Isotopic labeling to determine the water penetration depth and reaction sites in the limestone used in built cultural heritage

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This project on the interaction between fluids and carbonate minerals is focused on the alteration of limestone in anthropogenic settings. It deals with the alteration of limestone used in the facades of historic buildings subjected to atmospheric polluted environment. In the elevated parts, water as rainfall (runoff or wet deposition) or in vapor form (condensation or dry deposition) is the main agent of alteration. Thus, the rock/water interactions need to be well understood to propose adapted solution to better preserve the buildings. To identify the water transfer within the porous limestone and locate the reaction preferential sites, two isotopic tracers (D and ^{18}O) are used to monitor the alteration solution circulation in the porous network (D) and locate the zones containing the secondary phases, mainly composed of gypsum (^{18}O). Pristine materials from quarry and stones from monuments (in the Paris area) were thus altered to compare different stages of alteration. After characterization at different scales the alteration pattern, the samples are altered in the laboratory by realistic and controlled wet (rainfall simulation) or dry (controlled relative humidity) deposition using isotopically labeled solutions and analyzed by nano-SIMS to evaluate the alteration rates. The multiscale characterization has allowed proposing alteration mechanisms linked to the properties of the stones and their location inside the building. Isotopic analyses have enabled determining that the water penetration and the location of the reactive zones are different in pristine stone from quarries and stones from monuments. The results highlight the role of the alteration layer on the alteration mechanisms and long-term kinetics. This innovative methodology will contribute to improve the knowledge of stone chemical alteration processes to develop appropriate conservation strategies for the buildings.