A. Bizzarri (1), M. Cocco (2)

(1) I.N.G.V. – Bologna
(2) I.N.G.V. – Roma

THERMAL PRESSURIZATION IN 3 – D DYNAMIC SPONTANEOUS RUPTURE MODELS

We investigate the role of frictional heating and thermal pressurization on earthquake ruptures by modeling the spontaneous propagation of a 3–D crack on a planar fault governed by different constitutive laws and allowing the evolution of effective normal stress. We use both slip–weakening (SW) and rate– and state–dependent friction laws (RS); in this latter case we employ the Linker and Dieterich (1992) evolution law for the state variable and we couple the temporal variations of the friction coefficient with those of the effective normal stress.

Our modeling results confirm the findings of previous studies that thermal pressurization reduces the temperature increase caused by frictional heating. However, the effect of the slipping zone thickness (*w*) on temperature changes is stronger than that of thermal pressurization, at least for a constant porosity model. Pore pressure and effective normal stress evolution affect the dynamic propagation of the earthquake rupture producing a shorter breakdown time, larger breakdown stress drop and rupture velocity. Frictional heating and thermal pressurization also modify the traction evolution, depending on the value of and hydraulic diffusivity (*w*). Thermally activated pore pressure changes caused by frictional heating yield temporal variations of the effective normal stress acting on the fault plane. In the framework of RS friction, these thermal perturbations modify both effective normal stress and friction coefficient. Breakdown stress drop, slip–weakening distance and fracture energy increase for decreasing values of *w* and *w* and we propose scaling relations to evaluate the effects of these physical parameters.

We have also investigated the effects of choosing different evolution laws for the state variable. We have performed simulations accounting for the porosity evolution during the breakdown time. Our results point out that thermal pressurization modifies the shape of the slip–weakening curve. For particular configurations the traction versus slip curves display a gradual and continuous weakening for increasing slip: in these cases, the definitions of a minimum residual stress and the slip weakening distance become meaningless. The results of this study point out that thermal pressurization produces very large values breakdown stress drop, that should correspond to a nearly complete stress drop. If the results of these numerical simulations are applicable to real earthquakes, we should find a signature of these high stress drop values in the radiated seismograms. Seismological estimates of stress drop do not support the common evidence of a nearly complete stress release during dynamic failure. We will discuss this problem in this study.