

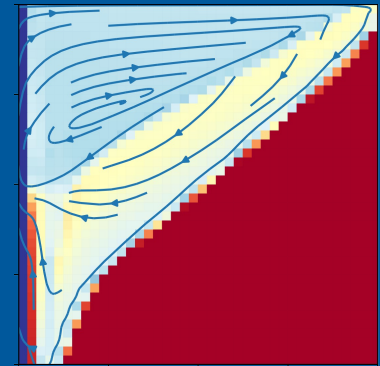
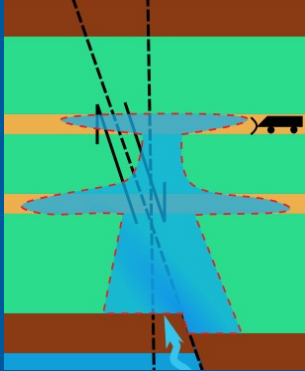
Inhomogeneous rock compositions and varying dissolution rates affect evolution and shape of leaching zones in potash seams

Svenja Steding^{1,2}, Thomas Kempka^{1,2}, Axel Zirkler³ and Michael Kühn^{1,2}

¹GFZ German Research Centre for Geosciences, Potsdam, Germany

²Institute of Geosciences, University of Potsdam, Potsdam, Germany

³K+S Aktiengesellschaft, Kassel, Germany



HS8.1.5 & ERE6 | EGU2021-1196

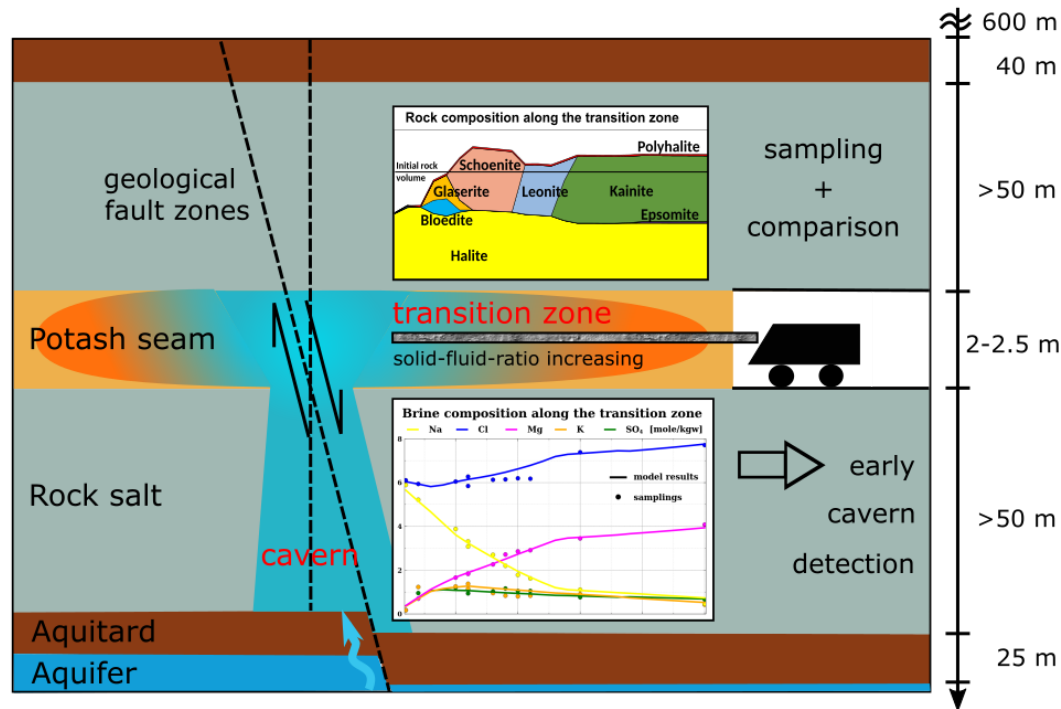
Motivation: Reproducing the formation of geogenic caverns within potash seams

Geogenic caverns = risk factor

- Groundwater migrates through geological fault zones and dissolves the normally tight salt body
- Preferential expansion along highly soluble potash seams occurs

Geochemical reaction model¹

- Titration model in PHREEQC quantifies brine and rock composition for different solid-fluid-ratios
- Over 1000 field samples validate the model results



