

## Strontium Isotope Evolution of Produced Water in the East Poplar Oil Field, Montana

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The East Poplar oil field on the Fort Peck Indian Reservation in eastern Montana has been in production for more than 60 years, largely from the Charles Formation of the Mississippian Madison Group. The Poplar dome is in the western part of the Williston Basin and is breached by faults and modified by local dissolution of Mississippian evaporites as described by Orchard in 1987. Because of past disposal practices, groundwater in the shallow aquifers has been contaminated in places by oil-field brines with salinities up to several times that of sea water. In cooperation with the Fort Peck Tribes' Office of Environmental Protection, the U.S. Geological Survey is continuing hydrochemical studies with the addition of strontium (Sr) isotopes as described by Peterman and others in 2010.

Samples of uncontaminated and progressively more contaminated groundwater from domestic wells show little variability in  $^{87}\text{Sr}/^{86}\text{Sr}$  values averaging  $0.70817 \pm 0.00017$  (2 S) but a fifty-fold increase in Sr concentrations (0.24 to 12.5 mg/L). Twenty samples of brine collected directly from producing oil wells define two isotopic groups. One group (10 samples) has a small range in  $^{87}\text{Sr}/^{86}\text{Sr}$  ( $0.70816 \pm 0.00024$  with 12.2 to 338 mg/L Sr) and could possibly represent the groundwater contaminant. The other group has a larger range in  $^{87}\text{Sr}/^{86}\text{Sr}$  ( $0.71061 \pm 0.00190$  and 34.5 to 51.7 mg/L Sr) and likely could not have produced the contaminant trend. Two of the brine samples in this second group are from the Late Mississippian Heath Formation overlying the Madison Group and have  $^{87}\text{Sr}/^{86}\text{Sr}$  values of 0.70928 and 0.70942. The remaining samples in the second group with  $^{87}\text{Sr}/^{86}\text{Sr}$  from 0.70962 to 0.71175 are identified as being from the Charles Formation or more generally from the Madison Group, and these brines have possibly migrated upward from older clastic units along faults or by cross flow concomitant as a consequence of the extended production from the Charles Formation. This is consistent with the suggestion of Jarvie (2001) that oil from the Bakken Formation has mixed with oil from the overlying Charles Formation in the East Poplar oil field.