Holocene climate variability revealed by high-resolution speleothem records from east-central North America

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Background

(Alley, 2007)
\( \delta^{13}\text{C} \) in Speleothems

- Interpreted as changes in the type or density of vegetation overlying the cave (Dorale et al., 1998).

- Higher biogenic activity and/or a higher proportion of C3 vegetation (i.e. more precipitation) results in more negative \( \delta^{13}\text{C} \) values.

- More depleted when the climate is in a moist state and are comparatively enriched during times of drought due to the influence of moisture on soil respiration rates (McDermott, 2004).
Overall, interpreted as variations in cave temperature and properties/sources of meteoric water (McDermott, 2004).

Hardt et al., (2010): enriched $\delta^{18}\text{O}$ as representative of an increase in relative contribution of summer precipitation, due to variation in Bermuda High circulation intensity.
Correlation maps of winter season (DJFM, 1948–2000) PNA index and climate parameters: A) zonal wind (u) at the 500 hPa level, B) meridional wind (v) at the 500 hPa level, C) surface air temperature for PNA+ and D) precipitation for PNA+.  

Liu et al., 2011
Trace elements as proxies

• Used to interpret the hydrogeochemical processes in the epikarst zone as well as the partitioning that occurs at the calcite-water interface.

• During periods of low rainfall, trace element ratios generally increase as a result of the longer residence time of water in the soil and epikarst zones.

• A coupling between $\delta^{13}$C values and Sr/Ca ratios can exist due to the occurrence of prior calcite precipitation in the vadose zone in times of low moisture availability, which will leave the remaining solution enriched in both $\delta^{13}$C and Sr in relation to Ca (Springer et al, 2008).
Setting

Mississippian Greenbrier Formation
Methods

$^{18}\text{O}$ & $^{13}\text{C}$ : IRMS (VPDB)

$^{230}\text{Th}$ : MC-ICP-MS

Sr : ARTAX $\mu$-XRF
Bruker Artax μ-XRF
Results

HC2-02

41 ± 7
590 ± 52
1103 ± 8
2089 ± 30

(yr BP)

1 cm
BCC-002 Record
Springer et al., 2008

- Coincident Sr & δ¹³C enrichment interpreted as drought events in eastern N. America
- 6 of the 7 events coincide with N. Atlantic IRD events
Conclusions

- More $\text{Th}^{230}$ age dates needed
- Slow growth rate during the early to mid Holocene of HC2-03 hinders proxy interpretation
- $\delta^{13}\text{C}$ & Sr time series are linked through the effects of precipitation
- $\delta^{18}\text{O}$ variability attributed to changes in the relative proportion of summer precipitation, a function of the Bermuda High and PNA+/-
- Drought events from BCC-002 not comparable in HC2-02 or HC2-03, but whether it is due to poor age control or a localized climate signal remains to be determined
References

• Alley, R.B. 2000. Ice-Core evidence of abrupt climate changes. PNAS 97, 1331-1334.