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Evaluation of diffusion coefficients in rock pore water by means of horizontal and vertical through-diffusion experiment

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Diffusion is one of the main mechanisms of solute transport in pore water of geologic media. Relations between diffusion coefficients and porosities of rocks have been evaluated by several previous studies. However, the effect of density-driven flow in through-diffusion experiments has not been considered, and the diffusivity-porosity relationships proposed in the literature might be changed.
Therefore, the degree of density-driven flow in the horizontal diffusion cell, which has been conventionally used for diffusivity measurements, is evaluated quantitatively. The diffusion experiment using Fontainebleau sandstone was conducted for KCl and KI aqueous solutions with various concentrations (densities). The results show overestimation of the diffusion coefficient due to the density-driven flow, and are explained by a theoretical model using a diffusion-advection equation. Based on this theory, a diagram to evaluate the condition at which the measured diffusion coefficient does not include the effect of density-driven flow is presented.
Then, the vertical diffusion cell has been constructed for the precise determination of diffusion coefficients without the effect of density-driven flow, even for highly permeable rocks.
The relationships between diffusion coefficients and porosities are finally reconsidered by eliminations of data including the effect of density-driven flow and additions of data measured by the vertical diffusion cell.

Keywords: effective diffusion coefficient, effective porosity, density-driven flow