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Actively heated fiber optics based thermal response test

Kai Gu[1], Bo Zhang[1], Bin Shi[1], Chun Liu[1], Peter Bayer[2], and Zhuang Wei[1]
[1]School of Earth Sciences and Engineering, Nanjing University, Nanjing, China (gukai@nju.edu.cn)
[2]Institute of Geosciences and Geography, Martin-Luther University Halle-Wittenberg, Von Seckendorff-Platz 4, 06120 Halle (Saale), Germany

In the pursuit of sustainable development and the mitigation of climate change, shallow geothermal energy has been widely recognized as a type of clean energy with great potential. Accurate estimation of thermal ground properties is needed to optimally apply shallow geothermal energy technologies, which are of growing importance for the heating and cooling sector. A special challenge is posed by the often significant heterogeneity and variability of the geological media at a site.

As an innovative investigation method, we focus on the actively heated fiber optics-based thermal response test (ATRT) and its application in a borehole in Changzhou, China. A copper mesh heated optical cable (CMHC), which both serves as a heating source and a temperature sensing cable, was applied in the borehole. By inducing the electric current to the cable at a relatively low power of 26 W/m, the in-situ heating process was recorded at high depth resolution. This information serves to infer the thermal conductivity distribution along the borehole. The presented field experience reveals that the temperature rise in the early phase of the test should not be used due to initial heat accumulation caused by the outer jacket of the CMHC. The comparison of these results with those of a conventional thermal response test (TRT) and a distributed thermal response test (DTRT) in the same borehole confirmed that the ATRT result is reliable (with a difference less than 5% and 1%, respectively). Most importantly, this novel method affords much less energy and testing time.

Additionally, to estimate the uncertainty and limits associated with the method, a 2D axisymmetric numerical model based on COMSOL Multiphysics® has been developed. The results indicate that an accurate calculated thermal conductivity requires heating duration to be in the range of 90~400 min considering test efficiency and cost. Our study promotes ATRT as an advanced geothermal field investigation method and it also extends the applicability of the thermal response test as a downhole tool for measurement of soil hydraulic properties.