New developments in diffusion measurements using laboratory-based X-ray sources

TOM AL[1,*], SAM MORFIN[1], GOLROKH HAFEZIAN[1],
CHARLES CADIEUX[1], SAMUEL KUMAHOR[1]

[1] Department of Earth and Environmental Sciences,
University of Ottawa, Ottawa, ON, K1N 6N5, Canada
[*correspondence: tom.al@uottawa.ca]

Measurements of diffusion and sorption properties of rocks are key aspects of site characterization for a deep geological repository. Knowledge of diffusion properties is required for engineered barriers and for geologic materials in the near and far field surrounding a proposed geologic repository. Accordingly, diffusion investigations are commonly conducted at a variety of scales, ranging from 10s of mm to 100s of m. This work is focused on measurements conducted at the laboratory scale, most often using samples of drill core. In the context of radioactive waste management, X-ray radiography methods have been in use for decades [1,2] to study diffusion of at the laboratory scale (10s of mm). The measurements have the advantage of being rapid and they provide time- and spatially-resolved tracer data. Studies commonly employ iodide as a tracer because it has a high X-ray absorption cross section and it is transported conservatively in most geologic materials, but X-ray radiography has also been applied to study reactive transport of cesium [2]. Here we report on two new developments; i) X-ray absorption measurements using energy-dispersive X-ray spectrometers, and ii) a radiographic method suitable for low porosity rocks.

Rather than measuring total X-ray attenuation in the sample, as is done with radiography, spectrometry allows for measurement of attenuation only in the energy range corresponding to the K absorption edge for the tracer. The main advantages of spectrometry are that artifacts from beam hardening are virtually eliminated, calibration is simplified and it provides optimal sensitivity to the tracer.

Granitic rocks have been proposed to host deep geological repositories because of their low permeability, but they pose unique challenges for radiography. In low porosity rocks, the signal-to-noise ratio is very low. Furthermore, with medium- to coarse-grained heterogenous granites, image registration errors are large relative to the measured signal. We will show that these challenges can be overcome by rotating the sample continuously during image acquisition.

[1] Tidwell *et al.* (2000). *J. of Contam. Hydrol.* **42**, 285–302.
[2] Loomer *et al.* (2013) *Appl. Geochem.* **39**, 49-52.