Petrographic comparison of four recent stalagmites from Baradla Cave Hungary - implications for the paleoclimate interpretation

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Baradla Cave is a world heritage site situated in the northeastern part of Hungary. The cave itself formed supposedly from the Pliocene in Mesozoic marine carbonates and today has a total length of 25 km. The climate of the area is continental most of the precipitation arrives during early-summer, however, the main infiltration period is from November to April when precipitation exceeds evapotranspiration. According to recent monitoring data, temperature in the cave varies around 9.8°C throughout the year while the pCO_2 of the cave air follows a seasonal cycle. The CO_2 mixing ratio is highest (~4200 ppm) during the summer and lowest during in winter (~1600 ppm).

The Nehéz-út ("NU") and the Vaskapu ("VK") branches are situated about 300 m away from each other and at a distance of about 1 km from the entrance of the cave. Four small, actively forming stalagmites were retrieved from here in 2014 (Fig. 1.). The aim of our study was to analyse their microfabric to improve our understanding how they can be used as proxies for environmental reconstruction.

Carbonate material for radiocarbon analysis was drilled out as 6-7 sampling lines from all four stalagmites parallel with the lamination. Petrographic thin sections were prepared and photographed under polarizing light and fluorescent blue light microscopes using 2x magnification. Lamina counting was performed along the growth axis of all stalagmites to check if the number of laminae is in agreement with the radiocarbon ages. Assuming the lamina couplets were forming annually, all radiocarbon sample lines were associated with a number of years according to the number of laminae they sampled. This way plotting the time-ranges of the radiocarbon samples derived from lamina counting against the atmospheric ^{14}C bomb peak the continuous growth and annual lamination of the stalagmites could be proved (Demény et al., 2016). The thickness of laminae was also measured in each stalagmite to compare it with the change in microfabric and isotopic composition and to check if it could be used as an independent proxy.

Using a petrographic microscope, two different types of fabrics were identified based on the samples' extinction under crossed polars: a mosaic and a columnar fabric (Frisia, 2015). The latter includes two other subtypes: columnar open fabric has high intercrystalline porosity, while the other columnar fabric is more compact. Lamina couplets in the open columnar fabric consists a thin, porous lamina, often covered by a thin detrital coating and a thicker lamina of dense calcite. In the open columnar fabric porous, inclusion-rich laminae are thicker. Comparing the average thickness of lamination we found that open columnar fabric has wider lamina couplets. Mosaic fabric was common in the very bottom of the stalagmites with no lamination and without any fluorescence.

Two of the stalagmites (NU-1 and VK-2) consist of only open columnar fabric with parts of mosaic fabric by the clay surface they grew on, one stalagmite consist of both columnar fabrics (NU-2) while the other stalagmite (VK-1) had a reasonably denser fabric with frequent and thick detrital coatings in its laminae of columnar calcite. In the latter several uneven surfaces were also identified which questioned the continuous growth of this stalagmite.

