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A long, discontinuous speleothem record of Pleistocene hydroclimate variability in Central Europe

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Speleothems, such as stalagmites or flowstones, are unique continental archives of past climate and environmental dynamics. Past climate records can be established and precisely dated by a variety of independent proxies (such as δ^{18}O and δ^{13}C) and U-series disequilibrium methods, respectively.

Here we present new speleothem δ^{18}O and δ^{13}C time series from a 1.3 meter-long flowstone core (BÄ-1) drilled in the Bärenhöhle, Swabian Alb, Southern Germany. Bärenhöhle developed in Upper Jurassic limestone in the Pliocene and Early Pleistocene under epiphreatic conditions. Cave sediments and speleothems in the Bärenhöhle can be subdivided in at least 13 periods of speleothem growth, which reveal several accumulation and erosion processes during the early and middle Pleistocene. This makes the Bärenhöhle and its speleothems major archives for reconstructing past karstification and landscape development of the Swabian Alb. Furthermore, the location of Bärenhöhle can be strategically used to reconstruct past changes of mid-European hydroclimate and associated Northern Hemisphere (NH) mid-latitude atmospheric pattern as well as shifts of regional vegetation again the outstanding potential of speleothems from Bärenhöhle.

The morphology of the flowstone core shows a complex succession of several growth periods, suggesting a discontinuous formation of BÄ-1. This is for example indicated by five thin sand layers and two soda straw layers (up to 3-4 cm think and clearly positioned in a North-South direction) where no flowstone formation occurred, related to a stream that flowed through the cave, possibly during deglaciation periods. Furthermore, the petrography of the flowstone core is varying between the different segments that are separated by the aforementioned layers. In principle two types of calcite crystal fabrics are observed, white/translucent open columnar fabrics and yellowish compact calcite fabrics, whereat open columnar fabrics appear only in upper part of the flowstone core and compact fabrics mainly in the bottom part of the flowstone core. A first set of U-Th ages and the correlation of the BÄ-1 δ^{18}O time series to the benthic stack δ^{18}O time series and a benthic δ^{13}C time series reveal that the upper half of the flowstone core grew from c. 83 kyrs to 530 kyrs. Based on these preliminary analyses we find that the flow stone core includes several glacial-interglacial cycles during the last 530 kyrs, but did not grew during peak glacial conditions during MIS 12, 10 and presumably 6.

Absolutely dating of the bottom half of the flowstone core is not possible due to the secular equilibrium of U- and Th-isotopes, but U-isotope ages, the history of cave sediments in Bärenhöhle and a first magnetic record of BÄ-1 suggest that it grew between 530 kyrs and about 1.4 million years before present. However, both δ^{18}O and δ^{13}C values from the bottom half of BÄ-1 show pronounced changes of several per mil that partially follow the bentic δ^{18}O and δ^{13}C time series, which suggest that some glacial-interglacial cycles are recorded.

In summary, our preliminary set of analyses on BÄ-1 emphasise the high potential of speleothems (including BÄ-1) and sediments from Bärenhöhle for Pleistocene climate and environmental reconstructions.