Geophysical Research Abstracts,
Vol. 10, EGU2008-A-07956, 2008
SRef-ID: 1607-7962/gra/EGU2008-A-07956
EGU General Assembly 2008

Solute exchange between a fracture and the surrounding porous matrix – an analog experiment

L. Michel, **Y. Méheust**, J. Bouquain, J.-P. Caudal, J. de Bremond d'Ars, J.-R. de Dreuzy, P. Davy

Université Rennes1, Geosciences Rennes, UMR CNRS 6118, Rennes, France

Contaminant transport in heterogeneous fractured aquifers occurs mostly through the networks of intersecting fractures. The physical mechanisms of solute transport in a single fracture with impermeable walls are well identified (Dronfield and Silliman 1993; Roux, Plouraboué et al. 1998; Keller, Roberts et al. 1999; Detwiler and Rajaram 2000): advection, Taylor-Aris dispersion, roughness dispersion, aperture-variation dispersion and molecular diffusion. In contrast, when the permeability of the surrounding rock matrix cannot be neglected, there is, to our knowledge, no fundamental description of the mass transfert coefficient between the region of high permeability (the fracture) and that of low permeability (the surrounding matrix).

We address here solute transport through a synthetic fracture with a porous wall. We present an analog experimental model setup in which we can focus on specific dispersion mechanisms, neglecting molecular diffusion, in order to extract descriptive laws that will be integrated in future numerical models. The planar horizontal fracture is 1 m long, 5 cm wide and its mean aperture is 5 mm. It is bounded by either two smooth parallel Plexiglass plates (impermeable walls configuration), or by one such plate and a porous medium consisting of 1 mm glass beads ("semi-permeable" configuration). A permanent laminar water flow is forced through the fracture at controlled mean velocity ($\sim$ 1mm/s). The flow conditions inside the experimental fracture.are well characterized, using three-dimensional numerical simulations of the flow (with the COMSOL/FEMLAB software). A dye (patent blue) injection system simulates a point source of contaminant along the center plane of the experimental fracture. The tracer plume is tracked using a visualization system based on (i) lasers illuminating

a series of vertical linear optical sensor arrays, and (ii) 4 cameras positioned side by side and providing a composite image of the fracture length, viewed from the side. The two measurement systems yield consistent quantitative temporal descriptions of the tracer concentration, integrated over the fracture width and at several positions along the fracture length.

We first validate the setup by checking the conservation of the total dye quantity in the impermeable walls configuration, with comparison to classical advection-dispersion models (for different injection modes). It appears that the classic one-dimensional advection-dispersion model does not hold, due to the large vertical shear in the advecting flow. The impermeable-porous configuration is then investigated. Mass transfer between the fracture and the bounding porous matrix are measured, for various concentrations of the injected dye and with different geometries (roughness) of the fracture-matrix interface. Changing the overall flow rate allow investigation of the gravity effects, which are generally disregarded in theoretical studies. As recently suggested by Polak, Grader et al. (2003), they are observed to be significant.

References:

Detwiler, R. L. and H. Rajaram (2000), *Water Resour.Res.* **36**(7):1611-1625.
Dronfield, D. G. and S. E. Silliman (1993), *Water Resour.Res.* **29**(10):3477-3483.
Keller, A. A., P. V. Roberts, et al. (1999), *Water Resour.Res.* **35**(1):55-63.
Polak, A., A. S. Grader, et al. (2003), *Hydrology* **67**:95-112.
Roux, S., F. Plouraboué, et al. (1998), *Transport in Porous Media* **32**: 97-116.