11th World Conference on Neutron Radiography
WCNR-11
2-7 September 2018 | Sydney, Australia

Contribution ID : **122** Type : **Oral**

INVESTIGATION OF HYDROMECHANICAL PROCESSES IN POROUS ROCK USING 4D NEUTRON IMAGING

Tuesday, 4 September 2018 09:40 (20)

INTRODUCTION

The characterization of localized deformations and its effects on the permeability of rocks is fundamental to a number of resource engineering challenges, e.g., hydrocarbon and water production and CO_2 sequestration. However, the complexity of performing conclusive experimental campaigns to analyze the hydro-mechanical behavior of porous subsurface rocks leads to a lack of necessary ground truth to develop analytical and numerical models.

In this work the coupling of triaxial deformation and the evolution of fluid flow in porous rocks (in particular sandstone) is explored using high-speed neutron imaging. Neutrons are highly sensitive to hydrogen, providing the ideal probe for detecting fluids (*e.g.*, water and oils) in dense porous materials such as rocks [B1]. Furthermore the property of neutrons to distinguish between isotopes allows to use deuterated (heavy) water, which attenuates the beam less than the light water, as contrast agent. In this way it is possible to track the front between two fluids which have similar flow properties but very different neutron interactions.

EXPERIMENTAL METHOD

The experimental campaign was performed at the Cold Neutron Tomography and Radiography (CONRAD-2) [B2] instrument at Helmholtz Zentrum Berlin (HZB) where it was possible to acquire fast tomographies in 1 minute.

The samples were deformed ex-situ in a triaxial apparatus in Laboratoire Sols, Solides, Structures, Risques (3SR, Grenoble). X-ray tomographies were acquired before and after the triaxial loading to obtain the strain fields through Digital Volume Correlation (DVC) [B3]. During the experiment light water was flushed through the sample while fast tomographies were acquired. Therefore, a relation between deformation and changes in permeability field can be analyzed.

In order to be able to image the advancing fluid front and quantify its velocity in 3D, the experimental setup controls the pressure on the top of the sample, the confining pressure and the water flow rate while measuring the volume of the water leaving the sample and the pressure on the bottom of the sample.

RESULTS

Five samples of Vosges sandstone were deformed under triaxial conditions at 30 and 40 MPa confining pressure and loaded to different levels of axial strain to be able to study the changes in permeability with different degrees of deformation. An example of the strain fields determined using DVC analysis of the x-ray tomographies acquired before and after the loading is shown in Figure 1. Figure 2 shows an example of a neutron tomography image of the light water advancing into the heavy-water saturated sample; the image has been thresholded to show just the light-water in the sample.

Indico rendering error

`Could not include image: Problem downloading image (https://drive.google.com/open?id=1Lhw327asNAKGLluB`

Indico rendering error

```
Could not include image: Problem downloading image (https://drive.google.com/open?id=1wR7kznLJwbDXEHcT
```

[B1] S.A. Hall. *Geophysical Research Letters*, 40, 2613-2618, 2013.

[B2] N. Kardjilov, et. al. *Journal of Applied Crystallography* 49 (2016), p. 195-202.

[B3] E. Tudisco et. al. *Physics Procedia-10th World Conference on Neutron Radiography*, 69, 509-515, 2015.

Primary author(s) : ETXEGARAI, Maddi (Laboratoire 3SR); Dr TUDISCO, Erika (Division of Geotechnical Engineering, Lund University, Lund, Sweden); TENGATTINI, Alessandro (Institut Laue Langevin/Universite' Grenoble Alpes,); Dr HALL, Stephen A. (Division of Solid Mechanics, Lund University, Lund, Sweden); Dr VIGGIANI, Gioacchino (Universite Grenoble Alpes); Dr KARDJILOV, Nikolay (Helmholtz Zentrum für Materialien und Energie, FG-GTOMO, 14109 Berlin, Germany)

Presenter(s) : ETXEGARAI, Maddi (Laboratoire 3SR)

Session Classification : Speaker Sessions and Seminars

Track Classification : Geoscience