Dynamics of fracturing saturated porous media

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It is now generally recognized that mode I fracturing in saturated geomaterials is a stepwise process except for a few exceptions. This is true both for mechanical loading and for pressure induced fracturing. Evidence comes from geophysics, from unconventional hydrocarbon extraction, and from experiments [1]. Despite this evidence only very few numerical models and none of the exact solutions capture this behaviour. We summarize first the relevant experiments and the numerical solutions for the quasi-static case. Then we show our numerical results: for homogeneous media they are obtained with a model based on Standard Galerkin Finite Elements in conjunction with a cohesive fracture model; for stochastically heterogeneous media with Monte Carlo simulations on a truss lattice model incorporated in the Biot equations [2,3]. Both mechanical loading and pressure driven fractures are considered because their behaviours differ in the direction of the pressure jumps. We explore then stepwise crack tip advancement and pressure fluctuations in dynamic fracturing. Full dynamic analyses of examples dealing with both hydraulic fracturing and mechanical loading are presented. The stepwise fracture advancement is confirmed in the dynamic setting as well as the pressure fluctuations, but there are substantial differences in the frequency contents of the pressure waves in the two loading cases. Comparison between the quasi-static and fully dynamic solutions reveals that the dynamic response gives much more information such as the type of pressure oscillations and related frequencies and should be applied whenever there is a doubt about inertia forces playing a role -the case in most fracturing events.

References

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