

Deconvolving oxygen isotope signatures of lacustrine carbonates to reconstruct the composition of paleo-precipitations

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The isotopic signature of paleo-precipitation is an important tracer for past climates. Although direct evidence of isotopic composition of past rainfall is restricted to ice cores and mineral fluid inclusions, it is also possible to reconstruct the oxygen-isotope composition of precipitation using minerals and biominerals preserved in sediment records, including those of carbonate lakes. In lakes with short residence time and minimal evaporative enrichment or catchment effects, the oxygen isotope composition ($\delta^{18}\text{O}_{\text{lake}}$) should very closely reflect the isotopic composition of paleo-precipitation ($\delta^{18}\text{O}_{\text{ppt}}$). In turn, the $\delta^{18}\text{O}_{\text{lake}}$ is an important control on the oxygen isotope composition of the lacustrine carbonate ($\delta^{18}\text{O}_{\text{CaCO}_3}$), along with the temperature of calcification (T_{calc}). If we are able to independently infer T_{calc} and isotopic equilibrium between water and calcite is confirmed (or any offsets constrained), $\delta^{18}\text{O}_{\text{lake}}$ can be reconstructed from $\delta^{18}\text{O}_{\text{CaCO}_3}$.

However, evaporative enrichment and other hydrological effects can modify the isotope composition of lake water, especially in shallow lakes with longer residence times. In such cases, the resulting complex signatures recorded in sediments need to be deconvolved using independent estimates of $\delta^{18}\text{O}_{\text{lake}}$ and/or water temperature.

Ultimately, reconstructions of the isotopic composition of rainfall from lacustrine carbonates can be directly compared to isotopically-enabled climate model. Forward modelling with output from GCMs equipped with isotope diagnostics can greatly enhance our understanding and help quantify uncertainties in paleo-precipitation reconstructions.