Résumé du séminaire du jeudi 04 mai 2006:

Fault Zone Structure and Dynamic Weakening: evidence from laboratory experiments, field observations and numerical simulations.

Massimo Cocco, *Istituto Nazionale di Geofisica e Vulcanologia, Dept. of Seismology and Tectonophysics, Rome (cocco@ingv.it)*

In this study I will discuss the results of recent geological observations of fault zone structure as well as of laboratory and seismological studies aimed at constraining the dynamic traction evolution during earthquake ruptures. Fracture mechanics has been considered for a long time by seismologists and geophysicists as a reference framework for interpreting dynamic earthquake propagation. Although it has been always clear that earthquakes in natural faults are much more complex, this approach has often been used to identify and describe the different physical parameters defining the energy balance and the mechanical work required to sustain rupture propagation. To this goal, dynamic fault weakening has been represented by a slip weakening law and fracture energy and the characteristic slip weakening distance have been considered as constitutive parameters (depending on the material or fault zone properties). In this framework, fracture energy is one of the key ingredients to describe the energy flux per unit area at the crack-tip and the dynamic energy release rate spent to allow the crack advance on the fault plane.

Recent field observations reveal that natural fault zones are characterized by an evident slip localization and a complex structure: slip occurs on a principal slipping zone located in a ultracataclastic fault core, which is surrounded by a damage zone. The main implication of these observations is that faults have a finite thickness and are filled by gouge and wear materials produced during faulting. Slip localization has been also observed during laboratory experiments of fault friction at relatively large displacements. One significant consequence concerns the main observable physical quantities characterizing the rupture process: shear stress, slip and slip velocity used in the constitutive formulation should be considered macroscopic averages of complex processes occurring within the slipping zone (gouge formation and evolutions, fracture of asperity contacts,…). In this context, fault friction should also be considered in a macroscopic sense or as a phenomenological description of complex processes occurring within the fault core.

In this study I will review the classic concepts used in fracture mechanics and I will interpret the evolution of dynamic traction during earthquake propagation to define the macroscopic frictional work. By presenting new results of seismological investigations I will discuss the estimates of critical slip weakening distance and fracture energy. These parameters cannot be considered as constitutive parameters and they are indeed scale dependent quantities. The traction evolution on the fault plane has been constrained for several recent earthquakes; the traction versus slip curves has been used to measure the breakdown work (W_b), defined as the excess of work over some residual frictional stress. These estimates of breakdown work are equivalent to fracture energy defined in the classic slip weakening model. Breakdown work is computed for complex traction evolutions characterized by an evident dynamic fault weakening. It represents the work spent to allow the rupture to advance, but for real earthquakes on natural fault zones it might contain an indefinite mixture of heat and surface energy. This conclusion has important implication for the earthquake energy balance and for the definition of the macroscopic frictional work. In this work, I will compare the inferred breakdown work with geological estimates of surface energy. The latter might be useful to constrain the partitioning between surface energy and heat.