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Parametric sensitivity to gas-entry pressure in 2-phase flow models in a deep geologic disposal of radioactive waste.

TOPIC 03: Fluid (Water, gas) transport and solute migration

Abdellah Amri ¹, Zakaria Saadi ¹, Rachid Ababou ², Magdalena Dymitrowska ¹

¹Institut de Radioprotection et de Sûreté Nucléaire (PSE-ENV/SEDRE), 31

Avenue de la Division Leclerc, 92260 Fontenay-aux-Roses, France. - Fontenay-

Aux-Roses (France), ²Institut de Mécanique des Fluides de Toulouse (IMFT),
Université de Toulouse / INPT-UPS-CNRS, 1 Allée du Professeur Camille Soula,
F-31400 Toulouse, France. - Toulouse (France)

Abstract

After closure of a deep geological disposal (DGD), some gases will be generated through a number of processes. As gas concentration rises, a separate gas phase may be formed. If gas pressure exceeds gas entry pressure, a 2-phase flow may occur, potentially resulting in a decrease of the repository performance [1].

Therefore, a demonstration of the long-term safety of the repository requires a good characterization of hydraulic properties of its host rock and engineered barriers near full water saturation.

A number of studies have focused on air-entry pressure (P_e) as a parameter to correct the classical van Genuchten-Mualem (VGM) model used in unsaturated soil hydrology for water retention and permeability curves [2], [3]. However, numerical simulations with gas-entry pressure effects in 2-phase flows are not available. In this work, a new approach is developed, consistent with experimental measurements of hydraulic properties of clay host rock and clay-based materials. As a first step, the RETC code [4] is modified by implementing a modified VGM model [3] accounting for gas-entry pressure, and by introducing gas permeability in addition to water permeability and water retention curve. All these hydraulic properties are combined in a single objective function. Figure 1 shows the resulting simultaneous fit to data of hydraulic properties of the argillaceous layer of Callovo-Oxfordian (COx) rock which has been chosen by Andra as a possible host-rock for deep geological disposal of intermediate-level long-lived and high-level radioactive wastes in eastern France. To use this new model with gas-entry pressure parameter, modifications were necessary in the TOUGH2 code [6]. Thus, the capillary pressure is set as primary state variable instead of gas saturation. After numerical verification of the revised version of TOUGH2, the Andra's PGZ1 experiment [7] is modeled (Figure 2). The preliminary results show that a non-zero gas entry pressure leads to considerably higher gas pressures than those simulated by the classical model with $P_e=0$ while keeping all other materials parameters unchanged.

The optimal fit shown in **Figure 1** indicates that hydraulic properties are sensitive to P_e near full water saturation. **Figure 2** confirms such sensitivity and indicates that in order to predict the fate of gases in DGD a careful estimation of P_e is necessary. Further work includes accounting for the hysteresis effect, and simulations at large space-time scales in the DGD.

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Figure 1. Optimal simultaneous fit of CO_x hydraulic properties. The data points are borrowed from Gerard P.(2011) [5]:
 (a) water retention curve $S_w(h)$; (b) absolute water permeability $K_w(h)$; (c) absolute gas permeability $K_G(h)$.
 We have chosen to constrain full water saturation and intrinsic permeability to be the same in the two models.

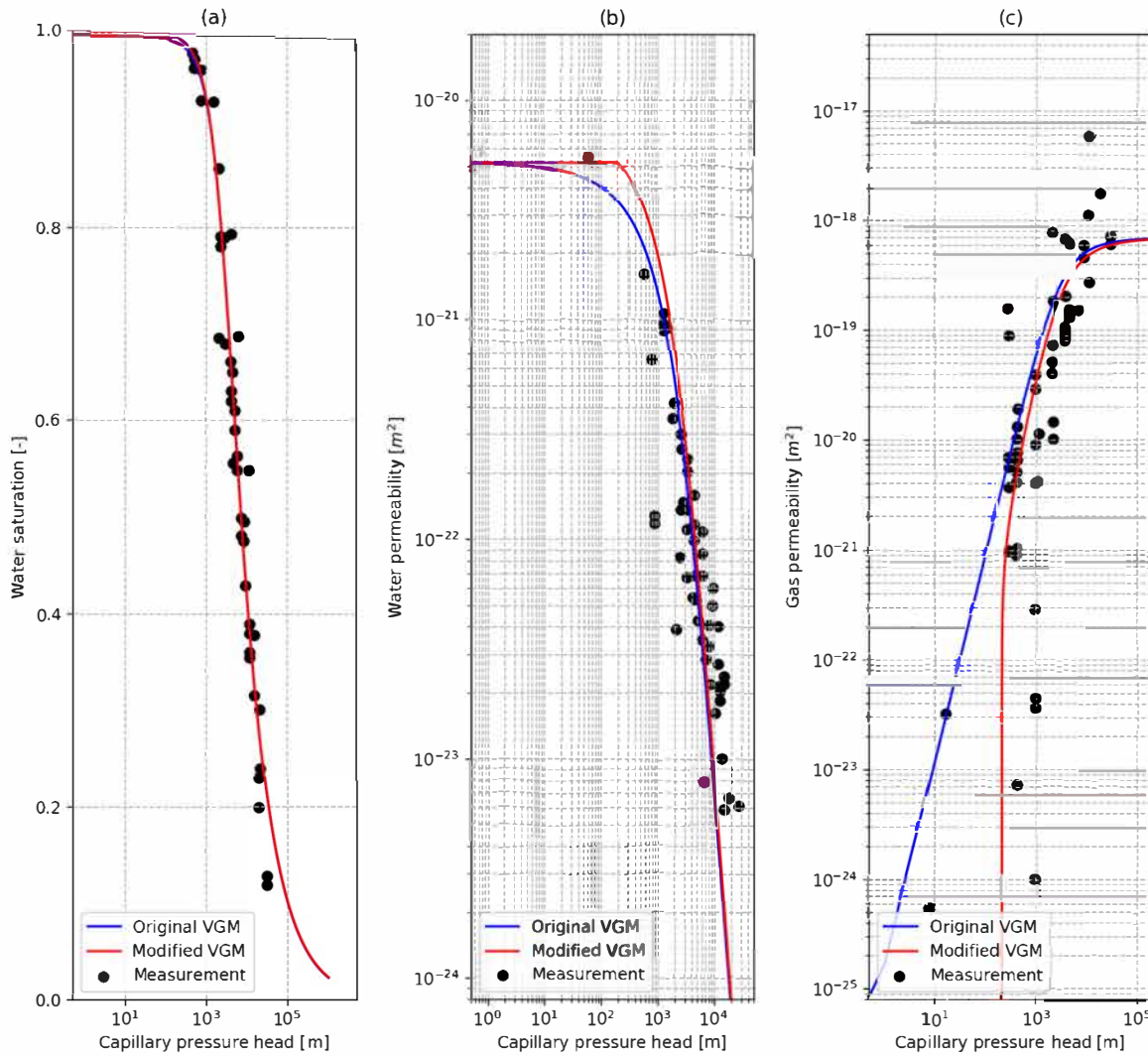


Figure 2. Gas pressures versus time in the Andra's PGZ1 test : Simulated in the present study with unmodified VGM properties ($P_e=0$), and simulated with modified VGM properties ($P_e=1.97$ MPa).

