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Features of the Isotope–Geochemical Carbon Composition of Oil in Fields at the South Tatar Arch

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Abstract—The carbon isotope composition of oil in the various regions of Tatarstan was found out to range from $\delta^{13}C = -32.5$ to $-28.6‰$. Oil in sedimentary rocks in the central part of the South Tatar Arch (STA) is characterized by a lighter carbon isotope composition ($\delta^{13}C < -29‰$) than oil in the southeastern STA slope ($\delta^{13}C > -29‰$), whose rocks are broken by deep faults. The oil of relatively heavy carbon isotopic composition is shown to be characterized by a high sulfur content, contains relatively much polar fractions, and is less catagenically mature that the oil with a relatively light carbon isotope composition. The source organic matter of oils, regardless of their carbon isotopic composition, in the South Tatar Arch was sapropelic material with an admixture of a bacterial component, which was transformed under reducing conditions when hosted in clay–carbonate sediments. The Devonian (D_2 gv) oil of the Bavlinskoye field (Well 475) in the southeast slope of the South Tatar Arch differs in composition from the other oils. Along with high contents of saturated (53%) and aromatic (36%) hydrocarbons, this oil is characterized by a relatively heavy carbon isotope composition and a sublinear curve of the isotope-fractional distribution of components. A similar distribution of components with a heavy isotope composition of the asphaltene carbon is typical the Devonian (D_3 psv) oil of the Abdrakhmanovskoye field (Wells 719 and 312) in the crest STA part, which generally has a relatively light carbon isotope composition and a contains low concentrations of polar fractions.

Keywords: oil, carbon isotope composition, isotopic fractionation curves, biomarkers, sedimentary rocks, South Tatar Arch

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INTRODUCTION

Lateral migrations, which can cover distances as long as 20–170 km at platform territories (Chakhmachev, 1993, Neruchev and Smirnov, 2007; Karaseva, 2019), sometimes fails to form hydrocarbon accumulations of source organic matter occurring within this distance alone. Additional amounts of hydrocarbons can therewith be provided by the migration of fluids coming from underlying formations and fault zones in the basement rocks (Ashirov et al., 2000; Kayukova et al., 2009; Plotnikova et al., 2013; Muslimov and Plotnikova, 2019). Admixtures of such fluids in oil accumulations may manifest themselves in the form of isotopic–geochemical features that are acquired by the hydrocarbons under the effect of processes in rocks of different lithological–geological profile and induced by catalytic, adsorption, and other properties (Gurko et al., 1987; Rodkin, 2002; Kosachev et al., 2015).

An example of different rocks occurring in contact in the territory of the Republic of Tatarstan is the producing rocks of the Middle–Late Paleozoic sedimentary complex, which rest immediately on a weathering crust of the crystalline basement. Although the thickness of the sedimentary sequence is small and its oil-generation potential is relatively low (709 Mt oil), more than 170 oil fields were discovered in the territory of the republic in 18 producing horizons (*Oil and Gas Potential of the Republic of Tatarstan,* vol. 1, 2007; Larochkina, 2008). According to data on the biomarkers, Tatarstan oils belong to a single type, and the source organic matter of this oil consisted mostly of marine shallow-water material (Petrov, 1994; Kayukova et al., 2011; Kiseleva and Mozhegova, 2012). The candidates for the source rocks are thought (Gatiyatullin et al., 2005; Gordadze and Tikhomirov, 2007; Anan'ev, 2010) to be the Domanik siliceous–carbonate formation of Tatarstan. The most probable candidates are the mid-Frasnian and late Frasnian–Tournaisian carbonate formations in the Kama–Kinel paleotrough system (Kiseleva and Mozhegova, 2012) or deeper sitting Domanikoids of Late Devonian age in nearby depressions, for example, in the Buzuluk