PhD Position at Université Gustave Eiffel – Navier Laboratory

Pore Network Modeling of Multiphase Flow in CO_2-Water-Rock Systems under Variable Thermodynamic and Flow Regimes

Context

The climate-decarbonization policies of the European Green Deal include Carbon Capture and Storage (CCS) as a mitigation option for hard-to-abate sectors. CCS involves the capture of carbon dioxide (CO_2) and its permanent geological underground storage. In France, for example, current CCS pilot projects target deep saline aquifers in two formations of the Paris Basin: the Dogger (carbonates) and the Keuper (sandstones).

The efficiency of CCS operations in achieving target storage capacities and effectively trapping CO_2 depends on the multiphase flow behavior at the pore scale, which governs macroscopic properties such as relative permeability. However, the characterization of CO_2–water multiphase flow remains complex due to strong pressure and temperature gradients in the geological formations, multiple flow regimes (capillary-, viscous-, and gravity-dominated) and complex thermodynamic behavior of CO_2 under reservoir conditions. While laboratory experiments provide valuable insights, they cannot fully capture the wide range of conditions encountered in real storage operations and may suffer from limitations in sample representativity.

The PhD project

This PhD project aims to develop advanced pore network models (PNMs) to simulate CO_2–water multiphase flow in porous media under varying thermodynamic and flow conditions, and to bridge the gap between pore-scale phenomena and reservoir-scale modeling.

The research will focus on the following key tasks:

- Development of dynamic pore network models integrated with phase equilibria models and equations of state to account for pressure, temperature, and flow regime dependencies on multiphase flow properties.
- Representative Elementary Volume (REV), investigating the scale at which relative permeability becomes representative for target rock types and informing experimentalists on appropriate sample sizes.
- Development of an upscaling methodology to use robust, state- and pore-structure dependent relative permeability models suitable for reservoir-scale simulations

This work will contribute to improving the predictive capability of pore-scale models and enhancing our understanding of how pore-scale physics impacts large-scale CO_2 storage performance.

Supervision Team

The PhD candidate will be supervised by:

Amade Pouya (Senior Researcher, Université Gustave Eiffel) – amade.pouya@univ-eiffel.fr

Ana Loyola (Associate Researcher, Université Gustave Eiffel) – ana.loyola@univ-eiffel.frAmade Pouya (Senior Researcher, Université Gustave Eiffel) – amade.pouya@univ-eiffel.fr

Philipp Braun (Associate Researcher, École Nationale des Ponts et Chaussées, Institut Polytechnique de Paris) – philipp.braun@enpc.fr

Application Process

Interested candidates should contact the supervision team no later than the **18th April** using the email addresses provided above and submit the following documents: a **CV, a motivation letter, two reference letters, and Master's transcript.**

After a first interview round, the candidate selected by the supervisors will be invited to an oral exposition in early June, during which they will present their background and discuss the project. Final selection is subject to approval by an external evaluation committee.

Job requirements

Applicants should meet the following requirements:

- Master's degree (or equivalent) in geosciences, geotechnical engineering, reservoir engineering, or a closely related field
- Strong proficiency in English (written and spoken)
- Interest in numerical modeling, multiphase flow, and energy transition applications
- Motivation to conduct scientific research and autonomy

The following skills are highly desirable:

- Programming experience (e.g., C++, Python)
- Experience with pore network modeling and/or finite volume methods
- Experience with modeling of fluid flow in porous media

About Navier Laboratory and Gustave Eiffel

The successful applicant will join the Geotechnics group at the Navier Laboratory and will be enrolled as a PhD candidate at Université Gustave Eiffel.

Navier is a french joint research unit of the Ecole Nationale des Ponts et Chaussées (ENPC), the Gustave Eiffel University and the National Center for Scientific Research (CNRS), located in the Cité Descartes in Marne-La Vallée (outskirts of Paris). The staff (nearly 170 people) conduct research on mechanics and physics of materials, structures and geomaterials, and their applications to geotechnics, civil engineering, transport, geophysics and energy. Societal challenges concern sustainable construction, natural risks, environment and energy.

Université Gustave Eiffel is a leading French public research university dedicated to advancing knowledge and innovation in the fields of sustainable cities, infrastructure, transportation, and environmental engineering. With a strong emphasis on interdisciplinary research, the university brings together expertise in engineering, geosciences, materials science, and socio-economic studies to address key challenges of the ecological transition.