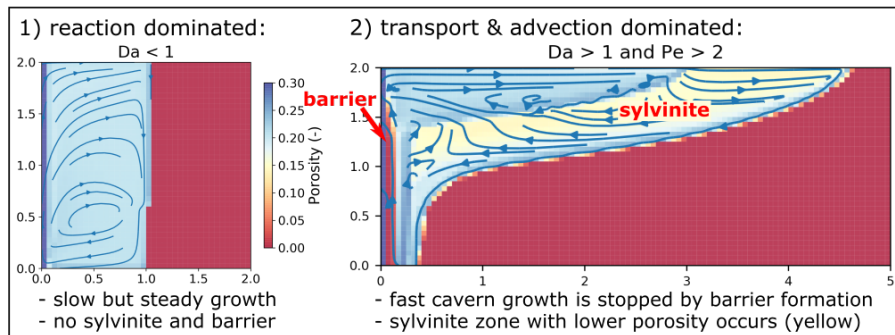
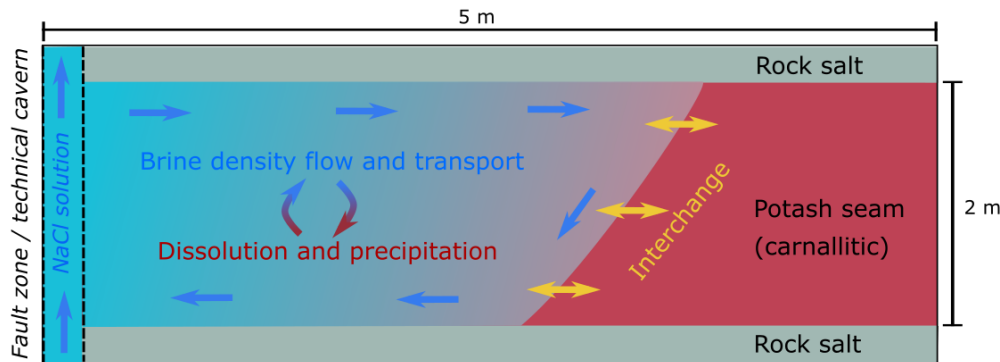
Coupling: Reactive transport model quantifies salt cavern evolution in space and time

2D reactive transport model¹

- Coupling hydraulics and chemistry
- Solving the solid-liquid dissolution problem by using a new approach called 'interchange'

Péclet and Damköhler number

- Cavern and barrier formation, shape, rate of growth and mineralogical composition can be determined based on Péclet (Pe) and Damköhler (Da) number
- Pe is controlled by the porosity, Da is controlled by the dissolution rate



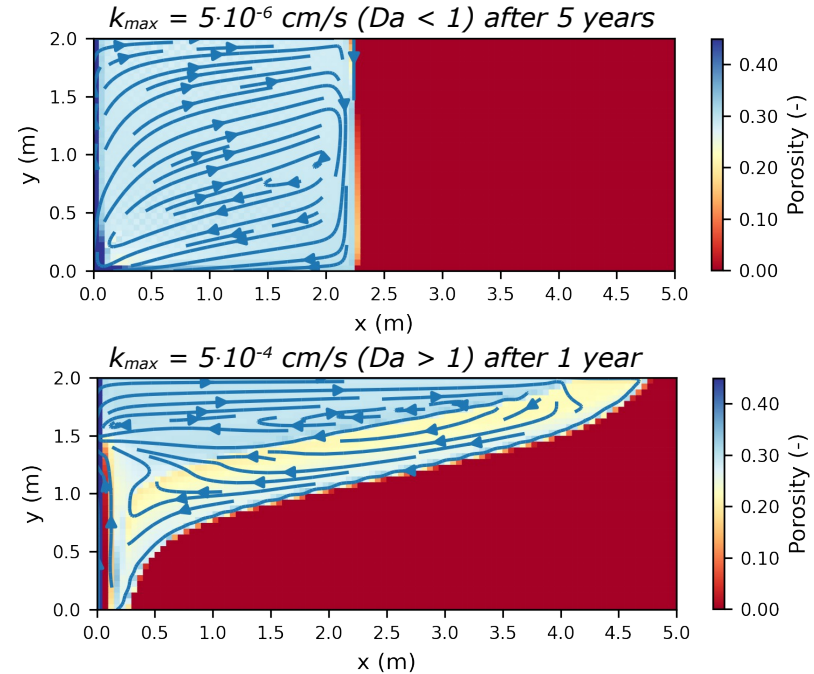
Reactive transport model extended by dispersion and saturation-dependent dissolution rates

Dispersion reduces Péclet number

- Dispersion length assumed as 0,05 m
- Diffusion coefficient increases → Pe decreases
- Porosities $\approx 30\%$ still result in $Pe \gg 2$

Rate constant $k_{\max}$ determines Damköhler

- Effective dissolution rate = $k_{\max} * (1 - 10^{SI})$
- Damköhler number $Da = k_{\max} / \text{flow velocity } q$
- $k_{\max} < 10^{-5} \text{ cm/s} \rightarrow \text{reaction-dominated } (Da < 1)$
 $k_{\max} > 10^{-5} \text{ cm/s} \rightarrow \text{transport-dominated } (Da > 1)$
- Saturation-dependency results in slower decrease of cavern width from top to bottom



Heterogeneities slow down cavern growth if dissolution rates yield a Damköhler number > 1

Convection cells control growth

- The **higher** a convection cell, the faster the cavern growth
- Rock salt inclusions act as barriers
- The **wider** the barriers, the more independent convection cells occur

Heterogeneities relevant if $Da > 1$

- In reaction-dominated systems, insoluble inclusions play a **minor** role
- In transport-dominated systems, they **slow down** cavern growth and **steepen** the front by **reducing** convection speed

