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Deep conduit flow in karst aquifers revisited

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Caves formed in soluble rocks such as limestone, anhydrite, or gypsum are efficient drainage pathes for water moving through the aquifer from the surface of the host rock towards a resurgence. The formation of caves is controlled by the physical solution of the host rock by water and by the chemical solution of the host rock by water enriched with carbon dioxide. Caves as large underground voids are simply the end member of secondary porosity and conductivity characterizing the aquifer.

Caves and their relation to a (paleo-)base level are found both close to a (former) water table (water-table caves) and extending far below a (former) water table (bathy-phreatic caves). An explanation for this different speleogenetic evolution is the *structural control*: Fractures and bedding partings are preferentially enlarged around more prominent faults, thus the fracture density in the host rock controls the speleogenetic evolution. This widely accepted explanation can be extended by adding other controls, e.g. a *hydraulic control*: As temperature generally increases with depth, density and viscosity of water change, and particularly the reduction of viscosity due to the increase in temperature enhances flow. This hypothesis was proposed by Worthington (Worthington, S. R. H.: Depth of conduit flow in unconfined carbonate aquifers, Geology, 29 (4), 335–338, 2001) as a major controlling factor for the evolution of deep-bathyphreatic caves.

We compare the efficiency of structural and hydraulic control on the evolution of a cave passage by numerical means, adding a third control, the *chemical control* to address the change in solubility of the circulating water with depth. Our results show that the increase in flow through deep bathy-phreatic passages due to the decrease in viscosity is by far outweighted by effects such as the decrease in fracture width with depth due to lithostatic stress and the decrease in solubility with depth. Hence, the existence of deep bathy-phreatic cave passages is more likely to be controlled by the structural effect of prominent faults.