Deep Regional Fluid Flow in the Northeastern Flank of the Williston Basin: Implications for Hydrocarbon Migration

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The Williston Basin Architecture and Hydrocarbon Potential Project is a collaborative program aimed at developing a geological model of Paleozoic to Mesozoic aged rocks in Eastern Saskatchewan and Manitoba, Canada. Given that the Williston Basin hosts an active groundwater flow system, understanding the hydrogeology is essential because fluid flow in basins can influence the accumulation of exploitable mineral and oil deposits. Thus, a hydrogeological analysis of the entire geologic section has been undertaken to identify driving forces, determine flow directions and rates, and potential hydrocarbon migration pathways and entrapment mechanisms.

Detailed mapping of hydraulic head and water chemistry has been conducted on 19 aquifers ranging in age from the Cambrian to the uppermost Cretaceous. Flow directions determined from maps of equivalent fresh-water hydraulic-head indicate dominantly updip flow of formation waters from SW to NE across the study area. Mapped formation water salinities range in total salinity from 5 to 350 g/L and indicate significant density variations between formations and across the area. Density-dependent fluid flow is important in certain aquifers because downdip flow decreases the upward driving force for cross-formational flow and enhances hydrocarbon trapping capacities. Cross-formational flow associated with the salt dissolution edge of the Prairie Evaporite Formation has resulted in dissolution features in/above Mississippian formations. Vertical migration of fluids from the Devonian promotes upward mixing and thus oil charging of basal Mississippian units (Bakken Formation) along/near the subcrop edges. These hydrogeological results are assisting with new understanding of hydrocarbon migration pathways/plays in the North Eastern portion of the Williston Basin.