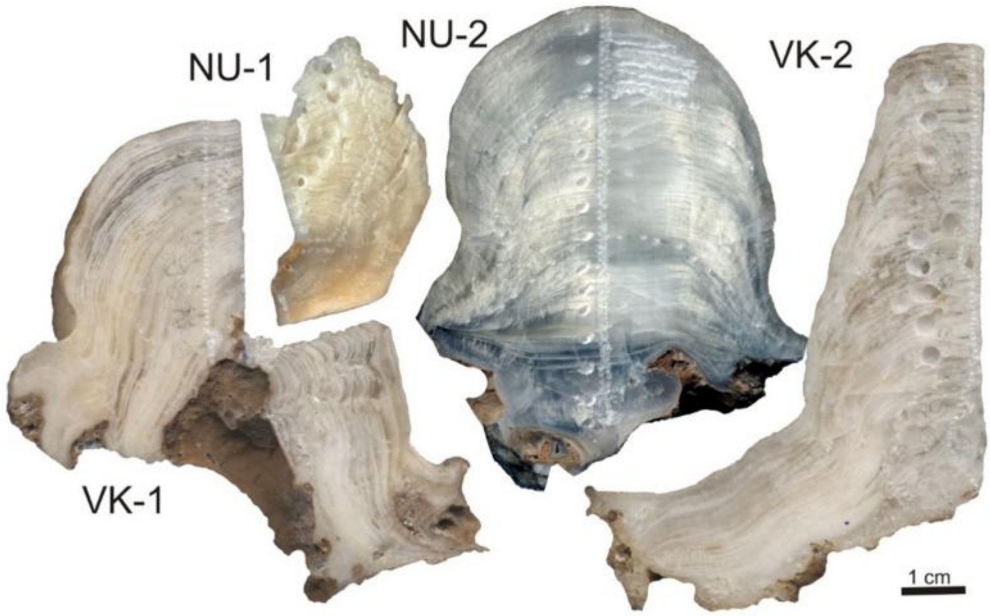

Fig. 1 Cut, polished and scanned surfaces of the four stalagmites collected from Nehéz-út (NU1, NU-2) and Vaskapu (VK-1, VK-2), Baradla Cave.

We compared the growth rates of the four stalagmites (Fig.2) based on the lamina counting and thickness measurements and also on the location of the atmospheric ^{14}C bomb peak. Stalagmites with more porous fabric (NU-1 and VK-2) showed higher growth rates compared to the denser ones (NU-2 and VK-1). Considering this, a uniform sampling size (0.5 mm diameter) and distance (1 mm) for $\delta^{18}O$ and $\delta^{13}C$ analysis can result in data series with very different temporal resolution. To mitigate this sampling bias all stable isotope analysis drill spots on the stalagmite surfaces were cross-checked with the thin-sections and given lamina dates. This way their geochemical information could be plotted on a common timescale.

Comparing the four $\delta^{18}O$ and $\delta^{13}C$ data series we found that stalagmites with similar fabric (the more porous NU-1 with VK-2 and the denser NU-2 with VK-1) had much more similarities in their stable isotopic composition than the ones with different fabrics. In the next step, all $\delta^{18}O$ and $\delta^{13}C$ data were cross-plotted. Samples drilled from similar fabrics formed partially overlapping groups. The most distinct group was formed by the samples drilled from mosaic fabric; where $\delta^{18}O$ values were always between -10 and -11 ‰, while $\delta^{13}C$ values showed a greater variation between -7 and -9 ‰.

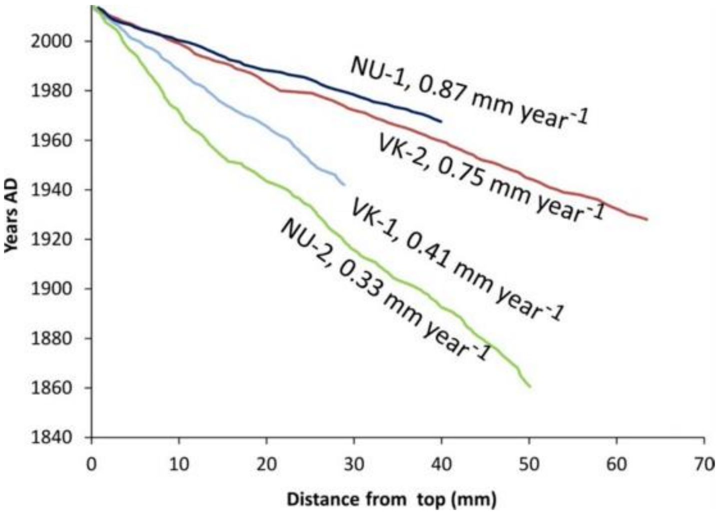

Fig. 2 Different growth rates of the four stalagmites based on lamina counting, Nehéz-út (NU1, NU-2) and Vaskapu (VK-1, VK-2).

These results are quite contrasting regarding that all stalagmites were collected from the same branch of the cave. The "NU" and "VK" coded collection sites were in a hundred metres distance from each other, however fabrics and growth rates were very distinct even at the same sampling site. These results call the attention that very different seepage pathways and reservoirs can feed nearby dripping points in the same cave, resulting in stalagmites with contrasting fabrics and geochemical features forming on the same site.

Acknowledgements

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