Timing of Dansgaard-Oeschger events in Central Europe

based on three precisely dated speleothems from Bleßberg Cave, Germany

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Introduction

The last glacial period and especially **Marine Isotope stage 3** (MIS 3, ca. 57 - 27 ka) was characterized by various climate oscillations (i.e., rapid **increases in temperature**, followed by a gradual cooling, **the Dansgaard-Oeschger (D/O) events**).

Although their causes are still not fully understood, clear evidence for their supra-regional character was found in various climate records around the globe. However, **European speleothem** samples, which grew during MIS 3, **are limited** and mainly restricted to alpine regions (Fig.1), where glacier meltwater enabled speleothem growth, and to south/south-western parts of Europe characterised by a generally warmer climate.

This led to the opinion that it was **too cold and/or too dry in central Europe to enable speleothem growth**.

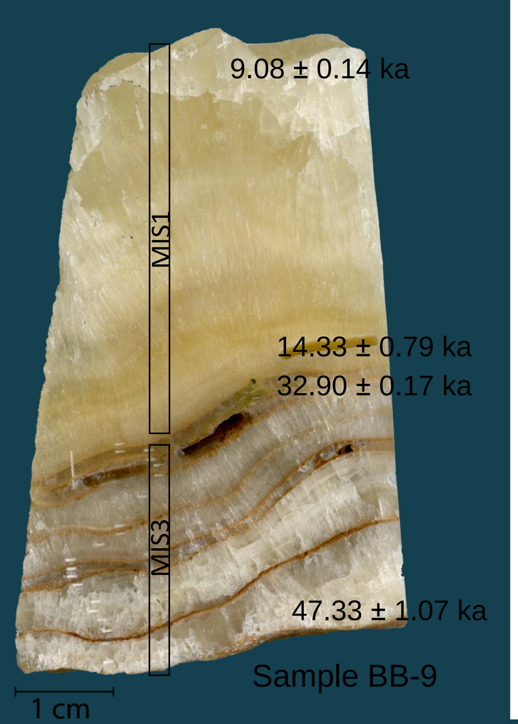
Fig.1

Map of Central Europe showing all caves where speleothems grew during MIS 3.

A Bleßberg Cave (this study)
B Bunker Cave
C Grotte des Puits de Pierre-la-Treiche
D Spannagel Cave
E Hölloch Cave
F Sieben Hengste Cave
a Eifel maar lakes

Flowstone BB-9

- eight distinctive growth phases, seven during MIS 3
  - spatial resolution of growth layers range within < 2 mm and a few cm
- growth phases correlate with **six D/O-events** (Fig. 7)



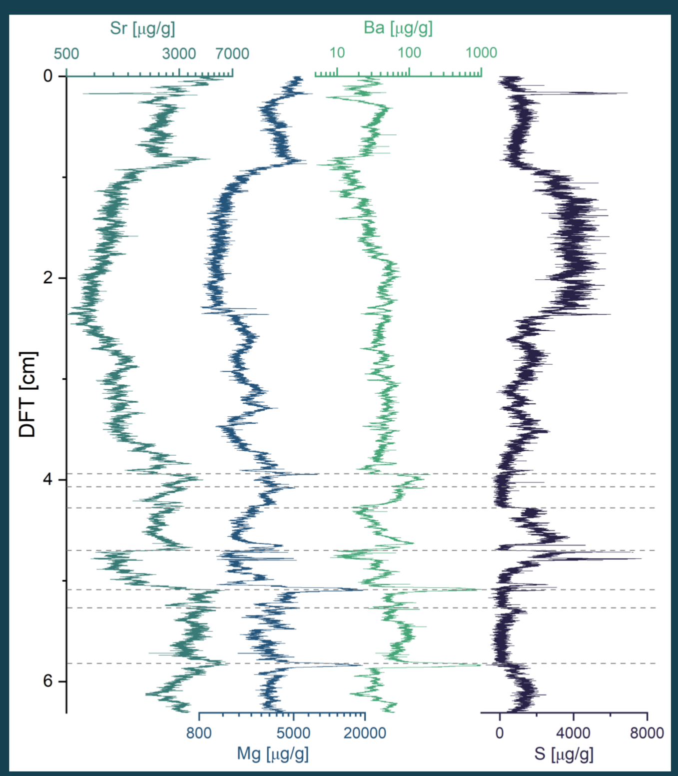


Fig.2

Concentrations of Sr, Mg, Ba and S of flowstone BB-9 plotted against the distance from top (DFT). The seven hiatuses of the sample are indicated with dotted grey lines, spikes in the trace element concentration around those hiatuses are very likely caused by detrital contamination. The upper part of the sample up to the first hiatus at 3.94 cm dates to MIS 1, the lower part of the sample dates to MIS 3.

