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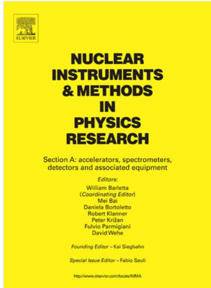

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Fluid-flow measurements in low permeability media with high pressure gradients using neutron imaging: Application to concrete

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ABSTRACT

This article focuses on a new experimental apparatus for investigating fluid flow under high pressure gradients within low-permeability porous media by means of neutron imaging. A titanium Hassler cell which optimises neutron transparency while allowing high pressure confinement (up to 50 MPa) and injection is designed for this purpose and presented here. This contribution focuses on the development of the proposed methodology thanks to some preliminary results obtained using a new neutron imaging facility named NeXT on the D50 beamline at the Institute Laue Langevin (Grenoble). The preliminary test was conducted by injecting normal water into concrete sample prepared and saturated with heavy water to take advantage of the isotope sensitivity of neutrons. The front between these two types of water is tracked in space and time with a combination of neutron radiography and tomography.

Keywords: fluid flow, neutron imaging, porous media, heavy water, normal water

1. INTRODUCTION

The investigation of fluid flow in porous media, and specifically full field measurements of local processes, is of significant interest for many industrial and environmental applications such as the disposal of hazardous waste, water evaporation and infiltration in soil. Local measurements of fluid flow in 3D present a convenient way to access a permeability field in different engineering porous media (such as concrete, bricks and ceramics, rocks, fuel cells *etc.*). The ability to deduce a permeability field has important repercussions on the development of better hydraulic material models (which can be thermo-, hydro-mechanically coupled).

In the case of an incompressible fluid (water for specific pressures for instance), under laminar flow condition, the permeability of the medium can be directly obtained by applying Darcy's law. The concept of permeability defined by Darcy's law, expresses, on a macroscopic scale, the physics of the flow of a viscous Newtonian fluid (the forces due to the viscosity dominate inertial forces) at the scale of pores. In the literature, many authors have made gas- or water-permeability measurements on different materials such as concrete,[1–3] mortars,[4] rocks,[5] *etc.*. Standard laboratory experiments consist in measuring flow from one end of a test specimen to the other without full knowledge of how the fluid flows in the sample. The current measurements only allow for the identification of average characteristics where extrapolation to the engineering scale (power stations and dams for concrete, rock mass for CO_2 reservoir, oil pumping, shale gas, *etc.*) is necessary. In the case of homogeneous materials and an assumed homogeneous flow, this can be sufficient. However, a large number of complex heterogeneous materials are routinely used in engineering practice today (concrete and reinforced concrete are an excellent example), whose permeability is locally inhomogeneous. In the case, the understanding of the details of fluid

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