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Investigating soil water movement and pedogenic carbonates formation by measuring the stable isotope composition of water in Vertisols

Okafor, B.[1], Breecker, D.[1], and Warden, J.[2]
Bokafor1208@gmail.com
1. Jackson School of Geosciences, University of Texas at Austin, Austin, TX, USA

Water movement in soils plays a critical role in plant growth, the transport of dissolved species, and the recharge of subsurface reservoirs (Gazis, 2004). In this study we trace water using stable oxygen and hydrogen isotope ratios in clay-rich soils (Vertisols) that are common on floodplains in central Texas and the uplands of the Blackland Prairie. Our objectives are twofold. First, a better understanding of water movement in these soils would help improve water management and irrigation operations and also models of contaminant transfer from the surface to groundwater. Second, water movement in these soils influences the formation and oxygen isotope composition of pedogenic carbonate. Floodplain Vertisols are good modern analogs for many of the paleosols typically used to reconstruct past climates. Therefore improved understanding of modern Vertisols helps interpret the oxygen isotope composition of paleosol carbonate nodules.

We hypothesize that: 1) evaporation occurs deeper in Vertisols than other soils and 2) that peodgenic carbonate records the oxygen isotope composition of mean annual precipitation. Previous natural abundance isotope tracer work indicates that evaporation is typically limited to the top 20cm in soils (Gazis 2004). Evaporation from clayey soil is expected to be different because clay rich soils crack when dry, exposing deeper parts of the soil to air.

On September 17, 2012, we collected soil samples from the top meter of a Trinity River floodplain Vertisol on Richland Creek Wildlife Management Area, southeast of Dallas, Texas. Soil water was extracted from soil samples by boiling under vacuum for isotopic analysis and gravimetric water content was measured for each soil sample. Our results show that water content generally decreases with depth in the top meter and that soil samples with the lowest water content have the lowest $\delta^{18}O$ and δD values ($\delta^{18}O$ = -6‰ at 100 cm). These trends in water content and isotopic composition are the opposite of the trends expected for evaporation of water. The $\delta^{18}O$ value of soil water at 100 cm is substantially lower than the $\delta^{18}O$ value of mean annual precipitation in Austin and similar to the $\delta^{18}O$ value of precipitation that falls during large events ($\delta^{18}O$ = -7‰ Pape, 2010). This suggests that large rainstorms may preferentially recharge the deeper portions of these slowly permeable (when wet) soils. This interpretation requires continued monitoring to verify. If true, the $\delta^{18}O$ value of pedogenic carbonate in clay rich paleosols may be biased toward the $\delta^{18}O$ values of large events. The variation in isotopic composition with depth in these soil profiles could illustrate the alternation between large and small rain events.

If large rainstorms are proven to be the main source for recharge in deeper sections of Vertisols, improved irrigation operations would have to be made for deep rooted crops during periods of frequent small rain events. Also contaminants infiltrating into groundwater resources would be important mainly during large rain events, since small events would not infiltrate deep enough to recharge aquifers.

Keywords: Vertisols, Stable Isotopes, Groundwater Recharge, Evaporation, Pedogenic Carbonate