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Characterization of the carbonate rocks of the Calcari di Cagliari Formation using a combined petrographic, geomatic and geophysical approach.

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The methods and the tools aimed at characterizing and analysing the carbonate materials used in the historic built heritage often follow different ways according to the different branches of applied research involved in the knowledge process. In this framework, the 3D digital models both of in situ architectural elements and of significative samples of rocks used as building materials can play an important role in relating different data and disciplines aimed at the prevention and conservation of the Cultural Heritage. Although the 3D geomatic and geophysical digital models represent privileged tools of the diagnostic analysis, they must be supported by the knowledge of the textural characteristics of the rocks under investigation with petrographic analyses. In order to study the stone materials heavily used in the historic built heritage and analyse their vulnerability to the conditions in their environment, it can be beneficial to study appropriately prepared samples and make as many measurements as necessary with different techniques. Moreover, some analyses are destructive and there is a limit to the number of samples that can be sacrificed. For this reason, in the analysis of rock samples, non-destructive techniques are constantly being improved. In this study, using a suitably implemented integrated methodology we analysed in detail samples of the carbonate rocks of the Calcari di Cagliari formation represented by Pietra Cantone, Tramezzario and Pietra Forte lithologies, mainly used in the past as construction materials for the buildings of the Historical Centre of Cagliari (Italy). Our methodology is represented by an integration of the geomatic survey carried out by structure-from-motion (SfM) digital close-range photogrammetry and the seismic tomography normally used for the in situ inspection adapted to laboratory tests on samples of the above lithologies using ultrasonic frequency signals. The rigorous metric of the geomatic 3D models was used to implement the ultrasonic survey by which internal characteristics and physical properties of the studied material are detected thanks to the spatial variations of the longitudinal velocity obtained after the tomographic inversion. The geomatic and geophysical data were complemented by an accurate analysis of the above carbonate materials by optical and scanning electron microscopy in order to detect their textural characteristics and especially the nature and distribution of their porosity. The

microscopy analyses were integrated by mercury intrusion porosimetry (MIP) to obtain further information on the pore network, particularly on the effective porosity, pores-throat diameters/radii, permeability and tortuosity of the investigated materials. All the above parameters were found to affect the geomatic and geophysical behaviour of the carbonate materials. The integration of the multi-technique data produced in this study contributes to better understand the interaction between the investigated materials and the environment.

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