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Sub-millennial scale reconstruction of late Quaternary critical zones in Utah, USA using laminated soil carbonate rinds

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Soil carbonate is calcite ($CaCO_3$) that forms in dryland soils worldwide. It has been widely used as a paleoclimate archive on long timescales (>10^5 yr) because its carbon and oxygen isotope composition are related to vegetation and soil water isotopes during the time of formation. Advances in high-resolution techniques now permit paleorecord development from laminated soil carbonates on Quaternary timescales (0–2.7 Ma) with data resolution of 10^2–10^3 yr, as demonstrated by studies in the United States (USA), Syria, Turkey, and Siberia [e.g., 1, 2]. For example, in our prior work, we generated ^{14}C, clumped isotope, δ^{18}O, and δ^{13}C transects from a southern Utah (USA) laminated rind [2]. The fidelity of the 35–5 ka records of temperature, soil water, and vegetation is supported by prior regional inferences.

Here, we assess how laminated rinds will provide new kinds of information about ancient soils. The western USA had large changes in the geographic and elevational distribution of plants and moisture during the last glacial period [e.g., 3], but soil responses remain difficult to assess. We are therefore using a suite of six laminated rinds from southern Utah to explore critical zone changes over a ≈750 m elevation gradient. Preliminary radiocarbon dates are in stratigraphic order and rinds grew from the last glacial period into the Holocene (<11.8 ka). Six SIMS-based δ^{18}O transects range from approximately -15 to -5 ‰ VPDB, with individual transects having internal variability between 3 to 10 ‰. We hypothesize changes in the seasonal timing of soil carbonate formation (e.g., spring to summer) caused the larger δ^{18}O ranges. Interestingly, however, elevation is a poor predictor of average δ^{18}O values and δ^{18}O variability, potentially indicating site-specific controls. These inferences are intriguing, especially in the context of forthcoming carbon isotope and clumped isotope records (proxies for vegetation and soil temperature, respectively), and highlight the sensitivity and heterogeneous responses of dryland soils to climate change.

References

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