EURAD HITEC – INFLUENCE OF TEMPERATURE ON THE BEHAVIOUR OF CLAY-BASED MATERIALS

Markus OLIN, VTT Technical Research Centre of Finland Ltd, Finland
Dragan GRGIC, University of Lorraine, CNRS, GeoRessources, France
Jiří SVOBODA, CTU in Prague, Centre of Experimental Geotechnics, Czech Republic

Introduction and objectives

Most of Safety Cases limit maximum disposal container surface temperatures to 100˚C to protect undesirable evolution. Higher temperature limits could have significant advantages such as allow disposal of higher enrichment/burn-up spent fuels and shorter interim storage/cooling requirements. HITEC aims to improve Thermo-Hydro-Mechanical (THM) description of clay based materials at elevated temperatures. The host rock clays will be studied under saturated conditions under 120˚C, while buffer bentonites will be studied both in saturated and unsaturated conditions under 150˚C.

Conclusions

The experiments and modelling at higher temperatures has required much development work, which has been carried out successfully. Key results:

- New experimental observations and models for both materials studied in HITEC: clay host rock and buffer bentonite
- Safety case guidance will the final product of HITEC
- Still open questions after HITEC in clay understanding in repository conditions. Therefore, after EURAD, clay should be studied in EURAD-2, too

Clay host rock

The THM behaviour of the host clay rocks is significant for the design and long-term safety. When temperature increases, the pore water is compressed due to the difference between thermal expansion coefficient of water and the solid skeleton of the rock, leading to an over pressure. In far field, this could induce rock damage and reactivate fractures/faults. In the near field characterised, this could induce fracture opening or propagation in this fractured zone, altering the permeability. Short-term triaxial compression tests at different temperatures and confining pressures were performed on the COx (Callovo-Oxfordian) claystone (Fig. 1). It resulted that the peak strength decreases overall with the increase of temperature up to 100˚C for both orientations (parallel and perpendicular to the bedding plane). Self-sealing tests were also performed at different temperatures on the COx claystone (Fig. 2). Sealing of the initial fracture occurs more quickly on a parallel sample than on the perpendicular sample. In addition, the self-sealing process is fast at the beginning of the test and stabilizes after one month. These first results are very promising and give confidence to the positive impact of the self-sealing process on the fractured rock. The temperature impact on the self-sealing process has still to be analysed.

Bentonite

The buffer bentonite task deploys knowledge on hydro-mechanical behaviour at high temperatures. The investigation of buffer behaviour at high temperatures is important for the design optimization of the underground nuclear waste disposal facility and for the long-term safety. The increase of temperature may result in strong evaporation near the heater and vapor movement towards the external part of the buffer.

HITEC seeks to understand if such conditions are tolerable or if they would impair buffer safety functions.
The research is divided into 3 domains. First looks into properties of thermally treated bentonite. Second investigates bentonite properties at elevated temperatures. Third uses laboratory models to look into bigger picture. At the same time a numerical models based o new results are developed.

Example of results are shown in Figure 3 & 4. BCV bentonite was thermally treated @150 ˚C in dry state and as a suspension for various time periods. The results show no influence on swelling pressure. A slight influence has been observed only for dry treated material.

