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Authors

Maher, Katharine
DePaolo, Donald J.
Christensen, John N.

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A coupled Sr/U isotopic method for measuring rates of silicate dissolution and infiltration rates at the Hanford Site, Wa.

Katharine Maher¹, Donald J. DePaolo² and John N. Christensen³

¹kmaher@usgs.gov

²depaolo@eps.berkeley.edu

³jchristensen@lbl.gov

Long-term vadose zone infiltration rates at the Hanford Site, Washington, are critical for assessing the transport of radionuclides to the groundwater and eventually the Columbia River. Sr isotopes (⁸⁷Sr/⁸⁶Sr) in the unsaturated zone pore water are controlled by the ratio of the dissolution rate of the solids to the infiltration flux, and therefore provide either a long-term estimate of the infiltration flux if the weathering rate is constrained, or vice versa. The ²³⁴U/²³⁸U of the pore water responds to chemical weathering, infiltration, *and* the α -recoil flux of ²³⁴Th to the pore fluid. Previous estimates of the ratio of the dissolution rate to the infiltration flux from Sr isotopes for a 70 meter vadose zone core are combined with a model describing the evolution of ²³⁴U/²³⁸U values in the pore water and solids to constrain the infiltration flux *and* dissolution rate. The weathering rates calculated from the two isotopes systems behave differently in response to the assumed value for the infiltration rate—weathering rates from the Sr method increase as a function of increasing infiltration, whereas U rates decrease as a function of increasing infiltration. This opposing behavior is due to the difference between the isotopic composition of the solids relative to the fluid at the top of the profile. The coupled model for both the ²³⁴U/²³⁸U and the ⁸⁷Sr/⁸⁶Sr data converges on a long-term infiltration flux of 3-5 mm/yr, and bulk silicate dissolution rates between 10^{-15.7} and 10^{-16.8} mol/m²/sec. This suggests that the coupled application of U and Sr isotopes in natural systems may be useful for constraining two widely important variables, fluid flow and reaction rates.

In addition, methods to accurately determine the α -recoil loss fraction in heterogeneous sediments are also compared, including geometric arguments and measurements of the ²³⁴U/²³⁸U in fine-grained size fractions and strong acid leaches. In general, strong acid leaches provide a means of quantifying both the α -recoil loss fraction, and the isotopic composition of the dissolving solids. The U-series isotopic method may be especially useful in determining solid-fluid reaction rates where precise age constraints for the system are not available because the process of α -recoil loss, when accurately quantified, provides a chronometer for the dissolution rate.