Timing of Dansgaard-Oeschger events in Central Europe based on three precisely dated speleothems from Bleßberg Cave, Germany

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Introduction & Motivation

European speleothems, which grew during MIS 3, are limited and mainly restricted to alpine regions (Fig.1). This led to the opinion that it was too cold and/or too dry in central Europe to enable speleothem growth.

Here we present three speleothems (BB9, BB10 and BB15) from Bleßberg Cave, Germany which grew during MIS 3.
By a combination of different sampling approaches for using the ^{230}Th/U-dating method we were able to precisely determine several growth phases of these flowstone samples which correlate with various D/O events (Fig. 2). This enables a better understanding of the timing, progression and especially the peak of D/O events in Central Europe.

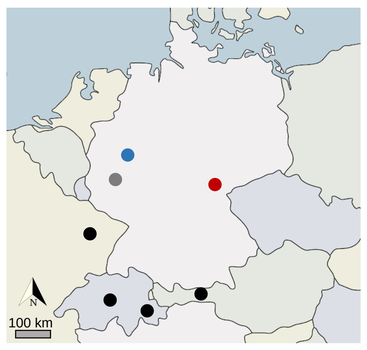

Fig.1 Map of Central Europe giving an overview of caves where speleothems grew during MIS 3. The red dot indicates Bleßberg Cave (this study). The blue dot indicates Bunker Cave, the grey dot the Eifel maar lakes, the black dots the cave locations of the composite NALPS record and one cave in France, with speleothem growth but no measured proxy data.

