Measurement and Modeling of Tracer and Thermal Tests in a Meso-Scale Geothermal Field Laboratory

A. J. HAWKINS[1*], M.W. BECKER[2] AND J.W. TESTER[3]

[1]Stanford University, Stanford, California, 94305 (*correspondence: ajh01@stanford.edu)
[2]California State University, Long Beach, Long Beach, California, 90840, USA
[3]Cornell University, Ithaca, New York, 14850, USA

Meso-scale field tests at the Altona field site in Altona, NY served as a low-temperature geothermal analog for heat exchange experiments and inert/reactive tracer tests. For six days, heated water circulated through a cold, sub-horizontal bedding plane fracture 7.6 m below ground surface between two wells seperated by 14 m. A network of thermal sensors monitored reservoir heat up at 13 monitoring wells throughout the 10 x 10 m well field. Reactive tracers included cesium, an adsorbing tracer, and phenyl acetate, a thermally degrading tracer. The adsorbing tracer test estimated heat transfer surface area and the thermally degrading tracer monitored reservoir heat up by estimating the effective reservoir temperature during different stages of heating. An inert carbon-cored nanoparticle (C-Dots) and iodide measured the Residence Time Distribution (RTD). Computational modeling efforts included an inverse model for identifying non-uniform fracture aperture distribution. Ground Penetrating Radar (GPR) measured the spatial distribution of saline tracer circulated between the injector/producer well pair.

Conventional methods predicted a 4 °C temperature rise in the production well in roughly 90 d. Measured production well temperature, however, rose 4 °C in just 8 h. Interpretation of the tracer tests using a non-uniform fracture aperture distribution resulted in a predicted production well temperature rising 4 °C within roughly 12 h. Results of the field tests, laboratory measurements, and computational models suggest that rapid thermal breakthrough occurred as a result of extreme flow channeling through a 1 m wide flow channel that directly connected the two wells.