Thermal expansion of Ançã limestone after contamination with three different sodium salts

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Abstract: The crystallization of soluble salts causes harsh and recurrent damage to porous building materials, giving rise to some of the most difficult problems that appear within the conservation of our cultural heritage. Part of this difficulty stems from the complexity of the underlying processes that, after decades of research, are not yet fully understood.
Over time, several mechanisms have been proposed to explain the damage caused by soluble salts [1]. One of them is the differential thermal expansion, which is based on the fact that salt crystals usually have higher coefficients of thermal expansion than porous building materials. The effect of temperature could, therefore, cause the salts to expand and exert pressure in the pores [2]. This could, for example, lead to differential dilation and consequent detachment of salt contaminated layers of the material. Strikingly, however, not much research has been conducted on this mechanism and the few reported results have often been contradictory [3,4].
To help clarify the possible relevance of thermal dilation within salt decay processes, we have performed experimental work on the well-known Ançã limestone. This stone is very susceptible salt decay problems and can be found in several classified monuments in Portugal [5]. It was contaminated with sodium chloride (NaCl), sodium sulphate (Na_2SO_4) or sodium nitrate ($NaNO_3$). Afterwards, the thermal expansion of blank and salt contaminated specimens was measured using an automatic dilatometer.
The results showed that the thermal expansion coefficient of the salt-contaminated specimens was systematically higher than that of the blank specimens. The difference seems to be more dependent on the amount of salt that remains in the pores after drying, rather than to the type of salt, which will be discussed in this presentation. We concluded that thermal expansion may, in fact, be one of the mechanisms involved in salt decay processes.

Keywords: thermal expansion; Ançã limestone; soluble salts; sodium chloride; sodium sulphate; sodium nitrate; salt crystallization; porous building materials

Acknowledgements: This work was performed under the research project DRYMASS (ref. PTDC/ECM/100553/2008) which is supported by national funds through the Fundação para a Ciência e a Tecnologia (FCT) and LNEC.

References:

[1] C. Rodriguez-Navarro, E. Doehne, Salt weathering: influence of evaporation rate, supersaturation and crystallization pattern, Earth Surface Processes and Landforms 24, 1999, pp. 191-209.
[2] R. U. Cooke, I. J.Smalley, Salt weathering in deserts, Nature 220, 1968, pp. 1226-1227.

[3] A. S. Goudie, Further experimental investigation of rock weathering by salt and other mechanical processes. Zeitschrift für Geomorphologie Supplementband 21, 1974, pp. 1-12.
[4] E. S. Larsen, C.B. Nielsen, Decay of brick due to salt. Materials and Structures 23, 1990, pp 16-25.
[5] D. Costa, J. Delgado Rodrigues, Consolidation of a porous limestone with nanolime, in proceddings of the 12th International Congress on the Deterioration and Conservation of Stone, Oral Presentations – Methods and Materials of Cleaning, Conservation, Repair, Maintenance; Logistics and Planning, session X, 2012.