



Subsidence and sinkholes related to quarrying in karst

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Quarrying is one of the most destructive anthropogenic activities in karst. Extraction of rocks generally produces loss of the original karst landscapes, partial or total destruction of caves, and might result in further negative effects even after the quarrying activity has stopped. The Apulia region of southern Italy, extensively covered by carbonate rocks, is the third Italian region as regards production of different types of limestones, which are widely used as building and ornamental materials. In the present paper, we describe a peculiar situation in the territory of Cutrofiano (Lecce province) where we have investigated the co-existence of sinkholes with surface and underground quarries, aimed at understanding the likely relationships between the anthropogenic activities and the occurrence of subsidence and collapse sinkholes. The local stratigraphy consists of a Cretaceous limestone bedrock overlain by calcarenites of Miocene and Pleistocene age; at the surface, Lower-Middle Pleistocene clays and sands crop out. The Pleistocene calcarenites have been quarried since the beginning of last century in underground quarries, that develop at depth ranging from 5-7 meters in the vicinity of the town, to 25-30 meters farther south. The quarrying activity produced in the years an extensive and very dense network of underground galleries (hundreds of meters long, 5 to 8-m high, 5-m wide) which has become the main feature of this territory, whilst quarrying was for several decades the main economical resource of the area. At the surface, the clays also were quarried (and partly they still are today) by means of surface excavations which reached 8-9 meters in depth. The Cutrofiano territory is characterized by diffuse presence of closed depressions, and by the occurrence of several sinkhole events in the last decades. Even though some of the latter seem to be related to the underground caves, the connection between the anthropogenic activity and the sinkholes is not straightforward. Aimed at a better comprehension of the phenomena, and at the assessment of the stability conditions in the

area, at both the surface and underground, we performed a number of speleological explorations and field surveys, and integrated the results of these activities with interpretation of multi-year aerial photographs. Historical research of data for the sinkhole events completed the first phase of data collection. All these data were later analyzed to verify the spatial distribution of depressions and sinkholes in the area, the possible interference with surface and underground quarries, and to understand the more likely models for sinkholes development at Cutrofiano. Research activities are still on going, by means of laser scanner surveys at selected sites to obtain detailed maps of the underground quarries, and detect the likely presence of fractures in the walls and vaults, as premonitory signs of further instability phenomena at the surface.