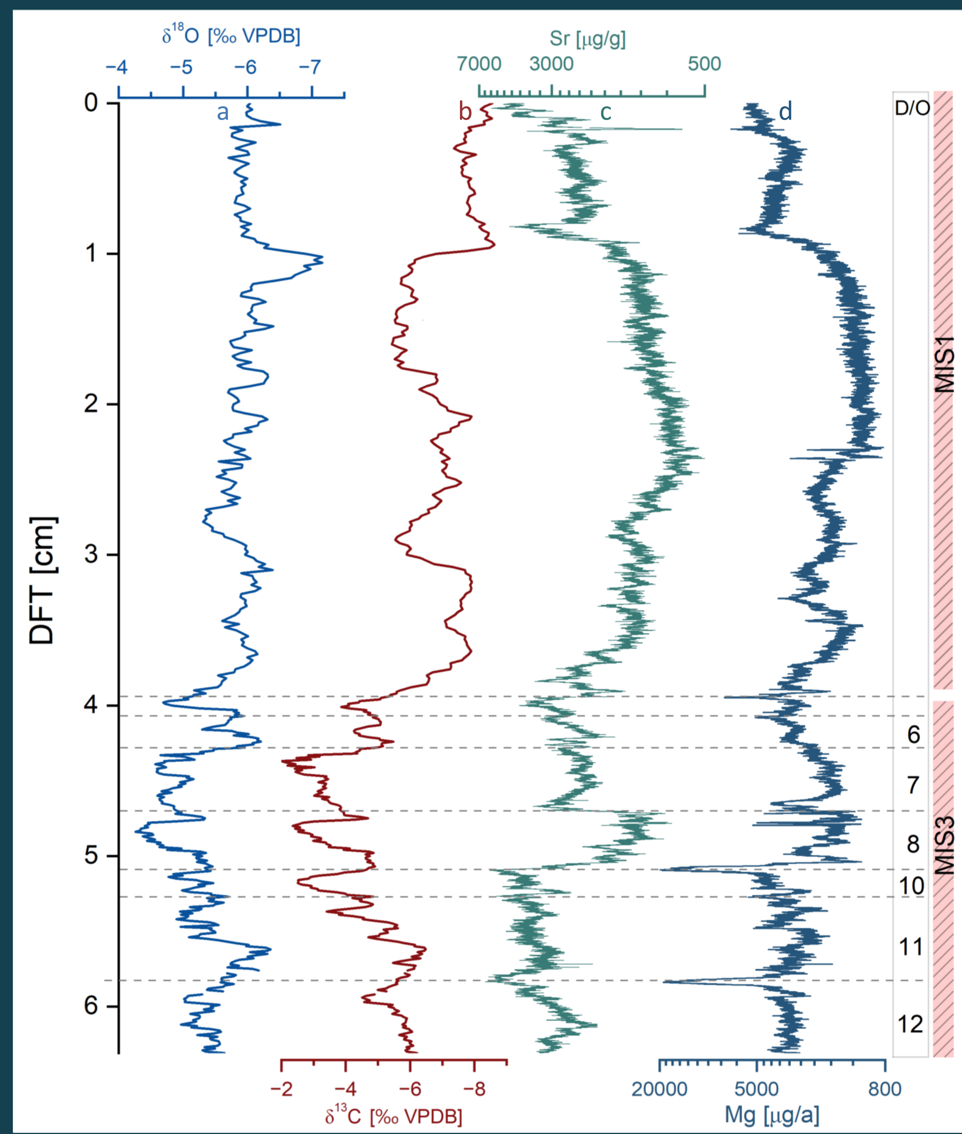


Fig. 3

Comparison of BB-9 proxy records ([a] $\delta^{18}O$, [b] $\delta^{13}C$, [c] Sr and [d] Mg concentration). All axis are inverted and plotted against DFT. The dotted grey lines indicate hiatuses. The red boxes show the timing of MIS 1 and 3, the numbers in the grey box indicate specific D/O-events during MIS 3.

