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Experimental modelling of thermal flow in saturated and unsaturated conditions and geophysical controls.

Luca Guglielmetti, Cesare Comina, and Giuseppe Mandrone
Earth Science Department, University of Turin, Italy

In low enthalpy geothermal applications most of the studies use numerical models to simulate heat fluxes and temperature variations induced by heat exchangers into the groud. This requires a fundamental understanding of how soil moisture content and grain size affect the soil's thermal behavior. Very few experimental data showing the effects of these variations are however available and the relationships determined are only empirical. In fact, temperatures and heat fluxes depends on the 1) thermal conductivity and on the 2) specific heat of the geological media. The first can be determined using steady state methods employed in a heat flow meter and divided bar apparatus or using transient methods. The appropriate measurement method depends upon many factors such as the expected thermal conductivity and temperature range. Transient methods suffer limitations related to the contact between the heater-element and the surrounding rock, whereas more uniform, steady temperature gradients can be maintined using guarded steady-state methods. For the second, in the case of soils and rocks, an appropriate methodology is described in the ASTM standards.

To study these aspects in a more consistent framework a series of tests have been conducted under controlled laboratory conditions. A sandy and gravel soil is studied in both in dry and wet conditions, also simulating the effect of a transient water table. The expected results are:

• to obtain reliable values of temperature propagation within different kind of geological media, to convert this values into soil thermal conductivity values and to compare this values with the ones used in other;

• to use the empirical data to simulate by means of numerical models the propagation of heat to forecast the changes in geothermal conditions of the soils due to the heat exchangers;

• to evaluate the potentiality of indirect geophysical measurements in monitoring the temperature propagation.

A box was instrumented to monitor how temperature and heat fluxes are controlled by soil moisture and by water table. Two electrical resistances, controlled by a thermometer, and a rheostat assure the desired heat flux from one side of the box. Both heat and cool thermal fluxes can be produced inside the box. Temperature measurements in different sections of the box (four measuring points) are carried out to figure out the time necessary to the heat to propagate within the soil until a thermal equilibrium is reached; soil moisture is measured at the same time. Devoted sensors are used to assure high accuracy in the measurement of temperature and soil humidity.

Electrical measurements have been moreover implemented to evaluate the effects of temperature on electrical resistivity. In this respect a series of electrodes has been placed along the central section of the box an a fast acquiring device has been used to measure locally (along the singles quadrupoles) the electric resistivity.