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Geophysical and geomorphological integrated investigations to identify mantled sinkholes

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In a mantled evaporite karst system, sinkholes are not always easily identifiable. These phenomena are not deeply studied in the Italian peninsula, because they do not cause so frequent and severe damages as for example in other countries like the United States and Spain. However, they are quite frequent in specific areas where gypsum is exposed or mantled, especially in some alpine valleys where evaporites acted as a tectonic lubricant during the main alpine orogenetic compression phases. This is the case of some portions of the north-eastern corner of Italy where, along the high Tagliamento valley, there are several villages built in areas where the alluvial deposits of the Tagliamento River created thick terraces over a buried evaporitic bedrock. In the past, within this area, several sinkhole events were recorded, few of them occurred below or close to the built houses and the farmers usually refilled the voids in order to continue to exploit the land, while ignoring the actual cause of those sudden events. This is the case of Quinis village, a hamlet of Enemonzo, where the farming activities masked for a period the precursor signs of the sinkhole occurrences. The outline of the sinkhole events appear to be particularly difficult in an urbanized environment where the geomorphological surveys do not guarantee a recognition of their characteristic shapes, while trenching activities are not always possible and are of high impact. For these reasons, geophysical techniques are a valid approach in the study of these phenomena.
In an area under cultivation, just outside from the inhabited zone, an integrated geophysical investigations (2D, 3D electrical resistivity tomography, and gravimetric measurements) have been performed in order to image the subsurface below a smoothed surface depression which represents a possible hint of a mantled sinkhole. In the 3D acquisition we used a “horseshoe” electrodic geometry, with 72 electrodes having a constant spacing equal to 2m and located all around the resistivity anomaly previously recognized along a 2D resistivity profile crossing the surface depression. A gravimetric profile with 10m-spaced data was at first realised along the 2D resistivity profile. Later 74 additional measurements were collected within a 5m grid centred in correspondence of the depressed area. The geophysical investigations permit to locate an approximately 15 m wide zone vertically extending for tens of meters. The evaporitic bedrock in the sinkhole area lies at a depth exceeding 100 m and is masked in the electrical data by an aquifer reaching a depth of about 45 m below the surface. The experience realised in the area permitted to identify the best approach to investigate these type of buried phenomena, highlighting that the 3D electrical tomography is a useful tool to image the lateral extension, the depth and the shape of the sinkhole.