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Heat and Solute Transport in a Discrete Rock Fracture

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In fractured rock settings, there are several activities such as the use of geothermal energy, the application of ground source heat pumps and the application of thermal remediation that require a thorough understanding of heat transport in these systems. To date there have been very few field experiments exploring heat migration under controlled conditions in a discrete fracture. By combining the study of heat transport and solute transport simultaneously, we can advance current knowledge of the fundamental processes of groundwater flow and transport such as solute and thermal dispersion, flow channelization and the development of preferential pathways in discrete fractures. To explore this, two field experiments were conducted at a site located in eastern Ontario, Canada, underlain by moderately-fractured granitic gneiss. The experiments were conducted between two wells, approximately 10 metres apart, which are connected by a highly transmissive fracture. This fracture is located approximately fifteen metres below the ground surface and was isolated in the source and observation wells using straddle-packer systems. The aperture of the fracture was measured hydraulically at 1.4 mm. Prior to each experiment, the resident groundwater at the depth of the fracture was approximately 8.1 ˚C. To establish a flow field, water stored on ground surface was injected in one hole at a flow rate of approximately 6.5 Lpm in the first experiment and approximately 8.9 Lpm in the second experiment. The arrival of heat and tracer was then observed at the other well. Once steady flow conditions were established, a heated water source of approximately 250-300L (depending on the experiment) with a temperature of up to 47 ˚C was introduced in the source well. A temperature breakthrough in the observation well of approximately 0.7 ˚C was observed in both experiments. In the first experiment heat breakthrough occurred two hours after the start of injection of heated water and in the second experiment heat breakthrough at the observation well occurred after one hour. A fluorescent organic dye was used as a solute tracer and introduced simultaneously with the heated water at the end of the heated water injection with a concentration of approximately 10 ppm. First arrival of the solute occurred at the observation well in only 7-8 minutes in both experiments. Analysis and interpretation of the results is being conducted using HydroGeoSphere, a numerical model that can accurately simulate both heat and solute transport in discrete fracture features having variable fracture aperture. Results of the preliminary simulations will be presented.