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Procedure to Determine Thermal Characteristics and Groundwater Influence in Heterogeneous Subsoil by an Enhanced Thermal Response Test and Numerical Modeling

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Abstract: Ground thermal conductivity and borehole thermal resistance are indispensable parameters for the optimal design of subsoil thermal processes and energy storage characterization. The standard method to determine these parameters is the Thermal Response Test (TRT) which results are evaluated by models considering the ground being homogeneous and isotropic. This method obtains an effective ground thermal conductivity which represents an average of the thermal conductivity along the different layers crossed by perforation. In order to obtain a ground thermal conductivity profile as a function of depth two additional key factors are required, first, a new significant data set: a temperature profile along the borehole; and second, a new analysis procedure to extract ground heterogeneity from the recorded data. This research work presents the results of an analysis procedure, complementing the standard TRT analysis, which allows to estimate the thermal conductivity profile from a temperature profile measured along the borehole during a TRT. In the analysis procedure, a 3D Finite Element Model (FEM) is used to fit simulation results with experimental data, by a set of iterative simulations. This methodology is applied to a data set obtained throughout a TRT of 1kW heat power injection in a 30m depth Borehole Heat Exchange (BHE) facility. A highly conductive layer have been detected and located at 25 m depth. In addition, a novel automated device to obtain temperature profiles along geothermal pipes with or without fluid flow is presented. This sensor system is intended to improve the standard TRT and it allows the collection of depth depending thermal characteristics of the subsoil geological structure. Currently, some studies are being conducted in double U-pipe borehole installations in order to improve previously introduced analysis procedure. From a numerical model simulation that takes into account advective effects is pretended to estimate underground water velocity and orientation.