3D INTERPRETATION OF AN *IN SITU* HEATING TEST IN THE CALLOVO-OXFORDIAN MUDSTONE

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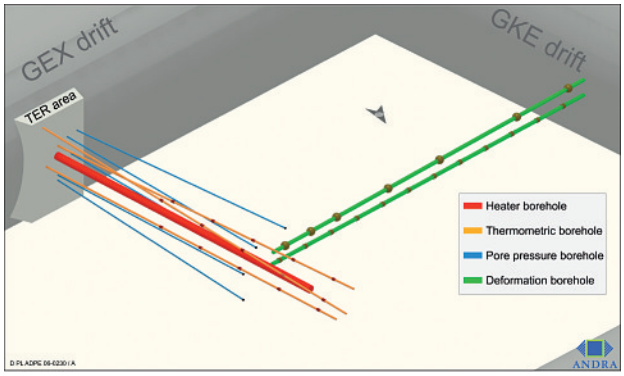
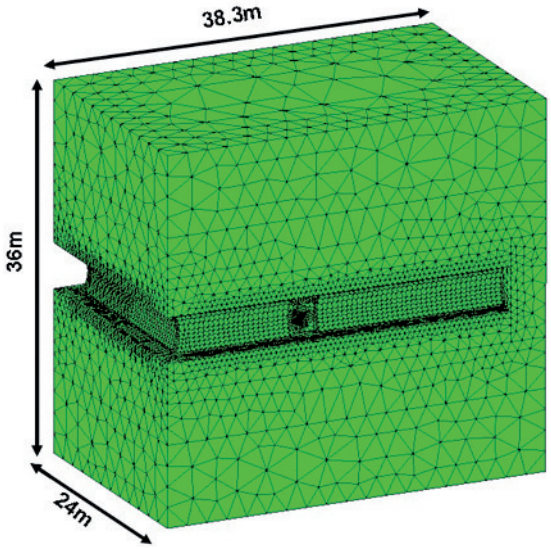
In order to improve the understanding of the thermo-hydro-mechanical (THM) behaviour of the Callovo-Oxfordian Clay, an *in situ* heating test (TER experiment) has been realized by ANDRA at Meuse/Haute Marne URL during the last years. In this experiment, one power-control heater has been placed in a horizontal borehole and several heating phases realized at distinct levels of power. Around this heating borehole, 32 temperature sensors, 5 water pressure sensors and 2 extensometers were placed in 8 different boreholes (Figure 1.a). This abstract presents the interpretation works performed in parallel by running 3D THM simulations.



a) 3D view of TER experiment

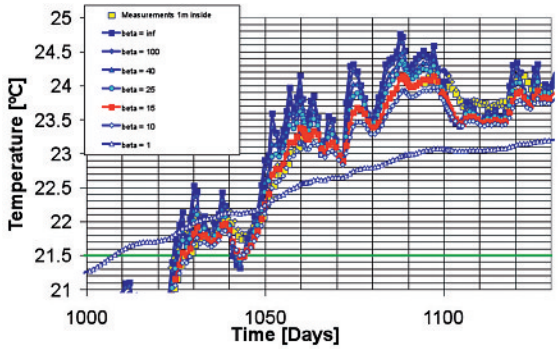


b) Geometry and mesh of the model

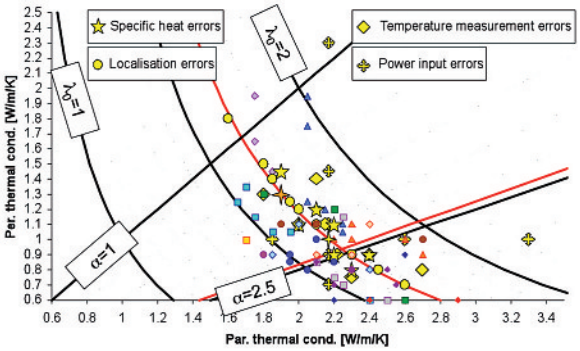
Figure 1: Test and modelling features.

