Globally-averaged speleothem $\delta^{13}C$ shifts record atmospheric pCO_2

D. O. BREECKER[1]

[1]The University of Texas at Austin;
(breecker@jsg.utexas.edu)

The suggestion that speleothem $\delta^{13}C$ values depend on atmospheric pCO_2 [1] is evaluated here using a global compilation of speleothem records. Global mean speleothem $\delta^{13}C$ anomalies over the past 90 kyr closely track those expected from the experimentally-determined atmospheric pCO_2 effect on C_3 plant $\delta^{13}C$ values [2]. Because the relevance of this effect to natural changes in atmospheric pCO_2 has been questioned [3,4], I evaluate here alternative explanations for the observed global mean speleothem $\delta^{13}C$ anomalies. The alternative effects considered include glacial-interglacial changes in mean annual precipitation and the $\delta^{13}C$ values of atmospheric CO_2 (MAP and $\delta^{13}C_a$, respectively, both of which control the $\delta^{13}C$ values of C_3 plants), mean annual temperature (MAT, which controls the stable carbon isotope fractionation between CO_2 and calcite) and belowground respiration rates. I evaluted these effects across the last deglaciation, a time period during which speoleothem data density is relatively high and paleoclimate climate changes are relatively well constrained [e.g., 5].

The sum of the $\delta^{13}C$ changes expected from Holocene-LGM changes in MAP [5], MAT [5] and $\delta^{13}C_a$ [6] is -0.3‰, an order of magntiude smaller than the observed shift of -1.9‰, suggesting these variables do not explain the observations. Exclusion of speleothem $\delta^{13}C$ records possibly sensitive to changes in respiration rates results in a Holocene-LGM global mean speleothem $\delta^{13}C$ anomaly of -1.4‰, which is similar to that for the full dataset, suggesting that changes in repiration rates also do not expain the observations. I thus conclude that 1) atmospheric pCO_2 is an important control on speleothem $\delta^{13}C$ values, 2) the pCO_2 effect should be removed from existing and future speleothem $\delta^{13}C$ records that span time periods during which atmospheric pCO_2 is known from ice core records, 3) global mean speleothem $\delta^{13}C$ anomalies provides radiometric ages for Pleistocene CO_2 variations and thus ice core climate records and 4) averaging multiple spleeothem $\delta^{13}C$ records might allow reconstruction of atmospheric pCO_2 in deeper time.

[1] Wong & Breecker (2015), *Quaternary Science Reviews* **127**, 1-18. [2] Schubert & Jahren (2012), *Geochimica et Cosmochimica Acta* **96**, 29-43. [3] Kohn (2016) *Geochemical Perspectives Letters* **2**, 36-43. [4] Diefendorf *et al*. (2015) *Earth and Planetary Science Letters* **429**, 33-44. [5] Alder & Hostetler (2015), *Climate of the Past* **11**, 449-471. [6] Schmitt *et al*., (2012) *Science* **336**, 711-714.