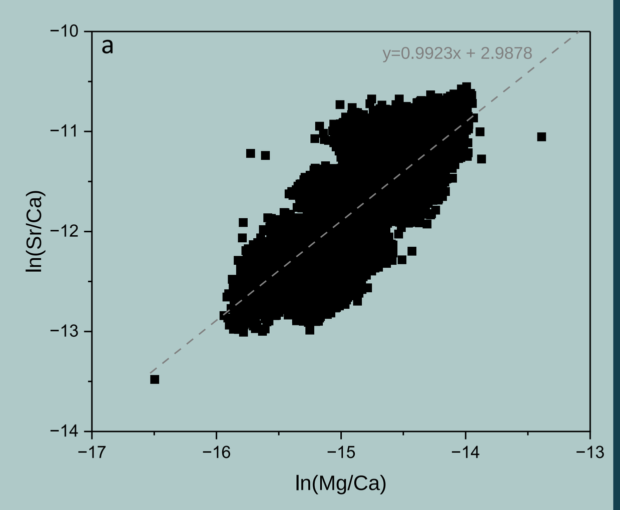
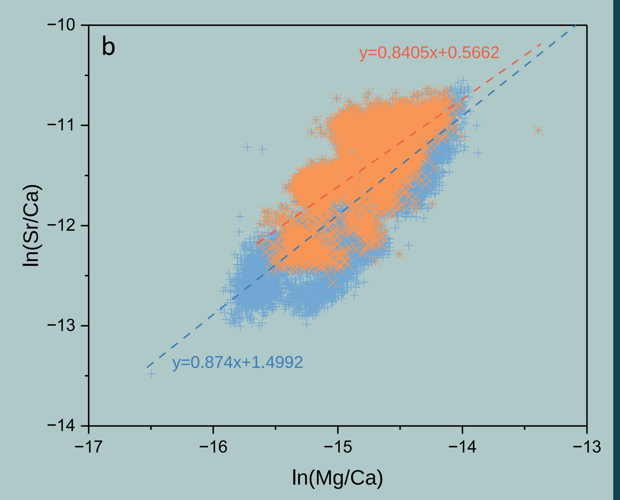


Fig. 4

ln(Sr/Ca) versus ln(Mg/Ca) plots of Sample BB-9 [a] for the entire sample and [b] split in MIS 1 (orange) and MIS 3 (blue). The slope of all trend lines through the data indicates that the Sr and Mg signal is dominated by PCP.



