

## **Risk evaluation focused on the valorization and management of cultural underground heritages**

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Around the present and old coastal areas of the Mediterranean Sea, the outcropping of soft calcareous and arenaceous stones (calcareous tuffs, encrouement calcaires, etc.) favoured the establishment and development of rupestrian civilizations. In many areas, these settlements raise a particular significance under anthropological and artistic point of view, such as the Matera “Sassi”, an Italian UNESCO World Heritage site. A number of cultural heritages remnants, consisting of rupestrian establishments which have artistic and cultural significance, are diffused on the Gravine and on the Lame (local name of major and minor canyons) of the Murgia flanks (Southern Italy). It is required to preserve these cultural assets, even having such an objective, a new use of them with exhibition purposes.

The most common environment on which are found these settlements are the slopes of the Gravine, carved into calcarenites. Despite to its excellent characteristic (good resistance coupled with an excellent workability), calcarenite is subject to decay for the negative interaction with the water of capillary or hygroscopic absorption.

The absorbed water by the rock interacts with each of its three phases, clastic or bioclastic granules of calcium carbonate, matrix and cement, but in particular with the carbonate cement which determine, in function of its concentration, dissolution or precipitation processes with synchronous effects on the technical properties of the rock. Therefore the structural weakening of the calcarenite leads to the possibility of brittle fracture of statically relevant parts of naturally or artificially carved mass, often in contexts where the actual geometry and the perception of risk cannot be properly evaluated. The fragility of the contexts, where the excavated continues with parts constructed with the same materials, leads to disastrous evolutions of the same in case of failure.

Recent studies on the underground cavities have allowed an assessment of the hazard related to the instability phenomena by using multivariate statistical models and, in particular, discriminant function analysis and logistic regression. These methodologies are suitably re-proposed to the underground environments of rupestrian settlements, after the implementation of some useful parameters to describe its specificity.

In these contexts, for the assessment of the material properties, the application of non-destructive techniques allows to focus on the critical areas or points and therefore to improve the performance of the hazard model, through expeditious assessments of the variability of the materials in relation to the most significant technical properties. This procedure should be considered preliminary and necessary for the enhancement of the architectural, artistic or archaeological sites with the intention to preserve and protect their safe fruition.