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Two-phase reactive transport modelling of heterogeneous gas production in low- and intermediate-level waste repository

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The widely-proposed approach to dispose low- and intermediate-level radioactive waste is to store it in a deep underground repository with a multiple barriers. A typical gallery is filled with concrete containers accommodating cemented steel drums of waste. Inside a container, different gases may be produced by (bio)chemical reactions, which include pH-dependent anoxic corrosion of metals, and the degradation of organic matter as well. Both reactions consume water and may lead to pressure build-up and transport of gas, both within and around the repository.

In order to investigate the controlling factors of this gas production process, coupled reactive transport model of component based two-phase flow in the OpenGeoSys framework is adopted here. The numerical study of Huang et al. [1] has shown that a realistic internal structure of a waste package, including the heterogeneous distribution of materials with different chemical and hydrological properties, and the exchange of mass at the boundaries are key factors that determine the evolution of the waste package. Based on the study of Huang et al. [1], the geometric configuration of the model has been further extended to reflect the various conditions of a multi-container disposal in a gallery. In a two-dimensional setup several model scenarios have been designed and simulated to study the change of gas production rate over time in relationship with water ability in various geological and waste storage setups.

In this presentation, we show simulation results covering the geochemical evolution of a waste package over 500 years. It is found that the initial water content in the waste compartment only controls the gas production rate for the first 40 to 60 years. The early pressure buildup and gas release rates is largely controlled by several critical parameters, including permeability of cement material, and water availability at the boundary. The sensitivity of these parameters is currently being investigated in detail.

[1] Huang, Y., Shao, H., Wieland, E., Kolditz, O., and Kosakowski, G. (2021). Two-phase Transport in a Cemented Waste Package Considering Spatio-Temporal Evolution of Chemical Conditions. npj Mater Degrad. 5, 4. doi:10.1038/s41529-021-00150-z