Dual-clumped Isotope measurements of Speleothems from Paraíso Cave, Eastern Amazon Lowlands, and paleotemperature reconstruction

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The application of clumped isotope paleothermometry to speleothems is known to be complicated by potential kinetic effects that will result in inaccurate carbonate formation temperatures [1, 2]. Dual-clumped isotope measurements (Δ_{47} and Δ_{48}) have been suggested as a means to detect and potentially correct for kinetic effects, but more datasets on natural speleothems are required to assess this method [3, 4]. If this is settled, dual-clumped isotope analysis can be applied for more precise paleotemperature reconstructions and supplement traditional isotope ($\delta^{18}O$ and $\delta^{13}C$) records of speleothems.

Here, we present new dual-clumped isotope data (samples n=16) of stalagmites from Paraíso Cave, Brazil, spanning Marine Isotope Stage 4 (~69 ka) to the late Holocene (~0.8 ka). The previously published $\delta^{18}O$ record of Paraíso Cave provides a rare record of tropical climate for the past 45,000 years. It shows a large decrease of ~ 6 ‰ from the late Glacial into the Holocene, which has been interpreted as increased extent of Rayleigh distillation and therefore precipitation amount in the Holocene compared to the late Glacial [5].

The new dual-clumped isotope data show (near-)equilibrium carbonate formation conditions for most samples. Reconstructed paleotemperatures from Δ_{47} measurements ($T(\Delta_{47})$) average 27 °C, within the range of modern cave temperature of 24 – 27 °C. Our data do not indicate variable kinetic fractionations, supporting the previous climate-based interpretations of the $\delta^{18}O$ record. The reconstructed $T(\Delta_{47})$, if taken at face value, indicates that the cave was not significantly cooler during the Last Glacial Maximum (LGM) compared to the modern. Following on the suggestion of drier LGM climates based on the $\delta^{18}O$ record, this might be explained by increased solar heating of the ground during the LGM due to lower plant cover and drier soil, which may have offset the effect of cooler LGM air temperatures. Our study indicates that the dual-clumped isotope analysis can be a powerful tool for paleoclimate reconstructions using speleothems, supplementing traditional isotope records.

References

[1] Affek et al. (2008), Geochim. Cosmochim. Acta 72, 5351–5360
[2] Daëron et al. (2011), Geochim. Cosmochim. Acta 75, 3303–3317
[3] Bajnai et al. (2020), Nat. Commun 11, 4005
[4] Guo and Zhou (2019), Geochim. Cosmochim. Acta 267, 196–226
[5] Wang et al. (2017), Nature 541, 204-207