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Fast high-resolution synchrotron micro-XRF mapping of annually laminated stalagmites

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Annual lamination in trace elements content allows to improve speleothem chronology as well as to extract paleoclimate information about fluctuations of the seasonal signal through time. Given the relatively slow growth and textural heterogeneity intrinsic in most speleothems, only high-resolution mapping techniques provide a viable approach to resolve trace elements variability at annual to sub-annual scale. Synchrotron radiation X-ray fluorescence microscopy (SR-μXRF) is, to date, the ideal technique as it provides quantitative, non-destructive fast scanning of large samples at the necessary high spatial resolution (0.5 – 5 μm).

Here we present SR-μXRF investigation of U/Th dated stalagmites from caves in different geographic and climate setting including semi-arid (Flinders Ranges, South Australia), temperate (Central Italy) and tropical humid (Cook Islands, Northern Laos) climates.

SR-μXRF analyses were coupled with high-resolution petrographic observation and LA-ICP-MS elemental analyses in order to verify the XRF elemental quantification and to test the relationship between fabric and trace element incorporation.

All the analysed stalagmites revealed faint to sharp annual lamination in Sr, and, occasionally, in other elements such as Br, Cu and Zn. In climate setting characterised by strong seasonal contrast stalagmites often exhibit fabric changes at annual to centennial scale that are reflected in the internal porosity as well as in the incorporation of trace elements. Fabric control and spatial heterogeneity is also evident in the intensity of the annual cycles and, in some cases, the amplitude of Sr cycles vary considerably from one line scan to the adjacent ones. This poses the question of the significance and reproducibility of trace element analyses in speleothems characterised by fabric heterogeneity.