Title: Characterization, Petrography, and Static Geologic Modeling of an Unconventional Carbonate Reservoir, Intervals of the Midale and Rival "Nesson" Beds in the Mississippian Madison Group, Burke County, North Dakota

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Abstract:
The Plains CO_2 Reduction Partnership based at the Energy & Environmental Research Center has selected the Rival Field area as one of its Phase III Regional Characterization sites examining promising oil fields with potential for carbon dioxide (CO_2) enhanced oil recovery. The Midale beds are at the base of the Charles Formation and conformably overlie the Rival beds from the Mission Canyon Formation. Together, the Midale/Rival intervals represent a 40–80-foot-thick, traditional warm-water near-shore neritic carbonate system that has been locally productive in the Rival, Black Slough, Portal, and Lignite oil fields located in Burke County, North Dakota.

The Midale beds of the Ratcliffe interval conformably overlie the Frobisher–Alida interval that was deposited during rapid carbonate progradation representing a shallowing-upward carbonate-to-evaporite sequence during Mission Canyon time. Progradation ceased, and a subtle transgressive sequence began to flood the shoreline, depositing the Upper Rival and Midale beds. The Upper Rival comprises a prominent skeletal shale zone 3–9 feet thick, restricting hydrocarbon movement between the Midale and Rival beds. The Midale is represented by two localized macrofacies defined by current petrographic and core plug analysis completed in two wells: 1) micritic, fossiliferous, sometimes argillaceous mudstones that have experienced variable (sparry) dolomite recrystallization, and 2) porous ooid/pellet grainstone banks partially cemented with sparry dolomite cement. The Midale is overlain by the argillaceous Three Fingers Formation and the 30-foot-thick Midale Salt, representing the updip seal for the reservoirs.

Two prominent structural noses representing shallow dipping anticlines are present in the northeast corner of the Rival Field. Production from the Midale reservoir is significantly better on structure than off. Pressure regimes can also be attributed to the structure along with the implication of wrench faulting and an associated fracture network. Basic seismic interpretation confirms the presence of a fault.

A 3-D static geologic model was built from 140 out of 312 wells available in the study area. The 140 wells represent quality wireline and core analysis suites normalized by the following techniques: core to log calibration, statistical normalization, Type Well method, and trend analysis regional normalization. Petrophysical analysis was performed to produce the following properties later upscaled into the 3-D model: total porosity, shale volume, effective porosity, permeability, and water saturation. A cloud porosity-to-permeability transform was used to better represent the heterogeneous nature of permeability distribution in both highly diagenetic reservoirs. Reservoir simulation will help minimize model uncertainty, update oil–water contacts, estimate CO_2 storage capacity, and reassess STOOIP.