Reconstructing rainfall from growth, trace-elements, and novel isotopes in speleothems

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Speleothems have become firmly established as archives of continental palaeoclimate. They provide some of the best-dated climate records available for the Pleistocene, and can be subsampled at resolutions as high as seasonal, offering potential to assess long-term climate changes at unprecedented resolution. A major goal of paleoclimate reconstruction in general is to assess past temperature, but speleothems also have potential to reconstruct rainfall patterns. This talk will overview approaches to such rainfall reconstruction; using chronology alone, with trace elements and with novel isotope systems.

Formation of speleothems requires liquid water and is not possible in particularly dry or cold environments. We will use examples from North Africa (Morroco) and Siberia as examples of the use of chronology alone to reconstruct periods of aridity and freezing respectively. The development of U-Pb approaches to date speleothems allows these reconstructions to be extended beyond the U-Th age limit into the Pliocene and older periods.

Trace element ratios in cave drip-waters are strongly influenced by water residence time in the karst, and therefore sensitive to precipitation rate. Mg/Ca ratios have been most successfully used for this approach, and are increased in dry periods due to exclusion of Mg from calcite as it forms in the overlying karst. Cd, on the other hand, is preferentially incorporated into calcite, so that dry period should lead to low Cd/Ca. We will show laboratory and field data that indicate the potential use of Cd/Ca as a rainfall indicator.

Stable isotopes of oxygen and carbon have been the most widely used tracers of paleoenvironment in speleothems, with $\delta^{18}O$ frequently used as a tracer of rainfall amount. The wide range of controls on $\delta^{18}O$ in both the atmosphere and the cave, however, make this a difficult tracer to interpret. Isotope ratios of the third major element in speleothems – calcium – have recently been shown to respond to rainfall. We will discuss the application of $\delta^{44}Ca$, and of other potential novel isotope tracers in speleothems.