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EGS in sedimentary basins: sensitivity of early-flowback tracer signals to induced-fracture parameters

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Artificial-fracture design, and fracture characterization during or following stimulation treatment is a central aspect of many EGS ('enhanced' or 'engineered' geothermal system) projects. During the creation or stimulation of an EGS, the injection of fluids, followed by flowback and production stages offers the opportunity for conducting various tracer tests in a single-well (SW) configuration, and given the typical operational and time limitations associated with such tests, along with the need to assess treatment success in real time, investigators mostly favour using short-time tracer-test data, rather than awaiting long-term 'tailings' of tracer signals. Late-time tracer signals from SW injection-flowback and production tests have mainly been used for the purpose of multiple-fracture inflow profiling in multi-layer reservoirs [1]. However, the potential of using SW short-term tracer signals for fracture characterization [2, 3] remained little explored as yet. Dealing with short-term flowback signals, we face a certain degree of parameter interplay, leading to ambiguity in fracture parameter inversion from the measured signal of a single tracer. This ambiguity can, to a certain extent, be overcome by

– combining different sources of information (lithostratigraphy, and hydraulic monitoring) in order to constrain the variation range of hydrogeologic parameters (matrix and fracture permeability and porosity, fracture size),

– using different types of tracers, such as conservative tracer pairs with contrasting diffusivity, or tracers pairs with contrasting sorptivity onto target surfaces.

Fracture height is likely to be constrained by lithostratigraphy, while fracture length is supposed to be determinable from hydraulic monitoring (pressure recordings); the flowback rate can be assumed as a known (measurable) quantity during individual-fracture flowback. This leaves us with one or two unknown parameters to be determined from tracer signals:

– the transport-effective aperture, in a water fracture (WF), or

– fracture thickness and porosity, for a gel-proppant fracture (GPF).

We find that parameter determination from SW early signals can significantly be improved by concomitantly using a number of solute tracers with different transport and retardation behaviour. We considered tracers of different sorptivity to proppant coatings, and to matrix rock surfaces, for GPF, as well as contrasting-diffusivity or -sorptivity tracers, for WF. An advantage of this SW approach is that it requires only small chaser volumes (few times the fracture volume), not relying on advective penetration into the rock matrix. Thus, selected tracer species are to be injected during the very last stage of the fracturing process, when fracture sizes and thus target parameters are supposed to attain more or less stable values.

We illustrate the application of these tracer test design principles using hydro- and lithostratigraphy data from the Geothermal Research Platform at Groß Schönebeck [4], targeting a multi-layer reservoir (sedimentary and crystalline formations in 4-5 km depth) in the NE-German Sedimentary Basin.

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