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Near surface geophysics techniques and geomorphological approach to reconstruct the hazard cave map in historical and urban areas

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This work, carried out with an integrated methodological approach, focuses on the use of near surface geophysics techniques, such as ground penetrating radar GPR and electrical resistivity tomography (ERT), and geomorphological analysis, in order to reconstruct the cave distribution and geometry in a urban context and, in particular, in historical centres. In fact, there are a lot of historical Mediterranean sites born on an original rupestrian settlement, of which often the new generations forgot the memory and new urban areas built on them burying any marks. The interaction during recent centuries between human activity (caves excavation, birth and growth of an urban area) and the characters of the natural environment were the reasons of a progressive increase in hazard and vulnerability levels of several sites.
The reconstruction of a detailed cave map distribution is the first step to define the anthropic and geomorphological hazard in urban areas, fundamental basis for planning and assessing the risk.
The integrated near surface geophysics and geomorphological techniques have been applied to the case study of Tursi hilltop town and its older nucleus called Rabatana, located in the south-western sector of the Basilicata (southern Italy), representing an interesting example of the deep bond between natural and man-made environments such as precious cultural heritage. The history of this settlement has always been deeply connected with the characteristics of the neighbouring environment and it seems possible that the first settlement was built by excavating the slopes of the sandy relief. It was a typical rupestrian settlement, where meteoric water was stored inside some cisterns excavated on the slopes.
During recent centuries, the increase in territory development by humans produced an increase in cave excavation in the Tursi–Rabatana urban area. To reconstruct the extremely complex near-surface hypogeal environment excavated in the sandy layers, a geophysical investigation has been carried out, integrating the method of ERT (a multielectrode system with a Wenner–Schlumberger array layout) with the GPR (profiles were obtained using a SIR 2000-GSSI system equipped with two antennas of 400 and 200 MHz, connected by fiber-optic cables to the control unit) profiling. During the field survey, four ERT measurements and eight GPR profiles were carried out along the road network of Rabatana.
The field survey permitted to evidence, for the Rabatana historical site, about 100 caves for which it is possible to see clear entrances, while at least 300 other caves are located in Tursi urban area and surroundings. This survey excludes all the caves and cisterns not directly ispectionable, but well showed in geophysical data.
Since 1973, this site was subjected to the evacuation of its inhabitants in a new urban site due to catastrophic landslides caused by intense rainfalls that occurred on January 1972. Starting from 1974, the Rabatana has been almost completely deserted. Recently, a renewed interest for this site has been developed to recover the historical center, removing the current constraint of total evacuation. However at present, the site is still characterized by a particular morphological history and environmental factors that generate widespread risk conditions for the inhabitants and built-up areas.
Morphological evolution of the sandy hillslopes on which Tursi town rises is characterized by very intense erosive phenomena such as landslides, deep gullies, rills, and piping, which affect the whole perimeter of urban settlements and threaten the conservation of these sites. From the point of view of the process of physical degradation, the sandy facies are characterized by desiccation cracks to which the piping erosion and detachment blocks along the slopes are closely linked. In some cases large voids do not develop, but seepage erosion and running sand cause morphologically similar surface collapse phenomena (sinkholes). Outlets spreading can cause landslide phenomena (rockfall and toppling) along the steep sandy–clayey slopes.

The secular multilevel cave excavation, developed along several fronts beneath the urban area, accelerated the pre-existing morphological processes acting on this site, favouring the water infiltration and subsurface erosional phenomena, characterized by widespread surface piping erosion of sandy bodies. Moreover, climate analysis carried out for the last century showed an increasing trend in rainfall intensity over short durations, which also induced an increase in hazard conditions of the slopes.

All the natural and anthropic conditions described above show as a deep knowledge of cave distribution and their geometry is the basis for a good urban planning to apply in historical site particularly vulnerable; it shows also as the integrated near surface geophysics techniques can powerfully contribute to acquire useful information to mitigate the anthropic risk and preserve the historical-monumental heritage.