Global-COE Frontier Seminar

Title: From the Nano to the Tectonic Scale - Rheological Constraints on Earthquake Nucleation and Coseismic

Speaker: Dr. David L. Goldsby
Affiliation: Department of Geological Sciences, Brown University
Date & Time: 14:00 - 15:00 on Monday, April 20, 2009
Place: Earth Science Bldg. 5F CHIKEN Lecture Room #513
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Abstract:

Static fault strength and earthquake nucleation are controlled by the frictional properties of rocks at slow, quasistatic slip rates. These properties have been extensively investigated in the laboratory and are well described by empirical rate- and state-variable friction laws. Despite the widespread application of these laws in earthquake mechanics, and the longstanding knowledge that macroscopic fault behavior results from the rheological properties of highly stressed microscopic asperity contacts on faults, specific contact-scale mechanisms are still the subject of intense research. Dynamic fault strength, at slip rates of mm/s up to ~1 m/s, is expected to be controlled initially by contact-scale mechanisms associated with rapid heating which differ from those underlying rate and state friction. With continuing coseismic slip, dynamic strength will be controlled by macroscopic mechanisms associated with heating of the entire fault zone, such as bulk melting and thermal pressurization of pore fluid. These and other high-speed weakening mechanisms have been largely unexplored in the laboratory. Yet, these weakening mechanisms control seismological observables, such as the pulse vs. crack nature of dynamic rupture, and the magnitudes of stress drops, peak accelerations, and strong ground motions.

Here I present the results of laboratory experiments designed to 1) identify the micromechanisms of rate and state friction and 2) investigate dynamic fault-weakening processes. Toward the first goal, indentation creep and 'scratch' tests are being conducted to measure frictional properties of single asperity contacts. Microstructural analyses correlated with the observed friction data help to constrain asperity-scale deformation mechanisms. Toward the second goal, we are conducting extensive high-speed friction experiments on a variety of crustal rocks. Our experiments to date activate two dynamic fault weakening mechanisms - ‘flash’ heating of asperity contacts, and weakening due to thixotropy of hydrated, ultra-comminuted wear products, i.e., ‘silica gel’, for silica-rich rocks. Both weakening mechanisms are strongly velocity-dependent and yield extrapolated values of the friction coefficient of 0.3 or less at seismic slip rates. The emerging view from these and other studies is that low shear strength of rocks at coseismic slip rates is the rule rather than the exception. This observation suggests a means by which faults can operate with high static strength and low tectonic stress, yielding low coseismic heat production and small static stress drops, in agreement with heat flow data and seismic data, respectively.