

Ichnology, Sedimentology, Stratigraphy and Trace Fossil-Permeability Relationships in the Medicine Hat Member of southeastern Alberta, Canada

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An abundance of natural gas is contained within the unconventional reservoirs of the Upper Cretaceous Medicine Hat Member (Niobrara Formation) in southeastern Alberta. Employing a traditional sedimentary geology approach, this study uses subsurface cores and geophysical wire-line logs to develop a new depositional model by integrating ichnology, physical sedimentology and stratigraphy. Additionally, air permeametry and micro-CT scans were performed to investigate the role trace fossils have on effective permeability distribution in the gas-charged reservoir intervals.

Core analysis revealed fourteen commonly recurring sedimentary facies that are grouped into in four facies associations: the proximal subaqueous foreset, the middle to distal subaqueous foreset, the proximal bottom, and subaqueous bay sub-environments of a wave-and river-influenced subaqueous clinof orm. The proximal foreset region is composed of multiple sets of tempestites with small-scale HCS and rare burrowing produced by diminutive *Planolites* and *Psilonichnus*. The deposition of the proximal foreset was dominantly under the influence of storm waves. The middle to distal foreset comprises planar-laminated fine sandstone with intervening siltstone and mudstone. A low diversity suite of traces is characteristic of the ichnology, which is limited to recumbent *Skolithos*, *Planolites* and *Siphonichnus*. Thin planar-laminated fine sandstone interstratified in thicker siltstone and mudstone with low to moderate burrowing intensities is characteristic of the proximal bottomset. The trace fossils within this facies association are diminutive and belong to the ichnogenera *Skolithos*, *Planolites*, *Phycosiphon*, *Teichichnus* and *Rhizocorallium*. Finally, the subaqueous bay deposits are manifest as moderately to well bioturbated siltstones and mudstones with interstratified pin-stripe laminated or massive sandstones. Overall, the deposition of the Medicine Hat Member was dominated by wave and river processes.

A network of seven stratigraphic cross-sections constructed over the study area, containing 42 wells, revealed five progradational sandstone bodies based on the observation of downlapping shingle morphologies. Petrophysically, mini-permeametry experiments indicated that trace fossils acted as a primary conduit for fluid flow. Furthermore, micro-CT scans revealed that ichnogenera with vertical elements were integral in connecting multiple horizontal flow pathways.

The results of this study demonstrate the utility of a multidisciplinary approach in solving reservoir problems. The study gives new insight into exploration and production strategies for the Medicine Hat Member in addition to contributing to the sparse literature on fine-grained, shallow marine depositional systems.