PhD Thesis Andra 2026

Experimental characterization and numerical modeling of the anisotropic hydraulic and THM properties of the Callovo-Oxfordian claystone

Context and motivations of the thesis

As part of the development of the Cigéo radioactive waste repository in Meuse/Haute-Marne, new characterization campaigns are planned, including the drilling of the first boreholes in the Cigéo site area and the development of underground structures. These campaigns aim to confirm the hydromechanical parameters of the Callovo-Oxfordian claystone and, where possible, reduce uncertainties. While many tests have been conducted in the past, the development of new test protocols or innovative devices could improve this characterization, taking into account mineralogical variability and further reducing uncertainties. Characterizing the hydromechanical properties of the Callovo-Oxfordian in samples is complex due to its intrinsic anisotropic behavior and very low permeability, its swelling capacity, creep, and the initial desaturation induced by sample collection and preparation. Furthermore, the exothermic phase of the waste causes heating of the host clay rock in areas near the excavations. The thermal properties of this clay rock must therefore be known in order to optimize the design of the storage facility.

The GeoRessources laboratory, and more specifically the HGM (HydroGeoMechanics multiscale) team, has been involved for three decades in laboratory experiments aimed at characterizing the permeability and coupled THM (Thermo-Hydro-Mechanics) behaviour of Callovo-Oxfordian claystone. This proposed thesis builds upon this previous work. It is motivated by the need to develop new techniques for characterizing these properties on samples of anisotropic argillaceous rock.

Objectives of the thesis

The aim of this thesis is to propose new test protocols and innovative measurement devices, as well as the methodology (analytical, numerical modeling) for determining the parameters and associated uncertainties, in order to better characterize the basic THM coupled properties (elastic coefficients, Biot coupling coefficients, thermal conductivity and diffusivity, thermal expansion) of an anisotropic clay rock, and its permeability (steady-state and transient regimes). Knowledge of these properties under highly complex experimental conditions is essential for assessing the feasibility and long-term safety of underground radioactive waste storage. As an example, the so-called "harmonic" method for measuring transient permeability will be developed, and it may be possible to develop devices capable of determining static and dynamic elastic parameters and their correlations on the same sample. The challenges lie in the very low permeability of the clay rock, the need for precise control of its saturation level, its structural anisotropy (transverse isotropy), and its natural heterogeneity, which necessitates a statistical analysis of its properties. HM and permeability tests will be performed in specific triaxial compression cells with strain measurements and precise temperature control. Thermal properties will be determined using specific devices (Optical scanning, dilatometer). Interpretation of transient permeability measurements (pulse test, harmonic method) will require the use of analytical solutions and numerical modeling (COMSOL Multiphysics®).

Scientific skills required

Solid basis in continuum mechanics, rock mechanics, transfers in porous media, rock physics, numerical modelling. Knowledge of geomaterials will be appreciated. The taste and interest for laboratory experiments are essential. Motivation and initiative, ability to work in a team.

Contract details

Duration: 3 years (October 1st, 2026 to September 31th, 2029)
Gross salary (ANDRA thesis): around 2200 € per month

Subject to acceptance of the application by Andra (audition of the candidate scheduled for the last week of March 2026).

Application file

Application deadline: **March 20th, 2026**

Documents to provide:

- Cover letter
- Curriculum vitae
- Copies of certificates of each university degree and Master's 1 and 2 scores
- Recommendation letter

Eligibility:

- All European citizens can apply
- Non-European candidates who already have student status in France can also apply
- Candidates must hold a Master's degree or equivalent
- Candidates whose first language is not French must have written and oral English skills

Supervision and contact

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