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Thermo-hydraulic characterization of a fractured shallow reservoir in Bergen (Norway) to improve the efficiency of a BHE field

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Sustainable thermal energy production from GSHP systems is greatly dependent on the thermo-hydraulic field, yet there are few realistic case studies which capture the dynamics of such systems. Here we present initial work on the static model for one such case example. A BHE field consisting of 12 ground heat exchangers in fractured crystalline rock has been supplying thermal energy for the past 20 years to meet the heating needs of a school located in Bergen, Norway. In recent years the heat pump COP has significantly decreased, which has been ascribed to a depletion of the extractable energy surrounding the BHEs, that is, by extracting more energy in the heating season than is naturally replaced in the summer. A numerical model of the underground is constructed to show the thermal depletion and determine a sustainable thermal use of the shallow reservoir (0-200 m). At this stage, the model represents the geology and structure of the underground, which consists of metamorphic rocks of the Nordåsvatnet Complex (Minor Bergen Arc, Ordovician): amphibolites, micaschists, augen gneisses and quartz-schists depict the first 200 m below ground level. Preliminary well tests in some of these BHEs showed how complex and heterogeneous is the hydrogeological field. Some wells are clearly connected, others show hydraulic head difference of more than 15 m even though they are close by. Future flow tracer tests and down-hole fracture characterization will be carried out for in-depth representation of the flow field. Here we present and discuss laboratory thermal measurements on samples collected in the area, especially a comparison of two thermal conductivity measurement techniques. Thermal conductivity measurements were carried out with the thermal conductivity scanner by Lippmann and Rauen GbR and with the KD2 Pro by Decagon Devices. The optical scanning technology and the transient line source method were therefore compared to get the most valuable results. Electrical resistivity and seismic wave measurements were also performed on some samples to investigate possible relationships between these physical properties.