An asymptotic framework for finite hydraulic fractures driven by multiple physical processes

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A particular class of fractures in the Earth develops as a result of internal pressurization by a viscous fluid. These fractures are either natural such as volcanic dikes driven by magma from beneath the Earth's crust, or man-made hydraulic fractures created by injecting a viscous fluid from a borehole in order to increase production from oil or gas reservoirs. This talk concerns the development of a theoretical framework to understand and predict the different modes of propagation of a fluid-driven fracture. These theoretical models can be used to understand and predict the transitions in different dominant behavior that arise.

The difficulty of solving this problem originates from the non-linearity of the equation governing the flow of fluid in the fracture, the non-local character of the elastic response of the fracture, and the time-dependence of the equation governing the exchange of fluid between the fracture and the rock. These nonlocal and nonlinear effects yield a complex solution structure that involves processes at the very small scale near the tip of the fracture. Our theoretical approach gives detailed solutions of the crack tip region and identifies the important processes controlling the fracture growth: viscosity, toughness and leak-off. The parameters which quantify these processes can be identified from critical scaling relationships: this gives us an understanding of the changes in behavior near the tip. This work has been applied to plane strain hydraulic fractures and assumes a self-similar solution. However, our methodology can be extended to situations when time-dependence must be included and when the issue of fluid lag is important.