



Methodologies adopted in the survey of the distinct pathologies displayed by the multitype volcanic natural stone applied on the Cathedral of Funchal, Madeira island

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The Cathedral of Funchal is a classified monument dated of the beginning of the XVI century which has been identified as the *ex-libris* of Funchal, the capital of the Atlantic island of Madeira. Dimension volcanic natural stone (blocks and plates) of distinct lithologies, such as, trachybasalt, trachyandesite, trachyte, tephrite, tuff and pyroclastic breccia extracted in several local quarries most of them actually without works, have been applied as both structural and ornamental elements. The tuff exhibiting both breccia and lapilli textures and colours (red, purple, green, yellow, brown and black) that has been extracted from the Cabo Girão (the highest cliff in Europe) quarry is the stone particularly responsible for the unique polychromatism that characterizes the cathedral façades. Due to the lithological diversity of the applied natural stone it exhibit differentiated pathologies. These are attributed to the effect of physical, chemical and physical-chemical factors, natural and anthropogenic, and several typologies could be identified, such as, salt crystallization, fracturation, fissuration, desintegration, powdering, exfoliation, blistering, scaling, and crusting/darkening (mainly caused by atmospheric pollution due to automobile traffic, but also to saline aerosols, or to biogenic colonization). Lapilli tuff, breccia tuff and pyroclastic breccia are the lithologies that show higher degradation under the form of mass loss. Degradation is particularly due to argillization, a generalized process leading to the formation of expansive clay minerals of the smectite type. Periodically restoration interventions are required. A common intervention contemplates the replacement of the most degraded

elements. This replacement should comply with certain criteria the most important one is that the replacing stone must have the same compositional, textural and aesthetic properties of the replaced stone. This achievement requires, first of all, the identification and protection of old quarries, presently with halted mining works, from where the applied natural stone had been extracted. Such protection is frequently in conflict with the utilization of other cultural heritage or with the environment. The authors of the present paper have carried out in the Cathedral of Funchal a thoroughly field and laboratory survey. High resolution photography assisted on the record of natural stone pathologies, represented by appropriate numerical and geometric symbols, could be classified stone by stone along the rows for each façade and panel. All the information gathered from the field survey was integrated into a geographic information system (GIS).