Heat transport with advection in fractured rock

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ABSTRACT

The two main mechanisms of heat transport in saturated porous media are diffusion and advection. In the numerical formulation of the problem via the FEM, it is well known that if advection dominates over diffusion (Péclet number $Pe > 1$), traditional Galerkin formulations cease to work [1], although in many practical engineering situations, such as the case of geological materials, fluid velocities generally remain small due to the low permeability and tortuosity of the pore system and this problem may be ignored [2].

However, this situation may change in the presence of open fractures or cracks, because these may become preferential paths for fluid circulation with fluid velocities significantly higher than those found in the surrounding porous medium, and therefore exceeding the limit condition $Pe > 1$. In the paper, these concepts are discussed, and a new FE formulation for large advection is described. It consists of an implicit extension of Taylor’s explicit formulation for the transient problem based on characteristics [1], which has been developed for traditional 2D continuum elements, and also for double-node zero-thickness interface elements. Some examples of application are presented, showing that even in the extreme case of pure advection ($Pe \to \infty$), the formulation seems capable of correctly representing the fluid transport of practically unchanged temperature profiles along the mesh.

REFERENCES
