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Comparison between traditional and enhanced Thermal Response Test for ground thermal properties estimation

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For the design and implementation of an efficient Ground Source Heat Pump (GSHP) system, the local subsoil represents the core element. Since the thermal performance of Borehole Heat Exchangers (BHEs) is site-specific, its planning typically requires the knowledge of the thermal proprieties of the ground, which are influenced by the local stratigraphic sequence and the hydrogeological conditions. The evaluation of the variations of the ground thermal conductivity (TC) along the depth, as well as its undisturbed temperature, are essential to correctly plan the BHEs field and improve the performance of the ground heat exchangers themselves.
Thermal Response Test (TRT) is a well-known experimental procedure that allows to obtain the thermal properties of the ground. However, the traditional method provides a single value of the equivalent TC and the undisturbed temperature, which can be associated with the average value over the entire BHE length, with no chance to detect the thermo-physical parameters variations with depth and to discriminate the contributions of the different geological levels crossed by the geothermal exchange probe. Indeed, different layers within a stratigraphic sequence, may have different thermal properties, according to the presence and to the flow rate of groundwater, as well as to granulometry and mineralogical composition, density, and porosity of the lithologies. The identification of the different contributions to the thermal exchange provided by each geological unit, in practice, can further support BHE design, helping to determine the most suitable borehole length and number, achieving the highest heat exchange capability at the lower initial cost of implementing of the entire geothermal plant.

In the last years, new improved approaches to execute an enhanced thermal response test have been developed, as the pioneer wireless data transmission GEOsniff technology (enOware GmbH) tested in this study. This measurement method is characterized by its sensors, 20mm-diameter marbles equipped by pressure and temperature transducers combined with a system of data storing and wireless data transmission. Released at regular intervals down the testing BHE, infilled with water, each marble freely floats allowing the measurement of the water temperature variations over time at different depths, in order to identify areas with particular values of thermal conductivity related to distinctive hydrogeological conditions or lithological assessment. This way, the GEOsniff technology allows a high-resolution spatially-distributed representation of the subsoil thermal properties along the BHE.

In this work, we present the test outputs acquired at the new humanistic campus of the University of Padova, located in the Eastern Po river plain (Northern Italy). The thermal conductivity data obtained by the GEOsniff method have been compared and discussed, by considering the standard TRT outputs. This innovative technique looks promising to support the optimization of the borehole length in the design phase, even more where the complexity of the treated geological setting increases.