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The anomaly in a breakthrough curve of a single well "push-pull" tracer test: A density driven effect?

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What method is appropriate to investigate an aquifer when there is only one well available? A single well "push-pull" tracer test (PP Test) may be a suitable method in order to characterize an aquifer and to obtain information about the hydraulic and chemical properties when only one well is available for the investigations.

In a PP test, a test solution that contains a known amount of solutes and a conservative tracer is injected into the aquifer ("push") and extracted afterwards ("pull"). Optionally, the test solution is flushed out of the well and the casing with untreated test solution with a so called "chaser" before being extracted. Also between the injection and the extraction phase a drifting time may be included. The breakthrough of the tracer during the extraction phase is measured and used for analyses and interpretation.

In the last three years, several PP Test campaigns were conducted at two different test sites in Japan (Hebig et al. 2011, Zeilfelder et al. 2012). The aim was to investigate the applicability of the PP Test method in different geological settings and in different types of aquifers. The latest field campaign thus focussed on the question how variations of the setup are influencing the breakthrough curve of the PP Test in order to develop and enhance this method. Also the standardization of the PP Test was an aim of this study.

During the campaign, a total of seven PP Tests were performed, while only single aspects of the setup were varied from test to test. The tests differed in injection and extraction rate, in the salinity of the injected test solution and in the use of a chaser solution.

The general shapes of the breakthrough curves were similar and conclusions about the repeatability of the PP Test could be drawn. However, a sharp anomaly was observed in the breakthrough curve of one specific setup type. By repeating this PP test under the same boundary conditions, we were able to recreate the anomaly and could exclude any technical aspects as a source. In this version of the PP test higher salinized test solution was injected into the aquifer. There are several hypotheses that could explain the behavior of the breakthrough curves of the tracer in this test design. Of all the possibilities (like sorption processes, unexpected tracer reactions, inhomogeneities in the aquifer, influence of the well design), we assume that ion exchange processes and density driven flow are the main reasons for the repeatedly observed anomaly.

References:

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