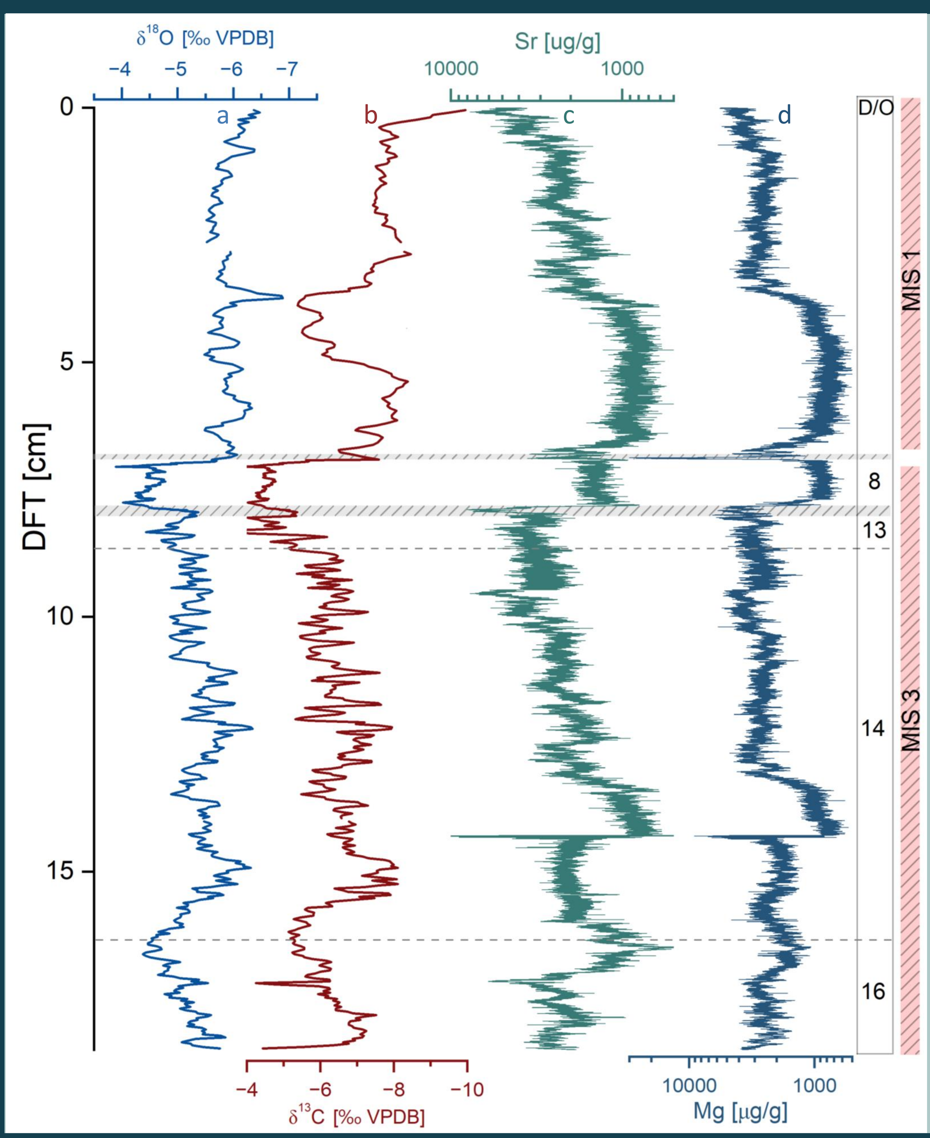


Fig. 5

Comparison of BB-10 proxy records ([a] $\delta^{18}O$, [b] $\delta^{13}C$, [c] Sr and [d] Mg concentration). All axis are inverted and plotted against DFT. The grey boxes indicate the two hiatuses, the grey dotted lines indicate potential growth stops based on the ending/beginning of D/O-events. The red boxes show the timing of MIS 1 and 3, the numbers in the grey box indicate specific D/O-events.

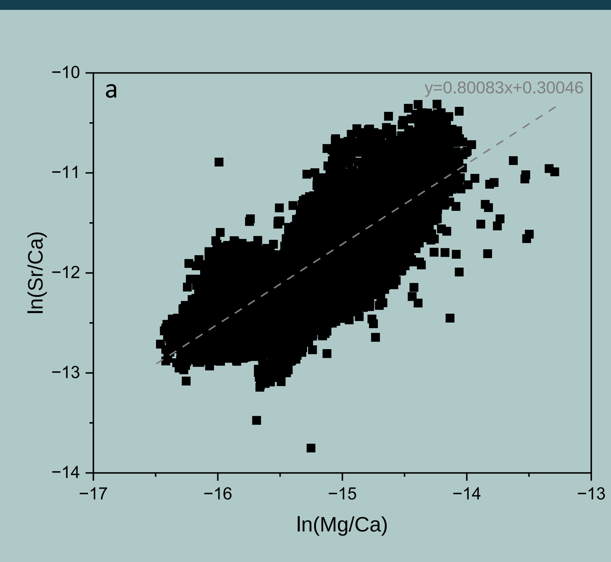
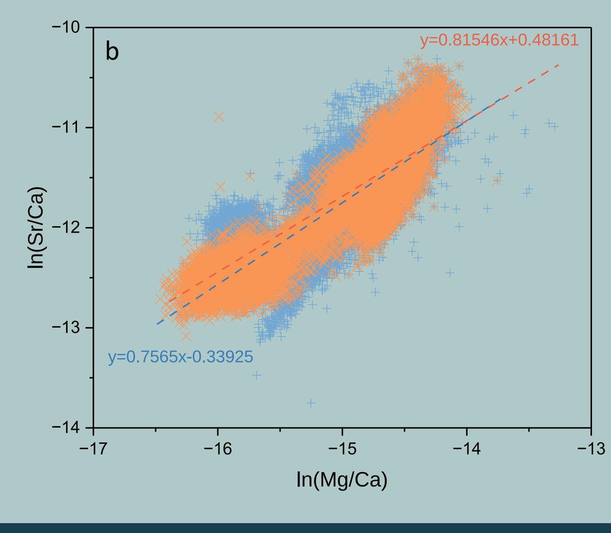


