Morphological alterations of stone surfaces by sodium sulfate crystallization: time-lapse monitoring by optical profilometry and digital imaging

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Abstract: Salt decay is a very destructive decay mechanism that frequently affects the porous building materials of the cultural heritage. Among the salts currently found in this context, sodium sulphate is one of the most harmful and complex. Here, we analyze the decay patterns to which it gave rise upon crystallization during drying of three natural stones of architectural relevance. The underlying degradation mechanisms are then discussed and explained.

The experiments were performed on the Bentheimer sandstone, Ançã limestone, and another Portuguese limestone with low porosity. Their morphological alterations were non-destructively monitored by optical profilometry, using a non-contact system equipped with a chromatic length aberration gauge. Time-lapse image recording was also carried out in selected cases. The tendency of the stones to absorb and transport water by capillarity was evaluated by measuring their sorptivity.

The three types of stone gave rise to distinct decay patterns: efflorescence, exfoliation (multi-layer delamination) and uni-layer delamination. Exfoliation took place during a single drying event. Therefore, it did not result, as it is often suggested, from the successive effect of wet-dry cycles.

These experimental results are discussed, explained and interpreted. Time-lapse animations are shown, which illustrate and make it easier to understand the evolution of the surface morphology and the general decay patterns of the different materials.

The experimental method allowed distinguishing the susceptibility of the different types of stones and the decay patterns they tend to develop. We concluded that these patterns depend primarily on the depth at which the salt crystallizes, and that sorptivity is the fundamental explanatory parameter. The optical profiling technique showed to be appropriate to monitor morphological alterations of stone surfaces due to salt crystallization, thereby helping to clarify the forms and mechanisms of decay. A proper understanding of these factors will allow choosing appropriate intervention methods.
Keywords: salt decay; salt crystallization; optical profilometry; natural stone, surface morphology; sodium sulphate

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