PhD thesis application in Geomechanics

Modelling the hydromechanical-gas behaviour of fractured clayey rocks

Collaboration ENTPE – ANDRA.
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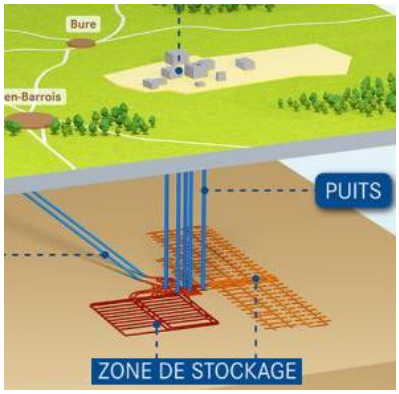
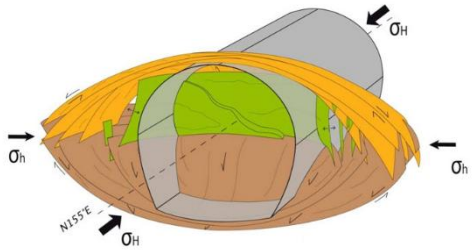
Project description

Context:

In the context of operating and **utilising underground spaces** (e.g., for transport, deep geological disposal, etc.), the behaviour of rocks surrounding galleries and tunnels determines their stability and usability, during both construction and operational phases. Failure to maintain the structural integrity of these excavations can lead to operational difficulties or a loss of structural stability. The Cigéo disposal facility project involves long-term, deep geological disposal solutions for wastes, requiring a thorough understanding, in the short and long term, of **underground structures** and of the **multiphysics behaviour of the surrounding rock mass**. The Andra possesses a substantial body of knowledge regarding the modelling and the characterisation of the behaviour of the Callovo-Oxfordian claystone, the host rock of the Cigéo facility, under hydraulic loading and gas injection conditions at various scales. This knowledge base has been established through testing on rock samples taken from the Meuse/Haute-Marne Underground Research Laboratory, in situ experiments, and modelling work based on equivalent porous medium approaches. Expanding this knowledge through experimental and numerical studies enhances the understanding of the physical processes occurring throughout the lifecycle of the Cigéo facility and facilitates their integration into design, optimisation, and safety assessments.



Cigéo deep geological disposal project (Andra).



Development of fractures around underground galleries (Armand et al., 2014).

Objectives and method:

The objective of the thesis work will be to develop and/or improve:
- (1) **numerical methods** to determine the coupling between the hydraulic properties of Callovo-Oxfordian claystone and deformation, based on pore networks derived from imaging-based characterization;
- (2) **models** (discrete and/or equivalent continuum) **representing the mechanisms of fracture initiation and propagation induced by gas solicitation** at the macroscopic scale, drawing on experimental data;
- (3) modelling at the scale of in situ experiments and Cigéo structures that incorporate the phenomenon of self-sealing;
- (4) models accounting for fracture re-closure and its consequences for Cigéo structures.

The thesis research works will aim to **reduce uncertainty regarding the hydraulic parameters of the Callovo-Oxfordian formation** (gas entry and breakthrough pressures, water permeability, water retention curve, etc.), and to enhance the understanding of **gas migration mechanisms in the argillite**. Among them, a focus will be put on the modelling and understanding of the mechanisms driving the transition from gas migration to gas-induced fracturing, the propagation mechanisms of existing fractures within the Callovo-Oxfordian formation in the context of underground repository, and the effects of self-sealing and fracture re-closure around the Cigéo repository structures during both the operational and post-closure phases.

Candidate profile

Candidates must hold an engineering degree or a Master's degree (Master 2) in civil engineering, mechanical engineering, materials science, geotechnical engineering, etc. The role requires an interest in numerical modelling in geotechnics (finite element method). Knowledge of soil and rock mechanics, geotechnics, continuum mechanics, and constitutive models (constitutive laws) is also required.

Application

Applications must be submitted by Dec. 2026 via email to benoit.pardoen@entpe.fr. They must include a CV, a cover/motivation letter, academic grades (detail of marks), a copy of passport or identity card (and, if possible, scientific/academic recommendation letters or at least scientific/academic references). Any additional document relevant for the application, e.g. showing the applicant's research experience, can also be transmitted.