Goldschmidt2020 Abstract

An X-ray spectrometry method for estimating diffusion and ion-exchange properties of rocks

SAMUEL MORFIN[1], GOLROKH HAFEZIAN[1], SAMUEL KUMAHOR[1], TOM AL*,[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. We present an X-ray spectrometric method for monitoring iodide and cesium (I^- and Cs^+) tracer migration in lab-scale diffusion experiments. This allows estimation of ion diffusion coefficients, cation exchange capacity (CEC) and ion-selectivity coefficients (Log $K_{Cs+/Na+}$) for Cs^+ exchange.

The method is similar to X-ray radiography [1,2] in its concept and advantages; it is non-destructive, rapid and it allows measurement of time- and spatially-resolved tracer-concentrations and spatially-resolved porosity. Analytical or numerical models may be used to fit the spatially-resolved concentrations to obtain the desired diffusion and ion-exchange properties at multiple time increments during the transient phase of solute diffusion [2].

Measurements are conducted in X-ray transmission mode, whereby a collimated beam (1 mm diameter in the current setup) is transmitted through a rotating cylindrical rock core. The beam is oriented normal to the rotation axis, effectively “sampling” a disk-shaped volume of the core with a height of 1 mm. An energy-dispersive detector (Amptek XR-100-CdTe) records the transmitted X-ray spectrum. Starting with the X-ray beam incident on either the top or bottom of the rock sample, a spectrum is acquired for a fixed time interval, typically 5 minutes. This is repeated in 1 mm steps along the length of the sample.

Rather than measuring total X-ray attenuation in the sample, as is done with radiography, spectrometry allows for measurement of attenuation only in a selected energy range. In the present work, measurements are conducted in specified energy ranges immediately below and above the K absorption edge for the tracer (33.2 keV and 36.0 keV for I^- and Cs^+ respectively). There are important advantages. The method virtually eliminates artifacts from beam hardening, it simplifies calibration and provides optimal sensitivity to the tracer.

[1] Cavé *et al.* (2009) *J. Contam. Hydrol.* **10**(1-2), 1–12.
[2] Loomer *et al.* (2013) *Applied Geochemistry* **39**, 49-52.