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An Electron Backscattered Diffraction (EBSD) study on the relationships between calcite fabric and fluid inclusions in cave stalagmites

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Cave stalagmites serve as archives providing valuable information about climatic and environmental changes in the past. Their chemical proxy data have been found to bear relationship with their calcium carbonate crystal fabrics, as the crystallization pathways influence both chemical and physical properties in differing extents. For instance, crystallization pathways can affect the spatial distribution of chemical species and/or micro- and nano-particulate, resulting in inhomogeneities in the concentration of trace and major elements along the same growth layer, with consequences on interpretation drawn from line scans. Pathways of crystallization not only control the overall stalagmite fabrics, but also the occurrence of crystal growth defects and nano-porosity that might become nucleation sites for the formation of larger, water-filled fluid inclusions. The latter have recently acquired a growing scientific interest as they can be used as proxies for paleotemperature reconstruction by means of nucleation-assisted microthermometry, oxygen isotope thermometry, or noble gas thermometry (e.g., Meckler et al., 2015).

Here, we used Electron Backscattered Diffraction (EBSD) on stalagmites consisting of calcite from Borneo and New Zealand aimed to study the relationships between fabric and fluid inclusions by investigating crystallographic orientations, grain boundaries and growth features. The goal is to gain insight on the processes of formation of the fluid inclusions in stalagmites and if/how they can be affected by deformation or physical change over time.

The analysed samples consist of alternating compact and open columnar fabric, characterized by mm to cm-sized domains where the calcite crystal *c* axis (i.e., the elongation axis) is almost perfectly iso-oriented. These domains show a further subdivision in smaller “sub-domains” with widths of tens to few hundreds of micrometres created by a rotation in the direction of the *c* axis in the order of 1-4°. Our preliminary results showed that most of the fluid inclusions are located at the boundaries between these “sub-domains”. An inverse correlation between the width of the "sub-domains" and the number of fluid inclusions was also observed. This suggests that fluid inclusions are significantly linked to the presence of intracrystalline defects. The latter are

potential sources of internal stress in the calcite lattice and relaxation of these internal stress fields could potentially result in post-formation volume changes of fluid inclusions. The scatter and distribution of formation temperatures derived from microthermometric analyses of coeval fluid inclusions within a single stalagmite growth band could, at least partly, be explained by such non-thermal processes.

Meckler, A. Nele, et al., Glacial–interglacial temperature change in the tropical West Pacific: A comparison of stalagmite-based paleo-thermometers, Quaternary Science Reviews 127 (2015): 90-116. https://doi.org/10.1016/j.quascirev.2015.06.015