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Alteration mechanisms and kinetics of limestone materials used in built cultural heritage

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This project on the interaction between water and carbonate minerals is focused on the alteration of limestone in anthropogenic settings. The alteration of limestone used in the facades of historic buildings has been studied when subjected to atmospheric polluted environment. Water in vapor or wet form (condensation or dry deposition, rainfall or wet deposition) is one of the the main agents of alteration because it acts as a vector of the aggressive species inside the porous materials. Thus, its action needs to be clearly understood. To this purpose, the water transfers within the porous limestone have been located and quantified using two isotopic tracers (D and ^{18}O). D enabled monitoring the alteration solution circulation in the porous network and ^{18}O enabled locating the zones containing secondary phases inside the limestone, mainly composed of gypsum and reprecipitated calcite. Stones from the Paris Administrative Court and exposed during several decades to an urban environment were altered in laboratory by controlled relative humidity using an isotopically labeled solution ($D_2{}^{18}O$). After 2 months, the alteration pattern of the stone was characterized at different scales and nano-SIMS and Tof-SIMS isotopic analyses were performed. The quantification of the reactive sites allowed to highlight a high alteration kinetics. Moreover, the multiscale characterization of the alteration patterns of the stone allowed identifying the presence of nitrate probably formed by a biological activity, implying a high retention of water that could cause the reactivity. Consequently, these results highlight the role of the nature of the alteration layer on the subsequent alteration mechanisms and long-term kinetics. This innovative methodology based on the use of isotopes will contribute to improve the knowledge of stone chemical alteration processes to develop appropriate conservation strategies for the buildings.