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Modeling the Fracturing of Rock by Fluid Injection - Comparison of Numerical and Experimental Results

Thomas Heinze, Boris Galvan, and Stephen Miller
Geodynamics/Geophysics, Steinmann- Institute, University of Bonn, Germany

Fluid-rock interactions are mechanically fundamental to many earth processes, including fault zones and hydrothermal/volcanic systems, and to future green energy solutions such as enhanced geothermal systems and carbon capture and storage (CCS). Modeling these processes is challenging because of the strong coupling between rock fracture evolution and the consequent large changes in the hydraulic properties of the system. In this talk, we present results of a numerical model that includes poro-elastic plastic rheology (with hardening, softening, and damage), and coupled to a non-linear diffusion model for fluid pressure propagation and two-phase fluid flow.

Our plane strain model is based on the poro- elastic plastic behavior of porous rock and is advanced with hardening, softening and damage using the Mohr- Coulomb failure criteria. The effective stress model of Biot (1944) is used for coupling the pore pressure and the rock behavior. Frictional hardening and cohesion softening are introduced following Vermeer and de Borst (1984) with the angle of internal friction and the cohesion as functions of the principal strain rates. The scalar damage coefficient is assumed to be a linear function of the hardening parameter. Fluid injection is modeled as a two phase mixture of water and air using the Richards equation.

The theoretical model is solved using finite differences on a staggered grid. The model is benchmarked with experiments on the laboratory scale in which fluid is injected from below in a critically-stressed, dry sandstone (Stanchits et al. 2011). We simulate three experiments, a) the failure a dry specimen due to biaxial compressive loading, b) the propagation a of low pressure fluid front induced from the bottom in a critically stressed specimen, and c) the failure of a critically stressed specimen due to a high pressure fluid intrusion. Comparison of model results with the fluid injection experiments shows that the model captures most of the experimental observations, including fracture evolution, excellent agreement of the entire load-unload stress strain behavior, and applicable to both drained and un-drained conditions.

Bibliography:

M.A. Biot. General Theory of Three- Dimensional Consolidation. Journal of Applied Physics, 12:155 - 164, February 1941.

P.A. Vermeer and R. de Borst. Non- associated Plasticity For Soils, Concrete and Rock. Heron, 29(37), 1984.

S. Stanchits, S. Mayr, S. Shapiro and G. Dresen. Fracturing of Porous Rock Induced by Fluid Injection. Tectonophysics, (503):129-145, 2011.