In a first step, the 3D model has been used to provide insights into the directional values of the thermal conductivity by means of back-analyses. An original method has been developed to include uncertainties on applied heat power, temperature sensor location and heat capacity in the analysis of the maps of errors (normalized difference between the measured and computed temperatures) (Garitte *et al.*, 2009). Numerical results evidence: 1) that the changes in temperature that occurred in the surrounding galleries during the test cannot be neglected during the back-analysis of temperature measurements. The best estimate is provided when the coefficient of heat transfer at gallery wall is equal to 20 W/m^2/K (Figure 2a); 2) Due to test configuration, characterized by an essentially radial heat flow around a cylindrical heater installed in a horizontally bedded formation, the back analysis provides a more precise estimation of the mean value of the thermal conductivity (1.65 W/m/K with standard deviation equal to 0.14) than of the anisotropy ratio (2.4 with standard deviation equal to 0.88) (Figure 2b).

In a second step, a full thermo-hydro-mechanical equations analysis has been conducted. Thermal parameters were taken from the previous back-analysis. Hydro-mechanical parameters were back-analyzed



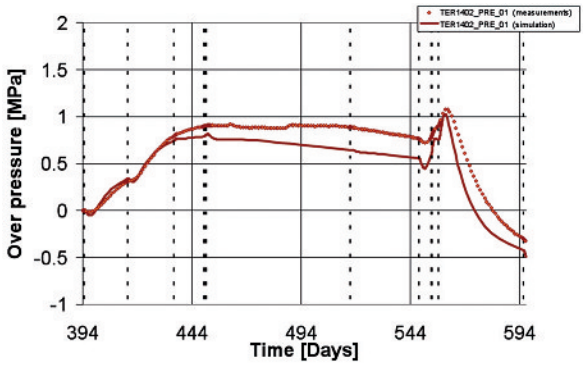
a) Comparison between measured and computed temperatures close to GEX gallery for different values of heat transfer coefficient



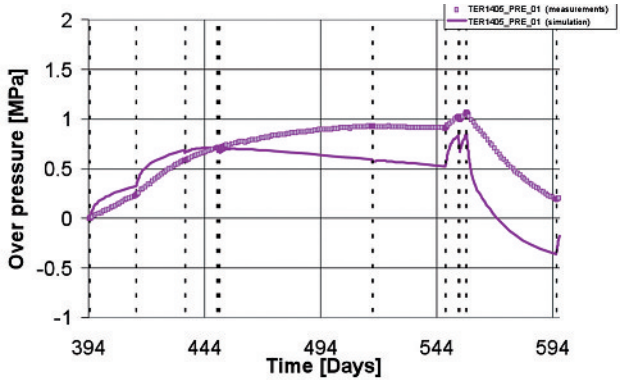
b) Best estimates of the directional values of the thermal conductivity at each sensor location

Figure 2: Thermal back-analysis.

from the first stage of heating (application of heat power in three steps – 238, 975 and 0 W- during 200 days). Pores pressures predicted by the model for the following phases are compared in Figure 3 with measurements obtained at two sensors, located respectively, at 0.53 m in the horizontal direction (Figure 3a) and 1.48 m in the vertical direction (Figure 3b).



a) at 0.53 m from the heater in the horizontal direction



b) at 1.48 m from the heater in the vertical direction

Figure 3: Comparison between predicted and measured pore pressure during the heating phases.

References:

Garitte, B., Gens, A., Vaunat, J., Wileveau, Y., 2007. Characterization of the THM parameters of Callovo-Oxfordian mudstone by interpretation of an in situ heating test. *Proc. 3rd Int. Meeting on Clays in Natural & Engineered Barriers for Radioactive Waste Confinement*, Lille, France, September 17-20, pp. 49-50.

Wileveau, Y., Su, K., 2007. In situ thermal experiments carried out in Opalinus clay and Callovo-oxfordian claystones by ANDRA – experimental design and measurement results. *Proc. 3rd Int. Meeting on Clays in Natural & Engineered Barriers for Radioactive Waste Confinement*, Lille, France, September 17-20.

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