Extraction of Thermal Characteristics of Surrounding Geological Layers of a Geothermal Heat Exchanger Using COMSOL Multiphysics® Simulations

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Introduction: A Thermal Response Test (TRT) obtain effective parameters of a Borehole Heat Exchanger (BHE), but not the thermal parameters of surrounding layers. Effects due to porosity, moisture or water flows is difficult to measure.

From experimental measurements on a BHE with five layers (Fig. 1. a, c) obtained during a 1kW injection TRT, we developed a 3D Comsol model (Fig. 1. b, d) which allows us to fit the temperature on an observer pipe into the borehole, by selecting thermal parameters of geological layers.

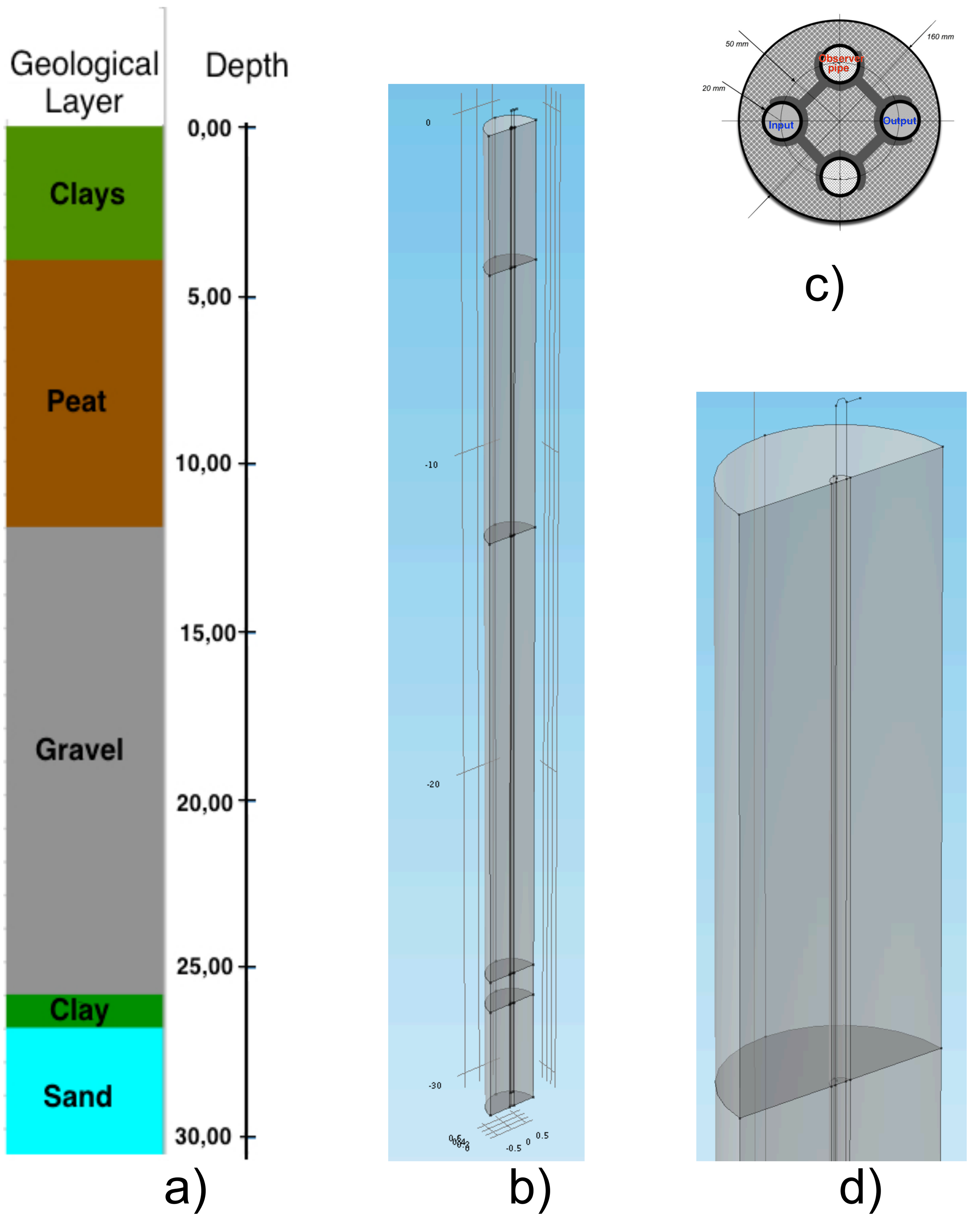

Figure 1. a) geological layers profile b) COMSOL Multiphysics® 3D model c) double U-pipe structure d) detail of pipe-flow model

Computational Methods: A BHE of 30 meters depth and 0,75m Ø, contains a drill of 0.18m Ø inside. This is inserted into the U-pipe and a observer pipe. This has been modeled using symmetry. Two physics interfaces has been used for the simulation in a Time Dependent Study: Non-Isothermal Pipe Flow and Heat Transfer in Solid.

Using the Non-Isothermal Pipe Flow (nipfl), constant power heater and heat transfer to borehole is modeled. Heat Transfer in Solid (ht) modeled the heat propagation from borehole to geological layers.

Results: A set of simulations have been carried out in order to find the thermal parameters profile of geological layers that fit the experimental temperature profile into observer pipe. Fig. 2 shows the relationship between experimental data (doted lines) and results of final simulation.

