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Monitoring of Bunker Cave (NW Germany): Assessing the complexity of cave environmental parameters

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Bunker Cave (N 51°22'03", E 7°39'53") is located in the Rhenish Slate Mountains in the western part of Germany and is part of a giant cave system in the area of Iserlohn (Hammerschmidt et al., 1995).As part of the DAPHNE (**Da**ted **Sp**eleothems - arc**h**ives of the paleoenviro**n**m**e**nt) project Bunker Cave is being monitored since the end of 2006.

The ongoing monitoring program is performed on a monthly base. Surface climate parameters are measured and samples of rain water, cave air, drip water at eight different drip sites and modern calcite precipitates from watch glasses placed beneath drip sites are collected.

Data sets include temperature, precipitation, calculated infiltration, drip rates, electric conductivity, pH, alkalinity, cations, anions and stable isotopes.

Bunker Cave shows a constant temperature throughout the year. Active calcite precipitation is higher in winter than in summer, which is due to lower cave pCO_2 in winter. The generally low pCO_2 values, however, support almost continuous calcite precipitation throughout the whole year.

Drip water $\delta^{18}O$ values reflect the mean annual isotopic composition of the rainfall in this area with no or less contribution of the summer rain. The slope of the MWL for local precipitation is close to the slope of both the global MWL and the local MWL at the nearby station Bad Salzuflen. The karst aquifer is well mixed as shown by the uniform drip water $\delta^{18}O$ values. Hence, the site is well suited to detect multi-annual climate trends using stalagmite stable isotope records.

In order to test the potential influence of kinetic isotope fractionation on the stable isotope signals at Bunker Cave, stable isotope data of modern calcite precipitated on watch glasses were compared to predicted values. Comparison of the $\delta^{18}O$ values of in situ modern calcite precipitates with the $\delta^{18}O$ values expected from equilibrium isotope fractionation suggests a small kinetic influence, which is probably related to the variability in drip rate (Mühlinghaus et al., 2009).

The coefficient of variation of discharge versus the mean discharge for each drip site, allows distinguishing between different discharge behaviours (Baker et al., 1997). Seasonal drips with up to 15 ml/min as well as seepage flow with 0.002 ml/min are monitored. Most of the eight drip sites show a consistent annual drip-rate pattern with a delay of several months compared to the main infiltration events. An instantaneous response to precipitation (i.e., piston-flow) is not observed at any drip site pointing towards a specific water capacity threshold in the soil and the karst aquifer.

The dominant aqueous species in the drip water are [Ca^{2+}] and [HCO_3^-]. However, [SO_4^{2-}] also shows high concentrations. The temporal variability in the chemical composition of the drip-water indicates different processes. Dilution and the influence of prior calcite precipitation are clearly distinguishable, especially during times of lower discharge.

Baker, A., Barnes, W.L. , Smart, P.L., 1997. Stalagmite drip discharge and organic matter variation in Lower Cave, Bristol. Hydrological Processes 11, 1541-1556.

Hammerschmidt, E., Niggemann, S., Grebe, W., Oelze, R., Brix, M.R., Richter,D. K., 1995. Höhlen in Iserlohn. Schriften zur Karst- und Höhlenkunde in Westfalen Heft 1, 153 S.

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