# A revisited compositional 2-phase flow model for gas transport at various scales in heterogeneous porous structures in a deep geological radioactive waste disposal facility

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## Abstract

There is a considerable challenge in modelling gas transport at different (spatial-time) scales in the saturated-unsaturated heterogeneous porous structure of a deep geological high-level radioactive waste disposal facility (HLW-DF). Inconsistencies in the conceptual physical two-phase flow models and uncertainties in the input parameters of such models (lack of knowledge, spatial variability…) can lead to misunderstanding of physical phenomena occurring in a HLW-DF, which may affect its performance during the post-closure phase. Therefore, there is a need for developing new physical approaches, and to account for uncertainties, in order to enhance the mathematical modelling of compositional two-phase flow models applied to gas migration in a HLW-DF.

The purpose of this work is twofold: (**i**) to study the sensitivity to gas entry pressure, as a parameter in the hydraulic properties of clay-based materials, on the modelling of gas transport in a state of near full water saturation, and (**ii**) to analyze the propagation of uncertainty of the input parameters of gas transport models at various scales. Based on the codes iTOUGH2 (Finsterle et al., 2007) and TOUGH2-MP (Zhang et al., 2008), three test problems are studied in this work.

The first test problem is based on a 2-phase flow experiment carried out during 1.5 years in a deep borehole inside the Callovo-Oxfordian (COx) clay rock, located in the Andra's underground laboratory (De La Vaissière, 2011). This modelling study reveals that the gas-entry pressure plays an important role in this experiment. This was demonstrated by an optimal fit of the hydraulic parameters of the van Genuchten-Mualem model (modified by Vogel et al., 2001). The least squares optimization was carried out through a single objective function, using measured points of water retention and of relative permeability (to gas and water) *vs.* capillary pressure in the COx clay rock.

The second test problem consists in the simulation of gas migration in a "module" composed of hundreds of waste cells, in a HLW-DF during 100 000 years. The heterogeneous porous structure in each waste cell is modeled in detail (host rock, EDZ, bentonite, concrete, backfill…). Simulations are run with zero and non-zero gas entry pressure to show the impact of this parameter to gas pressure inside the access drifts and main drift of the facility.

Finally, the third test problem consists in an application of uncertainty propagation methods in order to assess the uncertainty of model predictions due to input parameters uncertainty. Simulation results of gas and water fluxes during 100 000 years are presented using a simplified model of hydrogen migration in a HLW-DF (Saâdi et al., 2018), with appropriate probability density functions for the uncertain parameters (including the hydrogen source term, gas-entry pressure, intrinsic permeability and porosity).

## References

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