



## **Risk of groundwater inrush in subterranean gypsum quarries: the case study of Moncalvo near Asti (North Italy)**

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During the realisation of underground excavations in gypsum bedrock there is a possibility of intercepting large karst voids that can be completely filled with water under a considerable hydraulic pressure. The casual breaching of such voids can cause sudden and abundant water inrushes with consequences concerning safety of the excavation area and flooding of the tunnels. The presence of air-filled caves of great dimensions can also cause problems related to collapse of walls, ceilings and floors.

In the subterranean quarry of Moncalvo d'Asti (Central Piedmont, Italy) in January 2005 an important inrush (60,000 m<sup>3</sup> overnight) occurred causing damage to machinery and the flooding of several kilometres of underground tunnels. This inrush was caused by the breaching of a thin diaphragm of rock that separated the quarry from a large water-filled cave with water pressure of around 300 kPa along the front of the excavation. The rapid emptying of this void has caused a partial collapse of the roof of one of the largest cave chambers with the formation at the surface of a 20 metre wide sinkhole.

To prevent similar phenomena to happen in the future a hydrogeological study concerning the entire gypsum mass was carried out. These investigations included monitoring of water levels intercepted by a series of boreholes, measurements of flow rates of water veins encountered by the excavations and chemical analysis of the different types of water coming from several points.

This study has evidenced the presence of different drainage networks and the existence of a main karst circuit fed by diffused infiltration and recharge from the overlying marly-silty deposits and from adjacent minor less karstified systems in particularly fractured sectors of the gypsum. The waters coming from the main karst circuit are chemically very different from the waters deriving from deeper pathways.

To be able to continue the excavation of gypsum in safe conditions the water levels were lowered for a couple of metres through the realisation of a series of boreholes located at lower elevations. These boreholes have intercepted the most conductive aquifer developed along a marly limestone level located at the base of the Messinian evaporite sequence. Some near-horizontal drill holes carried out along the front of the excavations have also been realised and have intercepted a second karst system with water under pressure (> 300 kPa), independent from the main one. A controlled drainage is now being carried out (30 l/s) to slowly lower the hydraulic head so to avoid future collapse of these new karst voids.

Some geophysical surveys have also been carried out to discover other karst voids of great dimensions, but these did not give positive results. The performed investigations have shown the importance of hydrogeological studies and speleological surveys in understanding better the development of the karst systems and in the realisation of the excavation activities in conditions of safety, allowing to avoid expensive interruptions of the mining operations.