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U-series and Sr isotope systematics in soil carbonates from natural and managed dryland Critical Zones: Implications for inorganic carbon storage and transformation in dryland soils of the American Southwest

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Soil carbonates are dominantly present in dryland Critical Zone (CZ) and their formation could lead to important long-term carbon sequestration in arid to semiarid soils, or short-term storage in groundwater aquifers underneath drylands, depending on the Ca sources derived from silicate vs. carbonate weathering. In managed dryland CZ systems such as agricultural areas converted from natural drylands, irrigation has a profound effect on the dryland CZ carbon systems, especially by modifying soil carbonates such as altering their dissolution/precipitation dynamics. It is important to study the primary factors controlling soil carbonate dissolution/precipitation kinetics in managed dryland CZ systems, such as irrigation intensity and water chemistry, soil properties and hydrological flows. One key knowledge gap is to detect the formation of soil carbonates under irrigated conditions and distinguish them effectively from soil carbonates formed under natural conditions.

Here, we explore the potential of using U-series and strontium isotopes to investigate and distinguish the formation timescales and conditions of soil carbonates in both natural and managed dryland Critical Zones in American Southwest. We obtained new U-series and Sr isotope results from mature stage V soil carbonates in the Jornada Basin of southern New Mexico and compared to previously published U-series and Sr isotope results for younger Jornada soil carbonates as well as irrigation impacted soil carbonates from the Rio Grande alluvial valley in west Texas. Specifically, we applied the U-series dating method to study the timescales of soil carbonate formation in response to the climatic variabilities in the past (glacial or interglacial periods) and under managed conditions (modern irrigation). Furthermore, we focused on the initial ($^{234}U/^{238}U$) activity ratios recorded in soil carbonates to understand how they reflect the availability of soil moisture and changes in soil infiltration rates in CZ. We also compared Sr isotope ratios in soil carbonates, dust, and irrigation water to trace the Ca sources in soil carbonates. Our preliminary results show that U-series and Sr isotope systematics in soil carbonates characterize important differences in their Ca sources, timescales of carbonate formation and transformation, and environmental conditions (soil moisture and infiltration) in both natural and managed dryland Critical Zones.