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

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Abstract. The widely proposed approach to dispose of low- and intermediate-level radioactive waste is to store it in a deep underground repository with 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. Both reactions consume water and may lead to pressure buildup and transport of gas, both within and around the repository.

In order to investigate the controlling factors of this gas production process, a coupled reactive transport model of component-based two-phase flow in the OpenGeoSys framework is adopted here. The numerical study of Huang et al. (2021) 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. (2021), 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 in gas production rate over time in relation to water availability 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 are largely controlled by several critical parameters, including the permeability of cement material and water availability at the boundary. The sensitivity of these parameters is currently being investigated in detail.

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