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Geochemical, petrographic and physical characterizations and associated alterations of the volcanic rocks of the Romanesque San Nicola Church (Ottana, central Sardinia, Italy)

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In this research, the volcanic rocks belonging to the Sardinia Oligo-Miocene volcanic cycle (32 - 11 Ma) and building up the structure of the San Nicola church, one of the most representative churches of the Romanesque architecture, were studied. These stones were widely used in medieval architecture for the excellent workability, but they present some disadvantages, since they are greatly affected by alteration phenomena.
The main objectives of this research are i) to focus the mineral, chemical and petrographic compositions of the San Nicola stones, ii) the chemical and physical alteration processes affecting these materials, and iii) to establish the exactly provenance of the volcanic rocks.
Furthermore, a comparative study between the rocks from the ancient quarries and those forming the structure of the church was performed. In the ancient quarries, where presumably a more advanced alteration occurs due to the vertical alteration gradient, different facies of the same volcanic lithology, characterized by macroscopical evidences of chemical-physical degradation degree, were sampled. Petrographic, geochemical (both major elements that the traces) and physical-mechanical features of the collected samples were determined to highlight the compositional differences (density, porosity, water-absorption kinetics, mechanical resistance) as a function of the different alteration degree. Moreover, chemical-mineralogical analysis of the sample surfaces from the church, was performed, to highlight possible presence and nature of secondary newly-formed phases (e.g., salt efflorescence).
Several methodologies were applied to carry out physical-chemical and petrographic analysis: X-Ray fluorescence (XRF) and Inductively Coupled Mass Spectrometry (ICP-MS), X-Ray Diffractometry (XRD) for chemical and mineral composition; Optical and Scanning Electron Microscopy (SEM) for textures, mineral assemblages and microstructures studies; He-picnometry, water-absorption and mechanical tests for physical properties.
In the paper some significant result will be presented, to better illustrate the methodological approach and the results achieved in this field.
The results indicate that the volcanics of church have a mainly dacitic composition and come from local quarries. The XRD and optical analyses mainly consisting of K-feldspars and plagioclases), show the presence of an important glass fraction (about 40% vol.), and newly-formed minerals occur in different amounts. The most important are: smectite-group minerals (mainly montmorillonite) up to 30 wt%, gypsum up to 10 wt%, illite up to 5 wt%. Celadonite, glauconite, K-Ca-Mg sulfates, are occasionally detectable and generally occur in traces. In some samples of the church, the chemical alteration on the surface is not manifest since operate slower than the physical degradation. This latter generally occurs as macroscopic forms of pitting, exfoliation and alveolation.
The chemical analysis of the outcrop-samples show a mobilization increasing degree of alteration, with an consequent leaching for some elements. At the same time it shows a clear decrease in the mechanical strength, due to the increase of the total porosity and a decrease in the apparent density. These variations of the porosimetric characteristics (with total porosity between 20-50%) also determine an increase of the water absorption, with a potential increase in the interaction between the circulating-fluid and the rock.

Keywords: Medieval monuments, Mineralogic-petrographic features,
Physical properties, Chemical alteration, Physical decay