TRANSPORT UNDER ADVECTIVE TRAPPING

Juan J. Hidalgo\textsuperscript{1}, Insa Neuweiler\textsuperscript{2}, and Marco Dentz\textsuperscript{1}

\textsuperscript{1}IDAEA-CSIC, Barcelona, Spain

\textsuperscript{2}Leibniz Universität Hannover, Hannover, Germany
Motivation:

- Advective trapping occurs when solute enters low velocity zones in heterogeneous porous media.
- Classical approaches combine slow advection and diffusion into a dispersion coefficient or a single memory function.

Objective

- We investigate advective trapping in homogeneous media with low permeability circular inclusions.
- We build an upscaled model in the continuous time random walk framework.
Mean velocity in the matrix is proportional to the area occupied by the inclusions $\chi$.

Velocity in the inclusions is not constant. The mean velocity in the inclusions $\overline{v}_i$ is log-normally distributed and proportional to $\chi$.

**Figure 1:** Streamlines in a medium with randomly placed inclusions.

**Figure 2:** Velocity distribution inside the inclusions (top) and mean velocity distribution (bottom).
The breakthrough curves reflect the trapping of particles in the low permeability inclusions.

The trapping rate follows a Poisson distribution.

**Figure 3:** Transport through a medium with randomly placed inclusions.

**Figure 4:** Breakthrough curves at increasing distance from the inlet and advection-dispersion equation solution fit (top). The number of trapping events follows a Poisson distribution (bottom).
We consider advective-dispersive particle transitions in the mobile matrix

\[ dx(s) = v_{\text{matrix}} ds + \sqrt{2D_m ds} \xi(s), \]

with \( s \) the mobile time spend outside the inclusions, \( D_m \) is diffusion (from Eames & Bush, 1999) and \( \xi(s) \) a Gaussian white noise.

During the mobile time \( s \) particles encounter \( n_s \) inclusions. The clock time \( t(s) \) after the mobile time \( s \) has passed is given by

\[ t(s) = s + \sum_{i=1}^{n_s} \tau_i \]

where \( n_s \) is Poisson distributed and the trapping times \( \tau_i \) depend on the distance (random uniform) and the velocity at the visited inclusion (random log-normal)
**FIGURE 5:** Breakthrough curves at increasing distance from the inlet (dots) and upscaled CTRW model results (solid line).
Purely advective transport was here considered as a limiting case for advective-diffusive transport.

The shape of breakthrough the curves cannot be predicted with a macrodispersion coefficient.

We developed a CTRW model developed parameterized by measurable medium properties: the trapping rate (Poisson distributed), the velocity in the matrix (a function of $\chi$) and the mean velocity distribution inside the inclusions (log-normal).