

Experimental investigation on adsorption, deformation and transport couplings in microporous materials (Newpores project)

NewPores research project presentation

NewPores is an international hub dedicated to the mechanics and physics of porous materials, which intends to answer to new Energy and Environment challenges. This is a joint effort of the group on Geomechanics and Porous Materials (G2MP) of the Laboratoire des Fluides Complexes et leurs Réservoirs at E2S UPPA (France), the Centre for Sustainable Engineering of Geological and Infrastructure Materials (SEGIM) at Northwestern University (USA), the University of Vigo (Spain), the Technical University of Madrid (Spain) and University of Liège (Belgium).

Experimental investigation on adsorption, deformation and transport couplings in microporous materials

Microporous media are characterized by the presence of pores with diameters below two nanometers. Activated or natural carbons, tight rocks, clay, cementitious materials and biomaterials are among these materials. In recent years, a major attention has been paid on these microporous materials because the surface-to-volume ratio (i.e., the specific pore surface) increases with decreasing characteristic pore size. These materials can trap an important quantity of fluid molecules as an adsorbed phase. This is important for applications in petroleum and oil recovery, gas storage, separation, catalysis or drug delivery. For these microporous materials, a deviation from standard poromechanics, which was introduced by Biot 75 years ago, is expected. In very small pores, the molecules of fluid are confined. Interaction between molecules is modified. This effect – molecular packing – includes fluid-fluid and fluid-solid interactions and has significant consequences at the macroscale, such as instantaneous swelling. In different contexts, these deformations may be critical. For instance, in-situ adsorption-induced coal swelling has been identified as the principal factor leading to a rapid decrease in CO₂ injectivity during coal bed methane production enhanced by CO₂ injection. Generally, natural and synthesized porous media are composed of a double porosity: the microporosity where the fluid is trapped as an adsorbed phase and a meso or a macro porosity required to ensure the transport of fluids to and from the smaller pores. If adsorption in nanopores induces instantaneous deformations at a higher scale, the matrix swelling may close the transport porosity, reducing the global permeability of the porous system or annihilating the functionality of synthesized materials.

Experimentally, it is still difficult to characterize the effect of the adsorption-induced deformation on the global transport properties of a double porosity medium. Classically, the experimental protocol to measure an intrinsic permeability consists in imposing an axial gas flow through a porous medium and in measuring the mass flow, the upstream pressure and the downstream pressures at a given confinement pressure. By using the Klinkenberg's law, the intrinsic permeability is then deduced. Therefore, the measurement may be considered as global and the intrinsic permeability is supposed to be constant all along the sample, leading to a linear gradient of the pressure. However, under swelling deformation, the local permeability may be impacted and the pressure gradient may become non-linear. Consequently it is not obvious to collect experimental data for model validation on the influence of adsorption-induced because we cannot measure easily the pressure evolution along the porous medium under swelling. This is the main objective of this master internship.

Partners

- E2S Newpores project (an international hub for the mechanics and physics of porous materials)

Master candidate objectives

Within the Newpores project, the master candidate will be in charge of the design of an experimental platform allowing the local evolution of the pressure along a porous medium subjected to adsorption-induced deformation. The strategy will consist in placing several permeameters in series allowing to measure the pressure at different location along the porous medium.

Laboratory and internship location

– G2MP research team, LFCR lab (UMR5150 UPPA CNRS Total), Anglet, France (50%).

Grant – 560 € / month.

Duration – From March to August 2021 (6 months)

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