Understanding Salt Weathering in Khondalite through Mineralogy and Microstructure

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Salt weathering is one of the crucial agents of deterioration in porous building materials, especially in masonry systems along the coast. The cyclic environmental conditions involving changes in temperature, relative humidity and exposure to salt dissolved in moisture synergistically damage the materials. Driven by evaporation and moisture transport, salts like sodium sulphate and sodium chloride migrate through the pore network, undergo phase transitions depending on the salt type, and crystallize, often exerting significant crystallization pressures. These pressures can lead to the development of micro fissures, granular disintegration, scaling and surface blistering. The extent of damage depends on the type of salt, nature of the substrate, exposure conditions etc. [1,2,3]. The role of complex salt-pore interactions in aggravating the damage remains an active area of investigation. These interactions are driven by the mineralogy and microstructure of the substrate as well as the salt composition. To get insights into their complex coupling, studies encompassing the bulk scale and the pore scale are vital.

Our study focuses on the salt weathering of Khondalites, metasedimentary rocks, primarily composed of quartz, feldspar and garnet. They are visually appealing and are extensively used in historic structures along the eastern coast of India, notably in the Konark Sun Temple and Puri Jagannath Temple. The heterogenous mineralogy and microstructure, with regions of varying porosity and pore size distribution, results in preferential crystallization sites during salt weathering. The non-uniform pore structure makes it vulnerable to salt-induced decay under conducive environmental conditions. Characterizing salt weathering at the microscale remains challenging due to the difficulty of capturing in situ crystal formation without disturbing the microstructure, quantifying crystal growth and pore occupancy, and tracking crystallization dynamics.

The current study focuses on tracking the progression of salt weathering of cylindrical Khondalite specimens of diameter 9 mm and height around 2 mm using X-ray computed tomography (X-ray µCT). The development and propagation of sodium sulphate and sodium chloride precipitation, introduced in isolation, as well as crack formation, is tracked across weathering cycles mimicking the coastal climate of Eastern India. Complementary time-lapse µCT imaging allows for quantitative assessment of pore-filling and pore-emptying events during wetting and drying. The integration of imaging data provides critical insights into how crystal growth initiates, propagates, and ultimately contributes to stone failure, underscoring the value of pore-scale observation in understanding salt damage in heritage stones. These findings have broader implications for predictive modelling of salt decay.

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References:

1. A. E. Charola, "Salts in the deterioration of porous materials: An overview," Journal of the American Institute for Conservation, vol. 39, no. 3, pp. 327–343, 2000
2. J.M.P.Q. Delgado, A.S. Guimar˜aes, V.P. De Freitas, et al., Salt damage and rising damp treatment in building structures, Adv. Mater. Sci. Eng. 2016 (2016)
3. B. Lubelli, R.P.J. Van Hees, C.J.W.P. Groot, The role of sea salts in the occurrence of different damage mechanisms and decay patterns on brick masonry, Constr.Build. Mater. 18 (2004) 119–124.