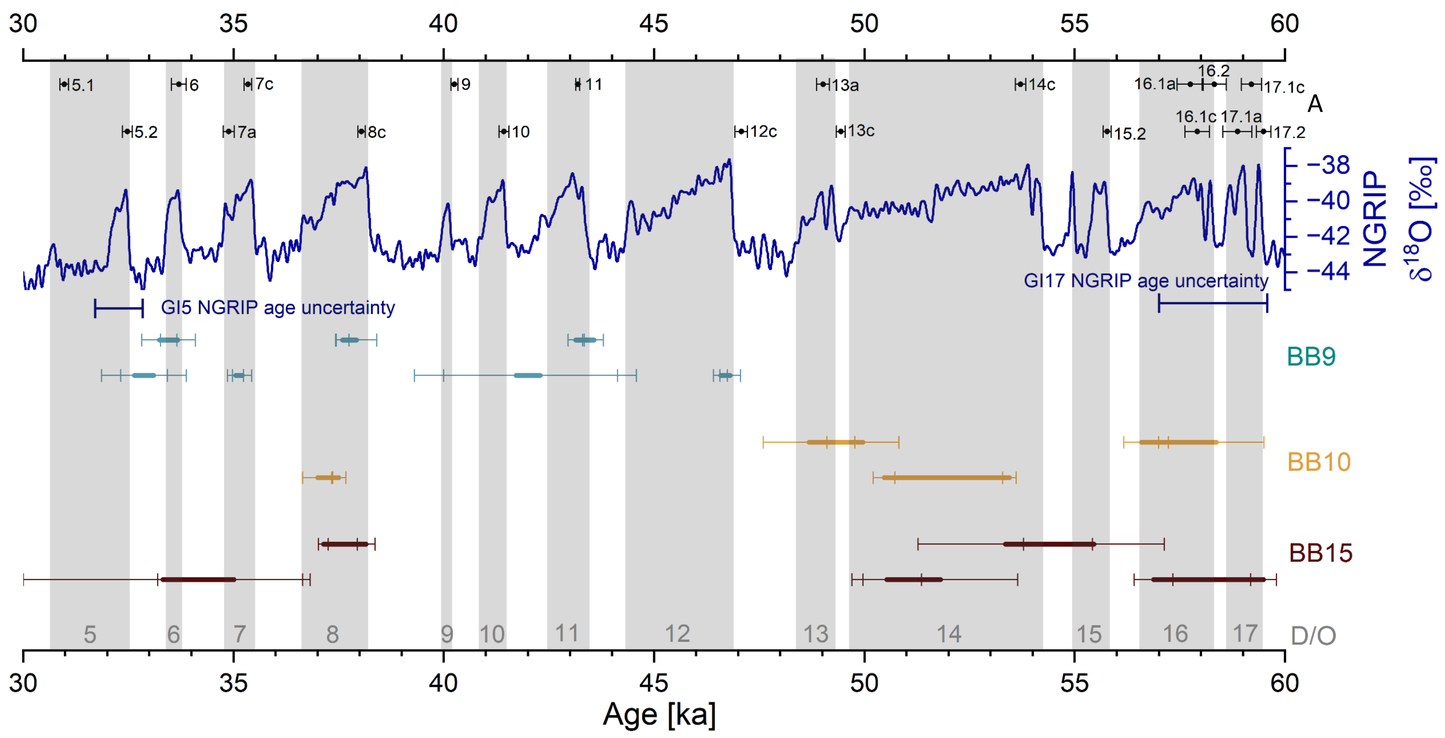

Fig.2 Timing and duration of the growth phases of the Bleßberg flowstones during MIS 3 based on the calculated age models including a 2σ uncertainty. The grey bars indicate timing and duration of D/O events based on the NGRIP ice core chronology (GICC05, Rasmussen et al., 2014), numbers are given at the bottom of the figure. The timing of the onset of various D/O events based on global speleothem stack (A, Corrick et al., 2020) are given on top of the figure, the numbers indicate the (sub) D/O events.