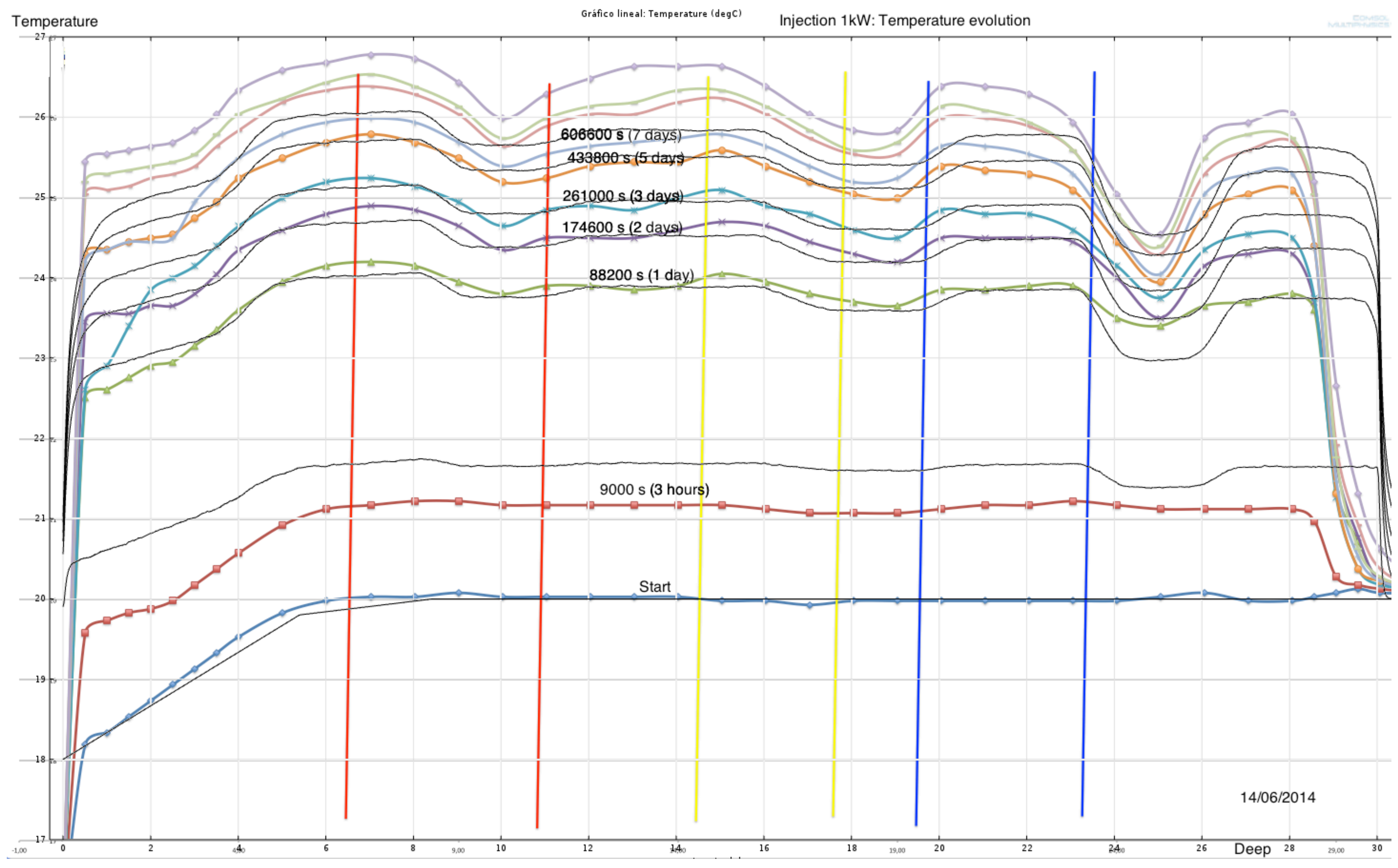

Figure 2. Experimental data (colored doted lines) and temperature simulation (black lines)

Fig. 3 shows the thermal conductivity profile to obtain the preceding data fit. A high conductive layer is detected between 24m to 26m.

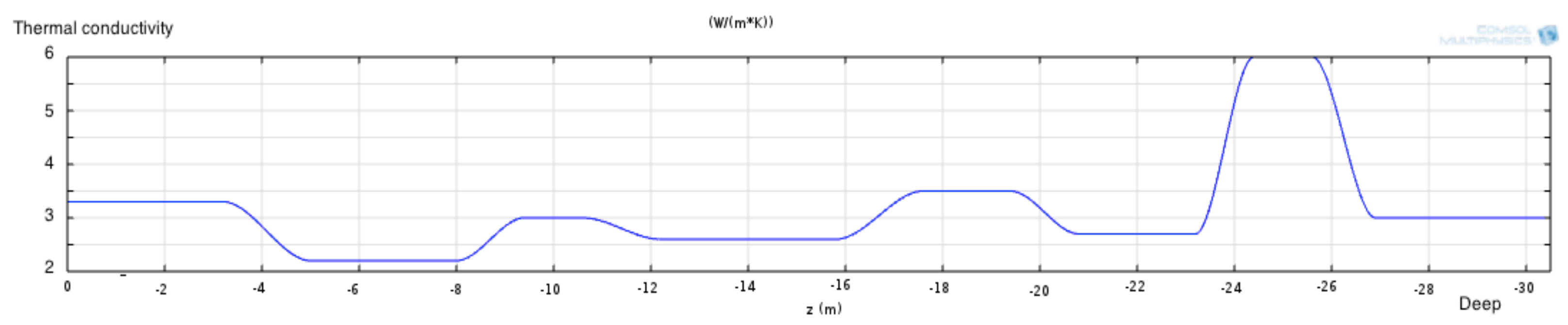

Figure 3. Thermal conductivity profile of geological layers

Conclusions: It has been demonstrated that is possible obtain the thermal parameters of geological layers of a BHE by fitting temperature evolution in an observer pipe inserted into borehole. These method allows detection of highly conductive layers and moisture or water flow effects. Future work intends to obtain a more accurate data fitting of measured and modeled data by an automatic process.

References:
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