Using Temperature Signals to Estimate Geometry Parameters in Fractured Geothermal Reservoirs

F. Maier[1], P. Oberdorfer[1], I. Kocabas[2], I. Ghergut[1], M. Sauter[1]
1. Georg-August University Göttingen, Applied Geology, Goldschmidtstr.3, 37077, Göttingen, Germany.
2. Batman University, Batman, Turkey

Introduction: Recently, heat has emerged as a useful type of tracer to characterize geothermal reservoirs. Thermal transients of injection/withdrawal test have been monitored and temperature is employed as the state variable. The temperature return profile is analyzed to identify the equivalent fracture with more precisely heat transport rate in a fracture/matrix configuration.

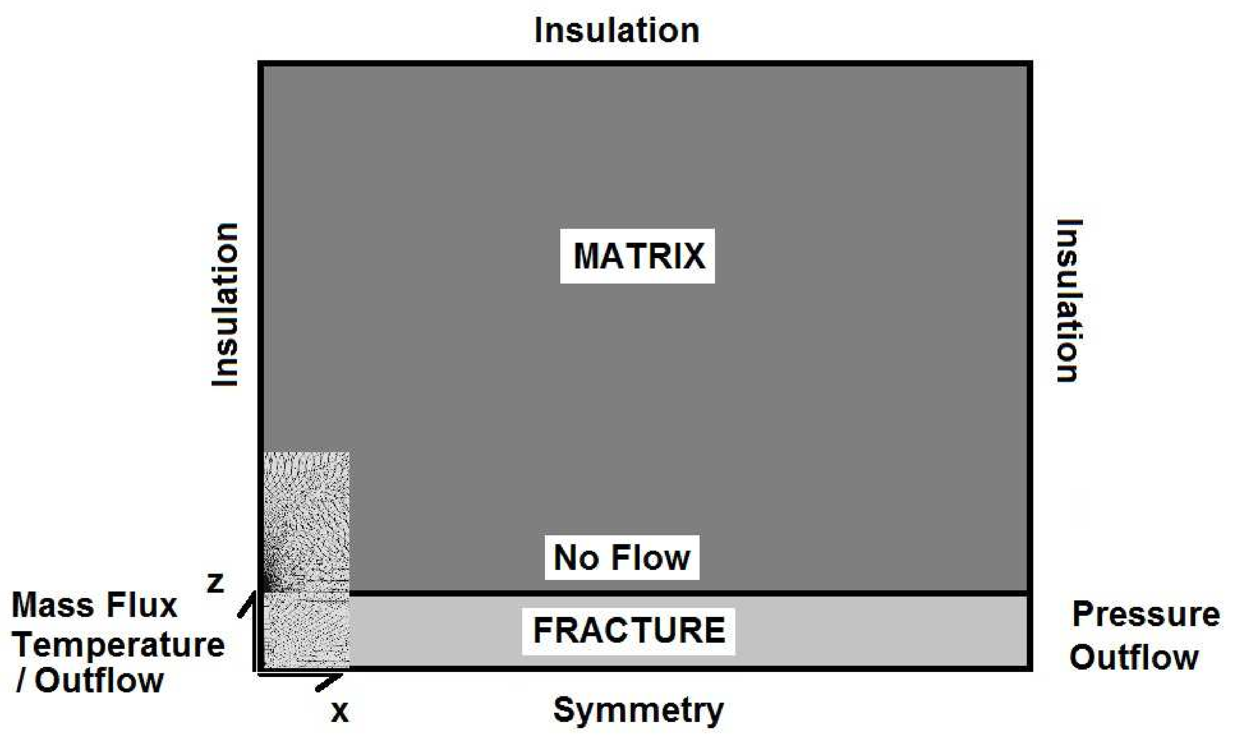

Figure 1. Conceptual sketch of the geometry and boundary conditions.

Computational Methods: Within that fracture/matrix geological configuration we assume an infinite lateral thermal conductivity *k* in the fracture whereas the heat conduction in the flow direction is neglected. In the matrix we assume a constant thermal conductivity

$$\rho c \frac{\partial T}{\partial t} + \rho c u \cdot \nabla T = \nabla \cdot \left(k \nabla T\right)$$

The injected temperature change is the numerical "bottleneck", since a vanishing dipersivity leads to an infinit cell Peclet number for a given element length.

