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What spring hydrographs tell us about karst hydrogeological systems

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A method for characterizing flow systems in karst aquifers by acquiring quantitative information about the geometric and hydraulic parameters of a karst conduit network from spring hydrograph analysis has been developed. The investigation method applied consisted of constructing simple conceptual models of karst systems, and deducing analytical formulae describing the connection between aquifer parameters and hydrograph recession coefficient.

Resulting formulae identified two, significantly different flow domains, depending on the overall configuration of aquifer parameters. During the baseflow recession of karst systems, the conductivity of karst conduits does not influence the drainage of the low-permeability matrix. In this case the drainage process is influenced by the size and hydraulic parameters of the low-permeability blocks alone. This flow condition has been defined as matrix-restrained flow regime (MRFR). During the baseflow recession of fissured systems and the flood recession of karst systems, the recession process is dependent not only on the hydraulic parameters and the size of the low-permeability blocks, but also on conduit conductivity, and the total extent of the aquifer. This flow condition has been defined as conduit-influenced flow regime (CIFR).

Analytical formulae demonstrated the drawbacks of equivalent models. While equivalent discrete-continuum models of fissured systems may reflect their real hydraulic response, there is only one adequate parameter configuration for karst systems that yields appropriate recession coefficient. Consequently, equivalent discrete-continuum models are inadequate for simulating the global response of karst systems. The global response of equivalent porous medium models corresponds to the transition between

matrix-restrained and conduit-influenced flow regimes. Consequently, the equivalent porous medium approach cannot be directly applied for modeling either karst or fissured aquifers.

Numerical groundwater flow modeling of the Bure aquifer (Ajoie, Switzerland) confirmed the applicability of the analytical formulae, demonstrated that field observations concerning the spatial geometry of karst conduits are generally insufficient, and that observed conduit networks must be extended to the entire domain in order to correctly reflect observed hydraulic response. Integrated numerical models also demonstrated that retarded recharge due to epikarstic storage can considerably decrease the baseflow recession coefficient of the entire aquifer. In such cases, the estimation of aquifer parameters from global response using analytical formulae equally requires information about the separate hydraulic behavior of the subcutaneous layer.