Study of water and cultural heritage limestone interaction using isotopic labelling

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This interdisciplinary project at the interface between geology, environmental chemestry and cultural heritage sciences deals with the alteration of limestone in their environment. It is focused on the interaction between limestones used in the cultural heritage and water from urban environments. Water is the main chemical alteration agent. Therefore it's the main parameter to focus on. Acutally, its action leads to two main processes: phase dissolutions and precipitations inducing changes in mineralogy and morphology of the stone. In order to understand the stone/water interactions an original methodology based on the use of water isotopes tracers (D and ^{18}O) was developped. Deuterium was used to localize water penetration front in the material, while ^{18}O enabled to determine secondary phase reaction sites. Pristine limestone from quarry and weathered samples from parisian monuments have been selected to compare different alteration stages.

Firstly, their main chemical and physical properties linked to the alteration were studied based on a multiscale characterization. Then, samples were altered in simulation chambers by realistic and controlled conditions. The reaction zones in the limestone were analyzed by nano-Secondary Ion Mass Spectrometry (nano-SIMS) on transverse sections. This experimentation enabled determining that water entirely penetrated in samples from quarry and from monuments, what highlights that the alteration layer does not seem to have a protective role. In surface or deeper inside the sample, ^{18}O enrichment highlights preferential reaction sites, localized in micro-cracks inside gypsum zones and along calcite grains.

This innovative methodology is a first step to understand the alteration mechanism formation on limestone used in the façade of the buildings. Understanding the mechanisms and especially the role of the alteration layer will contribute to improve the knowledge of stone chemical alteration processes to develop appropriate conservation strategies for the buildings.