FLUID-INDUCED FRACTURE INITIATION AND PROPAGATION IN GEOLOGIC SYSTEMS: A DISCRETE ANALYSIS

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Fluid flow typically introduces wide ranges of fluid pressure gradients within geological strata. These gradients vary in magnitude by the strength of the flow field, and ultimately affect mechanical behavior. In addition to fluid pressure gradients, strata may also be subjected to near- and far-field stresses by tectonic loading, sedimentation, or resource development. Thus, when fluid gradients develop in actively deforming regions, a strong coupling between the deformation field and the flow field may be induced. The degree of coupling ultimately relies on the poroelastic stress coefficient of rock, which is a function of drained and undrained behavior. Near-field stresses can also cause local changes in pore pressure fields but are probably secondary under the larger influence of regional scale pressure gradients. It is our hypothesis that fluid pressure gradients controlled by the hydrologic properties of rocks will influence fracture initiation and propagation in these rocks, especially in overpressured reservoirs and basins.

To address this hypothesis we developed two-dimensional models of fracture initiation and propagation using a non-continuum technique consisting of a discrete element model coupled with a lattice Boltzmann model of fluid flow [1]. Models exploring the rates of propagation and initiation of fractures were developed to help isolate the role of mechanical and hydrologic heterogeneities on overall system behavior. In addition, boundary value problems for coupled deformation and flow through axisymmetric cylinders were analyzed via poroelastic equations. These models, based on micromechanically based theory, permit us to quantify observed macroscopic behaviors.

Our conceptual model indicates that fluid pressure gradients should influence the timing and the location of observed damage in rocks. Our primary interests lie in identification of the main factors responsible for geological genesis of fractures. The qualitative role of fluids in geologic processes has been acknowledged for many years [2] as well as their role in fracture genesis. The combined laboratory and numerical experimentation attempts to highlight quantitatively the role of fluids in rock deformation. Ultimately, these results may apply to larger-scale poroelastic models of sedimentary basin evolution.

References

[1] Cook, B.K., D.R. Noble, and J.R. Williams. A Direct Simulation Method for Particle-Fluid Systems. Submitted to *Engineering Computations*, 2003.
[2] Hubbert, M. K. and W. W. Rubey. Role of Fluid Pressure in Mechanics of Overthrust Faulting. *Geological Society of America Bulletin* 70: 115-166, 1959.

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