Experimental report

29/04/2019

Proposal: **UGA-42** **Council:** 4/2018

Title: Flushthrough of Callovo-oxfordianclay at 20 MPa

Research area:

This proposal is a new proposal

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Samples: Si, O, K, Al, Na
callovo-oxfordian clay

Instrument	Requested days	Allocated days	From	To
D50 T	3	3	07/06/2018	10/06/2018

Abstract:

Hydromechanical investigation of the Callovo Oxfordian clay-rock with neutrons and x-ray imaging

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1 Introduction

The Callovo Oxfordian clay-rock (COx) is considered in France an ideal geological barrier for the disposal of radioactive waste, most importantly due to its extremely low permeability. This hydromechanical response of this hosting rock is complex and highly coupled, and its mechanisms are under investigation with *in-situ* or lab experiments since a number of years. This experimental study aims to demonstrate the mechanisms of water uptake in specimens of COx, motivated by the understanding of cracking observed during COx/concrete interface sample preparation. Water variation in the clay-rock mass is monitored combining both x-ray and neutron tomography, allowing material deformation and water movement to be quantified respectively. A preliminary study on the liquid water uptake of the Callovo Oxfordian has taken place using unconfined saturated prismatic COx samples of two different orientations; normal and parallel to the bedding plane Stavropoulou et al. 2018. Simple tap water was provided from the bottom with a sponge to the COx sample. While the combination of x-ray and neutron tomography was not operational at the time of these experiments, the presented experimental campaign includes for the first time simultaneous x-ray (42 $\mu m/px$) and neutron (50 $\mu m/px$) tomography.

Saturated solid cylindrical COx samples (d = 10 mm, h = 10 mm) have been used, of both orientations, normal and parallel to the bedding plane. Tap water was pushed to the sample from the bottom through a porous base and its response was followed during a couple of hours. Different samples have been scanned under different levels of effective stress from 0 to 100 kPa. For this purpose the clay-rock samples have been put under confinement in a specially designed aluminium cell. For the confinement has been used heavy water, which does not absorb neutrons. In this report some results from an unconfined clay-rock sample are presented briefly.

Figure 1 shows the vertical slices of the 3D images of an unconfined COx sample from both x-ray and neutron tomography. The existence of a crack in the middle of the sample is obvious in both sets of images, certainly clearer in the x-ray series. As water is pushed from the bottom, one can observe from the x-ray images a progressive crack closure with time (or scan number). This is in agreement with the swelling properties of this clay-rock when water enters its matrix and activates the smectite that triggers the swelling behaviour. In the neutron images, any evolution of the kinematics is less clear even thought the existing crack is also obvious. What is interesting is that the last vertical slice, shows an increase in attenuation at the location of the crack, revealing the appearance of water with which the crack has been filled in.

The calculation of the transformation tensor of the total image allows the calculation of the overall volumetric strain. The results for both imaging techniques (x-rays and neutrons) are pre-

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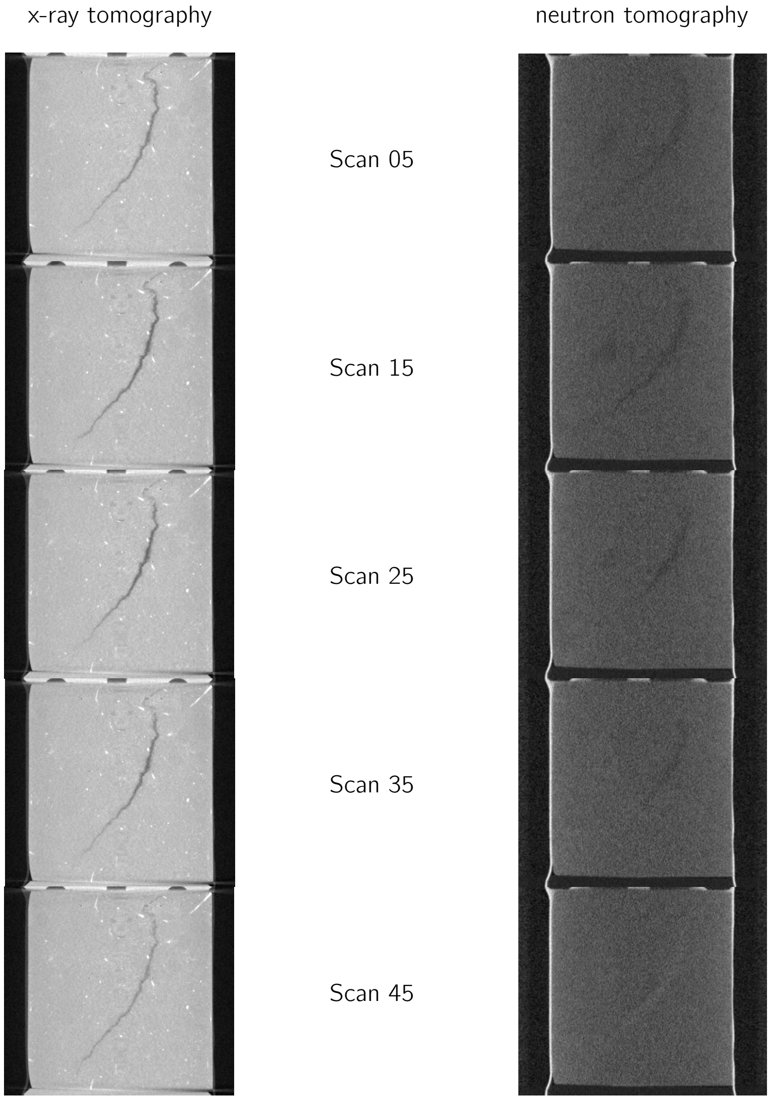

