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Experimental Study of Heat Transport in Fractured Network

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Fractured rocks play an important role in transport of natural resources or contaminants transport through subsurface systems. In recent years, interest has grown in investigating heat transport by means of tracer tests, driven by the important current development of geothermal applications. In literature different methods are available for predicting thermal breakthrough in fractured reservoirs based on the information coming from tracer tests. Geothermal energy is one of the largest sources of renewable energies that are extracted from the earth. The growing interest in this new energy source has stimulated attempts to develop methods and technologies for extracting energy also from ground resource at low temperature. An example is the exploitation of low enthalpy geothermal energy that can be obtained at any place with the aid of ground-source heat pump system from the soil, rock and groundwater. In such geothermal systems the fluid movement and thermal behavior in the fractured porous media is very important and critical. Existing theory of fluid flow and heat transport through porous media is of limited usefulness when applied to fractured rocks. Many field and laboratory tracer tests in fractured media show that fracture –matrix exchange is more significant for heat than mass tracers, thus thermal breakthrough curves (BTCs) are strongly controlled by matrix thermal diffusivity. In this study the behaviour of heat transport in a fractured network at bench scale has been investigated. Heat tracer tests on an artificially created fractured rock sample have been carried out.

The observed thermal BTCs obtained with six thermocouple probes located at different locations in the fractured medium have been modeled with the Explicit Network Model (ENM) based an adaptation of Tang's solution for solute transport in a semi-infinite single fracture embedded in a porous matrix. The ENM model is able to represent the behavior of observed heat transport except where the configuration of the fracture network gives rise to a fracture block characterized by a limited capability to store heat. As a consequence the observed BTCs show a greater penetration of heat in the system than ENM model. Furthermore the results show that heat transport in fractures is dominated also by thermal dispersion attributable to flow channeling inside them. The comparison with previous studies on solute transport carried out in fractured media shows that thermal BTCs are characterized by a more enhanced early arrival and long tailing than solute BTCs.

The residence time for heat transport is an order of magnitude higher than for solute transport experiments.

The results show that it is not possible to neglect the dispersion factor as well as the interaction between matrix and fractures in the study of heat transport in fractured media.