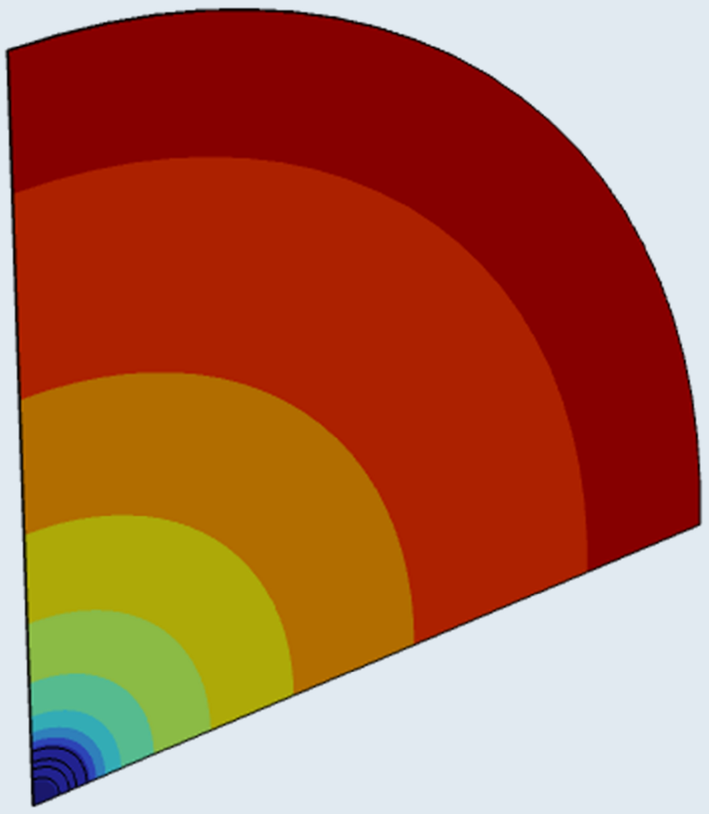

Modeling of Desaturation/ Resaturation of Geological Repository Barriers Considering Gas Generation

Processes in the geological repository are strongly coupled and non-linear, and thus require a sophisticated tool to solve a system of differential equations describing them

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Abstract

Activities such as excavation and ventilation of waste disposal tunnel of initially saturated porous media, the processes such as gas generation due to corrosion of waste package may also result in de-saturation of barriers.

This requires modelling of two-phase flow of miscible fluid (water and H2) considering important phenomena such as gas dissolution and diffusion, advective-diffusive transport in gaseous phase.

Evolution of material permeability and water retention need to be consistent with each other and based on the same measurement dataset. Modified Van Genuchten/Mualem model with representation of gas entry pressure as presented in [1] was implemented too.

In this study the analysis of repository barriers (backfill, concrete, inner excavation disturbed zone (EDZ), outer EDZ, host rock) hydraulic evolution and the scope of gas induced de-saturation was analysed with COMSOL Multiphysics®.

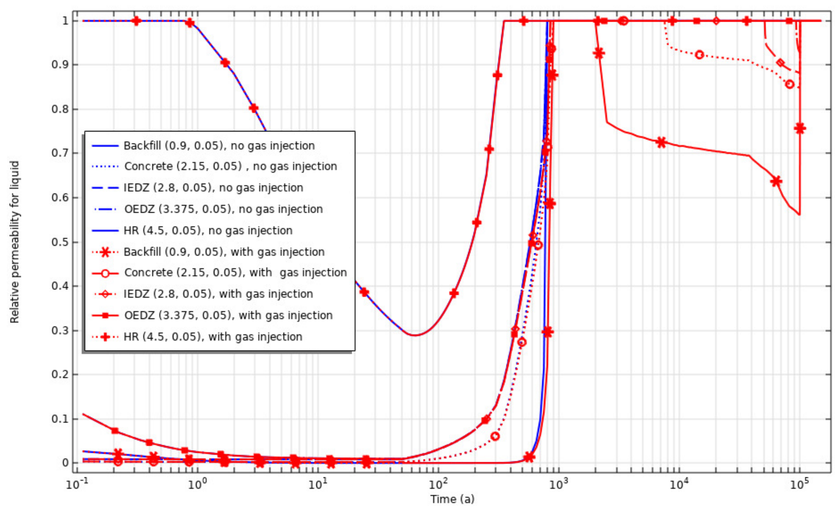

FIGURE 1. Relative permeability for liquid phase evolution at observation points with and without gas injection

