Impact of Kerogen Heterogeneities on Hydrocarbon Production in Unconventional Shale Reservoirs

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Abstract

Declining oil and gas prices highlight the need to improve efficiency of hydrocarbon (HC) production from unconventional shale reservoirs. The outstanding issues facing shale oil and gas industry are inaccurate estimates of oil/gas in place (GIP/OIP), low recovery of HC and rapid decline in well productivity after an initial phase of high production. Some of these issues could be addressed by developing better understanding of molecular level properties of kerogen, the component of shale that generates and contains the largest amount of HC in its pores. Several recent studies have focused on simulating the physico-chemical properties of kerogen such as its sorption capacity, flow and transport, and mechanical strength etc.. However, most of these simulation models are based on structural models based on kerogen “type”, derived from a very limited number of shale samples. Therefore, these studies do not account for variations that can potentially exist in kerogen molecular structure due to changes in sources of organic matter, paleo-redox conditions, microbial diagenesis, thermal history, pressure gradient, and differential kerogen cracking mechanism.In this study, we examine the heterogeneities that can exist in kerogen structure within a particular kerogen “type” at similar maturity stages in different shale basins and even within a single basin. We constructed average unit structural models of different kerogen samples using the information of aliphatic, aromatic and lattice structural parameters derived from 13C solid-state Nuclear Magnetic Resonance (NMR) analysis. Lattice parameters such as average carbons per aromatic cluster (C), average aliphatic carbon chain length (Cn’), and the fraction of aromatic carbons with attachments (FAA) were used to construct framework of the the average unit structure. The aliphatic and aromatic functional groups were then

attached to the framework in acordance to the 13C NMR data. We studied and compared molecular parameters of kerogen of all the three types: type I, type II and type III. We also discuss the impact of variations in molecular structure of kerogen on its physicochemical properties such as its density, porosity, sorption capacity, and mechanical behavior. These properties are very significant as they directly impact HC retention and release, fracturing potential, and petrophysical log based GIP/OIP estimates. Our initial studies emphasize the need to understand molecular level heterogeneities in kerogen for more accurate prospect evaluation and higher HC recovery.