Abstract

Density-induced fingering due to dissolution of CO_2 in water is considered a mechanism for speleogenesis. H. Scherzer [25] stated this process as "Nerochytic Speleogenesis" (NERO). Despite having similar effects to density-driven fingering of CO_2 in geological sequestration of greenhouse gases, it is so far not discussed as a mechanism for speleogenesis. Understanding the process could help in understanding karst formation, also known as karstification.

We developed a model in DuMu^x, also validated with MATLAB, that considered the dissolution of calcium-carbonate as a source/sink term in the Navier-Stokes model. We found the concentration of CO_2 at the top of the cave water table that leads to a concentration gradient between the region above and below the epiphreatic karst water table, and the flow-velocity to influence the rate of calcite dissolution. We ran simulations for different scenarios and compared the results to see the effects on the rate of calcite dissolution. The numerical comparison between DuMu^x and MATLAB showed consistency in predicting the rate of calcite dissolution.

Modeling a real-world karstification process in a bigger geological cave system is computationally expensive because of its size, presence of numerous cave minerals in karst water, and complexities involved in solving the governing equations. Therefore, to achieve simplification we imposed a few limitations in our model. We modeled a 2D-domain of size [15 mm$\times$5 mm]; considered only total inorganic carbon and calcium as source/sink terms; and switched-off the gravity, fixed the concentration of CO_2 at the top of the cave to a constant value, and set the density of karst water as a constant throughout the domain.