Tracing Fluid Migration via Stable Isotopes within the Mississippian Aquifers in the Williston Basin, Canada-U.S.A.

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Abstract

Water samples were collected from 114 producing oil wells in Mississippian aquifers across the Williston Basin including portions of Saskatchewan, North Dakota, and Montana. Target Mississippian aquifers included the Frobisher, Midale and Ratcliffe beds. These beds were correlated across the basin using geophysical well logs prior to sampling. Results reveal large variations in geochemical and isotopic compositions basin wide. Results show: i) formation waters have distinct chemical fingerprints ii) large variations in isotopic compositions indicate variable flow pathways within the aquifers, iii) portions of the aquifers host formation waters with a composition similar to original Mississippian seawater. Brines surrounding the residual seawater to the north and east originate from evaporate dissolution, therefore implying both brine forming mechanisms of evaporative concentration and evaporate dissolution are occurring in the Mississippian aquifers of the Williston Basin. Two separate flow regimes are interpreted in the Mississippian aquifers in the Williston Basin (Figure 1). These regimes are elucidated by means of integrating stable isotopic compositions and Br/Cl ratios of the formation waters. One flow regime originates from present-day meteoric water that evolved into a saline brine. The other flow regime originates from a large scale fluid flux occurring at the end of the Cretaceous, that evolved into a saline brine via halite dissolution. These new geochemical data indicate the Mississippian flow system is not a simple regional groundwater flow system, rather highly-variable across the basin. Unique isotopic fingerprints are present within the individual beds of the Mississippian aquifers. These hydrochemical fingerprints can be applied to petroleum exploration and production activities.

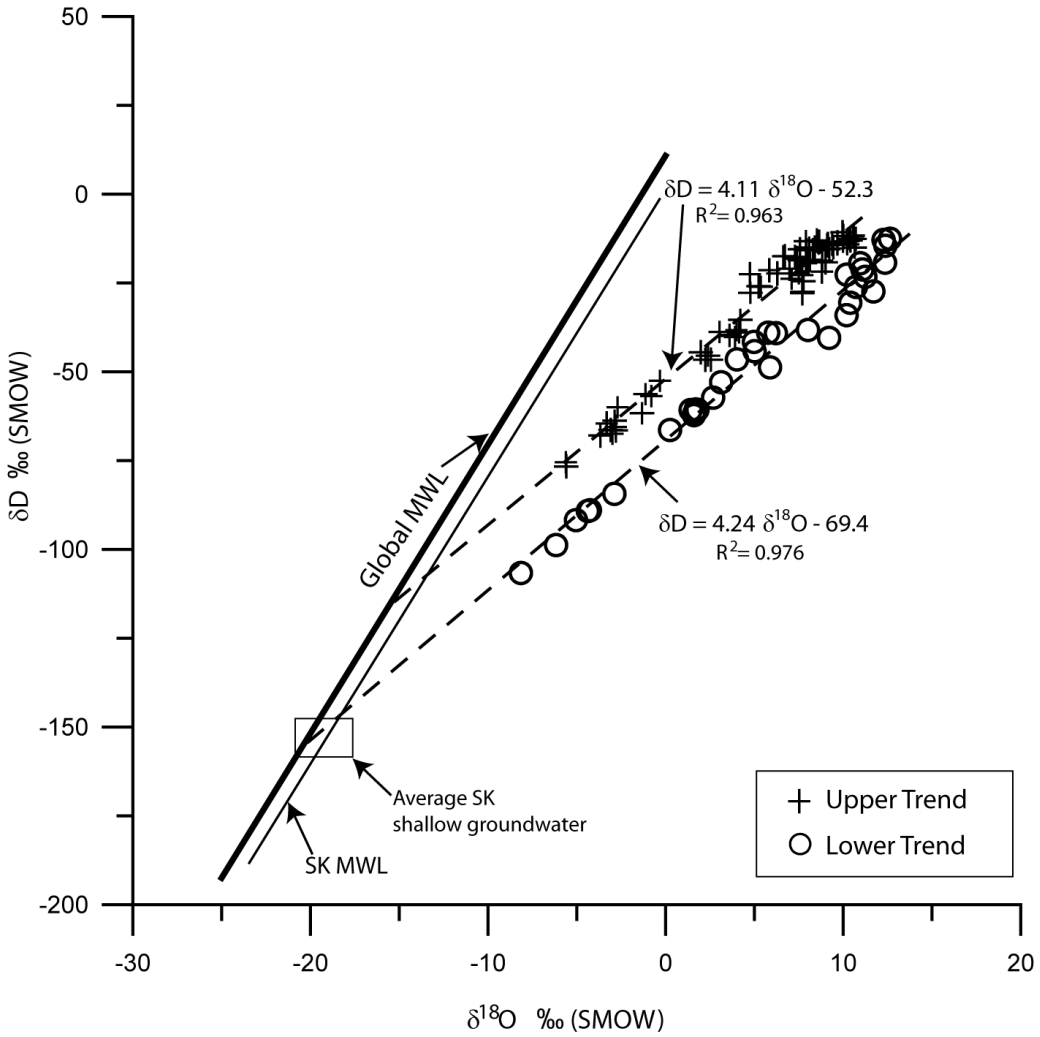

Figure 1: δD vs. $\delta^{18}O$ with data separated geographically and isotopically SK MWL modified from McMonagle 1987.