UNIVERSITY OF CAPE TOWN
IYUNIVESITHI YASEKAPA • UNIVERSITEIT VAN KAAPSTAD

The Department of Mathematics & Applied Mathematics
has the pleasure of inviting you to the seminar talk of

Anthony Peirce

University of British Columbia

on

The Mathematics of "Fracking"

Date: Tuesday 15 May 2012
Time: 12h00 (Refreshments will be served in M331 after the lecture.
Venue: M202, Mathematics Building, University Avenue, Upper Campus, UCT

Abstract: "Fracking" is used by the oil and gas industry to enhance the production of hydrocarbons. Recently there has been considerable controversy surrounding the fracking process due to environmental concerns. Fracking makes use of a process called hydraulic fracturing (HF) by which tensile fractures are induced to propagate in brittle materials by the injection of a pressurized viscous fluid. In this talk I provide examples of natural HF and situations in which HF are used in industrial problems. Natural examples of HF include the formation of dykes by the intrusion of pressurized magma from deep chambers. They are also used in a multiplicity of engineering applications, including: the deliberate formation of fracture surfaces in granite quarries; waste disposal; remediation of contaminated soils; cave inducement in mining; and, as mentioned above, the fracturing of hydrocarbon bearing rocks in order to enhance productivity of oil and gas wells. Novel and emerging applications of this technology include CO_2 sequestration and the enhancement of fracture networks to capture geothermal energy.

I will show how dimensional reasoning can be used to identify the fundamental power-law relationships between the variables depending on the balance between the dominant physical processes that are active. I will describe the governing equations in 1-2D as well as 2-3D models of HF, which involve a coupled system of degenerate nonlinear integro-partial differential equations as well as a free boundary. We demonstrate that a re-scaling of these models and dominant balance arguments can be used to identify special asymptotic solutions that are of crucial importance in the location of the fracture free boundary. I discuss the challenges for efficient and robust numerical modeling of the 2-3D HF problem and some techniques recently developed to resolve these problems, including: a novel Implicit Level Set Algorithm to resolve the free boundary problem; an Extended Finite Element (XFEM) methodology for HF; and a Kalman Filter methodology to identify the location of propagating fractures from remote measurements. The efficacy of these techniques is demonstrated with numerical results.

Relevant papers can be found at: http://www.math.ubc.ca/~peirce

Everybody welcome!