arctida craton, which was joined to the Siberian and Eastern Eurasian platform in the Permian. Reconstructions of plate motions and their correlation to stages of plume- and subduction-related magmatism will help elucidate the evolution of Mesozoic–Cenozoic petroleum basins in the Arctic regions.

This is the focus of the fourth paper in this section (Dobretsov, Polyansky, et al., 2013), which discusses tectonic subsidence and thermal models derived for several sedimentary basins using the backstripping analysis (on the example of Tyumenskaya SG-6 well and other wells drilled within the Yenisei–Khatanga and Vilyui petroleum basins) and 2D models for the Vilyuy rift-related trough. The results revealed several stages of rapid subsidence during a rifting phase, which can be broadly linked (both genetically and temporally) to the above-mentioned stages of plume-related magmatism (260–240, 190–170, 150–130 Ma). Very similar techniques have been used since the 1970s in petroleum geology for simulating thermal processes in petroleum-bearing sedimentary basins (Kontorovich and Trofimuk, 1973; Kontorovich et al., 1975; and others) as well as they form part of many of petroleum systems modeling software packages used for modeling petroleum generation processes in sedimentary basins (for examples see (Kontorovich, Burshtein, et al., 2013), (Safronov et al., 2013)).

This final paper in this section by N.V. Sobolev et al. (2013) presents new data on Triassic diamondiferous sedimentary rocks in the Arctic part of the Siberian Platform. The data given in the paper revealed a high variability of the composition of indicator minerals (eclogite- and peridotite-derived garnets, Cr-rich chromites, picroilmenites of different composition) in rocks. This is probably due to the presence of many sources of diamonds. They may have been transported from the Urals, in particular, as suggested by the development of a Triassic transcontinental river system (paleo-Taimyr, paleo-Lena), which acted as a major transportation route for sediment supply to the Laptev Sea during the Triassic and Jurassic (Miller et al., 2013).

The final section of this issue begins with the paper by A.E. Kontorovich et al. (2013) "Historical-geological modeling of hydrocarbon generation in the Mesozoic–Cenozoic sedimentary basin of the Kara Sea (basin modeling)". This paper is based on the extensive data from deep drilling, seismic exploration, as well as the results of lithological, petrographic and geochemical analyses of drill cores collected in wells within the northern parts of the West Siberian sedimentary basin, including the southern Kara Sea. Backstripping provides insights to the thermal and burial history of each major sequence in the southern Kara Sea area, using a large number of structural, tectonic, lithofacies, and isopach maps with account for rock decompaction. A chemical-kinetic