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Lithological Properties of Inception Horizons - The key to understand cave development along bedding planes

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Recent studies on the complex 3D geometry of large cave systems around the World allowed us to get statistical evidence of the inception horizon hypothesis. It clearly confirmed the idea that the development of karst conduits under phreatic conditions is strongly related to a restricted number of so-called inception horizons. An inception horizon is a part of a rock succession that favours the earliest cave forming processes.
However some main question remains: What makes one specific stratigraphical horizon favourable to karstification? What kinds of processes are involved and which of them are the most important? Furthermore is it possible to recognize an inception horizon by some lithological properties?

In order to understand the reason(s) why a specific stratigraphical horizon is used for cave development we sampled 18 inception horizons of six cave systems as well as the surrounding rock mass. More than 200 rock micro-cores have been drilled and analysed to determine parameters controlling the speleogenesis. The analysis of these cores gives a first idea of the different key properties of inception horizons.
From a theoretical point of view it can be expected that during the process of karst development the significance the property/ies will change, because they have been consumed or the associated speleogenetical processes become subordinated to others. Therefore we suggest using an approached named the "speleogenetic scale of influence". The idea is to consider the increase of porosity produced by the speleogenetic processes associated to one specific property. For example, the scale of influence of a pyrite crystal is determined by the dissolution capacity of the sulphuric acid produced by the weathering process of this crystal (i.e. around 6 time the volume of the crystal). This means that the influence of the pyrite can be assumed to be potentially relevant as long as the size of the pores is smaller than around 6 times the average volume of the pyrite crystals present in a rock; beyond this size the effect of the additional dissolution capacity related to pyrite dissolution is expected to become subordinate to other processes. Contrary other processes can only become dominant once the pores have reached a certain size. For example the total carbonate content has an influence on the dissolution rate of a rock mass only if the pore surface is larger than some square millimetres.

Considering the properties of the core samples we collected, the estimation of the influence scale and the incorporation into the general concept of the inception horizon hypothesis, we could recognize that (apart from the special case of gypsum) most properties are only significant during certain periods of speleogenesis:
1) The primary permeability it the controlling factor during the early inception phase (beginning of the karstification).
2) The pyrite content as well as the matrix composition (content and type) are mostly significant during the inception and gestation phases.
3) The total carbonate content is relevant during the cave development phase.
However it must be noticed that horizons with unfavourable properties can still be incepted and develop karstification: they just need more time. The evidence that only a few horizons feature a distinct cave development suggests that for most of the horizons the time needed to be incepted exceed the available time given by the hydrologic boundary conditions.

This approach makes it possible to identify potential inception horizons from lithological data (e.g. from drilling core). The identification of the position of inception horizons in a rock mass will provide a substantial

increase of information for engineering proposes as well as for karst hydrogeological investigations. It is thus now possible to assess, in a probabilistic way, the spatial distribution of karst occurrences inside a karst massif. This implies the identification of potential inception horizons and the reconstruction of the hydrogeolgical history (evolution of the hydogeological boundary conditions along the history of the karst system).