Harvard University Solid Earth Physics Seminar
***and* SEAS Applied Mechanics Colloquium**

4:00 p.m. Wednesday 12 February 2014
209 Pierce Hall, 29 Oxford Street

Mechanics of Hydraulic Fracturing and Related Seismicity

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Abstract: Hydraulic fracturing has become ubiquitous in allowing to tap vast tight oil and gas reserves in North America and elsewhere in the world. In this method, fractures are initiated and propagated from a well into hydrocarbon-bearing strata by a high pressure fluid injection. Once created, the fractures provide a conductive pathway for hydrocarbons from the reservoir rock to the well. Ability to predict and to better control fracture(s) growth and their final dimensions are essential in achieving the primary goal of fracturing (i.e. reservoir stimulation) and in minimizing environmental impact thereof (e.g. contamination of adjacent strata/aquifers due to excessive growth of the fracture height).

In the first part of the talk, we will review the physics and mechanics of fluid-driven fracture growth, as it presents an interesting hybrid of the viscous fluid flow (both in the fracture and through the permeable rock), rock deformation, and rupture. These physical processes are shown to be strongly coupled near the leading edge of a propagating fracture, and their resolution is essential to the accurate fracture growth prediction.

The second part of the talk provides an overview of microseismicity, as usually accompanies growth of hydraulic fractures. Induced seismicity is a manifestation of dynamic slippage on pre-existing fractures and faults within the stimulated reservoir rock volume, as prompted by locally perturbed (elevated) pore fluid pressure and/or stress. This slip may lead to dilation of the sheared fractures, and, therefore, stimulate production from the reservoir by increasing its permeability and connectivity to the hydraulic fracture. On rare occasions, dynamic slip induced by hydraulic fracturing is known to grow out into small-to-moderate size earthquakes. Some insight into a) how initially slow, aseismic fault slip may escalate into a dynamic rupture, and b) what may control the dynamic rupture run-out distance (seismic magnitude), is offered by simplified models of slip-weakening frictional faults “unclamped” by a diffusively spreading pore pressure perturbation.