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GPR based investigations of rock-cut monuments: the case study of the 'Tombs of the Kings' necropolis in Cyprus

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Architectural and archaeological monuments management requires a detailed understanding of building techniques and materials, and analysis of the state of preservation, in order to plan proper conservation interventions[1].
In particular, it is crucial to detect and map decay patterns, cracks and anomalies to assess stability of load bearing structures whose brittleness makes mandatory the use of non invasive investigations, in agreement with the Theories of Restoration[2]. The improvement of geophysical techniques in terms of sensor performance and resolution, the increasing availability of software for data analysis, processing and interpretation have led to an increasing interest in the use of in situ non-invasive technologies such as Ground-penetrating radar (GPR). GPR exploits microwave ability of penetrating non-metallic objects and registers into radargrams electromagnetic variations occurring in different media, such as subsoil or building materials. These variations are visible as hyperbolas and advanced data processing, among which microwave tomographic approaches[3], are useful to improve imaging capabilities and obtain easily interpretable images.
In the field of Heritage diagnostics, GPR contributes to answer several issues related to the structural stability assessment and the analysis of weathering of building materials, by respecting the value and fragility of the artefact[4]. The case study is Tomb 4 from the Hellenistic necropolis "Tombs of the Kings" in Paphos, Cyprus[5]. T4 is a rock-cut underground monumental complex. Monolithic columns/pillars support a portico surrounding a central atrium. Some of those suffered extensive quarrying probably since antiquity, while the monument's structure might have been affected by ancient or more recent seismic activity[6].
The radar data from T4 have been processed by using a linear microwave tomographic approach[7], which faces the imaging as the solution of an inverse scattering problem, exploits the Born approximation and it adopts the Truncated Singular Valued decomposition to obtain a reliable solution. The output is a tomographic image, normalized to its maximum value into the overall investigated region or into a slice, where the significant values identify target location and give information about their geometry. These images visualized clearly localize anomalies suggesting the presence of reflectors referable to cracks and material discontinuities, some of them not visible.
Future work on T4 foresees the integration of GPR and terrestrial laser scanner data to investigate its seismic performance and provide new information on the structural behavior of pillars.
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