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Characterization of thermal tracer tests and heat exchanges in fractured media

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Geothermal energy is a renewable energy source particularly attractive due to associated low greenhouse gas emission rates. Crystalline rocks are in general considered of poor interest for geothermal applications at shallow depths (< 100m), because of the low permeability of the medium. In some cases, fractures may enhance permeability, but thermal energy storage at these shallow depths is still remaining very challenging because of the low storativity of the medium. Within this framework, the purpose of this study is to test the possibility of efficient thermal energy storage in shallow fractured rocks with a single well semi open loop heat exchanger (standing column well). For doing so, several heat tracer tests have been achieved along a borehole between two connected fractures.

The heat tracer tests have been achieved at the experimental site of Ploemeur (H+ observatory network). The tracer tests consist in monitoring the temperature in the upper fracture while injecting hot water in the deeper one thanks to a field boiler. For such an experimental setup, the main difficulty to interpret the data comes from the requirement for separating the temperature advective signal of the tracer test (temperature recovery) from the heat increase due to injection of hot water through the borehole which induces heat losses all along the injection tube in the water column. For doing so, in addition to a double straddle packer used for isolating the injection chamber, the particularity of the experimental set up is the use of fiber optic distributed temperature sensing (FO-DTS); an innovative technology which allows spatial and temporal monitoring of the temperature all along the well. Thanks to this tool, we were able to estimate heat increases coming from diffusion along the injection tube which is found much lower than localized temperature increases resulting from tracer test recovery. With local temperatures probes, separating both effects would not have been feasible. We also show through signal processing how diffusive and advective effects may be differentiated. This allowed us to estimate temperature recovery for different heat tracer durations and setups. In particular we show that temperature recovery is highly dependent on hydraulic configuration such as perfect dipole or fully convergent heat tracer tests.