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Trace element patterns across rapid climate change events in Pleistocene speleothems from caves in the Alps

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Rapid climate shifts during the last glacial period are recorded in stalagmites from the Alps providing a very close match to the Dansgaard-Oeschger (D-O) pattern known from Greenland ice cores (e.g., Boch et al., 2011). This link is provided by oxygen isotopes which largely reflect a precipitation signal in the Alps. Carbon isotopes have proven more difficult to interpret, although they provide a means to identify calcite deposition in subglacial settings.

We currently explore trace elemental concentrations as complementary proxies of climate, soil and/or karst hydrology in well-characterized stalagmites from the NALPS dataset (Boch et al., 2011) across such climate change events. The focus is on elements whose geochemical relationships in speleothems are rather well understood (e.g. Sr, Mg, P, Al, Zn, Y). Continuous trace elemental profiles were analyzed adjacent to the high-resolution stable isotope sampling track using a state-of-the-art LA-ICP-MS at RHUL, featuring a rotating rectangular aperture and a two volume LA cell (Müller et al., 2009).

Results from Hölloch cave show large variations in Al which correlate with Rb and with high abundances of fine-grained detrital material; the latter sometimes reaching several millimeters in thickness. These layers are attributed to large and sustained flooding events and Al is used as a tracer of smaller events which lack visible mud layers. Although P and Zn co-vary with Al, their variance is not as distinct and changes within the sample. Sr, Ba and Mg are correlated in some parts of the stalagmite but lack a correlation in others. D-O events identified by large shifts in O isotopes are not reflected in concomitant changes of Sr, Ba or P. Mg does not follow the first-order trends of the O isotopes either, but shows a moderate correlation with the second-order O isotope variability during stadials. A stalagmite from Beatus cave shows generally smaller variations in trace element concentrations but also no apparent relationship with O isotope shifts.

The following conclusions can be drawn from these observations: (1) Trace element variability in these Pleistocene speleothems largely reflects water-rock interactions in the karst and lacks a direct link to the atmosphere. (2) In (paleo)phreatic caves Al and other elements associated with clay minerals allow to trace palaeofloods. (3) Soil processes do not seem to control trace element patterns in the drip water and speleothems but further investigations are needed.

Boch, R. et al. (2011), Clim. Past, 7, 1247-1259
Müller, W. et al. (2009), J. Anal. Atomic Spectrom., 24, 209-214