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Temporal gradient between temperature and the oxygen isotope value of precipitation in the early Eemian reconstructed from a speleothem from western Germany

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Speleothems, such as stalagmites, record the δ^{18}O value of the meteoric water that falls on the surface above the cave site. However, the δ^{18}O signals of speleothem calcite are also influenced by other, usually competing factors occurring in the soil zone above the cave as well as inside the cave on the surface of the speleothem. It is difficult to unscramble these different factors in order to recover unambiguous paleoclimatic signals.

A recently developed method utilising the noble gas concentration of the water incorporated in speleothem fluid inclusions enables the independent determination of the cave temperature at the time of speleothem formation (Kluge et al., 2008). The cave temperature usually corresponds to the mean annual air temperature above the cave. In addition, both experimental (Wiedner et al., 2008) and modelling studies (Mühlinghaus et al., 2007) improved the understanding of the isotopic fractionation processes occurring in the solution layer on the stalagmite surface and their dependence on parameters like cave temperature, drip rate and supersaturation with respect to calcite.

Here we present stable isotope data (i.e., δ^{18}O and δ^{13}C) and noble gas temperatures (NGTs) for a speleothem from Bunkerhöhle, western Germany, which was dated by ^{230}Th/U-dating. This stalagmite grew intermittently during the Eemian, Marine Isotope Stage 3 and the early Holocene. In the early Eemian the NGTs show a rise from approx. 2 to approx. 11° C. The δ^{18}O values recorded in this phase show a significant anti-correlation with the NGTs. This demonstrates that speleothem δ^{18}O reflects changes in surface temperature. Furthermore, it enables the reconstruction of the temporal relationship between the δ^{18}O value of precipitation and temperature at the cave site during the early Eemian. The reconstructed relationship is 0.14 ± 0.06 ‰°C, which is substantially smaller than the present-day spatial relationship. Further combined application of stable isotopes and NGTs on speleothems should allow the reconstruction of both the temporal and the spatial variability in the δ^{18}O values of past precipitation.

References

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