How tracer tests simulations strongly constrain flow and solute transport models in fractured chalk aquifers

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Abstract

Flow and solute transport in the saturated zone of a micro-fissured and fractured chalk aquifer (Geer basin, Belgium) has been studied by more than 35 tracer tests in 11 sites. The tracer tests campaign was preceded by a morphostructural study associated to a geophysical survey including electrical resistivity and refraction seismic measurements. Results provided information on the main expected fracturation axis where a series of injection and monitoring wells were drilled. In each of the 11 sites, multi-tracer tests have been performed in groundwater convergent flow conditions to pumping wells or draining galleries (used for drinking water production). The analysis of the detailed quantitative breakthrough curves allowed identifying various transport behaviours, from rapid advective to dominant dispersive processes with immobile water effects.

Groundwater flow and solute transport in such a fractured chalk can be simulated using different conceptual approaches. Using HYDROGEOSPHERE (Therrien and Sudicky, 1996), a comparison is made between two ways for representing the fracture zones: (1) high contrasted hydraulic conductivity zones with a classical REV approach and (2) the explicit representation of discrete fractures interacting with a porous medium.

Promising results are found using the discrete approach for representing the fractures. In this last case, an aperture of the order of the millimetre is enough for creating, where it is needed, a fast advective peak combined with a long highly dispersive component due to the chalk matrix. The discrete fracture approach prevents the modeller from introducing unrealistic parameters values in the fracture zones as it is generally the case in the classical REV-based method where the fractured zones are simply represented by elongated REV.

However, it is shown that the availability of field data, as multi-tracers test results, creates very high constraints to be taken into account in the calibration processes (i.e calibration on the measured groundwater flow and transport conditions). The detailed calibration on the different breakthrough curves is not an easy task and automatic calibration is not easy to organize. Results are particularly illustrative to show that a detailed parameterization and calibration of such a local situation remain difficult. Perspectives will be discussed about the potential use of automatic calibration tools as UCODE_2005 or PEST for solving such local situation models and the needed further steps for 'upscaling' local situation models at the scale of the whole aquifer or groundwater body.

THERRIEN R. & SUDICKY E.A. 1996. Three-dimensional analysis of variably-saturated flow and solute transport in discretely-fractured porous media. *J. Contam. Hydrol.* 23(1-2), 1-44.