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Visualization and quantification of weathering effects and water uptake processes in natural building stones by using neutron imaging

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Calcarenites are the most widely used natural building stones in Sicily. They are frequently subjected to very intense degradation due to salt growth [1, 2]. This process is often responsible for strong modifications of their pore network [3] and has a great influence in the mechanical properties and the durability of materials [4]. In addition, as water transport has a key role in the degradation processes, the quantification and visualization of fluidflow into the pore network of degraded stones represent useful tools in understanding the weathering process.

Classical approaches are usually performed by applying laboratory test routines for the determination of water absorption parameters. However, they cannot provide a description of the local distribution of water inside the stone. In this framework, neutron imaging has been demonstrated as a powerful technique for the visualization and quantification of the water distribution in partially saturated porous media [5]. Moreover, the possibility to perform dynamic measurements allowed monitoring the water uptake as function of time and to explore the complex processes involved in fluid transport [6-8].

In this study neutron radiography has been used with the aim of: a) monitoring and visualizing the fluidflow patterns inside porous structure of a local calcarenite widely used as building and replace stone in several Cultural Heritages, namely Sabucina Stone; b) quantifying the water distribution as function of time, in order to understand the effects of weathering on the behavior of the stone against water. In detail, samples of un-weathered and artificially weathered[9] Sabucina Stone have been scanned with neutron imaging technique at the IMAGINE beam line located at the Laboratoire Léon Brillouin (CEA/CNRS) in Saclay (France). Capillary water uptake has been monitored over time in samples subjected to different salt crystallization cycles.

Beside the qualitative data acquired from the raw neutron images (Figure 1(a)), quantitative results have been obtained thanks to the image processing of the radiographs (Figure 1(b)) [10]. First of all, the evolution of the wetting front position over time has been observed and the penetration coefficient has been determined. The results demonstrated that changes in the hydric properties of the stone occurred with the intensification of the degradation process. Even if a good agreement with standard

capillary absorption test has been obtained [11], the non-perfect linearity of capillary uptake process has been evaluated, due to the evidence of preferential flow paths. Therefore, neutron images have been processed in order to obtain quantitative water distributions as function of time. The contour plot of the water content value highlighted that degraded stones absorbed greater volumes of water than the un-weathered ones, due to the strong modification of their pore structure. Moreover, in weathered samples the quicker and deeper vertical spreading of the water was associated with an intense horizontal migration through pores enlarged by the degradation mechanisms. Finally, side effects, probably due to the more intense action of the degradation process close to the sample surface, were evidenced, determining different capillarity absorption properties for the inner and surface regions. In conclusion, neutron radiography has allowed a better understanding of the deterioration mechanisms affecting physical properties of building stones, supplying relevant data for planning powerfully actions to improve their durability.

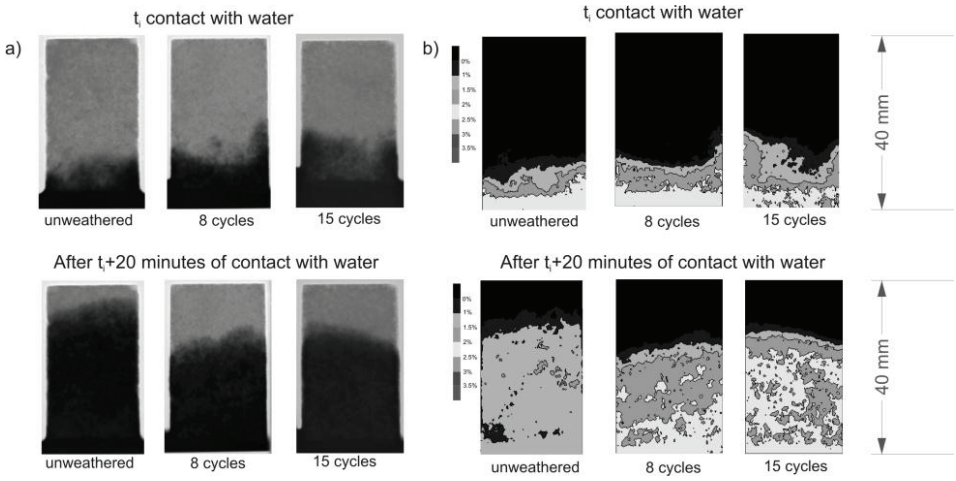

Figure 7. (a) Neutron radiographiesand (b) water content distribution (WC%) as function of time and degradation degree in samples representative of un-weathered and weathered Sabucina stones

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