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The stones and historic mortars of the Santissima Trinità di Saccargia Romanesque Basilica (Sardinia, Italy): a multi-analytical techniques' approach for the study of their features and provenance

Stefano Columbu (1), Marcella Palomba (2), and Fabio Sitzia (1)

(1) Department of Chemical and Geological Sciences University of Cagliari, Italy (columbus@unica.it), (2) Istituto di Scienze dell'Atmosfera e del Clima (ISAC) Unità Operativa di Supporto (UOS) - C.N.R. of Cagliari

Abstract:
A research project devoted to the study of building materials of the Romanesque churches in Sardinia is currently underway. One of the objectives of the project is to focus the mineral, chemical-physical and petrographic characterisation of the construction materials, as well as the alteration processes. To make a contribution to the preservation of Sardinian monuments, we suggests a new approach to define the different alteration-modes of rocks in function of their local exposure to the weather, studying: 1) the changes of physical properties on surface of stone (porosity, water absorption, micro-morphology) determined through laboratory tests and photogrammetry observations, 2) the alteration phases present on surface (e.g., secondary minerals, soluble salts) determined by mineralogical and chemical investigations.
This methodological approach will allow to select appropriate, suitable and compatible materials for replacing the original altered one's, and to plan appropriate strategies devoted to the restoration work.
In this paper the geomaterials used for construct the Santissima Trinità di Saccargia Basilica have been investigated. The church, finished in 1116 over the ruins of a pre-existing monastery, is the most important Romanesque site in the island. Have been studied the chemical alterations and physical decay of two different stones, as volcanic rocks (i.e. basalt) and sedimentary rocks (i.e. limestones) used in bichromy on the Basilica.
The main purpose is to observe the different modes of alteration of these two lithologies with different petrophysical characteristics, placed in the same conditions of weathering.
Macroscopic evidences show that the limestones, while not having a high porosity, they were strongly affected by alteration phenomena, especially in the outer surface of ashlars, due to the solubilization of the carbonate matrix.
The basalt rocks show no obvious physical alteration. Occasionally, in some ashlar located in basal zone of the monument structure, where the samples have a greater porosity, patinas of soluble salts on their surface can be observed.
The features of a selected set of samples, including the stones and historic mortars, has been determined by the application of different techniques, as X-Ray Diffraction (XRD), Thermal Analysis (simultaneous TG and DTA analysis), Optical Microscopy, X-Ray Fluorescence (XRF) and Inductively Coupled Mass Spectrometry (ICP-MS).
Mineral data, both from XRD and petrographic studies, show that limestones' ashlars consist of pure calcite (100 wt%) or to include other mineral species, especially dolomite (up to 15 wt%), as well as minor fractions of illite and quartz.
Newly-formed minerals occur in different amounts, both in limestones (gypsum up to 10 wt%, illite up to 5 wt%) and basalts (smectite-group minerals up to 10 wt%, K-Ca-Mg sulfates in traces).
Original masonry mortars show a qualitatively constant mineral association, mainly consisting of calcite (from 50 to 70 wt%), quartz (10-20 wt%), plagioclase (10-15 wt%), k-feldspar (5-10 wt%), gypsum (5-40 wt%), and illite (traces).
The heterogeneous composition and high porosity of study mortars strongly affected its durability. The weathering processes have seriously damaged their texture and consistency, also contributing to the instability of other building materials in contact.

Keywords: Medieval monuments, Mineralogic-petrographic features, Physical properties, Chemical-physical decay, Micro-photogrammetry