# Three-Dimensional Investigation of Pore Architecture Characteristics and Variation in Carbonate-Rich Mudrocks: Insights into the Controls of Pore Development

**Ibukun Bode-Omoleye[1], Javier Vilcaez[2], Michael Grammer[2]**
[1]Kansas Geological Survey; [2]Oklahoma State University

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## Abstract

This study investigates the micropore architecture of carbonate mudrock samples in three different formations including the Mississippian Meramecian STACK (Sooner Trend Anadarko Canadian and Kingfisher) and “Mississippi Lime” Plays in the Anadarko Basin of Kansas and Oklahoma, and one sample from the Upper Jurassic to Lower Cretaceous Vaca Muerta Formation of the Argentinean Neuquén Basin. The goal of this comaparative study is to characterize and analyze three-dimensional connectivity of pores in carbonate mudrocks down to the nanometer-scale, thereby increasing both qualitative and quantitative understanding of pore systems in a variety of carbonate mudrock samples.Two-dimensional backscattered electron (BSE) and secondary electron (SE) images of FIB cross-sectioned surfaces show complex pore geometry, with variations observed among the formations. Observations of both 2D cross-sections and 3D volumes indicate that interparticle, intercrystalline, intramineral, intraparticle, and organic matter pores associated with clay, carbonate, quartz, pyrite, and kerogen are the most prevalent components. In the BSE images, samples with high TOC, show kerogen ubiquitously filling the interparticle pore space between inorganic siliciclastic grains. Open pores of variable connectivity are observed in both the kerogen and inorganic matrix with the size, shape, and number of pores varying among the investigated samples. Kerogen- and matrix-related pore networks are segmented out and visualized in the reconstructed volumes. Estimates of organic matter and

pore volume percentages of the reconstructed carbonate mudrock volumes range from 0 to 90.0% for the kerogen and 0.2 to 2.3% for pores. Pore-size distributions suggest that although pores of less than 100 nm in diameter dominate in number, they do not necessarily dominate in total volumetric contribution in some samples. A comparative analysis of porosity, permeability, saturation and fluid flow petrophysical properties determined from the 3D volumes indicates a clear trend related to the identified rock fabric and organic matter content. The combination of the 2D SEM images and 3D reconstructions reinforce the variability and complexity of pore systems and the microstructures related to fine-grained carbonate-rich rocks.

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