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Assessing spatial trends of cultural stone weathering intensity using a hardness tester: The case of Manglieu Saint-Sébastien church (France)

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In heritage science, the quantitative assessment of rock hardness is of primary interest to characterize the degree of weathering of a cultural stone. Modern hardness testers are non-destructive and can be used on cultural heritage materials to collect repeated measurements of rock strength without causing damage. Furthermore, the development of portable solutions such as the Equotip Piccolo 2 facilitates the in situ hardness survey of a whole façade of a monument. It allows to address the question of spatial variability of weathering intensity within a monument, and the mapping of hardness values can reveal strong gradients or discontinuities in stone decay induced by restoration operations.

The present study deals with the spatial distribution of stone hardness on the façade of the Saint-Sébastien Romanesque abbey church at Manglieu, in the French Massif Central. It was built during the twelfth century and listed as a protected historic monument in 1840. During the Late 19th century, the lower part of the west-facing wall was restored and the original gneissic material was replaced by granitic ashlars. Since this operation, an intense deterioration has affected the original gneissic stones overlying the granitic base of the wall. Our objective is to quantitatively assess the effect of this restoration on the current spatial trends of the gneiss hardness. Rock strength values were collected using the portable hardness tester Equotip Piccolo 2, and the spatial distribution was investigated at two scales: (i) At the portal scale, the hardness values of all stones were measured based on 30 values per stone; (ii) At the stone scale, a systematic sampling method was performed on two gneissic ashlars in order to collect hardness values over a grid of 9 cm resolution. On each sample, the repeated impact method was performed: 20 consecutive measurements at the same location were collected in order to reconstruct the spatial variation of weathering degree within the stone surface.

At the portal scale, the results indicate an inverse correlation between the weathering intensity of gneissic stones and the vertical distance to the granitic ashlars, suggesting the deleterious effects of the water capillary rise enhanced by the incorporation of low porosity granite at the base of the wall. At the stone scale, the weathering maps display a strong spatial autocorrelation of hardness values, suggesting a gradual diffusive process of weathering within the stones.