What ^{17}O-excess may tell about evaporation in the past

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Deviations of triple oxygen isotope ratios from the meteoric water line ($^{17}O_{excess}$) can be extracted from gypsum, carbonates, amorphous silicates and ice. The underlying evaporation fundamentals in nature are now sufficiently understood that this parameter may become a useful quantitative tool in (paleo)hydrology.

Case studies from ponds and lakes desert in Chile (Atacama) and Iran (Sistan Province) demonstrate that the two fundamental types of evaporation - with and without constant recharge - imprint a specific isotopic signature of negative ^{17}O-excess and positive δ^{18}O values on the remaining water. Magnitudes depend strongly on humidity as predicted by the classic Craig-Gordon model. Authigenic mineral precipitates inherit this signature either in structurally bound water or in components that are in equilibrium with water while dissolved. Increasing evaporative loss - either between adjacent lakes or between different stages in the same lake over time - result in characteristic trends defined mostly by relative humidity. It is principally possible to reconstruct paleohumidity changes from lake sediments, or even absolute values as was recently demonstrated [1]. Generally, a successful reconstruction depends on two aspects. The first is the correct identification of reacharge and non-recharge evaporation conditions. The other is the magnitude of the offset in ^{17}O-excess and δ^{18}O between vapor of the ambient atmosphere that the lake evaporates into, and initial groundwater or runoff water that supplies the lake. This offset determines how well evaporation trends at distinct relative humidities are resolvable.

A case study from the glaciated German high Alps reveals another aspect of evaporation that may become available from ^{17}O-excess studies. Local winter and spring vapor appears to fall on well-defined mixing lines between the local evaporation end-member with distinctively positive ^{17}O-excess and negative δ^{18}O values, and the advected moisture's initial that is comparatively insensititve to variable moisture recycling along the air trajectory from its Atlantic source. If that finding can be reproduced elsewhere, it may become possible to reconstruct the past's regional hydrologic balance of high altitude glaciers from ice and snow pit records.

[1] Gazquez et al. (2018), Earth Planet. Sci. Lett. *481*.