Pore-scale and NMR Characterization of Unconventional Carbonate Mudrocks

Ibukunoluwa Bode-Omoleye[1]
[1]Oklahoma State University, Petrophysics, Stillwater, OK USA
ibukuno@okstate.edu

Contributors: G. M. Grammer (Oklahoma State University)

ABSTRACT

Petrophysical characterization and quantification of original hydrocarbons in place and producibility in unconventional reservoirs remains challenging. Porosity in the Mississippian-aged carbonate mudrock unconventional reservoirs of the southern midcontinent is less than 10%, with the majority of pores in the micro- to nano-pore class size (<62.5 µm diameter), and an average permeability of 0.1 milliDarcies. The first phase of this study has identified petrophysically-distinct facies based on relationships between rock fabric, dominant pore types, porosity, permeability, and nuclear magnetic resonance (NMR) response. However, the presence of complex micro- to nano-pore types and facies with similar 2-D pore architecture (size and geometry), despite exhibiting different petrophysical implications and NMR response complicates the apparent relationships between pore geometry and permeability. Thus there is a need to incorporate high-resolution 3-D pore architecture data and develop proxies which characterize pore connectivity and flow in carbonate mudrocks.

The objective of this study is to utilize a robust petrophysical-geological approach that accurately characterizes the influence of pore architecture and fabric heterogeneity in carbonate mudrocks. The petrophysical investigation will include laboratory-measured NMR, mercury intrusion capillary pressure (MICP), and specific surface area measurements to evaluate pore structure. Whereas, the geological analysis will combine detailed facies and pore-type descriptions with multi-scale image analysis of optical microscopy (OM), scanning electron microscopy (SEM), and focused ion-beam SEM (FIB-SEM) to obtain pore architecture data and are applied to investigate geological control of pore structure.

This approach is essential for improving predictability and understanding variability and origin of porosity and permeability in carbonates mudrocks.

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