

Thermo-poro-mechanical coupled processes during thermal pressurization around Nuclear Waste Repository

M N. Vu*, D. Seyedi* and G. Armand†

* Andra, R&D Division,
1-7 rue Jean Monnet, 92290 Châtenay-Malabry, France
e-mail: minh-ngoc.vu@andra.fr, darius.seyedi@andra.fr

† Andra, R&D Division, Meuse/Haute-Marne Underground Research Laboratory,
RD960, 55290 Bure, France
e-mail: gilles.armand@andra.fr

ABSTRACT

Clays and claystones are considered as potential host formations for nuclear waste disposal in various countries such as the Callovo-Oxfordian (COx) in France, Boom Clay in Belgium, and Opalinus Clay in Switzerland.

During the exploitation stage of deep radioactive geological disposal, exothermic reactions of waste provoke thermal perturbation within the repository environment. Heat emitted from radioactive waste diffuses through the near-field rock to the far-field. Therefore, the host rock is subjected to an increase of temperature (up to about 80°C). The temperature rise in a low permeability porous medium such as COx claystone, generates pore pressure increase essentially due to the difference between the thermal expansion coefficients of water ($\sim 10^{-4} \text{K}^{-1}$) and the one of the argillaceous rock skeleton ($\sim 1.28 \cdot 10^{-5} \text{K}^{-1}$). The experimental studies in this field showed that the amplitude of pressure variation is related to the temperature change through thermal pressurization.

This study investigates the thermo-poro-mechanical coupling involved in thermal pressurization of COx under the heat emitted from the radioactive waste. In this view, numerical simulations are also performed to estimate pore pressure increase and calculate $\Delta P/\Delta T$ which can be defined as a thermal pressurization coefficient. In fact, this coefficient differs from the classical one determined in undrained conditions. This calculated thermal pressurization depends on the rate of temperature increase, the stress state and the nature of the rock, i.e. the thermo-poro-mechanical parameters such permeability, Biot's coefficient, rigidity, thermal conductivity, etc. As for many sedimentary rocks, the THM parameters of the COx present a significant variability. Experiments show also the dependency of the thermal pressurization on the anisotropies of Young's modulus, of permeability and thermal conductivity tensors. The effect of these variabilities on the thermal pressurization coefficient is discussed through a sensibility analysis. The thermal pressurization stemming from this analyse are in agreement with the range obtained by laboratory investigation [1] and in-situ measure [2].

REFERENCES

- [1] M. Mohajerani, P. Delage, J. Sulem, M. Monfared, A.M Tang and B. Gatmiri, "A laboratory investigation of thermally induced pore pressures in the Callovo-Oxfordian claystone". *International Journal of Rock Mechanics and Mining Sciences*, Vol. **52**, pp. 112–121, (2012).
- [2] A. Gens, J. Vaunat, B. Garitte, Y. Wileveau, "In situ behaviour of a stiff layered clay subjected to thermal loading: Observation and Interpretation". *Géotechnique*, Vol. **57**, pp. 207-28, (2007).