Contribution ID: **311** Type: **Oral Presentation**

Advective trapping in the flow through composite heterogeneous porous media

Monday, 22 May 2023 17:15 (15 minutes)

We study the mechanisms of advective trapping in composite porous media that consist of circular inclusions of distributed permeability embedded in a high conductivity matrix. Advective trapping occurs when solutes enter a low velocity zone in the porous medium. Current multirate mass transfer (MRMT) models consider slow advection and diffusion but do not separate these processes, which makes parameterization difficult. Transport is analyzed in terms of breakthrough curves measured at the outlet of the system. We observe that the volume fraction occupied by the inclusion controls the curve's peak behavior, while the distribution of permeability is responsible for the shape of the tail. Using the continuous-time random walk framework, we derive a Lagrangian trapping model parameterized in terms of volume fraction and the distribution of conductivites in the inclusions. Then we show that this model is equivalent to a first-order MRMT and to a non-local partial differential equation for the mobile solute concentration derived by volume averaging of the microscale transport equation. The upscaled approach, parameterized by medium and flow properties captures all features of the observed solute breakthrough curves, and sheds new light on the modeling of advective trapping in heterogeneous media.

Participation

In-Person

References

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Session Classification: MS08

Track Classification: (MS08) Mixing, dispersion and reaction processes across scales in heterogeneous and fractured media