

Triple oxygen and hydrogen isotopes in hydration water of lacustrine gypsum for quantitative paleo-humidity estimates

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Triple oxygen and hydrogen isotopes of water during evaporation show different sensitivities to environmental parameters (e.g. temperature, relative humidity, etc.) [1,2]. Small deviations in the $^{17}\text{O}_{\text{excess}}$ and d-excess of meteoric waters can provide insights into environmental conditions at the time of water evaporation [2]. Recent studies have demonstrated that under certain conditions, gypsum hydration water (GHW) of lacustrine sediments preserves its original isotopic composition ($\delta^{17}\text{O}$, $\delta^{18}\text{O}$ and δD) and can be used to reconstruct the isotopic composition of paleo-water [4,5].

Here we reconstruct the triple oxygen and hydrogen isotopic composition of Lake Estanya (NE Spain) by measuring GHW and applying an isotopic mass balance to quantify changes in relative humidity (RH) in the western Mediterranean during the late Glacial-Holocene transition and the Holocene (15 to 0.6 ka). Monte Carlo simulations were used to find the most probable solutions to the model on the basis of previous regional and local paleoclimatic proxies. When the model is forced to satisfy both $^{17}\text{O}_{\text{excess}}$ and d-excess of the paleo-lake water, the number of possible solutions is drastically reduced and errors of ~3-5% (1σ) for RH can be achieved.

Using this approach, the isotopic values of Lake Estanya water during the Younger Dryas (~12.5 ka) are best fit by a RH of ~40-45% and windier conditions. This period was considerably drier and windier than the previous Bölling-Allerød period (~55-65% RH) and the latter Preboreal stages (~50-55% RH). Inferred Holocene RH values stabilized at around 70-75%, which is similar to the modern conditions in this region. Our study shows that coupling triple oxygen and hydrogen isotopes in GHW is a powerful new tool for quantitatively estimating paleoenvironmental conditions.

[1] Angert et al., (2004) *Geochim. Cosmochim.* **68**, 3487-3495; [2] Luz and Barkan (2010) *Geochim. Cosmochim.* **74**, 6276-6286; [3] Surma et al., (2015). *Geophys. Res. Lett.* **42**, 8456-8462. [4] Hodell et al., (2012) *Geochim. Cosmochim.* **77**, 352-368; [5] Grauel et al., (2016) *Earth Planet. Sci. Lett.* **438**, 37-46.