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Diffusion of water in the mesoporosity of a dry clay: an experimental study using space and time resolved X-ray diffraction

Henrik Hemmen (1), Lars Ramstad Alme (1), Jon Fossum (1), and Yves Méheust (2)

(1) Department of Physics, NTNU, Trondheim, Troendelag, Norway, (2) Universite Rennes 1, Geosciences Rennes (UMR CNRS 6118), Rennes, France (yves.meheust@univ-rennes1.fr)

We use space- and time-resolved X-ray diffraction as a tool for imaging the humidity content of a clay sample in situ, in a non-invasive manner. Imposing a humidity gradient between the two ends of a quasi-onedimensional temperature controlled weakly-hydrated sample of synthetic swelling clay, we follow the transport of water by monitoring the individual particle swelling.

Indeed, the swelling clay grains are nano-layered, that is, they consist of stacks of individual 1 nm-thick clay particles. They have the ability to incorporate water molecules in the nano-porosity between the layers, causing the interlayer repetition distance (d-spacing) of the stacks to depend on temperature and on the humidity present in the surrounding meso-porosity. A first experiment performed under controlled constant temperature and controlled humidity level all around the sample, varying the ambient relative humidity by steps, allows us to map the monotonous evolution of the d-spacing as a function of the relative humidity surrounding the clay.

The reproducibility and reliability of this relative humidity-controlled d-shift enables us to use d as a measure of the local humidity surrounding the clay particles in the second experiment, which addresses quasi-onedimensional water transport in the clay. In this second experiment, we map the d-spacing in space and time as water progresses along the sample, and are able to extract profiles of the relative humidity along the sample length. Their time evolution describes the transport of water through the mesoporous space inside the clay: An analysis of the measured humidity profiles based on the Boltzmann transform, under certain simplifying assumptions, yields a diffusive behavior that is either normal or possibly weakly anomalous.

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