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Isotopic labeling for the understanding of the alteration of limestone used in built cultural heritage

Mandana Saheb (1), Anne Chabas (1), Jean-Didier Mertz (2), Olivier Rozenbaum (3), and Aurélie Verney-Carron (1)

(1) Laboratoire Interuniversitaire des Systèmes Atmosphériques, 61 avenue du Général de Gaulle, 94010 Créteil Cedex, France, (2) Laboratoire de Recherche des Monuments Historiques, 29 rue de Paris, 77420 Champs-sur-Marne, France, (3) Institut des Sciences de la Terre d'Orléans, 1A, rue de la Férollerie, 45071 Orléans Cedex 2, France

This project belongs to a specific work aiming at developing isotopic tools to better understand the alteration of materials used in the built cultural heritage. It is focused on the study of the alteration of limestone used in the facades of historic buildings subject to atmospheric polluted environment. Actually in the elevated parts of the buildings, 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 18O) are used to monitor the alteration solution (D) and locate the zones containing the secondary phases (18O).

The Saint-Maximin limestone used in many monuments in the suburbs of Paris (France) as a building and restoration stone has been specifically studied. Pristine materials, stones from monuments (monuments in the Paris area) and samples altered in laboratory constitute the analytical corpus to compare different stages of alteration.

In a first step the stones are characterized at different scales to identify the alteration pattern (SEM-EDS, Raman microspectrometry, XRD, rugosimetry) and study the water transfers (X-ray tomography, mercury porosimetry, imbibition kinetics). The samples are then altered in the laboratory by realistic and controlled wet or dry deposition using isotopically labeled solutions to locate the reaction zones by SIMS.

The multiscale characterization of the alteration pattern has allowed proposing alteration mechanisms linked to the properties of the stones and their location inside the building. Moreover, the location of the reactive zones inside the materials determined by the isotopic experiments helps examining the role of the evolution of porosity and formation of alteration products within the material, in order to estimate the alteration rate. This innovative methodology will contribute to improve the knowledge of stone alteration processes in order to develop appropriate conservation strategies for the buildings.