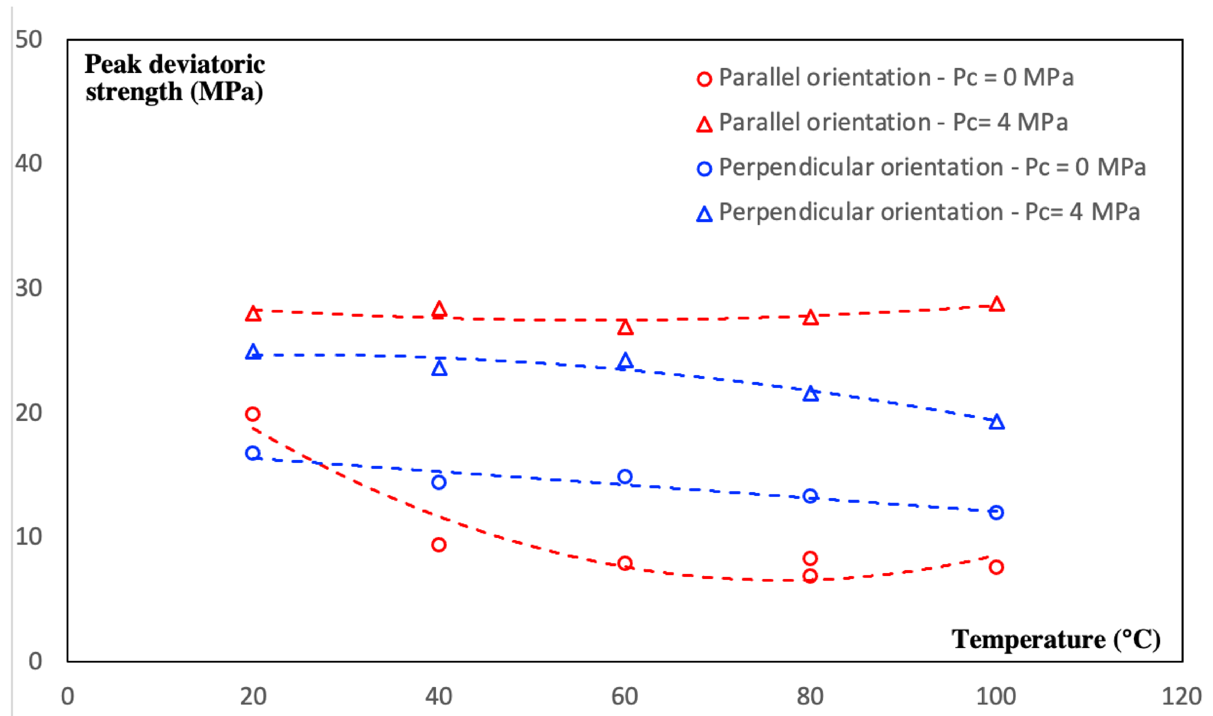

Figure 1. Evolution of the peak strength of COx claystone as a function of temperature, confining pressure Pc and orientation of the bedding plane.

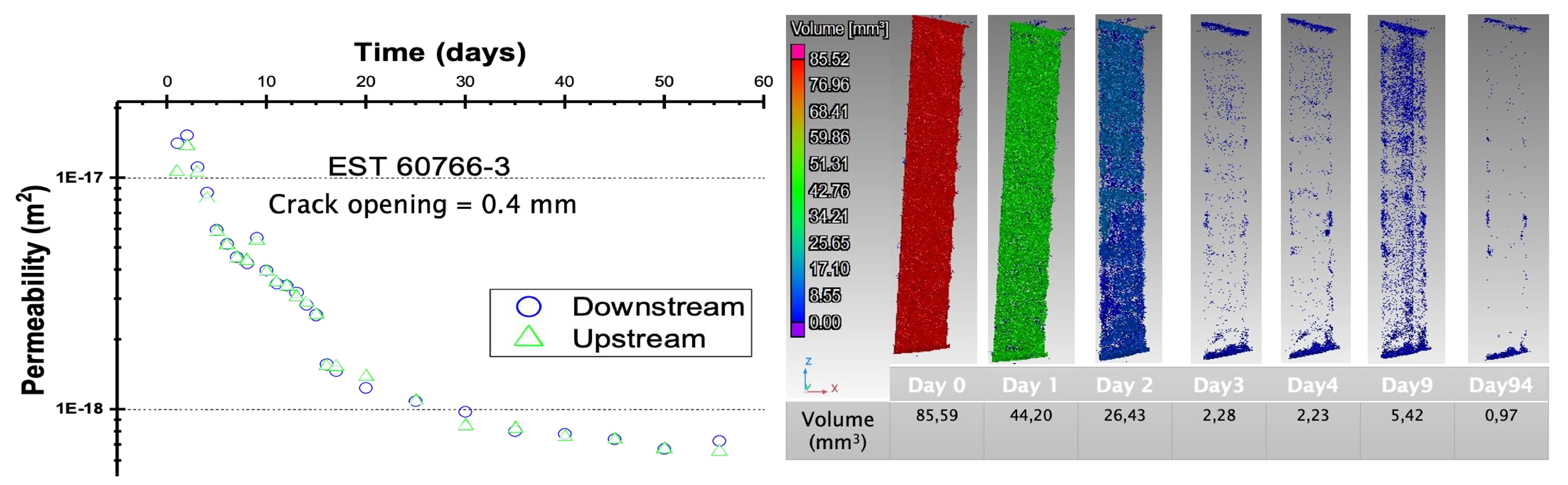

Figure 2. Self-sealing test on a parallel sample of COx claystone. Left: evolution of water permeability with time. Right: X-ray 3D tomography images showing the evolution of the crack volume with time (initial crack opening = 0.4 mm).

