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Revisiting Indian Summer Monsoon Reconstructions using Triple Oxygen Isotopes in Speleothems

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Indian Summer Monsoon (ISM) rainfall, the strongest monsoon domain on Earth, has shown significant decline in the second half of the twentieth century. The extent to which this instrumentally recorded decline reflects natural variability demands an understanding of the forcings on multi-decadal to orbital timescales. Palaeomonsoon reconstructions using speleothems from twenty-one Indian caves[1], largely based on conventional oxygen isotope ratio ($\delta^{18}O$), have provided valuable insights into ISM variability. However, such interpretations can overstate the climatic signal due to possible influences from kinetic effects and variations in temperature, precipitation amount, moisture source and transport.

In this context, triple oxygen isotopes systematics ($\Delta'^{17}O$), have recently emerged as a complementary proxy, offering additional constraints on hydrological processes. Mass-dependent deviations from the expected proportionality between $\delta^{18}O$ and $\delta^{17}O$ during equilibrium and kinetic processes, with negligible influence from temperature, provide information on humidity in source regions. We will present investigations of paired speleothem-dripwater samples from Indian caves. Oxygen fractionation factors ($^{17}\alpha$ and $^{18}\alpha$) derived from modern dripwater-speleothem pair can verify kinetic effects in the contemporary cave environment. A cave setting found to be suitable in the present, with poor ventilation facilitating slow CO_2 degassing and DIC re-equilibration, would likely have equilibrated speleothems given the progressive nature of karst dissolution. These fractionation factors and speleothem isotopic compositions can then be applied to reconstruct the $\Delta'^{17}O$ of parent waters and delineate the influencing factors.

A prerequisite for such applications is the standardisation of $\Delta'^{17}O$ measurements in carbonates using platinum catalysed CO_2-O_2 exchange method. We have resolved the theoretical-experimental gap in the $^{17}\alpha$ and $^{18}\alpha$ values. Using a modified experimental design, we confirmed that the deviations arise from thermal gradient. We will present corrected values of $^{17}\alpha$ and $^{18}\alpha$ accounting for the thermal gradient between hot and cold parts of the exchange reactor, an unavoidable component of CO_2-O_2 exchange system. This will allow accurate estimation of $\Delta'^{17}O$ values in carbonate-derived CO_2, strengthening the application of triple oxygen isotope systematics.

References

[I] Comas-Bru et al. (2020), Earth System Science Data 12 (4)