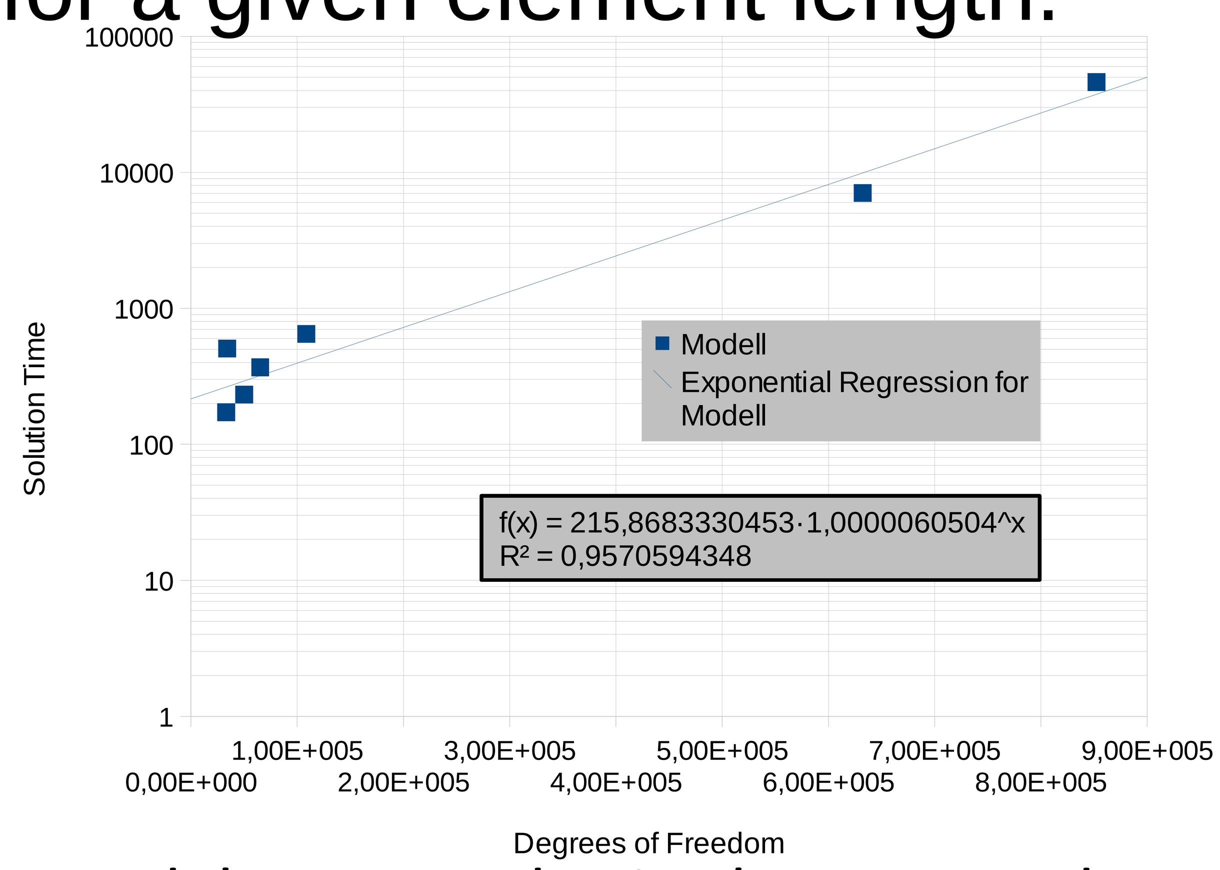

Figure 2. The models use quadratic elements and were solved on an Intel(R) Core(TM) i7 CPU, Q 820 @1.73GHz, 8 GB RAM, 64-bit Windows 7 system.

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Results: The Temperature signal was recorded at the outlet and compared with an analytical solution (Kocabas 2010). For an increasing heat transfer rate parameter α we obtain increasing fracture/matrix heat exchange.