Fig. 6

In(Sr/Ca) versus ln(Mg/Ca) plots of Sample BB-10 [a] for the entire sample and [b] split in MIS 1 (orange) and MIS 3 (blue). The slope of all trend lines through the data indicates that the Sr and Mg signal is dominated by PCP.



Flowstone BB-10

- three distinctive growth phases, two during MIS 3
  - at least one recognizable additional growth layer within the second hiatus from top, but too small/short to sample
- growth phases correlate with **4 D/O-events** (Fig. 7)

Flowstone BB-15

- very similar in appearance to BB-10
- four distinctive growth phases, three during MIS 3
  - like sample BB-10 there might be additional growth layers within the hiatuses, which are too small/short to sample
- growth phases correlate with **5 D/O-events** (Fig. 7)

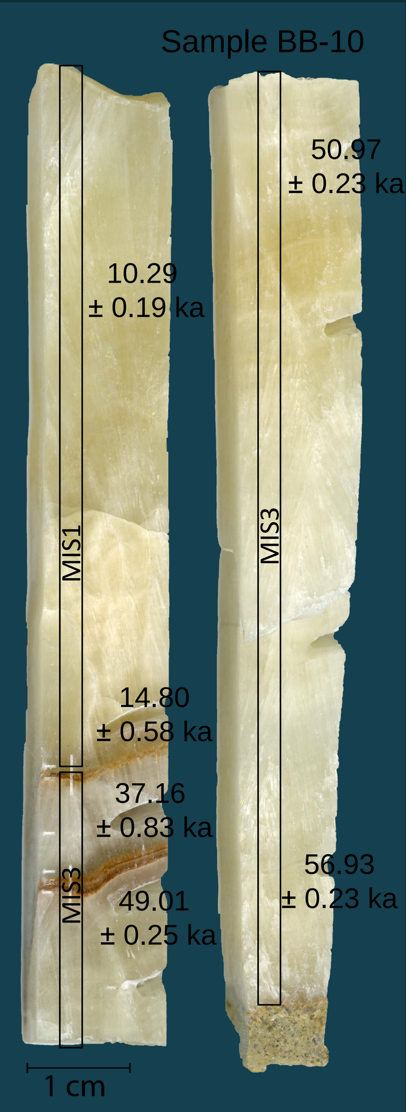
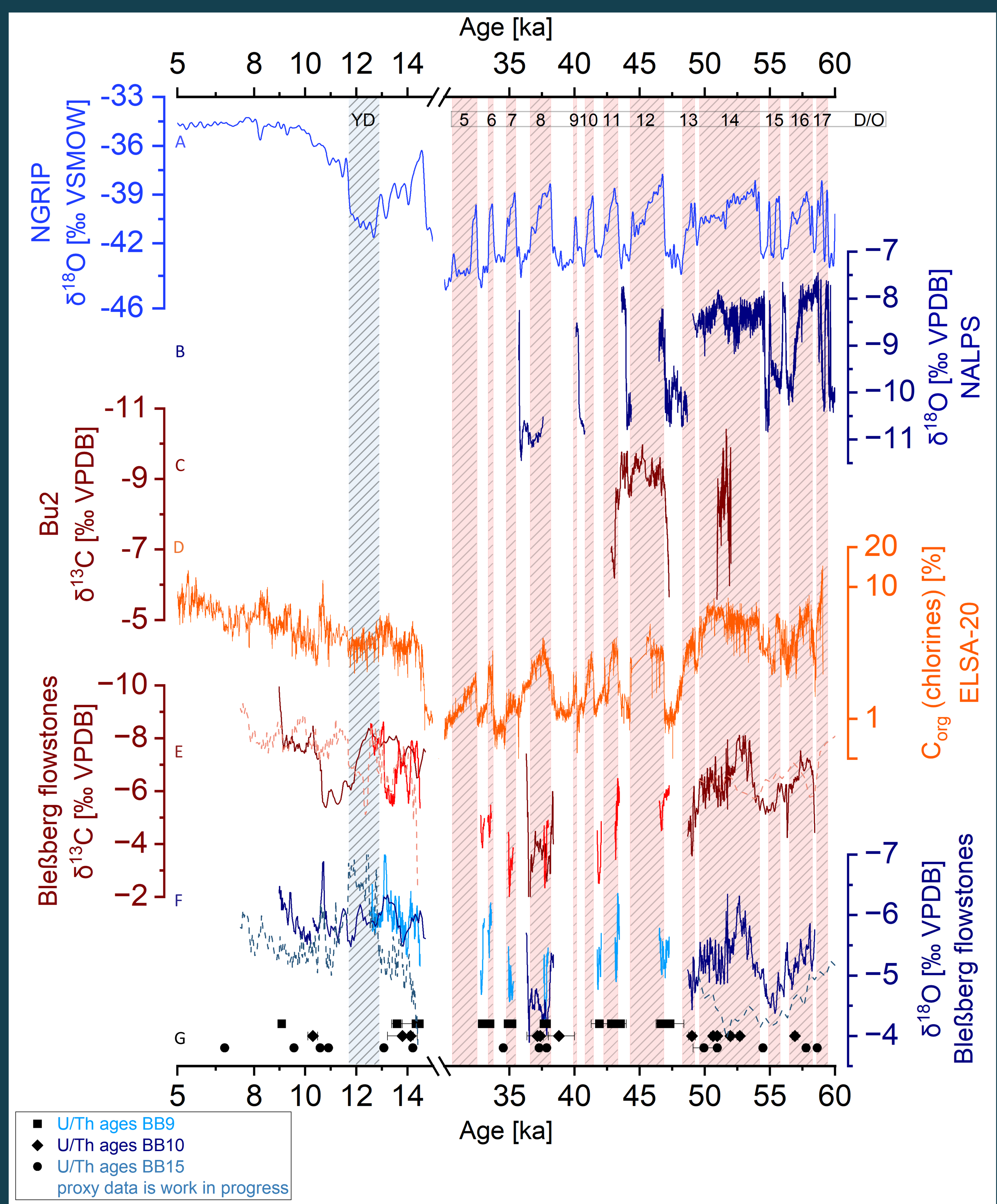


