



## **Sinkhole development induced by underground quarrying, and the related hazard**

M. Parise and M. Delle Rose

Institute of Research for Hydrogeological Protection, National Research Council, Bari, Italy (m.parise@ba.irpi.cnr.it, +39 080 592 9611)

Sinkholes are extremely widespread in Apulia, a very flat and carbonate region, that acted as the foreland during the phases of building up of the Southern Apenninic Chain in Miocene time. This is due to the presence of soluble rocks throughout the region, that highly predispose the area to this very subtle natural hazard. In addition to the natural setting, which favours their development, sinkholes may also be induced by anthropogenic activities. In the latter sense, underground quarrying represents one of the most dangerous activities in karst areas.

Apulia has a long history of quarrying. Since the roman time, the local rocks, from the Cretaceous micritic limestones to the Quaternary calcarenites, have been intensely quarried and used as building and ornamental materials. In several settings of the region, the rocks with the best petrographic characteristics are located at depths ranging from a few to some tens of meters. This caused the opening of many underground quarries, and the development of a complex network of subterranean galleries. Underground quarrying had a great impulse at the turn between the XIX and the XX century, when a large number of quarries was opened. Later on, after the Second World War, most of the quarries were progressively abandoned, even because of the first signs of instability, both underground and at the ground surface. With time, the memory of the presence and development of the underground quarries was progressively lost, with severe repercussions on the safety of the land above the excavated areas. Lack of knowledge of the subterranean pattern of galleries, combined with the expansion of the built-up areas at the surface, resulted in increasing significantly the vulnerability of exposed elements at risk. Events such as the 29 March, 2007, at Gallipoli only by chance did not result in any casualties, when a 15-m wide and 5-m deep sinkhole opened in a few hours at a road crossing, above the site of an old underground quarry.

Within the framework of research programs devoted to recognition of sinkholes in Apulia, and addressed to the evaluation of the sinkhole hazard, this paper examines in detail the distribution of sinkholes related to underground quarrying in Salento, the southern part of Apulia, where the presence of subterranean quarries is particularly high. Through description of some case studies, the main problems related to underground quarries, and the development of sinkholes are discussed, even taking into account civil protection issues, that is in terms of the effects these phenomena may have on the local communities.