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Temperature reconstruction from dripwater hydrochemistry, speleothem fabric and speleothem δ13C: towards an integrated approach in temperate climate caves

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Accurate reconstruction of past climate records from speleothem minerals requires a thorough understanding of both environmental and hydrologic conditions underpinning their formation. These conditions likely influenced how speleothems incorporate chemical signals that are used as climate proxies. Thus, a thorough investigation of environmental and hydrologic parameters is a pre-requisite to gain robust palaeoclimate reconstructions from stalagmites.

Here, we present a systematic study of soil, dripwater and speleothems in temperate climate caves at different altitudes, which allowed the assessment of how mean annual air temperature in the infiltration area (MATinf) influences vegetation cover, soil pCO_2 and, eventually, pCO_2 of karst water and cave air. Our study demonstrates that for caves developed in pure carbonate rocks, the soil and aquifer pCO_2 are directly related to the MATinf (Borsato et al., 2015).

It is well known that soil and aquifer pCO_2 control carbonate dissolution and the carbonate-carbonic acid system. By establishing a relationship between dripwater pCO_2 and MATinf, we show that dripwater Ca content and calcite saturation state SIcc) are correlated with MATinf when unaffected by Prior Calcite Precipitation. In particular, dripwater saturation (SIcc = 0) is reached at a MATinf of 4.4°C in our study area. This MATinf delineates a "speleothem limit", above which speleothems composed of sparitic calcite should not form (Borsato et al., 2016). In fact, sparitic calcite speleothems do not form, today, in caves with a MATinf < 4.4°C. This relationship offers the opportunity to estimate past MATinf from fossil sparitic calcite speleothems found in high-altitude caves by comparing the required SIcc for their formation to the present-day dripwater SIcc.

Furthermore, soil and aquifer pCO_2 control dripwater DIC δ13C as well as calcite δ13C in speleothems that were not significantly influenced by kinetic fractionation. A linear correlation between calcite δ13C and MATinf was obtained for modern sparitic speleothems that formed at isotopic equilibrium (Johnston et al., 2013).

The combination of these two approaches (present-day dripwater SIcc and calcite δ13C in sparitic speleothems) can be used to reconstruct the past MATinf for high-altitude caves.

References:

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