

PhD OPENINGS AT THE UNIVERSITY OF MINNESOTA

Theoretical and Experimental Research in the Mechanics of Fluid-Driven Fractures



The Petroleum Geomechanics Group at the University of Minnesota (UMN) is seeking talented doctoral students to conduct theoretical and experimental research on the mechanics of fluid-driven fractures. Hydraulic fractures represent a particular class of tensile fractures that propagate in solid media, typically under pre-existing compressive stresses, as a result of internal pressurization by an injected viscous fluid. Hydraulic fractures are most commonly engineered for the stimulation of hydrocarbon-bearing rock strata to increase the production of oil and gas wells, but there are other industrial applications such as remediation projects in contaminated soils, or preconditioning and cave inducement in mining. Furthermore, hydraulic fractures manifest at the geological scale as kilometre-long vertical dikes bringing magma from deep underground chambers to the earth's surface, or as sub-horizontal fractures known as sills that divert magma from dikes.

Hydraulic fractures represent a challenging area of research in view of the moving boundary nature of the problem (propagating crack edge and generally distinct fracturing fluid front), and the non-linear and non-local coupling between fluid flow in the crack, opening and propagation of the fracture, and diffusion of fluid in the surrounding permeable medium). Coupling of these various processes lead to a multiplicity of time and length scales, which are reflected mathematically by the existence of intermediate time asymptotics and a cascade of singularities at the crack tip, see <http://www.hydraulicfracturing.org/Research/theory-1.html> for further details and for references. The research group at the University of Minnesota is a leader in this area, with several breakthroughs to its credit, the results of a sustained effort over more than 10 years.

The current research is concerned with the propagation of a hydraulic fracture near a free surface. The investigation involves an international cooperation between the University of Minnesota and CSIRO Petroleum in Australia. Fundamental questions that arise in connection to this problem are related to the influence of the in-situ stresses and gravity on the shape of the fracture (including the breakthrough radius, the distance from the fluid source at which the fracture daylights), the evolution of the fracture shape and size, the variation of internal fluid pressure with time and the dependence of the process on the rock and fluid properties. The modeling effort, the focus of the activity at the UMN, will deal with the development of computational models capable of simulating the growth of a bowl-shaped fracture, and with the tabulation of solutions in a parametric space to ensure most generality of the obtained numerical solutions. The laboratory work, to be carried out at CSIRO Petroleum, will involve near-surface hydraulic fracturing experiments in Polymethylmethacrylate (PMMA) and in silica glass, under confined and unconfined conditions.

For inquiries, please contact Dr. Emmanuel Detournay (detou001@umn.edu). Interested individuals should have a bachelor or Master's degree from the Departments of Mathematics & Mechanics, Physics, or Geophysics. The research fellowships are awarded on a competitive basis and include a full tuition coverage, health insurance, and an approximately \$1,600 monthly stipend.

Geomechanics Program at the UMN. The graduate program in Geomechanics at the University of Minnesota focuses on the applications of scientific principles and engineering techniques to the study of rock, soil, subsurface fluids, and biological materials. The program has seven full-time faculty and one adjunct faculty member in geomechanics engineering, with several faculty in related fields. Graduate enrollment in the group includes approximately twenty-five students. Majority of the full-time students are in the Ph.D. program. For more details, see the Geomechanics Brochure at <http://www.ce.umn.edu/graduate/geome/>.

University of Minnesota. Founded in 1851, the University of Minnesota is one of the most comprehensive public universities in the United States and ranks among the most prestigious. It is both the state land-grant university, and the state's primary research university, with faculty of national and international reputation. The University's annual budget is over \$2.2 billion; its 2004 sponsored research awards totaled over \$500 million. The University main campus is centrally located in the Minneapolis - St Paul metropolitan area with over 2.5 million people, see <http://www1.umn.edu/twincities/index.php>.