

Short-Term Temperature Fluctuations in Central Europe during MIS 3

J. Klose^{1*}, S. F. M. Breitenbach², M. Weber¹, H. Vonhof³, B. Schröder⁴, N. Marwan⁵, L. Katzschmann⁶, D. Scholz¹

¹Institute for Geosciences, Johannes Gutenberg University, Mainz, 55128, Germany

²Department of Geography and Environmental Sciences, Northumbria University, Newcastle upon Tyne, UK

³Max Planck Institute for Chemistry, Mainz, 55128, Germany

⁴German Research Centre for Geosciences, Potsdam, 14473, Germany

⁵Potsdam Institute for Climate Impact Research, Potsdam, 14412, Germany

⁶Thuringian State Office for the Environment, Mining and Nature Conservation (TLUBN), 07745, Jena, Germany

*Correspondence to: J.Klose (ieklose@uni-mainz.de)

The last glacial period and especially Marine Isotope Stage 3 (MIS 3, ca. 60 – 30 ka) was characterised by rapid climate oscillations and periodic warm phases. While first discovered in Greenland ice cores, these warm Greenland Interstadials (GIs) have been identified in numerous climate records globally with a strong emphasis on the northern hemisphere and especially the North Atlantic region. However, only few speleothem records from Central Europe are available, presumably due to too cold and dry climate conditions leading to unfavourable conditions for speleothem growth. Here, we present a composite record of flowstones from Bleßberg Cave, Germany, showing episodic speleothem deposition during the last glacial period contemporaneous with individual GIs and revealing Central European warm phases during MIS 3.

By combining high-resolution solution-based and in-situ laser ablation ²³⁰Th/U-dating, we accurately determined the timing and duration of eight particularly warm periods during MIS 3. These favourable climatic conditions for speleothem growth occurred intermittently from around 60 to 32 ka, lasting much longer than previously reported in other speleothem records from Central Europe. The onset of speleothem growth lagged behind that of the GIs, covering approximately 88% of their total duration during the early phase and around 25% during the middle and late phases of MIS 3. These findings indicate a trend of progressive climatic cooling during MIS 3, with the phases of speleothem growth representing persistent warm phases in Central Europe.

In addition, the Bleßberg flowstones are highly sensitive to climate change and particularly short-term temperature fluctuations. The longest continuous growth phase of the Bleßberg speleothems coincides with GI 14, the longest GI of MIS 3. We applied a multi-proxy approach (i.e., stable isotopes, trace elements, LOPs, Ca isotopes, fluid inclusions and fluid inclusion-based temperature reconstructions), which revealed two centennial-scale cold events during

GI 14. One of them coincides with cold event GI 14b in the Greenland ice core record, which has not been discussed in any other terrestrial climate record from Central Europe yet. Our results document Central European warm phases during MIS 3, indicate rapid regional temperature fluctuations and the absence of continuous permafrost in this region.