Fig. 7

Comparison of the $\delta^{18}O$ and $\delta^{13}C$ records of all three Bleßberg Flowstones and other MIS 1 and 3 climate records. The red boxes indicate the timing of various D/O-events based on the NGRIP chronology [1], the blue box shows the timing of the Younger Dryas. [A] NGRIP $\delta^{18}O$ record [1], [B] NALPS $\delta^{18}O$ record from alpine speleothem samples (Fig. 1) [2], [C] Bu2 $\delta^{13}C$ speleothem record from Bunker Cave, Germany (Fig. 1) [3], [D] ELSA-20 C_{org} (chlorines) record from Eifel maar lake drill cores (Fig. 1) [4], [E] Bleßberg flowstones $\delta^{13}C$ records (this study), [F] Bleßberg flowstones $\delta^{18}O$ records (this study), [G] corr. U/Th ages (including uncertainties) of the Bleßberg samples (this study, detailed information attached to graph).



Conclusions

- both stable isotope records (**$\delta^{18}O$ and $\delta^{13}C$**) are very likely to represent changes in **precipitation and vegetation density**
  - indicating e.g., D/O 14 as a particularly humid D/O-event
- **strong influence of PCP** on both stable isotope signals, as well as on Sr and Mg
- the **trend** noticeable in the stable isotope records highlights the change of a more humid climate period during D/O 13 – 16, a less humid period during D/O 5 – 12 and an increase in humidity with the start of MIS 1 and the Holocene
- since sample **BB-9** only shows very **short growth phases** it is very likely that they correlate with the **peaks of the corresponding D/O-event** in Central Europe, indicating the most humid and/or warm period of the specific D/O-event

References

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