ORAL PRESENTATION - 48TH IAH CONGRESS (2021): "INSPIRING GROUNDWATER"

ABSTRACT ID 59
FOR SESSION 06: *Geothermal and hydro-energy*

MODELING HOT AND COLD WATER INJECTIONS IN A FRACTURED AQUIFER: INFLUENCE OF THE THERMAL GRADIENT DIRECTION ON MEASURED BREAKTHROUGH CURVES

***Richard Hoffmann**[1,2], Pascal Goderniaux[2] and Alain Dassargues[1]*

[1]Hydrogeology and Environmental Geology, Urban and Environmental Engineering, Liège University, Belgium
[2]Geology and Applied Geology, Polytech Mons, University of Mons, Belgium

E-mail address of corresponding author: Richard.Hoffmann@uliege.be

Heat tracer tests have shown a high potential to estimate hydraulic and thermal conductivities and heat capacity at the field scale. Most often, such tracer tests are performed in moderately warm aquifers by injecting hot water, compared to the natural background. For aquifers with a high natural background temperature, such as in tropical regions, it is interesting to inject cold water.

Several tracer tests with injection of hot and cold water were conducted in a weathered/fractured aquifer in southern India. The natural background temperature was about 30 °C. In the injection well, a sub-horizontal fracture was isolated by use of a packer system for injection of 1000 L of hot (50 °C) and cold (10 °C) water, respectively. Tracers were recovered by pumping in a well at a distance of 5.4 m and connected by the isolated fracture. The observed temperature breakthrough curves were characterized by their thermal recovery rate and cumulative energy recovery. A plot of logarithmic time against the logarithmic observations translated in residence time distributions allowed to estimate the breakthrough curve tailing slope values close to 1.5 for all temperature tracers, representing a diffusive behavior.

For simulating the observations numerically using HydroGeoSphere, a low-porosity and low-hydraulic conductivity porous medium, intersected by highly transmissive discrete fractures, is defined. The fracture aperture, the effective transport porosity, the hydraulic conductivity and the specific storage coefficient of the porous medium were manually calibrated minimizing the differences between observations and simulations of the drawdown and temperature breakthrough curves. The estimated tailing slope values are well reproduced. The observed and simulated thermal recovery rate and the cumulative energy recovery tend to be lower for a cold water injection. Small differences remain between the simulated hot and cold water tests even when no density-viscosity effect is considered and all calibrated parameters are similar. These results confirm that heating and cooling the porous medium from an injected highly permeable fracture is influenced by conduction. However, the conduction direction (from the fracture towards the matrix or vice-versa) influences the thermal recovery rate. For the first time, it is evidenced that the difference in results from similar hot and cold water tracer tests is not only due to water density-viscosity changes but induced also by the inversed direction of the thermal gradient between the fracture and the matrix.

References

- Dassargues, A. 2018. *Hydrogeology: Groundwater science and engineering*. 1st ed. Boca Raton, Florida: CRC Press.
- Hoffmann R., Maréchal J.C., Selles A. and A. Dassargues. 2021. Heat tracing in a fractured aquifer with injection of hot and cold water. *Groundwater* (in press).
- Klepikova, M.V., S. Wildemeersch, T. Hermans, P. Jamin, P. Orban, F. Nguyen, S. Brouyère, and A. Dassargues. 2016b. Heat tracer test in an alluvial aquifer: Field experiment and inverse modelling. *Journal of Hydrology* 540: 812–823.
- Selles, A., R. Hoffmann, W. Uddin, P. Goderniaux, A. Dassargues, J.-C. Maréchal, and V. Tiwari. 2019. Smart temperature tracing using heat and cold water in India - VIDEO: YouTube video. Retrieved from https://www.youtube.com/watch?v=cx6s4cGj1sc
- Wildemeersch, S., P. Jamin, P. Orban, T. Hermans, M.V. Klepikova, F. Nguyen, S. Brouyère, and A. Dassargues. 2014. Coupling heat and chemical tracer experiments for estimating heat transfer parameters in shallow alluvial aquifers. *Journal of Contaminant Hydrology* 169: 90–99.