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Assessment of a Geothermal Doublet in the Malm Aquifer Using a Push-Pull Tracer Test

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Geothermal exploration of the Malm aquifer in Bavaria is highly successful. Data about the long-term operation, however, is still scarce, although detailed knowledge about the processes occurring in the aquifer is a key requirement to run geothermal facilities efficiently and economically.

While there usually is a constant flow of data from the production well (temperatures, hydraulic data, hydrochemical conditions, gas composition) not even the temperatures in the immediate surrounding of the reinjection well are accessible or known.

In 2011 the geothermal facility in Pullach was extended with a third geothermal well reaching into the Malm aquifer which is now used as a reinjection well. The former reinjection well was converted to a production well after 5 years of operation. This setting offers a unique opportunity to study the processes in the vicinity of a reinjection well and provides the data base to describe the hydraulic, thermal and hydrochemical performance of the reservoir.

The viscosity of the reinjected cold water is increasing by 60% compared to the production well, thus one would expect an increase of the reinjection pressure as the cold water plume spreads around the reinjection well. Measurements, however, show a significant decrease of the reinjection pressure, suggesting processes in the aquifer which positively change the hydraulic properties and overcompensate the viscosity effects. Hydrochemical data and modeling indicate that a dissolution of the matrix along the flow pathways is responsible for the decreasing reinjection pressures.

The change of the flow direction from reinjection to production was used to conduct a push-pull tracer test. Here, a series of fluorescent dye pulses was added to the reinjected water before the former reinjection well was shut down (push phase). These tracers included a conservative tracer (Fluorescein), surface-sensitive tracers (Eosin/Sulforhodamin B), and a NAPL-sensitive tracer (Na-Naphthionate).

After changing to production mode in October 2012 the pull phase was started. The different behavior of the tracers within the reservoir delivers data about dispersion, sorption properties, matrix interaction and the regional flux. First tracer breakthrough curves point to a significant heterogeneity of the flow pathways and that regional flow is not negligible.