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Near-surface geophysical investigations inside the cloister of an historical palace in Lecce, Italy

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Near-surface geophysics can play a major role in the framework of the Cultural Heritages diagnostics as the recourse to non-invasive geophysical methods is usually the only way to gain information on subsurface properties that can affect the stability of historical structures and accelerate degradation processes. In most cases the deterioration of ancient buildings is due to various causes: external, such as pollution, biological degradation and adverse climatic or microclimatic conditions; internal, such as a particular geological or hydro-geological setting or a combination of both. Therefore, being able to discriminate between the different sources and to identify the main process of decay becomes essential for the development of effective remediation actions.

The present case study shows the main results of an integrated geophysical campaign performed inside the cloister of an important palace in Lecce, Southern Italy, in order to investigate the possible subsurface causes of deterioration affecting its pillars and walls and, more importantly, some altars of the annexed church. The historical building, named Palazzo dei Celestini, was formerly a monastery directly connected to the Basilica of Santa Croce and nowadays is the head office of the Province of Lecce Administration and the Prefecture. With its rich baroque façade, Palazzo dei Celestini and Santa Croce is the most famous architectural complex of the historical centre of Lecce. Its foundations generally rest on a very shallow and sometimes outcropping wet calcarenitic basement, evidenced by previous geophysical surveys performed in the nearby. The high capillarity of the local fine-grained calcarenitic stone used as building and ornamental material for the historical complex was thought to be responsible for the deterioration problems evidenced at some altars of the church and in the lower portion of the walls and pillars of the palace, although a previous microclimatic study inside the Basilica had pointed out that external causes, such as local increase in relative humidity and insufficient air circulation, could also contribute to enhance the state of decay. The geophysical survey was aimed at evidencing the general stratigraphical and hydrogeological setting of the area, and possible natural or anthropogenic causes of local increase in subsoil moisture that could promote the rising of moisture through the building structure. Ground penetrating radar (GPR), Electrical Resistivity Tomography (ERT) and Induced Polarization (IP) investigations have been performed in order to obtain a detailed stratigraphical mapping of the shallow subsurface and to identify zones of increased water content.

The use of different antenna frequencies (100, 200 and 500 MHz) allowed us to obtain a multi-resolution stratigraphical mapping of the shallow subsurface at slightly different penetration depths and to identify different-sizes ancient and modern drainage systems. The spatially dense high-frequency survey, after careful data processing and proper visualization as time-slice maps and 3D iso-amplitude volumes, provided a detailed mapping of the drainage network, whose local failures could be correlated to the observed decay phenomena.

A conductive layer between 1.3 and 2.5 m, especially in the western portion of the ERT profile closest to the Basilica of Santa Croce, could indicate a local increase in water content, which could be responsible of the higher degree of stone decay and efflorescence phenomena in the altars located in the western part of the Basilica. A narrow high-conductive feature, evidencing also anomalous IP values, can be ascribed to a presumable vertical drain, whereas localised conductive anomalies, corresponding to characteristic hyperbolas in the GPR profiles, are interpreted as presumably leaking pipes.

The example shown in this study demonstrates that the combination of different geophysical methodologies, complemented by other physical, geological and biological techniques, is crucial for obtaining an exhaustive knowledge of the status of historical monuments and to identify the possible causes of damages in order to improve the cultural heritage management.