Petroleum Geochemistry and Petroleum Systems of Cretaceous Oils and Sources Rocks from the Powder River Basin

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Abstract

The Powder River Basin is one of the prolific petroleum provinces, situated in northeastern Wyoming and southeastern Montana. The geology of the region is well established, but the organic geochemistry and petroleum systems evaluation of the oils produced from the multiple Cretaceous reservoirs are not very well researched and published. This paper attempts to characterize the organic geochemistry of the oils and source rocks from all Cretaceous reservoirs, thereby establishing oil families, identifying their sources, basin wide oil migration pathway analysis from source rocks to reservoir rocks. This study documents whole oil molecular compositions, saturate and aromatic biomarkers, and its carbon isotope compositions from oils from 13 different Cretaceous reservoirs. This study also reports source rock geochemistry data that include Leco-total organic carbon (TOC), pyrolysis, and vitrinite reflectance analysis from the Mowry and Niobrara formations, which are interpreted to be the major source rocks in the basin. Cretaceous oils observed in this study are derived from organic rich marine clastic source rocks and are observed to be geochemically homogenous with only minor variations in their molecular composition and biomarker characteristics. Geochemical data suggest two major families of oils are produced from Cretaceous reservoirs in the Powder River Basin. The oils produced from the reservoirs below the Mowry source rocks are interpreted to be Mowry sourced and similarly, oils produced from the reservoirs above the Niobrara are interpreted to be Niobrara sourced. Oils from reservoirs that occur between Mowry and Niobrara contain either Niobrara or Mowry derived oils or combination of the two. Vitrinite reflectance data and its equivalent from Tmax (Jarvie et al., 2001; Rahman et al., 2016), Hydrogen Index (HI) (Olson, 2008), and triaromatic sterane ratio (TAS) (Mackenzie et al., 1981; Peters et al., 2005) show excellent agreement with one another. These data suggest that the highest maturity oils and source rocks occur near the basin axis; and become less mature with increasing distance from the basin's center. The maturity equivalents calculated from the oils suggest that most of the reservoirs are filled with migrated oils as result of primarily vertical migration and some secondary lateral migration from source rocks. This study highlights many important ways in which petroleum geochemistry can be used to better evaluate these unconventional reservoirs: 1) by identifying source rocks, reservoirs, oil families, the existence and extent of hydrocarbon migration, 2) by predicting and understanding the quality and type of petroleum fluids stored in tight, unconventional reservoir rocks, and 3) by explaining the petroleum systems elements, petroleum types and migration patterns in certain areas in these tight reservoirs.