U/Th dating & sample structure

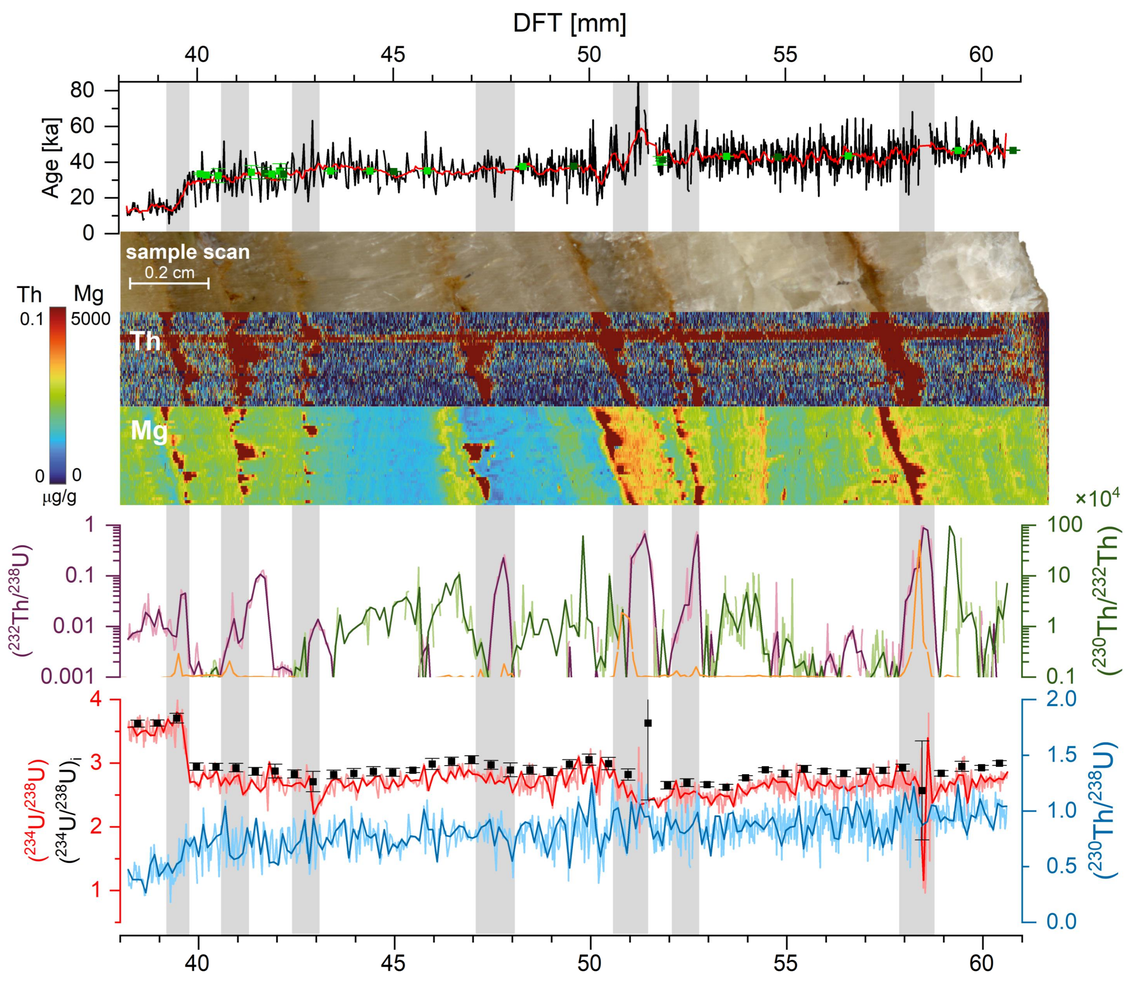

Fig.3 Overview of several BB9 measurements against distance from top and indicated hiatuses (grey bars):

- **Age [ka]** Resulting ^{230}Th ages based on a LA transect (black line) and the corresponding mean ages (red line); high precision handheld (dark green) and MicroMill (light green) sampled U/Th ages
- **Th and Mg [µg/g]** trace element mapping of the sample scan area
- **(^{232}Th/^{238}U)** high values indicate detrital contamination
- **(^{230}Th/^{232}Th)** low values indicate high initial ^{230}Th
- **PC1** of trace element principal component analysis (PCA), detrital component (orange line), indicates hiatuses/growth stops (indicated by grey bars)
- **(^{234}U/^{238}U) and (^{230}Th/^{238}U)** LA U/Th linescan (transect) data (red and blue lines) used for age calculations
- **$(^{234}U/^{238}U)_{initial}$** calculated initial ratios based on LA transect data (black squares); potential indicator of source effects

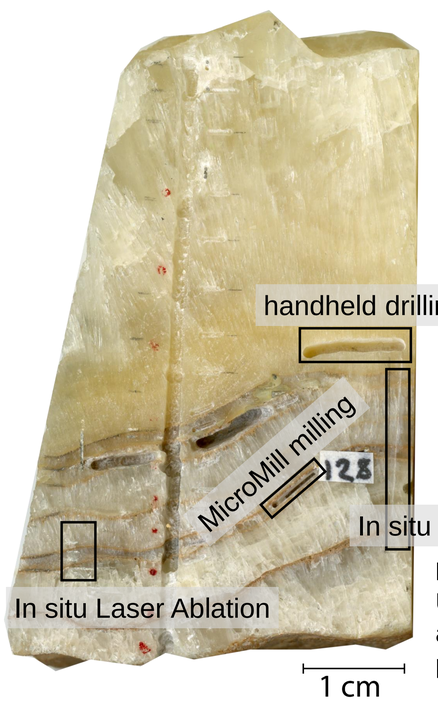

Fig.4 Flowstone BB9, all different sampling techniques for the U/Th dating are highlighted and labelled. Both handheld drilling as well as MicroMill milling needed a subsequent chemical preparation prior to the measurement.

