EGU24-3704, updated on 20 May 2024
https://doi.org/10.5194/egusphere-egu24-3704
EGU General Assembly 2024

High-resolution reconstruction of infiltration in the South Pacific based on stalagmites fabrics and chemistry.

Silvia Frisia[1], Mohammadali Faraji[1], Andrea Borsato[1], Adam Hartland[2], John Hellstrom[3], Danielle Verdon-Kidd[1], and Alan Greig[3]

[1]University of Newcastle Australia, Earth Sciences, CHALLAGAN, Australia (silvia.frisia@newcastle.edu.au)
[2]School of Science, University of Waikato, Hamilton 3240, New Zealand
[3]School of Geography, Earth and Atmospheric Sciences, The University of Melbourne, VIC 3010, Australia

Annually laminated stalagmites provide hydroclimate proxy data extending well beyond the instrumental period. Calcite fabric, stable isotope ratios and trace element time series from stalagmites from Pouatea cave in the Southern Cook Islands were used to reconstruct the variability of effective infiltration over the past 350 years. The reconstruction was validated through cave monitoring, dripwater hydrochemistry, calcite farming experiments, and comparison with rainfall instrumental data and climate index records.

Infiltration was found to modulate trace element variations at a seasonal scale, via dilution of marine aerosols contribution reduced rock–water interaction time and reduced prior calcite precipitation. To quantify infiltration, trace elements were utilized to complement the C and O isotopes ratios and fabric-based reconstructions of wet/dry phases. Through regression analysis Mg, Na, and P were identified as the elements most sensitive to infiltration, while Sr, Ba, U and Y display a more complex behaviour. Magnesium was found to be the most reliable element for hydroclimate reconstruction, superior to Na even though they both predominantly derive from marine aerosol. This difference can be attributed to the incorporation of Na^{+} in speleothems, which mostly depends on the availability of inter-crystalline sites and/or nano-porosity, whereas Mg^{2+} substitutes for Ca^{2+} in the calcite lattice and is mostly unaffected by crystal fabric.

Transmission Electron Microscope investigations and associated EDS-based elemental mapping allowed observing that the presence of Na inhibits pathways of calcite crystallization by particle attachment) which then result in more compact fabrics during dry periods when the influence of marine aerosols is enhanced. When crystallization by particle attachment is dominant, both micro- and nano-porosity characterize the resulting fabric. Consequently, a porous fabric would mark periods of more intense infiltration, most likely because of the *dilution* of inhibitors such as Na (and Mg).

Transfer functions were then established between Mg and effective infiltration. Overall, the O isotope ratios, trace elements and fabric-based reconstructed infiltration data indicate that the main driver of rainfall in the South Pacific is the location of the South Pacific Convergence Zone (SPCZ), which in turn is modulated by the El Nino Southern Oscillation (ENSO).