Testing seasonal resolution trace element and stable isotope proxies of East Asian monsoon rainfall

K.R. JOHNSON[1] C. HU[2] AND G.M. HENDERSON[1]

[1] Department of Earth Sciences, Oxford University, UK;
Kathleen.Johnson@earth.ox.ac.uk;
Gideon.Henderson@earth.ox.ac.uk

[2] China University of Geosciences, Wuhan, China;
chyhu@cug.edu.cn

A 2.5 m long annually laminated stalagmite, HS-4, collected from Heshang Cave, China (30.44°N, 110.42°E), formed continuously during the last 9.5 kyr and contains seasonal variations in stable isotope and trace element composition. We conducted a pilot study to assess the potential of these seasonal cycles for use in seasonal resolution paleoclimate reconstruction. We micromilled small sections of HS-4 at monthly resolution (50μm) and measured $\delta^{18}O$, $\delta^{13}C$, Mg/Ca, Sr/Ca, Ba/Ca, and U/Ca ratios. We directly compare this conventionally analyzed data to data collected *in situ* via LA-MC-ICPMS (Mg/Ca, Sr/Ca) and SIMS ($\delta^{18}O$). In addition, we compare the measured geochemical cycles with seasonal cycles of rainfall, temperature, drip rate, and drip water chemistry from Heshang Cave.

Mg/Ca, Sr/Ca, Ba/Ca, and $\delta^{13}C$ are strongly positively correlated (R^2 = 0.65-0.98), suggesting a common environmental control. Geochemical modeling results indicate that the observed seasonal cycles may be largely described by seasonal variations in the amount of prior calcite precipitation that occurs. This prior calcite precipitation leads to increased $\delta^{13}C$ values because ^{12}C is preferentially degassed. Likewise, any trace element with $D<<1$ will become enriched in the remaining groundwater as calcite precipitation occurs. During dry periods, with slower groundwater flow, vadose waters undergo a greater degree of CO_2 degassing prior to speleothem formation and therefore, speleothem calcite formed during dry periods will have higher Mg/Ca (and other X/Ca ratios) and $\delta^{13}C$ than that formed during wet periods. These seasonal cycles, because they are mainly controlled by rainfall, are therefore useful as paleomonsoon proxies.

The seasonal $\delta^{18}O$ cycle in HS-4 is similar to the seasonal cycle in drip water $\delta^{18}O$, with a distinct maximum occuring in May, coincident with summer monsoon onset. We use this $\delta^{18}O$ maximum as a chronological marker. Mg/Ca, Sr/Ca, Ba/Ca, and $\delta^{13}C$ values in HS-4 are low during the wet summer monsoon and high during the dry winter monsoon. U/Ca exhibits the opposite pattern, possibly because it is removed from solution by adsorption on to calcite surfaces.