Single Well Tracer Modeling – A Case Study for the Horstberg Z1 Site

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At the geothermal research drilling Horstberg in North West Germany studies for the characterization of a vertical fracture are performed. The fracture was created by a massive hydraulic stimulation in 2003 in approx. 3700 m depth within rocks of the middle Buntsandstein. The fracture surface is in the order of 100,000 m², depending on the flow rate at which water is injected. Besides hydraulic characterization, multiple tracer tests are planned. At the depth of interest the reservoir temperature is around 150 °C, pressure is around 600 bar (60 MPa) and due to salinity the water density is around 1200 kg/m³.

For characterizing hydraulically created fractures in deep geothermal reservoirs only few possibilities exist. If the fracturing is aseismic tracer tests are today the best way to deduce on the size of the created fracture. Various tracers are possible, besides conservative tracers – which are rare for the conditions of deep geothermal reservoirs – also reactive tracers can be used for extending the obtained information. Retardation, but also differences in the diffusivity can be used as additional information. However, while the practical realization of such a tracer test is already difficult, the evaluation of the obtained results leads to an ill-posed-problem. Various parameter combinations can lead to the same tracer recovery result. Typically for deep geothermal reservoirs numerous key parameters are only known within some range. For improving the evaluation, while reducing the uncertainty, inversion methods are possible. The application of stochastic methods is tedious, however, given the computational resources a large set of possible model results can lead to a better evaluation of the measured data.

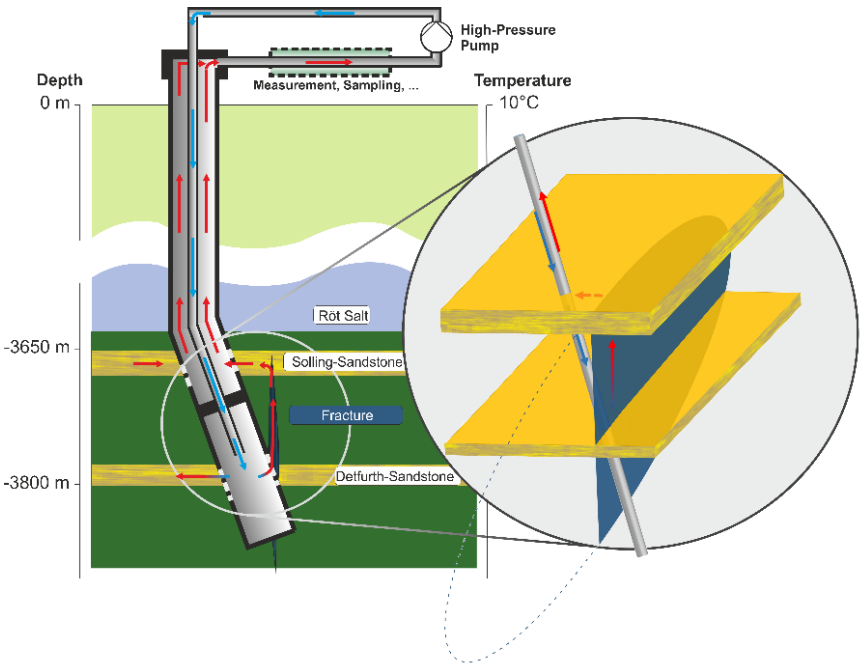

Figure 1: *Sketch showing the setup of the one-well circulation.*

According to the setup shown in Figure 1 the following parameters are only roughly known and have to be estimated: (1) permeability Solling sandstone, (2) permeability Detfurth sandstone, (3) permeability remaining rocks, (4) fracture aperture, (5) distance between fracture in the Solling and the borehole.

Based on a 3D model which is simplified but does still reflect the main reservoir properties a grid of parameter combinations is computed which allows to identify general trends and sensitivities.

In a second step classical inversion methods will be used for the identified limited parameter range.

The general current situation at the Horstberg Z1 site in northern Germany will be explained and results of the performed modeling study will be shown.