# MODELLING THE INFLUENCE OF WATER CONTENT ON THE MECHANICAL BEHAVIOUR OF CALLOVO-OXFORDIAN ARGILLITE

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The clay formation provides the geological background to many industrial and engineering applications. Especially in recent years, these types of material have been largely studied because they can be considered as potential host geological barrier for the underground storage of high level radioactive wastes. In view of this, several underground laboratories have been constructed in different countries. For instance: the Meuse/Haute Marne underground research laboratory (France), excavated in Callovo-Oxfordien argillite; the Mont Terri underground rock laboratory (Suisse), constructed in Opalinus clay; the HADES Underground Research Laboratory (Belgium), located in Boom clay; the AECL underground research laboratory (Canada), achieved in the Lac du Bonnet granite batholith. The research realised in the underground laboratories allows us to obtain extensive experimental measurements and helps us to get a good understanding of the generalised behaviour of theses clays when subjected to complex solicitations (thermal, hydraulic, mechanical and chemical).

In the underground storage, the experimental investigation and numerical prediction show that coupled hydro-mechanical processes will occur in the geological barrier for a very long time due to excavation/ventilation and subsequence backfilling/sealing (Tsang, 1987; Tsang *et al.*, 2000). In the excavation and exploitation stage, the unloading of host rock creates an EDZ zone and induces an increase local of permeability by several orders of magnitude around the galleries. Moreover, additional damage may be induced by the desaturation/resaturation processes during ventilation/backfilling phase. On the other hand, the behaviour of clay formation is affected also by the presence of water and the pore pressure evolution. It is necessary to achieve a good understanding of the coupled hydro-mechanical behaviour to of clay formation for the designer of an underground storage.

This paper focus on the hydro-mechanical response of Callovo-Oxfordien argillite, a stiff, layered Mesozoic clay, located at 500 m depth in Eastern France. Thanks to its low permeability, significant retardation properties for solute transport, high mechanical strength and self-healing capacity when facture, the Callovo-Oxfordian argillite is studied as potential geological barrier for radioactive wastes and an underground research laboratory, called M/HM URL is under construction.Various experimental studies have been performed to study the different aspects of rock behaviour. Meanwhile, different constitutive model have been proposed for this material (Andra, 2005). Among recently proposed models for argillites, the contributions Zhou *et al.* (2008) and Jia *et al.* (2009) are of direct interest to this paper. Zhou *et al.* (2008) have proposed a unified approach for modelling of elastic–plastic and viscoplastic behaviour coupled with induced damage in Callovo-Oxfordian argillite. Both instantaneous and differ plastic deformations are described within the unique constitutive model. Material damage induced by microcrack is coupled with plastic deformation. Jia *et al.* (2009) have developed a constitutive model, where the plastic deformation was considered as the principal mechanism, to consider coupling between plastic deformations and damage and evolution of mechanical properties with water content. In addition, a special attention is paid on the residual state of rocks after peak strength and the shrinkage/swelling deformation during the desaturation/resaturation processes. However, the influence of water content on the elastic proprieties and the long term mechanical behaviour of argillite are not dealt with in these models. These two phenomena will be studied in this paper.

Firstly, a synthesis of experimental study on the poromechanical behavior of argillites is presented. Special attention is given to the influence of water content on the long term mechanical aspects of the clay

behaviour. In the second part, after a brief the coupled elastoplastic damage model proposed by Jia *et al.* (2009), the time-dependant behaviour of argillite is incorporated in the previous model by using the unified approach (Zhou *et al.*, 2009). The influence of water content on the long term mechanical behaviour of argillite under different water contents is taken into account in the framework of partially saturated porous media. The proposed model is validated by simulation of a series of creep tests with different water content. Finally, the experiment performed on the hollow cylindrical sample (Pham, 2007) is simulated and analyzed. The evolutions of deformations generated and masse of sample is googly predicted by the simulations. The numerical results help us get a good understanding of the drying/wetting impact on the poromechanical behaviour of argillite.

**References:**

Andra, 2005. Dossier 2005, Référentiel du site de Meuse/Haute-Marne. *ANDRA report n° C.RP.ADS.04.0022*, Paris, France.

Jia, Y., Bian, H.B., Su, K., Kondo, D., Shao, J.F., 2009. Elastoplastic damage modelling of desaturation and resaturation in argillite formation. International Journal for Numerical and Geomechanics. Available online, DOI: 10.1002/nag.819.

Tsang, C.F., 1987. Coupled processes associated with nuclear waste repositories. Tunnelling and Underground Space Technology 2 (3), 347.

Tsang, C.F., Tephansson, O. S, Hudson, J.A., 2000. A discussion of thermo-hydro-mechanical (THM) processes associated with nuclear waste repositories. International Journal of Rock Mechanics and Mining Sciences 37, 397-402.

Pham, Q.T., 2006. Effets de la désaturation et de la resaturation sur l'argilite dans les ouvrages souterrains. Doctorial thesis, Ecole polytechnique.

Zhou, H., Jia, Y., Shao, J.F., 2008. A unified elastic-plastic and viscoplastic damage model for quasi brittle rocks. *International Journal of Rock Mechanics and Mining Science*, available online, doi: 10.1016/ j.ijrmms.2008.01.004.