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Impact of matrix diffusion on heat transport through heterogeneous fractured aquifers

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In this study, we illustrate key features of transport in heterogeneous fractured aquifers, when the fluid-rock diffusive exchange is a significant player, like in the case of heat transport. This advective-diffusive behavior is determined by the combined effects of flow velocity heterogeneity in the fracture system, and diffusive exchange between the fluid in the fractures and the rock matrix. In this context, the temporal evolution of the response to a pulse injection exhibits a post-peak pre-asymptotic regime, with a slope that deviate from the traditional signature of matrix diffusion. This deviation is driven by the variability of both velocity field and fracture aperture field. We illustrate the impacts of these two factors, under different conditions of heterogeneity and fracture network connectivity. We derive theoretical models that predict the pre-asymptotic tail under three extreme cases that can be related with specific network structures, i.e., networks dominated by large or small fractures, networks with highly or poorly channelized flow. These theoretical predictions are compared with results from numerical simulations in different sets of three-dimensional discrete fracture networks. Based on the numerical and theoretical results, we determine that the combined observation of solute and heat transport responses allows classifying the network in terms of connectivity structure, and partially characterizing the fracture aperture variability in terms of upscaled parameters.

Participation

In-Person

References

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