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Salt Weathering on Buildings and Stone Sculptures

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Modification of the physical properties of rocks due to salt crystallization.

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ABSTRACT

This work aims to track the signature of physical properties induced by damages on rocks, mainly limestones, during the crystallization of sodium sulfate salt, commonly formed by weathering within the porous network. Any changes on physical properties during salt saturation, that simulates the meteoric weathering percolation on building rocks, will impact on the rock behaviour in place. Changes in grain cohesion or apparition of microcracks generated by mechanical (salt crystallization) or thermal stresses (thermal expansion and/or fatigue) will have effects on the rock structure. These textural changes will bring a level of brittleness to the rock that will irremediably decrease the rock durability (fracturing, collapsing risks…). Salt crystallization tests are performed by imbibitions/evaporation of salt supersaturated brine into two French lutetian limestones corresponding to the "roche fine" type with different degree of alteration: (i) fresh limestone sampled at Saint Maximin sur Oise and (ii) strongly altered limestone coming from the top of an external wall exposed to weathering of the historical church of Magny-en-Vexin.

A large number of physical properties were acquired on cylindrical samples such as porosity, permeability, water content and its distribution (i.e pore size distribution), P wave velocity and its anisotropy, thermal conductivity and the electrochemical impedance spectrum. Their microstructures were also characterized using a X-ray scanner before and after every test of crystallization by imbibitions/evaporation cycles under atmospheric pressure and applying different temperatures and relative humidity environmental conditions. Two acoustic transducers and electrical electrodes combined to a thermocouple placed at each end of the samples were used to record any micro-seismic events from microcracks, grain displacements or any other mechanical damages induced during saturation and salt crystalization. Temperature changes recorded by the thermocouple were associated to phase transitions of the salt involving chemical reactions (dissolution and/or crystallization processes). The influence of the environmental conditions on salt crystallizations and their localizations, with the help of the X-ray images, in the samples is particularly interesting to predict the physico-chemical behaviours and help to limit the rock damages for building preservation considerations.

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