Methodology

Mass balance equations for each fluid (*i: w, H_2*) were solved with the Coefficient PDE interface of COMSOL Multiphysics®.

$$\frac{\partial m_i}{\partial t} + \nabla \vec{l}_i = Q; \vec{l}_{H_2} = \left(\rho_{H_2}\mathbf{q_G}\right) + \mathbf{i}_{H_2} + \left(\rho_{H_2} H \mathbf{q}_{\mathrm{ML}}\right) + \mathbf{i}_{H_2\_d};$$

$$\vec{l}_w = \left(\rho_w \mathbf{q_G}\right) + \mathbf{i_v} + \left(\rho_w H \mathbf{q}_{\mathrm{ML}}\right);$$

$$\mathbf{i}_{H_2\_d} = -\rho_w D_e \nabla\left(\frac{\rho_{H_2\_d}}{\rho_w}\right); \mathbf{i}_{H_2} = -\rho_w D_{e,g} \nabla\left(\frac{\rho_A}{\rho_w}\right), \mathbf{i_V} = -\mathbf{i}_{H_2};$$

$$\mathbf{q}_{\mathrm{ML}} = -\frac{\boldsymbol{k_{ML} k_{rML}}}{\boldsymbol{\mu_w}}\left(\boldsymbol{\nabla} P_L + \rho_w \mathbf{g}\right); \mathbf{q}_{\mathrm{G}} = -\frac{\boldsymbol{k_G k_{rG}}}{\boldsymbol{\mu_G}}\left(\boldsymbol{\nabla} P\right),$$

Unsaturated conditions: $P - P_L > P_{entry}$

Results

Modelling of two-phase flow conditions in the vicinity geological repository results showed desaturation of excavation disturbed zone (EDZ) and host rock to some extent due to ventilation of 50 years (Figure 1). H_2 gas injection (50-100 000 years) led to desaturation of engineered barriers and part of excavation dirsturbed zone (EDZ) close to gas generation place vanishing soon after finish of gas generation, meanwhile host rock remained saturated during gas injection phase (Figure 2).

Analysis of these processes is a part of LEI activities in EC programme EURAD Work package GAS.

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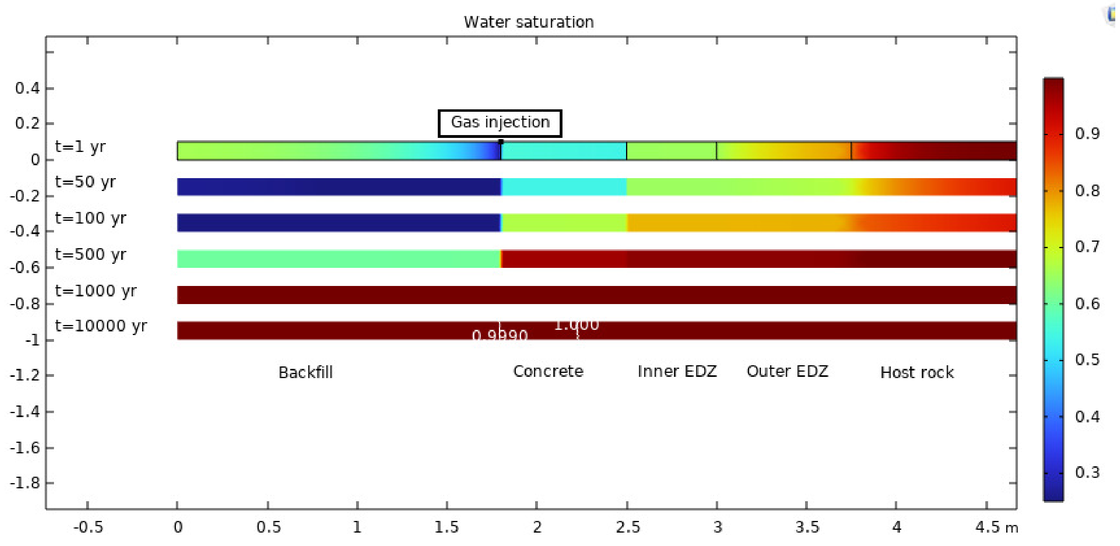

FIGURE 2. Saturation of engineered and natural barriers at diffferent times

REFERENCES

1. Abdellah Amri, Zakaria Saâdi, Rachid Ababou. Parametric Sensitivity to Capillary Entry Pressure in Two-Phase Water–Gas Flow Models: Deep Geologic Disposal of Radioactive Waste. Transport in Porous Media (2022) 145:13–43. https://doi.org/10.1007/s11242-022-01780-w