The Behavior of Methane in Nanometer Pores in the Marcellus Shale: Results from Contrast Matching Neutron Scattering

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Abstract

Shale and other tight reservoirs represent an increasingly viable source of economic quantities of petroleum resources globally. Petroleum in these systems is stored in pores both within organic matter and the mineral matrix. In thermally mature plays such as the Marcellus Shale, which is in the dry-gas window, the majority of the gas has been shown to be contained in organic matter (e.g., solid bitumen) pores typically 4 adsorption up to the zero average contrast (ZAC) pressure and at 60ºC within two mineralogically different (clay-rich and carbonate-rich, respectively) Marcellus Shale samples using the NIMROD (Near and InterMediate Range Order Diffractometer) instrument at the ISIS Pulsed Neutron and Muon Source. The use of the NIMROD allowed for CD4 accessibility to pore spaces to be explored for a nominal pore size distribution from ~10 nm down to the atomic regime. By reaching the CD4 ZAC pressure for both samples (~600 bar), it is possible to examine the distribution of open versus closed pores within the samples as any residual scattering observed at this supercritical state is attributed to the scattering from inaccessible pores. The degree of closed nanopores within shale reservoirs is a key component to assess; petroleum present within these pores is unlikely to be produced as there is no pathway to the interconnected flow network that leads to the well head, even within zones of active hydraulically-fractured stimulation. Initial results indicate that up to 20% of the total pores within both samples are inaccessible to CD4 with no significant differences observed between the samples. This lends support to assertions that, for shale samples within the dry gas window, nanometer scale porosity is primarily within the associated

organic matter and that mineralogical variations may play only a limited role in dictating fluid behavior within these systems. These findings will be discussed in the broader context of evaluating methane behavior within thermally mature shale reservoirs and also serve to highlight the power of ZAC neutron scattering for examining open versus closed porosity within petroliferous organic matter.