# Implications of Facies and Pore Architecture on NMR-Response in Carbonate Mudrock Reservoirs: Mississippian-Lime Play Case Study

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## ABSTRACT

Recent work on the ‘Mississippian Lime' unconventional carbonate reservoir of the southern Mid-Continent has shown that expected relationships between pore geometry and laboratory measured porosity and permeability, which are well-defined in conventional carbonate reservoirs, are not readily apparent in carbonate mudrocks as a result of the highly irregular internal pore architecture. These new insights emphasize the need to continue to develop proxies by which these unconventional reservoirs can be better characterized. Nuclear magnetic resonance (NMR) is an established tool that provides direct information on porosity, pore size and pore size distribution, making it an invaluable tool in characterizing carbonate pore systems. The understanding of transverse relaxation time (T2) distribution is extensive and continues to grow in conventional carbonates, however, limited work has been done to constrain the application of the methodology to carbonate mudrocks.

In this study, NMR analysis is combined with various imaging tools that have defined multiple scales of pore types. This multiscale pore characterization integrates both visualization (optical microscopy, SEM and micro-CT) and basic petrophysical information for facies and pore-type description and grouping. The relationship between the NMR response, rock fabric and pore architecture variation is assessed to test the efficacy of NMR analysis in predominantly micro- to nano-scale pore systems and contribute to the understanding of fluid flow in unconventional carbonate reservoirs.

Results show a grouping of fabrics correlative with porosity and permeability in three petrophysically-significant facies: burrowed calcareous siltstones, bioturbated calcareous siltstones, and skeletal-peloidal packstone to grainstones. In general, T2 curves exhibit up to 3 modes: varying by facies and pore types present. Fabrics with minimal dissolution or diagenetically-enhanced cementation show T2 curves with the lowest amplitudes and very short T2 relaxation times, while high amplitudes and longer T2 characterize rocks with larger pore areas and are typically associated with higher abundances of pores. Results also show that T2 cutoff values used in partitioning bound and free fluid in conventional carbonates leads to an overestimation of bound fluid in the unconventional rocks.

Incorporating this geologic-petrophysical facies analysis within a sequence stratigraphic allows for increased predictability of reservoir quality and delineation of flow units within these low porosity and permeability carbonate reservoirs.