Oxygen isotope variation in pedogenic carbonates and the potential to constrain paleoaridity

EMILY J. BEVERLY[1], NAOMI E. LEVIN[1], BENJAMIN H. PASSEY[1], JAY QUADE[2]

[1]University of Michigan, Earth and Environmental Sciences, 1100 North University of Ave, Ann Arbor, MI 48109, ebeverly@umich.edu

[2]University of Arizona, Department of Geosciences, 1040 E. 4th Street, Tuscon, AZ, 85721, quadej@email.arizona.edu

Oxygen isotope distributions in pedogenic carbonates have been widely used to investigate changes in terrestrial hydroclimate and the timing of mountain uplift. However, these studies are limited by the difficulty in relating $\delta^{18}O$ values of pedogenic carbonates ($\delta^{18}O_{pc}$) to $\delta^{18}O$ values of local meteoric waters ($\delta^{18}O_{mw}$), given the influences of seasonality, soil temperature and soil water evaporation. Clumped isotope (Δ_{47}) measurements of pedogenic carbonates make it possible to constrain soil temperature and then in combination with $\delta^{18}O_{pc}$ values, calculate the $\delta^{18}O$ value of soil water ($\delta^{18}O_{sw}$). Understanding the relationship between $\delta^{18}O_{sw}$ and $\delta^{18}O_{mw}$ values is critical to expanding the utility of oxygen isotope studies in pedogenic carbonates. Here, were compile new and published isotope data from pedogenic carbonates on six continents and a variety of soil orders, elevations, and climates. We use Δ_{47}-derived soil temperatures to calculate $\delta^{18}O_{sw}$ values where available and then compare these values to local mean $\delta^{18}O_{mw}$ values to calculate $\varepsilon_{sw\text{-}mw} = \delta^{18}O_{sw}\text{-}\delta^{18}O_{mw}$. When we compare $\varepsilon_{sw\text{-}mw}$ values to local climate and geographic parameters, we observe a negative correlation with the aridity index (AI = precipitation/ potential evapotranspiration). We view the negative relationship between AI and $\varepsilon_{sw\text{-}mw}$ as indicative of the degree to which soil evaporation alters $\delta^{18}O_{sw}$ values relative to input $\delta^{18}O_{mw}$ values. Understanding the systematics of $\delta^{18}O$ values in modern soils using existing $\delta^{18}O$ and Δ_{47} data from modern pedogenic carbonates sets up a framework for developing triple oxygen isotopes ($^{16}O\text{-}^{17}O\text{-}^{18}O$) to constrain the effects of soil water evaporation on $\delta^{18}O_{pc}$ values. Ultimately the use of $^{16}O\text{-}^{17}O\text{-}^{18}O$ measurements in pedogenic carbonates will extend the utility of these records because it can be used both as a metric of paleoaridity and to facilitate reconstructions of $\delta^{18}O_{mw}$ values. Preliminary results indicate that the combination of Δ_{47} and $^{16}O\text{-}^{17}O\text{-}^{18}O$ in carbonates will be a powerful tool to quantify hydroclimate change in terrestrial paleoenvironments.