

A Multi-Proxy Speleothem Approach to Understanding the South American Monsoon System During the Last Glacial Cycle

Parmenter, D; Olson, E J; Velasquez, H; Clavel, A; Verheyden, A; Piccirillo, L; Rodbell, DT; Gillikin, DP; Edwards, RL

For the past few decades, many researchers have sought to understand how tropical hydroclimate responds to climate change via lakes, marine sediments, and speleothems records. Speleothem $\delta^{18}\text{O}$ records throughout South America have shown that regional rainfall responds to Northern Hemisphere forcing on the millennial scale. Areas under the influence of the South Atlantic Convergence Zone (SACZ) have also shown a close relationship with local insolation on longer timescales. However, apart from the Cruz et al. (2007) record in Southern Brazil, long-term speleothem records throughout the continent have relied primarily on stable oxygen isotopes and are therefore limited to describing large-scale regional variability in rainfall. As such, many areas in South America still lack long-term records of local hydroclimate, which is critical to understanding how different components of the monsoon system respond to orbital and millennial-scale climate change. One proxy that has gained more attention in recent years is trace metal-to-calcium ratios (TM/Ca). Sr, Mg, and Ba to Ca ratios in speleothems are known in certain situations to respond to the degree of Prior Calcite Precipitation (PCP) above a drip site, a phenomenon directly tied to local aridity. In this study, we have obtained high-resolution TM/Ca measurements to pair with stable isotopes from samples spanning 23 to 66 ka from Huagapo Cave in the Peruvian Andes (11.27°S; 75.79°W). TM/Ca ratios in these samples are strongly correlated ($R^2 > 0.89$), making them suitable for use as PCP proxies. We see that decreases in $\delta^{18}\text{O}$ during Heinrich events are accompanied by a drop in TM/Ca. The period defined by the MIS 4/3 transition is accompanied by a simultaneous increase in TM/Ca and $\delta^{18}\text{O}$. TM/Ca and $\delta^{18}\text{O}$ negatively correlate with local insolation for the entire record. Interestingly, the Paraíso Cave record from the Amazon Basin shows no correlation between regional or local hydroclimate and insolation during the last glacial period. The discrepancy between the two records and the close relationship between TM/Ca, $\delta^{18}\text{O}$, and local insolation in Huagapo samples, may call for a revised interpretation of Andes speleothem $\delta^{18}\text{O}$ variability, which was originally thought to reflect rainout over the Amazon Basin.

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