MIS 3 in Central Europe

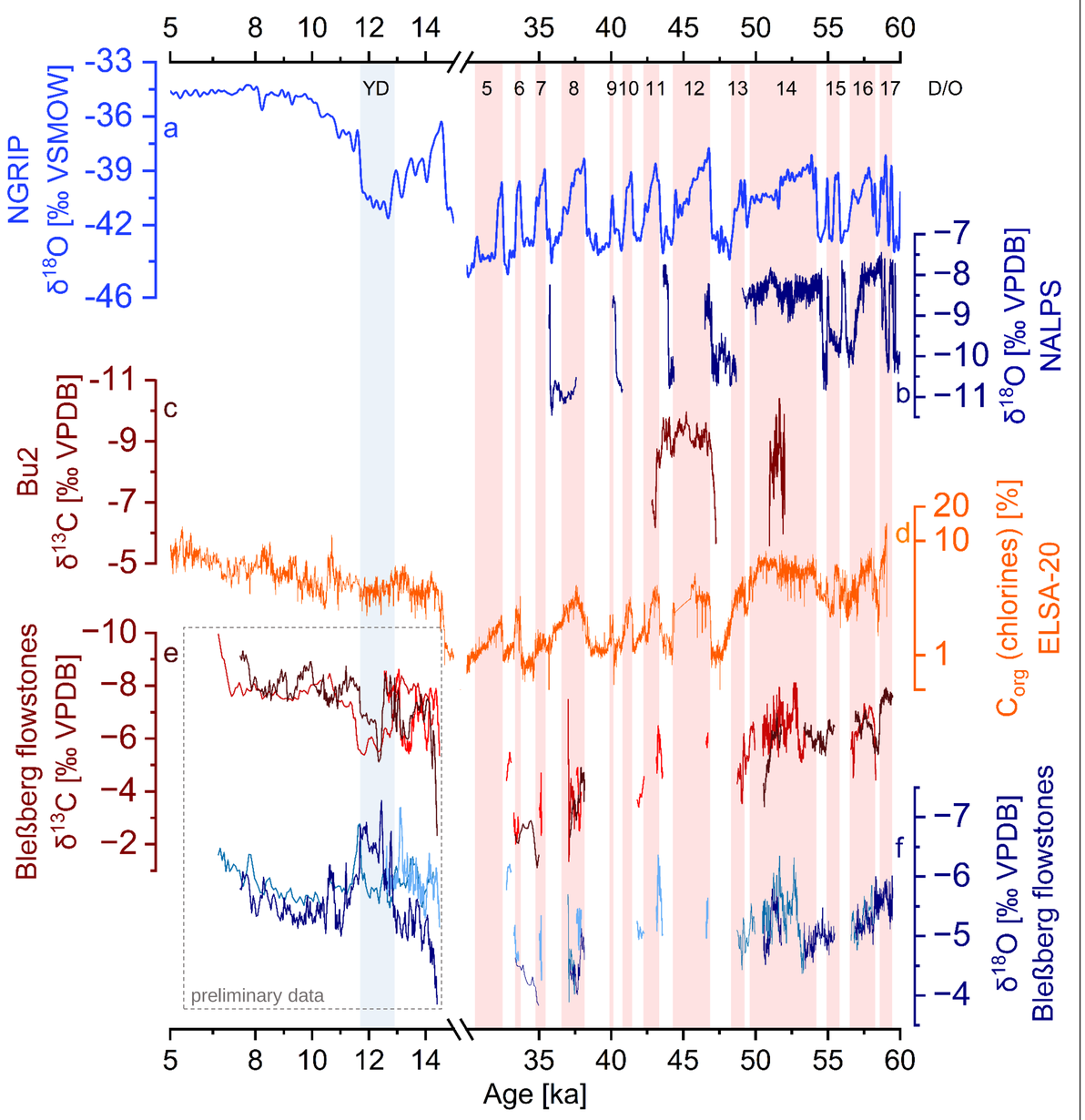

Fig.5 Comparison of the $\delta^{18}O$ and $\delta^{13}C$ records of all three Bleßberg flowstones (e and f) and other MIS 3 and 1 climate records. The red boxes indicate the timing of various D/O-events, the blue box shows the timing of the Younger Dryas based on the NGRIP GICC05 chronology.
a NGRIP $\delta^{18}O$ record (Rasmussen et al., 2014),
b NALPS $\delta^{18}O$ record from alpine speleothem samples (Mosley et al., 2014),
c Bu2 $\delta^{13}C$ speleothem record from Bunker Cave, Germany (Weber et al., 2018),
d ELSA-20 C_{org} (chlorines) record from Eifel maar lake drill cores (Sirocko et al., 2012),
e Bleßberg flowstones $\delta^{13}C$ records (this study),
f Bleßberg flowstones $\delta^{18}O$ records (this study).

Conclusion

- Bleßberg growth phases often **correlate very well with several D/O events**, allowing a better insight on MIS 3 in Central Europe, which in fact wasn't too cold/dry to enable speleothem growth
- Bleßberg growth phases very likely don't represent the onset or entire duration of the D/O events, but the **peak and warmest** phase of it
- While the proxy data is still work in progress **a clear trend in both stable isotopes** is evident
- Early MIS 3 (60 – 50 ka) shows **similar values to MIS 1** especially in the $\delta^{13}C$, indicating a similar climate in terms of precipitation, vegetation and maybe even temperature

References

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