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Weathering of speleothems: study of diagenesis with non-destructive techniques

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Non-destructive techniques (NDT): X-Ray Microtomography (CT scan) and Nuclear Magnetic Relaxometry and Magnetic Resonance Imaging (NMR-MRI) have been used to obtain a three dimensional reconstruction of the inner part of a speleothem, since one of the main concerns when working with speleothems is the common need of using destructive techniques for their study, from the first collection inside the cave to the last microscopic or geochemical analysis.
Common calcite microfabrics have been studied, resulting in different porosities and hydric behaviors and, as a consequence, also different sensibility to diagenetic processes related to the influx of waters.
The NMR-MRI technique is sensitive to the magnetization and relaxation times of protons, which allows obtaining an estimation of the amount of water in the sample. In the CT tomography, the diminution of the energy of X-rays passing through the stalagmite is a function of its density and atomic number. The results of both techniques show the porosity distribution, and also the inner textures formed during the growth of the stalagmite and later diagenesis. A complete map of fluid inclusions as well as the open porosity fully saturated with water was obtained, together with relaxometry data related to size, shape and surface-to-volume ratio of the pores.
The analyses show that stalagmites can behave as complex, small-scale hydrological systems, and that circulation of waters through them following complex nets of interconnected pores might be a common process. As circulation of waters favours diagenetic transformations which involve geochemical and isotopic changes, characterization of flow patterns appears as a key task for outlining areas susceptible of such modifications. This is critical in paleoclimate studies based in speleothems, when geochemical and stable isotopic data are used as paleoenvironmental proxies and absolute ages are obtained by means of radioactive isotope ratios. It has also obvious implications for studies based in fluid inclusions in speleothems.
These NDT allow determining the diagenetic transformations when substantial changes in drip waters occur in the cave environment, showing a high potential for characterization of any kind of speleothems as well as other continental carbonates. CT scan and NMR-MRI could be very useful tools for helping to select the most appropriate microfacies for further palaeoclimatic studies.