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ABSTRACT TITLE: Isotopic Signatures of Groundwater Sources at the Rifle Site

ABSTRACT: The DOE's Old Rifle site is a former uranium mill site situated on a floodplain of the Colorado River in western Colorado. The geology of the site consists of 6-7 m of Quaternary alluvium overlying a relatively impermeable unit of the Tertiary Wasatch Formation. A 2-3m thick perched water aquifer on top of the Wasatch contains elevated concentrations of uranium that are derived from a combination of uranium left from the milling activities and elevated natural uranium in the groundwater. Understanding the importance of the various possible sources of uranium is key to determining realistic remediation goals for the site. To assess the importance of external background sources of uranium, we are conducting a chemical and isotopic study of potential sources of the groundwater at the site.

The Rifle floodplain is bounded on one side by the Colorado River and a combination of eroded units of the Wasatch Formation and terraced Quaternary alluvial deposits around the rest of the floodplain. Additional potential sources of groundwater include surface infiltration. Water derived from the Colorado River is very dilute and contains very low levels of uranium. Surface infiltration is limited by clay-rich sediments from the alluvium used to cover the site following removal of contaminated sediments in the 1990s. These clay-rich units also cover much of the terraced alluvial deposits adjacent to the site, suggesting that infiltration through those sediments is also limited and possibly similar in chemistry to infiltration at the site.

Water samples from seeps and springs emanating from eroded exposures of the Wasatch Formation have the highest dissolved salt concentrations including sulfate concentrations as high as 31.5 mM (compared to <1 mM in the Colorado River and ~2 mM in seeps from the overlying alluvium) with $\delta^{34}S$ values as low as -18‰. These high sulfate concentrations and low $\delta^{34}S$ values are attributed to dissolution of gypsum veins in the Wasatch with $\delta^{34}S$ values as low as -56‰ that were derived from rapid oxidation of localized deposits of reduced organic matter in the Wasatch Formation (Conrad et al., in prep). The high sulfate waters also have uranium concentrations as high as 0.65 µM, which could also be derived from the oxidation of the reduced zones. The maximum uranium concentrations measured in the Rifle groundwater are ~1.5 µM, suggesting that as much as 40% of the uranium in the groundwater is derived from natural sources. Sulfate concentrations in Old Rifle groundwater are also elevated (up to 10 mM) and have low sulfur isotope ratios ($\delta^{34}S$ values as low as -10‰). Simple mixing models indicate that 30-40% of the groundwater in the Old Rifle aquifer is derived from Wasatch groundwater. There are small variations in the hydrogen and oxygen isotope compositions of the water at the site, with the two end-members being Colorado River water (average δD = -125‰, δ18O = -16.7‰) and the highest sulfate Wasatch waters (average δD = -107‰, δ18O = -13.4‰). This suggests that the water isotope compositions may represent a conservative tracer for inputs of Wasatch water to groundwater at the site. The $^{87}Sr/^{86}Sr$ of groundwater, springs and surface covers a wide range (0.7106-0.7112), varying systematically with Sr concentration across the flood plane. Taken together, the isotope signatures provide a promising method for distinguishing natural uranium inputs to the Old Rifle aquifer from uranium derived from the milling activity.