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DC resistivity surveys compared to direct 3D surveys methods to characterize underground cavities in eastern Sicily (Italy)

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The study and characterization of caves is a complex problem because not all underground cavities are accessible and therefore cannot be characterized by direct methods, such as topographical or geomatic methods. Therefore, geophysical surveys play a key role, as they can provide information on the size and shape of underground cavities from surface measurements.

In this work, two underground cavities characterized by different geological contexts and located in eastern Sicily (Italy) were studied: i) the “Micio Conti Lava tube”, a lava cave located in the municipality of San Gregorio di Catania and ii) the “Chiusazza Cave”, a complex karst cave located in the area of Syracuse. The two caves were investigated using both DC resistivity surveys and direct methods for 3D reconstruction (terrestrial laser scanner (TLS) and photogrammetry by unmanned aerial vehicle (UAV)).

In the “Micio Conti Lava tube”, N. 11 ERT (electrical resistivity tomography) profiles and N. 18 TLS stations were performed, while in the “Chiusazza cave”, N. 11 ERT profiles and N. 23 TLS stations were implemented.

In both cases, aerophotogrammetry was used to generate the 3D models of the epigeal environments. Geoelectrical surveys were performed using the dipole-dipole quadripolar configuration and a cluster analysis (K-means) was performed on the 3D resistivity models of both caves. This analysis revealed for each site two groups of clusters, highlighting areas with different resistivity values. A comparison between the resistivity models and the clusters showed a good overlap between the clusters identified in the central portion of the two models and the areas characterized by the highest resistivity values. This approach allowed the identification of isosurfaces for both areas that enclose the areas associated with the shape, position and size of the investigated cavities. In the "Micio Conti Lava Tube" area, the cavity is characterized by resistivity values higher than 17000 Ω-m while, in the Chiusazza cave area, the cavity is identified by resistivity values higher than 4000 Ω-m.

Comparing the results obtained by resistivity and 3D TLS models, an excellent correspondence can be observed for the "Micio Conti lava tube". Instead, for the "Chiusazza Cave", the models do not seem to fit perfectly in the central portion, probably due to the limited coverage of geoelectrical surveys in this area due to the prohibitive logistic conditions of the site.

This study confirms that DC resistivity methods are suitable for identifying and characterizing underground cavities in different geological contexts. Cluster analysis allowed to identify the isosurface value to be assigned as the boundary of the area of the studied cavities. The results of this study clearly show that by integrating geophysical and 3D survey techniques, it is possible to increase the mapping and understanding capabilities of these geological structures, even if they are inaccessible from the surface.