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Is enhanced heat and tracer transfer by intermittent porous flow an important process in deep geothermal systems?

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In enhanced or engineered geothermal systems (EGS) a fluid is pumped into a fractured reservoir through an injection well and is extracted again in a production well. During this process, the fluid interacts with the rock and exchanges heat and in many cases mass (by dissolution and re-precipitation of minerals). In addition, fluid flow through pores and fractures alters the stress field and mechanical behaviour of the rock. Variations in pore pressure may lead to brittle failure and opening of fractures. Dissolution and precipitation of minerals under stress may lead to viscous compaction and closure of pore space and fractures. These processes are strongly physically coupled and we need to thoroughly investigate and understand these couplings in order to develop realistic predictive models for geothermal systems.

We have therefore developed numerical models based on a thermodynamically consistent set of non-linear differential equations for coupled porous fluid flow, temperature and tracer exchange and deformation, including reaction-induced viscous compaction and plastic opening of pore space. Naturally, these models contain a large number of adjustable parameters that are not always well constrained. The development of suitable non-dimensional expressions for such a coupled system is therefore of prime importance, as is the systematic exploration of the parameter space. We will determine for which temperatures and pressures, compositions, initial petrophysical conditions (porosities, permeabilities) and boundary conditions (injection fluid pressure) phenomena such as visco-elastic porosity waves may occur on the spatial and time scales relevant to EGS. Porosity waves are predicted to constitute an important fluid focusing and transport mechanism in sedimentary basins. They create transient or dynamic permeability in the reservoir and may allow for the rapid and focused transport of fluids, heat and mass in and out of the area close to the well without invoking the existence of an additional connected network of open fractures. If porosity waves form in EGS they create a pressure increase at their head and under-pressure in their tail. These pressure variations may again enhance or suppress reactions along the path of the wave and may act as precursors of classical hydraulic fractures.