Structural Engineering Seminar Series

CEE595S

Paul Segall

Professor, Stanford University

Understanding the Mechanics of Induced Seismicity

Abstract: Since the pioneering study at Rangely, Colorado, induced seismicity due to fluid injection has been understood to result from a decrease in effective normal stress acting on faults due to increase in pore-fluid pressure. Much attention has thus been given to the spatiotemporal distribution of pore-pressure resulting from injection. Yet, there are well documented cases in which oil and gas production, with dramatic decreases in reservoir pressure have triggered earthquakes. This is opposite to expectation based on the effective stress concept, but can be well understood with Biot's theory of poroelasticity. In this talk I will explore whether poroelastic effects are important in injection induced seismicity. Several surprising results follow from simple models, including that abrupt shut-in (cessation of injection) can lead to locally sharp increases in seismicity rate. In addition, poroelastic stressing can destabilize faults that are hydraulically isolated from injection horizons. Finally, the maximum magnitude of induced events has been observed to occur post-injection, which presents a clear problem for so-called 'stop light' mitigation systems. Dynamic rupture simulations on rough faults are being used to explore the size distribution of triggered earthquakes as a function of the background stress state. I suggest that under low ambient shear stresses rupture extents are limited by the time varying volume of perturbed crust. This leads to time dependence in the frequency magnitude distribution of earthquake sizes, as has been observed in Basel, Switzerland. In this limit, larger events post shut-in are not unexpected.

Bio: Paul Segall is a geophysicist recognized for his work on earthquake and volcanic processes. He is known for developing methods for utilizing deformations of the earth's crust, determined by both space and ground based sensors, to reveal fault slip and magma chamber dilation at depth in the earth, and for developing physics-based models of faults and magmatic systems. Segall was born in California and raised in upstate New York and Cleveland, Ohio. He graduated from Case Western Reserve University with B.S. and M.S. degrees in Earth Sciences, and from Stanford University with a Ph.D. in Geology in 1981. He worked at the U.S. Geological Survey, Office of Earthquake Studies from 1981 until 1993, at which time he joined the Geophysics faculty at Stanford. He is a Fellow of the American Geophysical Union and the Geological Society of America, a member of the U.S. National Academy of Sciences, and was awarded the James B. Macelwane Medal (1990) and the Charles A. Whitten Medal (2014) of the American Geophysical Union.

Monday, September 18th, 4:00-5:00pm
1310 Yeh Student Center