INFLUENCE OF GROUNDWATER TEMPERATURE VARIATION ON THERMAL PLUME MODELLING IN GEOTHERMAL OPEN LOOP SYSTEMS

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The Groundwater Heat Pump system is a technology that withdraws water from a well or surface water, passes it through a heat exchanger and discharges the water into an injection well or nearby river, developing a thermal plume of colder/warmer re-injected water, known as the Thermal Affected Zone (TAZ). Plumes are considered a potential anthropogenic geothermal resource or pollution, in fact they might pose a risk to groundwater use downgradient. It is then important to know early in the project whether the aquifer is suitable for the system to be implemented and whether the TAZ will interfere with existing wells, subsurface infrastructure or land use.

Physical processes affecting heat transport within an aquifer include advection (or convection), mechanical dispersion and diffusion (Diao et al., 2004). Plume propagation occurs primarily through advection (Lo Russo and Taddia, 2010), and tends to "degrade" following conductive heat transport, and convection within moving water (Hecht-Mendez et al., 2010). The results of a sensitive analysis realized by Lo Russo et al. (2012) indicates that the main hydrodynamic parameters that influence the heat transport are hydraulic conductivity and gradient.

As the hydraulic conductivity varies according to the temperature due to the variation of the water dynamic viscosity, in the present study we evaluate the influence on heat transport of the groundwater temperature variation induced by an open-loop system reinjection system. To investigate this topic a sensitive analysis has been realized using FEFLOW® 6.2 package developed by Diersch (2010).

FEFLOW gives the possibility to include or disregard the dynamic viscosity variation related to the groundwater temperature and therefore we simulated these two scenarios. For each of them nine different cases have been considered using the combination between three different conductivity classes and three different injection temperatures values. For each case (K-T_{reinj}) the isotherms obtained in both scenarios have been compared geometrically.

The two scenarios analysed highlighted that the variation of the dynamic viscosity with the groundwater temperature affects the extension of the TAZ in the cases of higher values of aquifer hydraulic conductivity and/or in the situations of warmer injected water and therefore in these modelling contexts it should be taken into account to correctly assess the subsurface thermal perturbation.

References

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