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Durability assessment of limestone subjected to surface treatments

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Weathering is inevitable in existing limestone structures due to their exposure to fluctuating and aggressive environmental conditions, such as wetting/drying, and the presence of salts. Therefore, conservation treatments are often deemed necessary in order to prevent or at least delay the progress of deterioration and to strengthen weathered stones.

This paper focuses on the effect of an ethanol-based laboratory produced water repellent and three water-based commercial products (water repellent, pure acrylic emulsion mixed with a water repellent with thermal insulation properties and consolidant) on the durability and other properties of three different types of limestone (massive chalk, calcarenite and bioclastic limestone). All test specimens were subjected to micro-destructive cutting tests before/after the application of the aforementioned surface treatments to investigate changes in resistance to cutting on the area close to the treated surface. They were also subjected to two cycles of salt contamination with 20% w/w Na2SO4•10H_2O solution by capillary absorption through their bottom face, until 2 mm of pore space was theoretically filled with salt crystals. Drying after salt contamination took place at 70 °C.

The results of the micro-destructive cutting tests showed increases in cutting resistance at the topmost area (1-2 mm below the treated surface) of the massive chalk and the calcarenite, but no significant changes in the case of the rather non-homogeneous bioclastic limestone. At the same time, the performance of each surface treatment varied from lithotype to lithotype. The laboratory produced water repellent showed a generally better performance; no signs of damage were detected due to the formation of salt crystals within the pores of the materials, i.e. subflorescence, when applied on the calcarenite and the bioclastic limestone. Very poor performance was observed for all treatments when applied on the massive chalk. This accounted for (i) intense salt efflorescence, (ii) blistering, (iii) cracking and detachment of stone surface material due to subflorescence and (iv) cracking of the vertical sides. The calcarenite proved to be more durable than the other two lithotypes under investigation, with the treated samples showing no sign of damage whatsoever. Nevertheless, the two commercial water repellents proved to be inappropriate for the bioclastic limestone, since more severe damage in the form of multiple cracking was observed to the treated sample, compared with the untreated one. In all the cases, the damage observed is attributed to the suppression of stage I drying by the surface treatments applied; this leads to evaporation of the salt solution mainly by vapour phase diffusion through the treated surfaces, which is a very slow process promoting damaging subflorescence.