

The distribution of triple oxygen isotopes in soil pore waters from three dryland sites in the Western US

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Evaporation from soils is an important component of the terrestrial hydrological cycle that is poorly constrained in the geologic record. Triple oxygen isotope geochemistry can offer constraints on evaporation in waters and authigenic minerals: evaporation causes measurable mass-dependent variation in $^{18}\text{O}/^{16}\text{O}$ and $^{17}\text{O}/^{16}\text{O}$ ratios that differ from meteoric waters, a metric termed $\Delta^{17}\text{O}$. $\Delta^{17}\text{O}$ is analogous to d -excess in its utility for detecting evaporation in waters, but it has the distinct advantage that it can be measured in authigenic minerals (i.e., carbonate, silicate, clays) to track ancient evaporation. Understanding how the distribution of $\Delta^{17}\text{O}$ in modern soil pore waters relates to the composition and timing of recharge rainfall, depth in the soil, and theoretical predictions are critical to interpret $\Delta^{17}\text{O}$ in paleosols. We systematically studied the $\delta^{18}\text{O}$, $\delta^2\text{H}$, and $\Delta^{17}\text{O}$ values in soil pore waters and rain over two years with seasonal sampling at three dryland sites in the US: Mojave National Preserve, California; Reynolds Creek Experimental Watershed/CZO, Idaho; and Jornada Experimental Range/CZO, New Mexico. The isotopic composition of soil water reflects seasonal cycles of recharge, mixing, and evaporation. The seasonal variability is pronounced at shallow (<50 cm) soil depths (> 15 ‰ range in $\delta^{18}\text{O}$) and muted at depths > 50 cm (< 5‰ range in $\delta^{18}\text{O}$), though even the deep samples are evaporatively modified compared to local precipitation. The $\delta^{18}\text{O}$ - $\delta^2\text{H}$ values delineate "soil evaporation lines" with slopes (2.1 to 4.2) that are shallower than those of the local meteoric water lines (5.5 to 7.9). The $\delta^{18}\text{O}$ - $\delta^{17}\text{O}$ relationship (i.e., λ_{soil}) of all measured soil water samples is 0.522, a value that falls between the value for pure kinetic evaporation ($\theta = 0.5185$) and the empirical meteoric water line ($\lambda = 0.528$). Both $\delta^{18}\text{O}$ - $\delta^2\text{H}$ and $\delta^{18}\text{O}$ - $\delta^{17}\text{O}$ relationships indicate that evaporation is a major driver of isotopic variation in soil water, but that recharge and mixing alters the isotopic compositions compared to Craig-Gordon based theoretical predictions of steady-state evaporation. These soil water data will be a key part of establishing an interpretative framework for using $\Delta^{17}\text{O}$ variation in modern and