Cave air controls on stalagmite growth rates and paleoclimate records

JAMES U.L. BALDINI[1], FRANK MCDERMOTT[2], DIRK L. HOFFMAN[3], DAVID A. RICHARDS[3] AND NICHOLAS CLIPSON[4]

[1]Department of Earth Sciences, Durham University, Durham, DH1 3LE, UK (*correspondence: james.baldini@durham.ac.uk)
[2]UCD School of Geological Sciences, University College Dublin, Belfield, D4, Ireland
[3]School of Geographical Sciences, University of Bristol, University Road, Bristol, BS8 1SS, UK
[4]UCD School of Biology and Environmental Science, University College Dublin, Belfield, D4, Ireland

Two very high-resolution cave air P_{CO_2} records from Crag and Ballynamintra Caves, Ireland, demonstrate that cave air P_{CO_2} values can vary dramatically on both hourly and seasonal timescales. Spectral analyses and modelling suggest that the seasonal fluctuations are predominantly influenced by temperature-modulated soil CO_2 production, with superimposed high-frequency, high-amplitude variability likely linked to ventilation. At our sites, mean values were lowest in the winter and highest in the summer, probably reflecting primary soil CO_2 production rates. Calcite growth rates responds to cave air P_{CO_2} variations because calcite deposition is partially dependent on CO_2 degassing rates from seepage water. The U-Th derived stalagmite extension rate, derived from four dates, compares extremely well with the modelled growth rate based on drip rate, cave air P_{CO_2}, temperature, drip water [Ca^{2+}], and thin film thickness. For well-mixed cave drips such as CC-Bil, elevated cave air P_{CO_2} depresses summertime growth rates at our sites while low winter P_{CO_2} encourages calcite deposition, skewing the value of geochemical climate proxies toward winter drip hydrochemistry. However, because soil air P_{CO_2} may increase relative to cave air P_{CO_2} in the summer, drips whose hydrochemistries vary seasonally may have greater summer growth rates. Consequently this may bias stalagmite calcite $\delta^{18}O$ records towards isotopically heavier summer drip water $\delta^{18}O$ values, resulting in elevated calcite $\delta^{18}O$ values compared to the 'equilibrium' values predicted by calcite-water isotope fractionation equations. Therefore, this possible seasonal dichotomy suggests that stalagmites growing during the same time interval, but fed by different end-member drip types, may preserve differing oxygen isotope records.

Spatial variability in the NAO-European winter precipitation $\delta^{18}O$ relationship: Implications for stalagmite proxy NAO index reconstructions

L.M. BALDINI[1]*, F. MCDERMOTT[2], C.G. MACPHERSON[1], H. HERCMAN[3] AND J.U.L. BALDINI[1]

[1]Department of Earth Sciences, Durham University, Science Labs, Durham, DH1 3LE, UK (*correspondence: l.m.baldini@durham.ac.uk)
[2]School of Geological Sciences, University College Dublin, Belfield, Dublin, D6, Ireland (frank.mcdermott@ucd.ie)
[3]Institute of Geological Sciences, Polish Academy of Sciences, Twarda 51/55 St., 00-818, Warsaw, Poland (hhercman@twarda.pan.pl)

Precipitation $\delta^{18}O$ data ($\delta^{18}O_p$) compiled from 54 Global Network of Isotopes in Precipitation (GNIP) stations (43 with $\geq$ 10 years of data) in the North Atlantic sector reveal the direction and strength of the $\delta^{18}O_p$-NAO relationship in mid-latitude, high-latitude, and Mediterranean Europe [1]. The NAO exerts the greatest impact on winter $\delta^{18}O_p$ in the European mid-latitudes (positive correlation) and high-latitudes (negative correlation) while the NAO-$\delta^{18}O_p$ relationship is weak at maritime southwest European and circum-Mediterranean GNIP sites [1]. Our analysis of the spatial NAO-$\delta^{18}O_p$ correlation pattern reveals that central European locations such as Poland are likely be optimal locations within Europe for compiling $\delta^{18}O$-based proxy records of past NAO-mode variability.

On this basis, stalagmite $\delta^{18}O$ records from Niedzwiedzia cave, SW Poland are currently being compiled to reconstruct past NAO-mode variability in the Holocene. During high NAO years, mean winter temperature in Krakow is warmer by 2.4°C while $\delta^{18}O_p$ is higher by 1.7‰. Statistical modelling is used to calculate the amplitude of the signal necessary to confidently identify NAO polarity in stalagmites from this region and to make statistically defensible arguments about the relative strength of NAO phases during the Holocene. The novel application of high resolution drip rate monitors for remote screening of potential stalagmite candidates in Niedzwiedzia cave will also be presented.

[1] Baldini, L.M., McDermott, F., Foley, A.M. & Baldini, J.U.L. (2008) *Geophys. Res. Lett.* **35**, L04709, doi, 10.1029/2007GL032027.