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Spatial organization and connectivity of caves

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The main particularity of karst systems is their hierarchical organization as three-dimensional network of conduits behaving as drain. They are recognized as having a major influence on fluid flow at reservoir scale. However, a karstic network is generally hardly continuously observable and their great intrinsic heterogeneity makes their characterization very complex. This media can be only observed by speleological investigation, conditioned to human possibilities. As a result, only few parts can be observed and therefore it is required to model the non-observable parts for reservoir characterizations. To provide realistic 3D models, non-observable karstic features will be generated using parameters extracted from observed ones.
Morphometric analysis of the three-dimensional karstic network provides quantitative measures that can (i) give information on speleogenesis processes, (ii) be used to compare different karst systems, (iii) be correlated with hydrogeological behavior and (iii) control the simulation of realistic karst networks.
Recent work done on the subject characterize the karstic network as a whole, without genetic a-priori. However, most of observable caves appears to have a polygenic history due to modifications in boundary conditions and some different karst features can be observed in a same cavity. To study the geometrical organization of caves, we propose to analyze 3D speleological topographies for which speleogenetic context is known. This way, it is possible to characterize karst features according to speleogenetic processes. Several morphometric descriptors have been calculated on three-dimensional topographies provided by speleological works. Some parameters describe the existence of preferential direction of karstification and preferential flow paths, other parameters describe the complexity, geometry and connectivity of the three-dimensional karstic networks. Through the study of fifteen different caves, 150km of 3D data have been analyzed corresponding to various speleogenetic contexts. First, this parameter set represents a database of karst morphology characteristics and can be then used to constrain 3D modelling. Second, it has been used in multivariate statistical analysis to distinguish karstic features according to speleogenetic contexts. These features are primarily dependent on the position in the karstic system, the type of recharge and the initial aquifer permeability. Quantification of karstic patterns allow to better constrain the global network architecture of speleogenetic systems. Several karstic patterns have been individualized independently of geological, geodynamical and geomorphological evolution.