Geophysical Research Abstracts
Vol. 19, EGU2017-11786, 2017
EGU General Assembly 2017
© Author(s) 2017. CC Attribution 3.0 License.

# Unravelling links between external weather, climate, cave speleothem growth and del13C records

Chris Waring (1), David Griffith (2), Stuart Hankin (1), and Graham Kettlewell (2)
(1) ANSTO Institute for Environmental Research, Lucas Heights, Australia, (2) University of Wollongong, Chemistry, Wollongong, Australia (griffith@uow.edu.au)

Interpreting speleothem $\delta^{13}$C records for robust palaeo-environmental reconstructions has often relied on correlation with other proxy records rather than an independent process-derived $\delta^{13}$C interpretation. We have taken the process path to $\delta^{13}$C speleothem interpretation by conducting multi-year continuous monitoring of external weather, soil and cave functional parameters, but particularly cave trace gases. $CO_2$ in cave air of the growing speleothem controls speleothem growth through dissolution in drip waters via the 3-phase chemical equilibrium

$2HCO_{3\ (aq)}^{-} + Ca^{2+}_{\quad (aq)} \Leftrightarrow CaCO_{3(s)} + CO_{2\quad (g)} + H_2O$ Eqn 1.

A response time of drip water pH to changes in cave $CO_2$ of less than 10 minutes demonstrates the expected chemical equilibrium (Eqn 1). Imposition of an exogenous source of high $CO_2$, from overlying karst soil, on the speleothem chemical equilibrium inhibits speleothem growth and may cause partial speleothem dissolution. Convective cave ventilation driven by external temperature contrast with the cave temperature is dominant in our study of Chifley Cave, Jenolan, NSW Australia. In summer karst soil gas and air from above is drawn into Chifley Cave and in winter from the lower cave entrance. Seasonal bi-directional cave ventilation with different $CO_2$ sources and concentrations directly links external temperature and high cave $CO_2$ to speleothem growth. The karst soil source of $CO_2$ (plant and microbial respiration) is temperature and soil moisture dependent, further accentuating the potential for seasonal speleothem growth bias. The strength and direction of convective cave ventilation is also dependent on external temperature. These 3 mechanisms link external temperature to speleothem $\delta^{13}$C.

Continuous measurement of three independent gas tracers Rn, $N_2O$ and $\delta^{13}C - CO_2$ confirms a summer karst soil gas origin of high $CO_2$, to over 10,000 ppm in Chifley Cave. Winter air-flow in the opposite direction with low ambient $CO_2$ shows a comparatively small addition of $CO_2$ with a $\delta^{13}C - CO_2$ isotopic label consistent with equilibrium speleothem growth, establishing a seasonal speleothem growth bias mechanism for convectively ventilated caves.

A soil source of high $CO_2$ not in isotopic equilibrium with drip-water outgassing $CO_2$ dissolving in drip waters during speleothem growth confers a more negative $\delta^{13}$C to a growing speleothem. However, if cave $CO_2$ is high, inhibiting speleothem growth, the exogenous $CO_2$ isotopic signature will not be incorporated into the speleothem isotopic record.

The magnitude and duration of these processes produce different outcomes for $\delta^{13}$C records in speleothems.