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Diagenetic Evolution of Organic Matter Cements: Implications for Unconventional Shale Reservoir Quality Prediction

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ABSTRACT

The impact of diagenesis on conventional sandstone and carbonate hydrocarbon reservoirs has a long history of study that has advanced to a stage where several empirical models have been developed for quantitative reservoir quality prediction. Advanced models combine depositional parameters (texture and composition) and chemical kinetics within a burial history framework. Diagenetic studies of unconventional shale reservoirs is less well advanced than their conventional reservoir counterparts. However, interest in mudstone diagenesis and reservoir quality prediction has increased with the dramatic growth of shale hydrocarbon production in North America during the past 15 years.

Cement is a solid material that binds together particles in a sedimentary rock. Cements are a product of diagenesis and are a main contributor to reservoir quality degradation in conventional sandstone and carbonate reservoirs because cements occupy former pore spaces, thereby reducing hydrocarbon storage volume and permeability. Understanding the origin and diagenetic evolution of cements is thus critical for reservoir quality prediction.

Mineral cements precipitate from aqueous solutions in response to chemical reactions between fluids and minerals in the rock as metastable mineral forms convert to more stable forms in response to changing temperature and pressure changes during burial. Mineral cements may also form at grain-to-grain contacts due to pressure solution phenomena.

The presence of organic matter in unconventional shale reservoirs adds to the complexity of diagenetic reactions resulting from changes during the conversion of organic matter to hydrocarbons with increasing thermal stress. Observations of scanning electron microscopic (SEM) images from drill core samples from a variety of producing shale plays in North America reveal the presence of both mineral and organic matter cements.