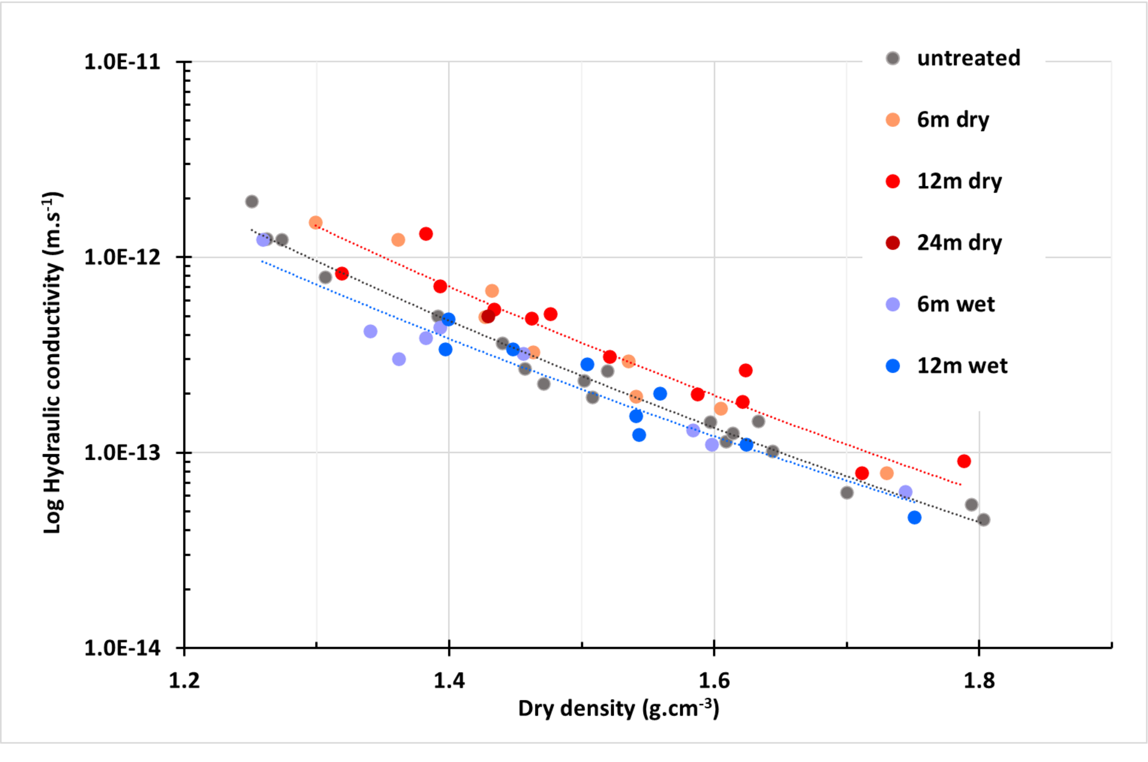

Figure 3. Hydraulic conductivity after thermal treatment @150°C.

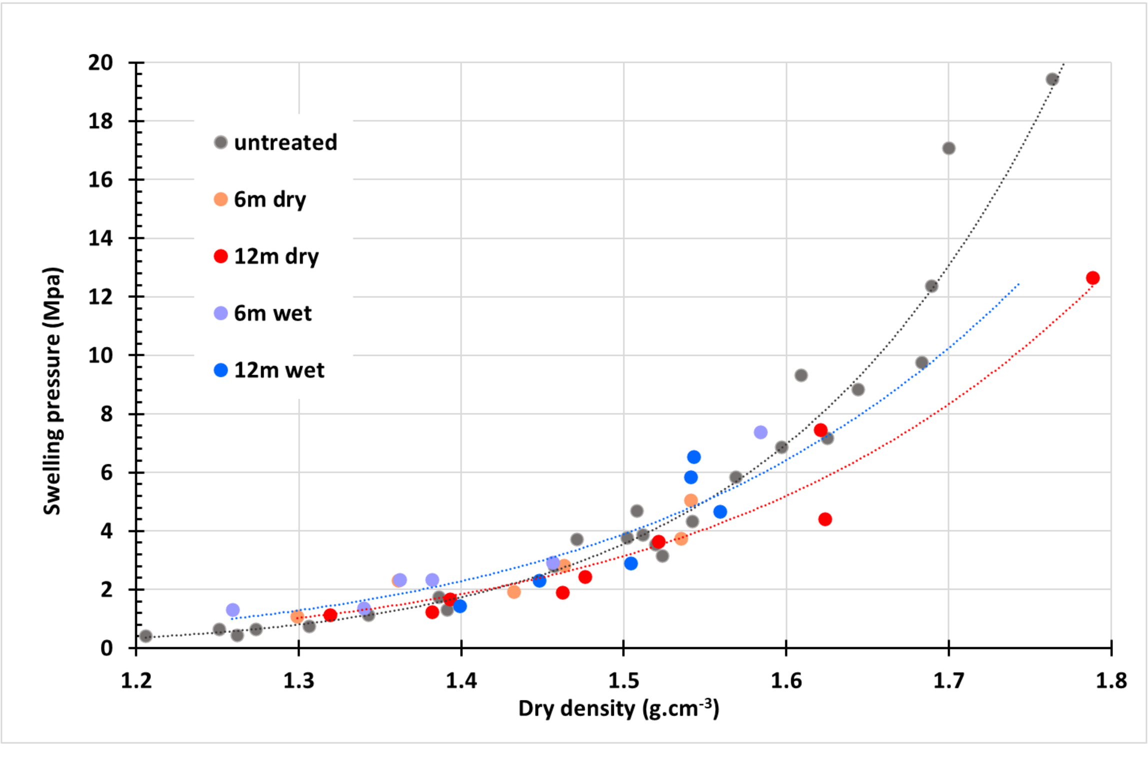

Figure 4. Swelling pressure after thermal treatment @150°C.

For more information

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