Goldschmidt 2026 Abstract
https://doi.org/10.46427/gold2026.34983

Joining Tooth Enamel Triple Oxygen Isotope Data and Body Water Modeling to Infer Hydroclimate Change: Evaluating Interpretive Frameworks and Paleo-humidity with Late Quaternary Fossils

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Tooth enamel triple oxygen isotopes ($\Delta'^{17}O_{enamel}$; paired enamel $\delta^{18}O$ and $\delta^{17}O$ measurements) have been proposed as a tool for reconstructing terrestrial aridity. This interpretation has been supported by both modern tooth enamel datasets and isotope body water models which suggest that $\Delta'^{17}O_{enamel}$ values are lowest under low relative humidity. Among different taxa, the relationship between $\Delta'^{17}O_{enamel}$ and humidity is accentuated in animals which maintain water balance predominately via free water consumed in leaves, while the relationship is reduced or absent in animals that maintain water balance by drinking large quantities of water.

We test the utility of $\Delta'^{17}O_{enamel}$ as a paleo-humidity proxy by combining isotope measurements with body water models. We selected north-central Texas as our study region and obtained fossil enamel from sites spanning the last ~30 ka. We analyzed $\Delta'^{17}O_{enamel}$ values from taxa which we expect represent various strategies for maintaining water balance. Among the fossil taxa, we expected $\Delta'^{17}O_{enamel}$ values of white-tailed deer, pronghorn, and camelids to strongly reflect humidity changes, while we expected beavers, mammoths, and mastodons to be relatively insensitive to humidity changes. With $\Delta'^{17}O_{enamel}$ values, we are able to investigate the water use ecology of extinct and extant taxa. Indeed, we observe the lowest $\Delta'^{17}O_{enamel}$ values among white-tailed deer, pronghorn, and camelids, while beavers, mammoths, and mastodons have higher $\Delta'^{17}O_{enamel}$ values. We complement the white-tailed deer observational data with a comprehensive isotope body water model. The model is tuned to white-tailed deer as i) the biological and ecological parameter values for this species are relatively well-constrained, ii) white-tailed deer are the most common individuals sampled in our fossil assemblages, and iii) we expect white-tailed deer $\Delta'^{17}O_{enamel}$ values to be sensitive to humidity changes. By combining the $\Delta'^{17}O_{enamel}$ data with deterministic solutions to the body water model, we aim to establish whether quantitative, robust paleo-humidity estimates can be generated using this approach. More broadly, our study represents important advances including, 1) critically evaluating the utility of $\Delta'^{17}O_{enamel}$ for better paleo-hydroclimate reconstructions and 2) using $\Delta'^{17}O_{enamel}$ to test hypotheses of water use strategies for extinct taxa.