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Model-based interpretation of tracer tests in fractured limestone and clayey till

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The importance of fracture flow and matrix diffusion was investigated in two different fractured geologies: limestone and clayey till. Natural- and forced-gradient tracer tests were designed and conducted to analyze the transport behavior in the two fractured media and to investigate the required model complexity for the simulation of solute transport. A discrete-fracture model was employed to plan and interpret the tracer tests in the two different geologic settings. We present results from:

1) A pumping test combined with depth-discrete tracer tests in fractured limestone using fluorescent and ionic tracers with different diffusion properties
2) An infiltration tracer test in clayey till using the color tracer brilliant blue to identify the major transport pathways

The pumping and tracer tests and geologic investigations showed that the fractured limestone is highly permeable with fractures dominating the primary solute transport. The conductivity of major fractures has a strong contrast to the limestone matrix. The diffusive interaction between fractures and matrix was revealed by significant tailing in the tracer breakthrough curves at the pumping well. The observed behavior demonstrated the importance of including fracture flow and transport in the modeling of solute transport at fractured limestone sites. The simultaneous injection of multiple tracers with different diffusion properties facilitated the analysis of compound-specific fracture-matrix interactions.

The infiltration tracer test in the clayey till was performed in a large-scale excavation at an agricultural field site to identify the major transport pathways and to assess groundwater vulnerability to pesticides leaching. The tracer experiment revealed low fracture conductivities. Despite many fractures were filled with precipitate and only few of the visible fractures were hydraulically active, they were still major transport pathways for the applied tracer. The infiltration depth and the diffusion length into the matrix were used to infer hydraulic apertures of the fractures. These are compared to the apertures determined in large undisturbed column tests on the same soil material. The infiltration tracer test allowed to identify the hydraulically active fractures. These were incorporated as a 3D fracture network into a 3D model representing these main preferential flow and transport paths as well as the exchange with the clayey till matrix.

References

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