Vertical organization of karst network or “speleogenesis in the dimension of length and depth” has been in research focus for more than a century. Different models have been proposed, each focusing the speleogenesis to: a) the vadose zone, where the solution is most aggressive b) the water table, where the density of flow is highest and c) to the phreatic zone, referring to the deep Darcyan flow paths.

Different models were unified into a single concept, the four state model of Ford and Ewers (1978). The model relates geometry of caves to the frequency of penetrable fissures. It has been successfully applied to numerous speleogenetic settings.

In the last decade these conceptual models have been also verified with the numerical ones. Gabrovšek and Dreybrodt (2001) modelled 2D unconfined fracture network in constant boundary conditions. The model showed the importance of flow focusing at the water table which is dropping in time due to the increasing permeability. Most simulations resulted in the formation of a water table cave at the base level. Deeper phreatic loops were more an exception than a rule, limited to the cases with the absence of flow paths in the vicinity of the base level. Similar results were obtained by Kaufmann (2003) who modelled a vertical fracture network embedded in a porous matrix. Base level changes have been also considered (Dreybrodt et al. 2005), demonstrating that valley incision and back filling can result in deep phreatic loops.

Carbonate massifs of young orogenes are normally heavily fractured due to the intense tectonic activity. According to the four state model, one would expect that water table caves would be common, but several studies reveal that they are more an exception than a rule. The *looping caves* with soutirages connecting different cave levels, are more common than the water table caves (Jeannin et al. 2000).

Speleogenesis in Alpine environments is influenced by high uplift and valley incision rate and irregular recharge.

Several works have stressed the potential importance of recharge variation in vertical development of karst network (e.g., Häuselmann et al. 2003) based on field observations. In this work we adopt some of these conceptual approaches and translate them into a simple mathematical model based on basic principles of flow, dissolution and transport. The full paper described in this extended abstract has been submitted to publication (Häuselmann et al. 2012).

The conceptual model is fairly simple: Initially we assume a master conduit discharging part of the karst massif to a spring at the base level. The incision of the base level starts and triggers the evolution of new pathways along some deeper levels below the master conduit. While master conduit also incises into an underground canyon, the deep pathways evolve toward maturity and capture increasing portion of flow. The question arises what will happen first: a) an underground – water table cave connecting both levels or b) all the flow will be diverted along the lower pathway.

The incision of the master conduit is a result of a combination of chemical and mechanical erosion. We make a rather crude (but reasonable for the purpose) assumption that it is constant in time.

The development of deep pathway is treated with the approach given in detail in several sources (Dreybrodt et al. 2005). The model couples flow and dissolution along a pathway (single fracture) through mass balance assuming that within each segment of the fracture, the dissolved mass contributes to the saturation ratio of the solution. Analytical solution is based on the approximation that the entire pathway is widened uniformly, defined by minimum dissolution rates at the exit (Gabrovšek and Dreybrodt 2000). This way dissolution and widening rates of the fracture is calculated. When the head difference between both ends of the pathway is constant, such coupling results in increasing flow rate, which in turn enhances dissolution rates and vice versa. The feedback mechanism ends with an abrupt increase of both, flow and dissolution rates, called *the breakthrough*. After the breakthrough, the dissolution rate along the pathway is constant and maximal and the flow rate increases at the maximal rate. Soon the pathway can capture all available flow.

In our model the evolution of deep pathway is driven by a variable hydraulic head. It initially increases in time as the valley incises faster than the master conduit. When valley passes the elevation of deep pathway, the head is maximal, latter the head drops with incision of the an underground.

The analytical solution for the evolution of a pathway under varying hydraulic head as given above, divides the parameter space into a region where the breakthrough of the lower pathway is possible (formation of a loop) and a region where the master conduit develops into a an underground.

We introduce the Loop-to-Canyon-Ratio (LCR), a parameter predicting which of the two outcomes is more likely to occur in certain settings.

Generally an initial master conduit is not straight, but undulates in both planes. One can also assume several sub-
vertical fractures (proto soutirages) connecting the level of
the master conduit and the deep pathway. In case of a
transient recharge, composed of floods and dry periods, the
event water is stored in the depression of the (undulating)
master conduit after the flood recession. This water seeps
along the proto soutirages towards the deep pathway and
enlarges them. Therefore, deep pathways evolve also when
the master conduit does not. This mechanism considerably
increases the LCR. Therefore, the loops evolve more likely
in transient recharge conditions.

Although the model includes several approximations, it
presents a step forward by assessing the relative importance
of some basic parameters related to specific speleogenetic
settings.

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