Computing the diphasic effective properties on nanoporous clayrock using Direct Numerical Simulation

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Résumé

1 Introduction

The low permeability of sedimentary clays as well as their chemical characteristics make them particularly suitable to serve as a natural barrier for radioactive waste geological storage. Due to the low permeability, the gas, mainly the hydrogen, originating from the bacterial corrosion of the metallic parts of the facility can be accumulated through time causing significant pressure rise at the interface between sedimentary clay and the facility components. Depending on the pressure, gas is transported through the clayrock with different mechanisms (with increasing pressure: diffusion, visco-capillary flow, dilatant flow and fracturing) (1). In this work, we will focus on the intermediate multiphase flow without structure evolution.

2 Material and methods

In the present work, we will use different approaches (Direct Numerical Simulations (DNS) (using Lattice Boltzmann Method (LBM) (2) and Smooth Particle Hydrodynamics (SPH) (3)), Pore Network Models (PNM)) and protocols (drainage simulation and co-current simulations) to assess the capacity of such methods to correctly predict the retention curve. Drainage simulations are performed with LBM using inlet and outlet reservoirs and pressure boundary conditions, and PNM. The co-current flow simulations, which consists in setting an initial phase distribution for a given saturation and the performing co-current with periodic boundaries, is performed using LBM and SPH.

The image data used in this study corresponds to an illite sample from Le Puy en Velay

*Intervenant

basin. Details on the sample, image acquisition and image segmentation may be found in (4). We use the image segmented by the watersheding-based method developed by (4) (Figure 1). There are 180 images of 1096 x 1095 pixels in total, with pixel size 5 x 5 nm. Since the distance between the consecutive images is also 5 nm, the voxel is a cube with 5 nm side. The DNS are performed on a sub-sample extracted from the original image. The sub-sample size is 101 x 101 x 102 voxels. PNM are performed on samples of various sizes. Experimental measurement of the retention curve is obtained using gravimetric water vapour adsorption-desorption isotherms.

3 Results

The simulation results will be compared to experimental data and discussed in regards to parametrization, cut length, pore pressure distribution and representativity. We demonstrated the challenges relating to using pore-scale simulations on low resolution data, the discrepancy between a drainage and a co-current approach. We show that despite such limitations, the DNS drainage simulation gives satisfying results for the higher saturation values (Figure 2).

References

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