Understanding the failure mechanisms of Malogne underground quarry and assess the influence of the underlying mining works

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Abstract

Instabilities related to shallow underground quarries, which are widely distributed in NW Europe, are a primary concern of raising geohazard in urban areas. Typically, they are developed in relatively soft rocks such as chalk by applying the room-and-pillar mining method. After exploitation often they are abandoned which raise the question about possible georisk related to collapses of different scale. This risk increases even more when the shallow cavities are undermined by deep underlying coal mines developed by the longwall mining. Failures related to instabilities of such complex structures can result in local or even large-scale collapses that may encounter significant areas on the ground surface. Therefore, it is necessary to understand the possible failure mechanisms as well as the instabilities triggering factors.

Nowadays, research on this topic is mostly limited to the study of shallow quarries and the related to them instabilities. The particularities of the present thesis consist of considering two mining levels located one above the other at different depths. The abandoned Malogne phosphatic chalk quarry, in which numerous collapses occurred during and after its exploitation, was chosen as a case study. The last large collapse of 2015 heightened interest among public authorities and scientific community concerning the assessment of the georisk in that area. Moreover, intensive underlying coal mining was carried out before, during, and after the chalk exploitation.

To address such complex geomechanical conditions multi-scale approach has been proposed. It includes a wide range of in situ observations and measurements, laboratory experiments, as well as numerical modelling. The main objective of the current work is twofold. Firstly, to assess the influence of the deep-seated coal mining works on the shallow-located chalk quarry and their possible interaction. Secondly, the current research aims to understand the failure mechanisms resulting from the mining works in the phosphatic chalk and to evaluate the impact of the different instability triggering factors that control them.

Based on the numerical modelling it was found that two different in origin, expression, and scope of influence failure processes might be evoked. The first one is related to the longwall mining method which has an important influence on the ground surface by inducing subsidence due to the coal seams extraction. The second one is linked to the room-and-pillar openings, which are more likely to provoke local-scale failures related to the roof and pillars.

Finally, the main failure mechanisms related to these two mining methods that were observed from the numerical models were compared with the in-situ observations and measurements conducted in the studied area, which were found to be in good agreement.
The proposed approach could serve for understanding the failure mechanisms in other mining sites developed in similar conditions and thus to help in assessing the georisk.