Strontium Isotope Detection of Produced-Water Contamination of Wetlands, Williston Basin, Montana and North Dakota

Zell E. Peterman[1], Kiyoto Futa[1], Joanna Thamke[2], and Todd Preston[3]
U.S. Geological Survey, [1]Denver, CO, [2]Helena MT, [3]Bozeman MT
peterman@usgs.gov

Wetlands (small lakes and sloughs) in northeastern Montana and western North Dakota are susceptible to contamination from produced water as a result of a half-century of petroleum production in the Williston Basin. The salinity of some of these lakes increases seasonally due to evaporation and some are perennially saline. These naturally saline lakes are generally a sodium sulfate type water, whereas produced waters are sodium and chloride dominated. However, distinguishing between natural salinity and salinity from contamination can be challenging using only major-ion chemistry because of overlapping compositions. Although evaporation increases salinity, it will not change the strontium isotopic composition expressed as δ^{87}Sr, the per mil deviation of $^{87}Sr/^{86}Sr$ from the value for modern sea water. In contrast, contamination of natural water by produced water with different Sr concentrations and δ^{87}Sr values will define predictable mixing systematics.

In an initial investigation, we sampled lakes, shallow groundwater, and produced water within a square-mile area in northeastern Montana; δ^{87}Sr values generally decrease with increasing Sr content. The produced-water sample has the largest Sr content (168 mg/kg) and smallest δ^{87}Sr (-1.67‰), both of which are in the range of values (39 to 617 mg/kg of Sr; δ^{87}Sr -1.30 to -1.79‰) reported by Quattrocchi and others in 2006 for 43 produced-water samples from the Weyburn field in Saskatchewan, about 60 miles north-northeast. One wetland sample has the largest δ^{87}Sr value of +1.72‰ and a Sr content of 0.43 mg/kg. A mixing model with a constant δ^{87}Sr value +1.72‰ and variable Sr concentrations from 0.5 to 5 mg/kg for the uncontaminated end member indicates that a sample of known contaminated groundwater with a Sr content of 36.9 mg/kg and a δ^{87}Sr of -1.30‰ contains about 18 percent produced water. The remaining 7 samples of shallow groundwater with values between -0.94 and +0.21 may be slightly contaminated with less than 3 percent produced water. Results from this initial investigation show that very small amounts of produced-water contamination are detectable using mixing systematics based on Sr isotopes and Sr concentrations.