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Extended Abstracts

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6.1
Hard rocks as specific media — methods and results

title: Modelling of single-well injection-withdrawal (SWIW) tests in fractured carboniferous sandstone

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Tracer experiments have been used extensively for the investigation of flow and transport processes in fractured media. Often only a limited amount of observation wells is available and there is not always a verified hydraulic connection between the boreholes, so that it may not be possible to conduct cross-hole tracer tests. Single-well tests require only one borehole and are therefore an advantageous method for the hydraulic characterisation of fault and fracture zones. Push-pull tests, also known as single-well injection-withdrawal (SWIW) tests, consist of a controlled injection phase where a tracer solution is being forced out into the rock from a borehole section and a production phase in which the flow field is reversed and the tracer is pumped back into the same borehole. Frequently, the tests include a resting phase between injection and withdrawal to include time-dependent transport processes. (Nordqvist, Gustafsson, 2002). The breakthrough curve (BTC) obtained by measuring the solute concentration at the well during the extraction phase is used to determine the aquifer characteristics. This is typically done by fitting the BTC to a model by adjusting the parameters of the model until a best fit is obtained.

For the characterisation of a fractured carboniferous sandstone, single-well injection-withdrawal tests will be carried out in shallow observation wells in the vicinity of the city of Bochum (Germany). Preliminary studies focused on the acquisition of physicochemical tracer properties. In order to determine the sorption coefficients of different fluorescent tracers, batch tests were conducted. Measurements in diffusion cells provided diffusion coefficients. In order to obtain cumulative information about matrix diffusion, dispersion and sorption properties, comparative multi-tracer tests were carried out in a sandstone block containing a natural single fracture of defined aperture. In addition to the laboratory experiments, hydraulic field tests were conducted. Results from slug-and-bail and pumping tests show transmissivity values around 10^{-4} m^2/s for the investigation area (Bender et al., 2007).

The results of the laboratory and field tests as well as the stratigraphical data of the boreholes were used to build up a numerical model. Numerical simulations using this model indicated that many interaction mechanisms have a similar influence on the tracer recovery curve. Sensitivity studies were carried out on the basis of the model in order to determine a design of subsequent push-pull tests, which allows to distinguish the different mechanisms. Of special interest were the evaluation of appropriate experimental attributes such as injection and withdrawal flow rates, duration of the different experimental phases, tracer selection and input concentrations. Furthermore, the modelling helps to estimate the possibilities and constraints of parameter estimation via push-pull tests.

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