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

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209 Pierce Hall, 29 Oxford Street

Geosciences Inspiring Engineering: What Dyke Swarms Teach us about Hydraulic Fracturing

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Abstract: Hydraulic fracturing has an extensive history of successful applications including quarrying/mining (since the 1890s), gas and oil extraction (since 1949), and Enhanced Geothermal Systems ("EGS", since the early 1970s). With perhaps only one notable exception, the Barnett Shale in Texas, this experience points to a mechanical system that tends to favor localization of fracture growth to one or two dominant hydraulic fractures rather than propagation of many simultaneous branches. This is in spite of 4 decades of attempts to generate complex networks of hydraulic fractures for EGS applications and more than a decade of efforts to generate Barnett-like networks of hydraulic fractures in other shale gas reservoirs. Man-made hydraulic fractures seem highly prone to localization.

On the other hand, there are more than 400 known examples of giant dyke swarms on Earth, Venus, and Mars. These stunning features are comprised of hundreds to thousands of subparallel to radiating dykes that originate from a common source region and that appear to have grown concurrently. So, in contrast to man-made systems, these natural systems of fluid (magma)-driven cracks appear to favor swarming dynamics rather than localization.

In this presentation I will tell the story of a recent research effort aimed at finding the ingredients required for swarming behavior to occur in systems of fluid-driven cracks such as dykes and hydraulic fractures. I will show that the missing ingredient has been a basic understanding of the attractive force in these systems, that is, why fluid-driven cracks would have any mechanical impetus to grow near one another in the first place. By showing how this key element of the system depends on geometry and the relative importance of viscous energy dissipation in the context of the energy balance of the system, engineers are now able to draw inspiration from the naturally-occurring dyke swarms in order to design more effective hydraulic fracturing treatments.