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Microlithofacies Analysis within Cardium Tight-oil Intervals

N.A. Solano*, C.R. Clarkson, F.F. Krause, and A. Kantzas
Geoscience Department, University of Calgary
*nasolano@ucalgary.ca

Summary

Tight-oil intervals within the Cardium Formation are volumetrically dominated by highly bioturbated siliciclastic intervals with variable ratios of biogenic to physical sedimentary structures. One of the major effects of this early biogenic activity is the sorting and mixing of adjacent, slightly different lithologies; a direct result of this is increased heterogeneity accounted in fine-scale reservoir properties. A combination of X-ray Computed Tomography (XRCT) and high-resolution pressure-decay profile permeability (PDPK) techniques are highlighted in this work as key tools for the detailed characterization of these highly heterogeneous lithofacies within the Cardium Formation at the Pembina field.

The analysis of XRCT datasets yields information regarding distribution of microlithofacies and their geometry. This information is coupled with appropriate mineralogical and compositional ranges to estimate density and porosity for each voxel in the CT volume. Profile permeability gathered at a sub-cm scale on slabbed surfaces provides a two-dimensional map for permeability, and can be used to derive correlations between porosity and permeability in the 3D volume.

Three dominant microlithofacies were found in the samples analyzed: SS1, SS2, and SH1. Average values of porosity are equal to 16.1% and 7.5%, for the relatively high (SS1) and intermediate (SS2) reservoir quality clusters, respectively; geometrical average for permeability values correspond to 4.5mD, and 0.65mD, respectively. SS1 clusters exhibit limited connectivity compared to their SS2 counterpart, and the SS2:SS1 ratio ranges between 3 and 5 for most of the samples investigated.

In spite of the relatively high permeability values associated with microlithofacies SS1, its limited connectivity and volumetric abundance preclude this rock type from dominating the fluid flow process in these rocks; in fact, permeability seems to be dominated by the matrix-like microlithofacies SS2, which exhibit average permeability values very close to those reported from routine analysis on core plugs and full-diameter core samples in this particular lithofacies. Further investigation of individual properties and connectivity of these microlithofacies clusters are valuable for the proper upscaling and modeling of key reservoir properties; this also represents a more reliable input for percolation studies, and more advanced fluid flow models tailored for these highly heterogeneous intervals within the Cardium Formation.