Triple oxygen isotopes of speleothems in the Amazon and southern China provide independent support for prior $\delta^{18}O$-based interpretations

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Speleothem oxygen isotope ($\delta^{18}O$) records have provided important insight into the timing and rate of change of Quaternary hydrologic processes. However, it can be difficult to parse how the $\delta^{18}O$ signal relates to the multitude of processes affecting drip-water and speleothem carbonate $\delta^{18}O$. We used a triple oxygen isotope framework to test interpretations of $\delta^{18}O$ speleothem records from Paraiso Cave (eastern Amazon, Brazil) and Shima Cave (central China). This framework identifies the dominant processes driving $d^{18}O$ through time through their characteristic trends in $\delta^{18}O$ vs. $\Delta'^{17}O$ space, where $\Delta'^{17}O = \ln(\delta^{17}O + 1) - 0.528\ln(\delta^{18}O + 1)$. For example, within-cave kinetic processes (e.g., drip rate) produce positive trends, Rayleigh distillation produces near-horizontal trends, and evaporation produces negative trends.

The Paraiso Cave speleothem $\delta^{18}O$ record shows a six per mil decrease from the Last Glacial Maximum (≈25 ka) to the mid-Holocene (≈5 ka). This record was previously interpreted as largely the result of variable precipitation (i.e., Rayleigh distillation; 58 to 142 % of modern levels, respectively). Our carbonate triple oxygen isotope data show a trend of -1.1 per meg/‰ (r^2 = 0.83), consistent with this view.

The Shima Cave speleothem $\delta^{18}O$ record shows a four per mil decrease over the most recent deglacial transition (20–13 ka with a hiatus from 18–16 ka). Records from southern China are commonly interpreted in terms of the Asian Monsoon (e.g., differing degrees of Rayleigh fractionation/integrated rainout from tropical oceanic source regions and changing proportions of moisture sources). Our data show a trend of 1.4 per meg/‰ (r^2 = 0.53). The relatively low slope of the trend suggests that Rayleigh distillation is important and, as modern precipitation data from Okinawa, Japan show a positive slope, the data may be explained as a mix of Rayleigh distillation and precipitation source seasonality, supporting previous interpretations.

For both cave systems, triple oxygen isotope data provide an independent line of support for prior interpretations. We conclude that such data, even at low temporal resolution, may be used to better constrain interpretations of higher resolution speleothem $\delta^{18}O$ records, providing an avenue for more robust quantitative paleoclimate reconstructions.