Investigating the Role of Shale Microstructure in the Storage and Delivery of Hydrocarbons by FIB/SEM Tomography and STEM Imaging

Mark E. Curtis[1], Carl H. Sondergeld[1], Chandra S. Rai[1], and Raymond J. Ambrose[2]
[1]*University of Oklahoma, Norman, OK*
[2]*Devon Energy, Oklahoma City, OK*

Shale reservoirs are providing a rapidly increasing portion of America's total hydrocarbon production; however, our scientific understanding of how hydrocarbons are stored and transported through shales remains limited. Many petrophysical properties are tied to the microstructure of shale which is on a size scale orders of magnitude smaller than conventional reservoir rocks. Using a combination of focused ion beam milling (FIB), scanning electron microscopy (SEM), and scanning transmission electron microscopy (STEM), the microstructure of shale samples from different plays has been investigated. Both FIB/SEM and STEM imaging show a complex and varying microstructure, with nanoscale pores of differing geometries located in both organic matter and the inorganic matrix. Using FIB/SEM tomography, 3D renderings of the microstructure of the shale samples have been generated. These renderings allow the visualization of the organic and pore networks and provide quantitative estimates of important pore network parameters such as porosity, pore size distribution, pore surface area and connectivity. In addition, STEM and SEM imaging indicate that the formation of pores in the organic matter may depend not only on thermal maturity but also on the type of organic matter. Understanding and quantifying the microstructure of shales will provide flow modeling constraints as well as more accurate estimations of hydrocarbons in place. The insights gained by these observations are raising new and important questions about the storage and transport of hydrocarbons in shales.