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Quantifying the effect of matrix diffusion on tracer transport in fractured reservoirs

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Tracer testing is commonly used to characterize fracture flow and transport processes. The interpretation of tracer data requires numerous forward simulations of tracer transport in a 3D fracture-matrix model, leading to significant computational burden. As matrix permeability is generally several magnitudes smaller than fracture permeability, some studies only considered a 2D fracture model to alleviate the computational burden. However, the impact of matrix diffusion, a mechanism that may affect tracer transport even in an extremely low matrix permeability model, is unclear. This study quantitatively investigates the effects of matrix diffusion on tracer transport through an analytical solution. Based on the results, we discuss the situations in which matrix diffusion has minimal effect on tracer transport and therefore matrix can be safely ignored. A dimensionless number that integrates fracture/matrix parameters and injection parameters is proposed to estimate matrix diffusion effect on tracer transport. For situations that matrix diffusion can not be ignored, we develop an equivalent injection function to accurately quantify the effect of matrix diffusion in a 2D fracture (matrix-free) model. The feasibility of the dimensionless number as well as the equivalent injection function is further examined through numerical simulations which consider complex geological conditions.

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