Msc and PhD application in geomechanics

Multi-Scale hydromechanical numerical analysis of damage in heterogeneous rocks applied to underground works

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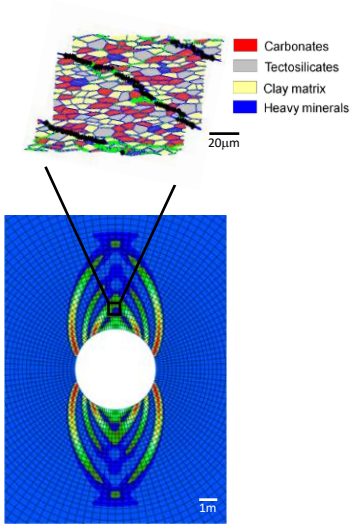
Project description

Context:

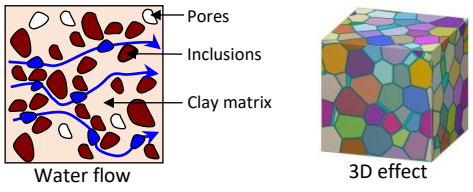
In the actual energy transition context, it is necessary to evaluate the underground potential as a storage and confinement space. Concerning the nuclear electricity production, a sustainable management of the hazardous nuclear wastes is required and is envisaged in deep geological repository. The underground low permeable rock formation has a key safety function by preventing the radionuclide migration. Thus, the stability and sustainability of the underground repository structures have to be assessed throughout a detailed study of the host formation complex behaviour.

Objectives:

The goal of this project is to investigate the multi-scale behaviour of clay rock, going from microscopic to macroscopic scale. Geomaterials, such as rocks, are multiphase porous media having a complex heterogeneous structure at different scales (from millimetric to microscopic scales). This structure conditions their macroscale behaviour and affects material damage as well as hydraulic properties evolution. The latter are of high importance and require a good understanding of the material behaviour. Predicting the influence of microstructural characteristics (from mineral scale) on large-scale rupture is a crucial issue in geomechanics. Various scientific questions have risen recently on how microstructural characteristics of heterogeneous materials can be considered at larger scale, and enrich macroscale modelling. The objective is to develop a **multi-scale and multi-physical modelling** allowing to predict the rock **hydromechanical behaviour** around underground excavations from its microstructure.



Deformations: microstructure damage and underground fracturing.



Hydromechanical coupled behaviour: fluid transfer, permeability evolution, 3D effects.

Method:

The research will be based on multi-scale approach and numerical method allowing to model microstructure media in a double-scale framework (FEMxFEM, by finite element method). The microscale material response (of 2D and 3D REV) will be used as an implicit macroscale constitutive law, by computational homogenisation. The project focuses on: **(i)** the **relation between microcracking**, macro-deformation, **and permeability evolution**; **(ii)** the **evolution of fluid flow** resulting from microcracking; **(iii)** the **reproduction of fractures and drainage** within the Excavation Damaged Zones (EDZ) around galleries; and **(iv)** the global short- and long-term safety of underground repository structures.

Candidate profile

Candidates can apply for a Msc and PhD scholarship at University of Lyon (ENTPE-LTDS, France). Applications are welcome from students graduated in the areas of civil, mechanical, physical, and materials engineering, or geosciences. Basic knowledge in mechanics of porous media, constitutive modelling of geomaterials, and interest for numerical methods is required. The project will give the applicant opportunities to develop various technical skills (advanced numerical methods, poromechanics, elastoplasticity, damage approach, liquid flow, hydromechanical coupling, etc.), and to integrate a dynamic geomechanics network having experiences in numerical modelling. The successful applicant will use and develop the non-linear finite element code LAGAMINE. The ability to communicate orally and write in English is required and international mobility is encouraged.

Application

Applications should be submitted by December 2023 for the Msc. project and by May 2024 for the PhD project by emailing a CV, academic grades (detail of marks), scientific/academic references, and recommendation letter to the supervisor at benoit.pardoen@entpe.fr. Any additional document relevant for the application can also be transmitted, especially for international applications.