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KarstALEA – a scientifically based method to predict karst-related hazards in underground constructions

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In underground construction in carbonate rocks, karst is a major issue. Karst occurrences entail specific hazards such as large voids, massif water inflow or sediment-filled voids. The underground construction itself as well as the environment can be affected (e.g. drying springs, sinkhole formation). Karst-related hazards can cause amongst others important delays, additional costs, safety-related problems on the construction site or the abandonment of a project.

Until know, most investigation methods considered karst occurrences as randomly distributed and unpredictable. However, recent research based on the 3D analysis of cave systems proved that up to 80% of karst conduits are located on few inception features. Inception features are discontinuities (e.g. bedding planes, beddings of mm to cm thickness with a contrasting mineralogy or primary permeability, joints, faults), which are particularly susceptible to karstification. Further, the karst conduit density and their characteristics depend on the locally dominant speleogenetic processes. Based on that, so-called speleogenetic zones can be delimitated. Karst conduit density is highest near the surface, where water drainage is concentrated with depth, and around the water table, where water is drained to the spring(s). As the spatial distribution of dominant speleogenetic processes change with time, paleo-speleogenetic zones can be delimitated. This is particularly important for the paleo-speleogenetic zones corresponding to past water tables.

The KarstALEA method combines the inception feature concept, knowledge about the spatial distribution of dominant – actual and past – speleogenetic processes (speleogenetic zones) and hydrogeological considerations. These leads to two major results:

(1) the spatial distribution of karst occurrence probability (zones of characteristic karst conduit density);

(2) the spatial distribution and characteristics of karst-related hazards, e.g. size and geometry of karst conduits, discharge and water pressure within a karst conduit and their variability, amount and characteristics of sediments within the karst conduits (KarstALEA zones).

Although the KarstALEA method does not allow to predict the real geometry of the karst conduits (e.g. their exact position and geometry), it significantly improves the prediction of the distribution of karst conduits and their characterisation (size, orientation, presence of water, sediment-fillings).

Back analysis of existing tunnels and prediction for new tunnels showed that the KarstALEA is an adequate and efficient method to predict karst-related hazards and is applicable in different contexts.