Conduit-Matrix Interaction and the Rate Limiting Step of Contaminant Transport in Karst

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Abstract

Conceptualizations of karst aquifers are often rooted in early research and exploration of solutionally enlarged conduits. As a result, models of the karst continuum fail to fully characterize telogenetic systems that show evidence of significant contribution from non-conduit processes. In a unique setting in the northern Great Valley of the eastern United States, extensive characterization of a Paleozoic karst aquifer provides the opportunity to explore non-conduit processes and the contributions of secondary porosity to overall fluid budgets in karst. At the U.S. Geological Survey Leetown Science Center, geophysical data and water-level hydrographs indicate that the extent of conduits in Paleozoic karst may be spatially limited and that secondary porosity may, in part, control the rates of downgradient chemical migration.

To improve our understanding of the influence of secondary porosity components on transport in telogenetic karst aquifers, two forced gradient tracer tests were conducted in wells intersecting solutionally modified zones. In each test, tracers were injected in shallow conduits (~15m depth) while vertical gradients were induced by pumping in packer-isolated deep conduits (~40m depth). Tracer concentrations were monitored in both injection and pumping wells. The results show that (1) contaminants may persist in zones of high permeability for much longer periods than previously expected, (2) the rates of mass transfer in individual karst conduits varies over distances less than tens of meters , and 3) fully saturated conduits may serve primarily as areas of storage at times of baseflow. These experiments offer additional information on flow across non-conduit zones under variable stresses, provide detail on the architecture of faulted conduit zones, and establish an understanding of transport properties along complex structural zones in telogenetic karst systems.