The Effects of Nano-Confinement on the Phase Behavior of Hydrocarbon Gases: An Experimental Case Study on a Kerogen-Rich Shale Gas Reservoir

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ABSTRACT

The prerequisites to economical unconventional shale gas production are accurate gas in place and net present value calculations as well as reliable reservoir simulations, all of which require a comprehensive understanding of reservoir fluid phase behavior. In shale gas reservoirs, knowledge of the fluid phase behavior is limited because of the interdependence of the rock and fluid properties. Shale gas reservoirs are characterized by nanopores of varying wettability. Confinement in these pores may alter the phase transitions of fluids. Although the effects of nano-confinement have been investigated both theoretically and experimentally in synthetic media; little is known about these effects in reservoir rocks. Therefore, we present systematic case studies involving the injection of both simple fluids (i.e., single-component) and gas mixtures into shale core plugs from a shale gas reservoir rich in nanoporous kerogen. First, the mineralogy, porosity, and permeability of the cores were characterized using ultra-high resolution micrographs generated with a Focused Ion Beam Scanning Electron Microscope (FIB-SEM) and Quantitative Evaluation of Minerals by Scanning Electron Microscopy (QEMSCAN). Subsequently, a specially designed and fabricated gravimetric capillary condensation apparatus was used to measure isotherms for both simple fluids and gas mixtures in the core samples. The experiments involving simple fluids allowed us to bridge the gap between fundamental studies in synthetic pores and those in real reservoir core samples. Our experiments involving the gas mixtures provide accurate phase behavior data, allowing us to develop insights into the storage and production mechanisms of shale gas that have direct implications for improved production strategies.