Figure 1: Vertical slices of 3D images from x-ray and neutron tomography

sented in Figure 2. Due to a technical problem, the x-rays are off during scans 29-34, after which they are back on, something that affects the neutrons measurement as clearly shown in this figure. The volumetric strain increases, confirming the swelling behaviour of the clay-rock, while this evolution is very similar when measured from either images.

The newly developed DIC code named SPAM Andò et al. 2017– allows the calculation of the strain vector magnitude, giving a vision of the kinematics evolution within the sample with time (Figure 3). The swelling response of the clay-rock sample is even more clear in this Figure, while the exact locations of any existing cracks are more clearly observed.

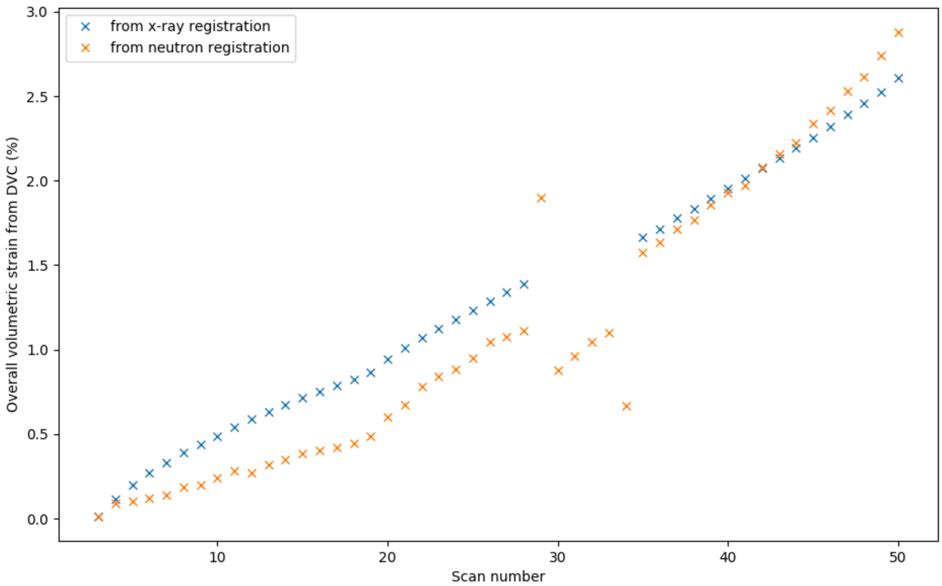

Figure 2: Evolution of the total volumetric strain of the sample from the images with both techniques

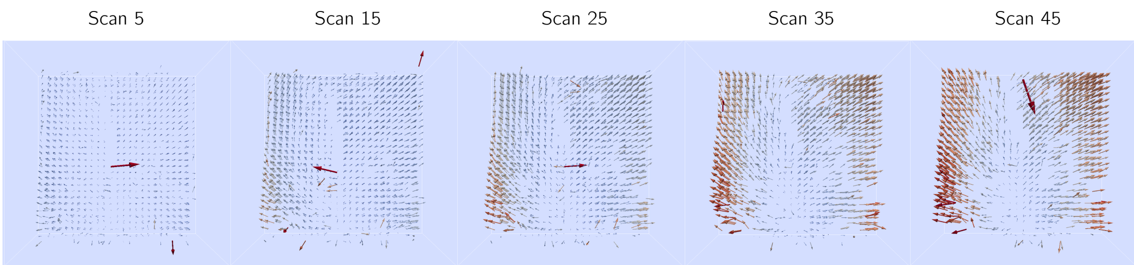

Figure 3: Vectors magnitude with the number of scan

References

Andò, E., R. Cailletaud, E. Roubin, O. Stamati, and the spam contributors (2017–). *spam: The Software for the Practical Analysis of Materials*. `https://ttk.gricad-pages.univ-grenoble-alpes.fr/spam/` (cit. on p. 2).

Stavropoulou, E., E. Andò, A. Tengattini, M. Briffaut, F. Dufour, D. Atkins, and G. Armand (2018). "Liquid water uptake in unconfined Callovo Oxfordian clay-rock studied with neutron and X-ray imaging". In: *Acta Geotechnica*, pp. 1–15 (cit. on p. 1).