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Thermoclastic and cryoclastic action on calcareous building stone: durability to artificial ageing

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Short and long-term climate changes are a critical factor of stone decay even in temperate Mediterranean areas, when the combined fluctuations of temperature and moisture lead to thermoclastism and cryoclastism. The effects of weathering are of particular concern in the conservation field, for the assessment of the vulnerability of outdoor-exposed stone materials in the historical built heritage. An example of this outline is Apulia, a region of southern Italy characterized by warm, dry summers and mild, rather rainy winters that can bring sub-zero temperatures; here, climate-driven decay can seriously affect the state of conservation of the local calcareous stone used in the monumental heritage, especially the most porous and softest materials.

The dynamic behavior of the Apulian calcareous stone in response to thermo-hygrometric stresses was studied here by means of an artificial accelerated ageing test, focusing on a single local stone variety known as "pietra gentile". It is a fine-grained, soft and porous calcarenite, which is exploited in the Murge area from the outcrops of the "Calcare di Caranna" Fm. (late Campanian?–Maastrichtian). The quarrying activity is concentrated in the territory of Valle d'Itria and mainly of Ostuni, touristically known as "the White Town", where the stone is widely used for the sacred and civil architecture.

The ageing test was programmed according to the typical climatic characteristics of the considered area, following the historical recordings by the official Apulian monitoring institute (Struttura di Monitoraggio Meteoclimatico, Centro Funzionale Regionale); in order to simulate the seasonal climatic changes, the extreme temperatures were considered, while the possible insolation effects for higher temperatures were also taken into account. So, samples of "pietra gentile" were subjected to 100 temperature cycles from 60 to –5 °C, in a climatic chamber with a maximum relative humidity of 60%. Before the ageing, the samples were petrographically characterized through optical microscopy on thin section, followed by a geotechnical parameterization with petrophysical measurements (dry density, total porosity, MIP porosity) and indirect ultrasonic and sclerometric tests. Then, after every 20 ageing cycles, the same tests stated above were carried out; in addition, the measurement of residual strains and SEM observations were performed. With this methodology, the gradual modifications in fabric, petrophysical and mechanical properties of the tested stone were analyzed.

The results revealed a high durability of the material to the conditions of ageing experimented. The main modifications of the samples concerned fabric, i.e. microcracking due to thermoclastic and cryoclastic action, which occurred only in limited areas for an uneven distribution of internal stresses. For this reason, no evident effects on the macroscopic integrity and physico-mechanical performance were noted, whereas the stone almost preserved the original strength and elasticity. Finally, the data gathered were used to suggest a method for the evaluation of the vulnerability of "pietra gentile" to freeze-thaw microcracking, based on the peculiar porosimetric distribution and the environmental conditions of weathering.

New information are globally provided about a stone material that has been largely used in the Apulian monumental heritage, but has received scarce attention from the archaeometric research so far.