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Characterization of a heterogeneous porous-fractured aquifer based on analytical solutions and hydraulic tomography

Ran Tao (1), Rui Hu (2), Huichen Yang (1), Pengxiang Qiu (1), Quan Liu (1), Yixuan Xing (1), and Thomas Ptak (1)

(1) University of Goettingen, Geoscience Centre, Applied Geology, Goldschmidtstr.3, 37077, Goettingen, Germany, ran.tao@stud.uni-goettingen.de, (2) Hohai University, School of Earthscience and Engineering, Focheng Xi Road 8, 211100, Nanjing, China

Hydraulic parameters such as hydraulic conductivity(K), storage(Ss) and diffusivity(D) are the key parameters that control the behavior of porous-fractured aquifers during hydraulic tests. Among these parameters, the D-value, i.e. the ratio of K and Ss, can directly describe the high parameter contrast between the fracture and the matrix.
In this study, we utilized analytical solutions for pumping test evaluation and travel time based hydraulic tomography to characterize a porous-fractured aquifer by estimating the spatial distribution of hydraulic diffusivity at an experimental field site in Goettingen, Germany.
Through the field experiments, 64 multi-level-cross-well pumping tests were performed using double packer systems. In each pumping test, water was pumped out of packaged sections within the pumping well sequentially, and the head responses were recorded at eight depths in an observation well. Based on the obtained field data, the K-and Ss-values were estimated based on analytical solutions, which indirectly provide the D values, and hydraulic signal travel time inversion was utilized to directly reconstruct the diffusivity distribution between the pumping and observation wells.
The analytical solutions provide hydraulic parameters and information about the type of aquifer hydraulic behavior and boundary conditions. The travel time based hydraulic tomography allowed the identification of structural properties of the investigated porous-fractured aquifer, showing as large contrast of D-values between the fracture and matrix. The combination of the two methods provided an improved characterization of the heterogeneous aquifer with respect to spatial distribution, aquifer type and boundary conditions.