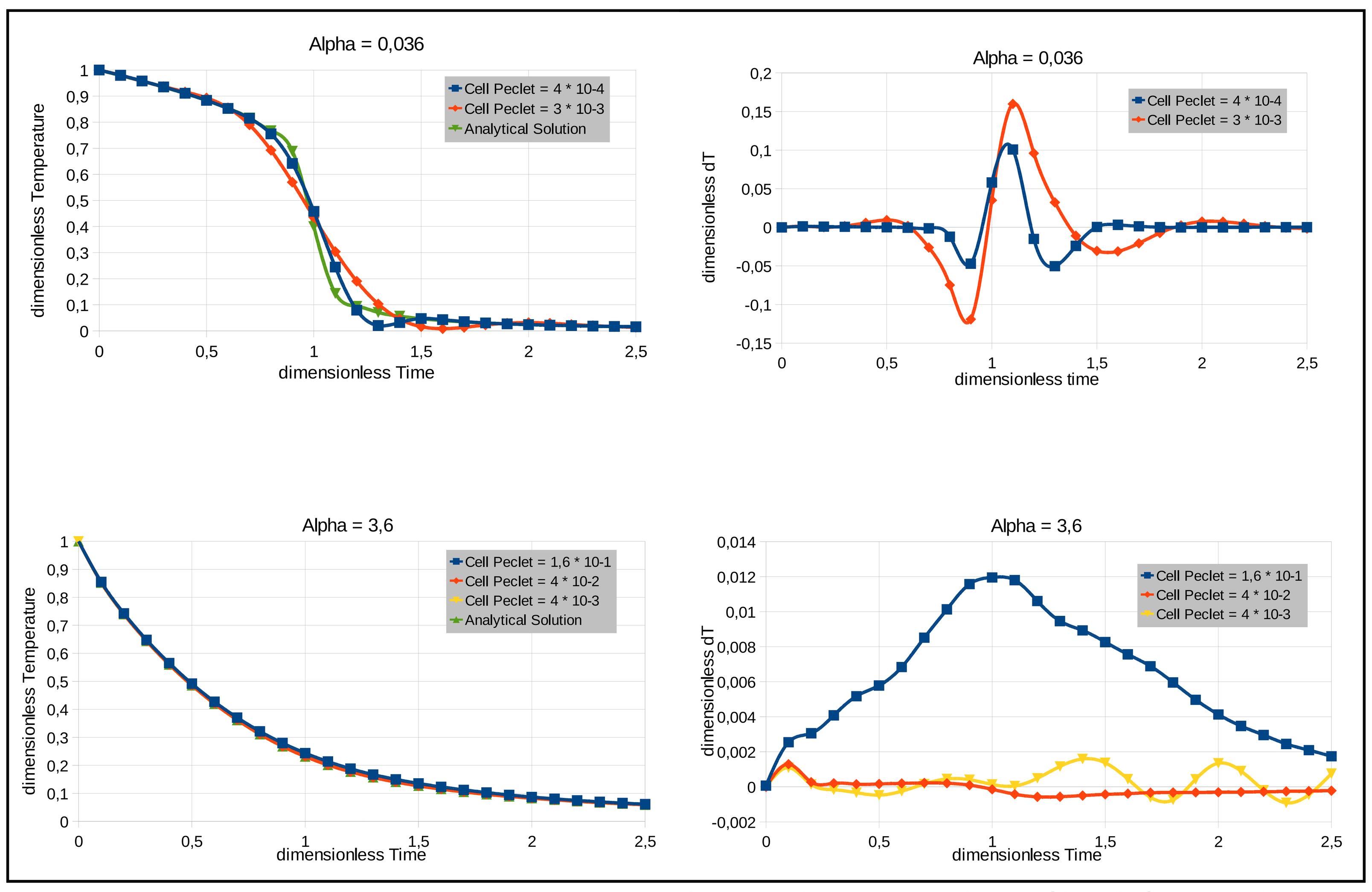

Figure 3. Temperature signal at the outlet (left) and bias due to numerical dispersion and element length (right)

→ α <1: Temperature signal is affected due to numerical dispersion

→ Data around temperature front is most biased

→ Small cell Peclet numbers narrow the affected zone

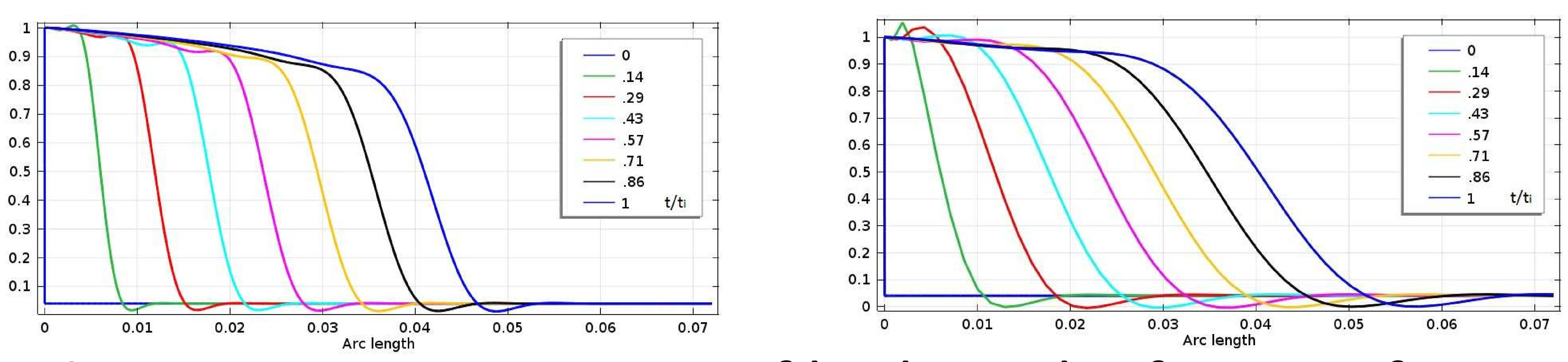

Figure 4. Temperature profils along the fracture for two cell Peclet numbers (left Pe=4*10^{-4} / right Pe=4*10^{-3})

Conclusions: The neglected diffusion/dispersion in flow direction is a benchmark to estimate the influence of (numerical) dispersion for further analysis towards geometry parameter.

References:

1. Kocabas, I.. "Designing Thermal and Tracer Injection Backflow Tests." World C.2010: 25-29. (2010)

Acknowledgements:
This work acknowledge financial support from the German Ministry for Environment (BMU) and the EnBW within project "LOGRO" under grant no. 0325111B, for the opportunity of conducting numerical and field SWIW tracer tests aimed at characterizing deep-sedimentary geothermal reservoirs in Germany.