Geophysical Research Abstracts, Vol. 7, 05125, 2005
SRef-ID: 1607-7962/gra/EGU05-A-05125

Fracture Propagation, Stable Sliding and Stick Slip by Pore Pressurization of a Fault Gouge Analog

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Thermal pressurization of pore fluid has recently been proposed as a mechanism for velocity weakening of fault gouge materials (Mase et al., [1984]).]). However, in drained conditions, recent theoretical studies (Walder and Nur [1984], Rice [1992], Miller [2003]) have emphasized that the development of pore pressure excess is profoundly influenced by the spatial and temporal variations of permeability. To investigate the effect of pore pressurization in drained conditions on fault gouges, a Fontainebleau sandstone sample of 14% porosity was deformed tri-axially at the Laboratoire de Géologie of ENS Paris, under 100 MPa confinement in saturated conditions. In this preliminary study, we present a non-exhaustive compilation of data obtained during this pore pressure cycling experiment, including AE locations, continuous ultrasonic waveform summaries of rupture, wavespeed and permeability variations, and mechanical data. Such an extensive set of experimental data is, to our knowledge, the first to be obtained and could enhance our understanding of earthquake genesis, foreshocks and aftershocks patterns.
The first cycle consisted in loading the sample elastically up to 250 MPa differential stress. A subsequent increase in pore pressure induced brittle failure at Pp=72MPa, with an associated stress drop of 150 MPa. Over 5 000 AE were located, demonstrating the formation of a fracture nucleation patch and instable failure propagation. Measured permeability showed that the nucleation of a damage/fault zone induced a permeability reduction. P wave velocities evolution also showed the extent of permanent damage in the rock. A lower permeability in the faulted region of the specimen induced large amounts of aftershocks, clearly highlighting the fault region, in particular during pore depressurization. Continuous ultrasonic waveforms of failure showed that the peak of activity was preceded by large amounts of premonitory AEs. Failure propagation was accompanied by the apparition of low frequencies in the acous-

togramm.
During the second cycle, the fractured specimen was reloaded elastically several times up to 145MPa differential stress. Subsequent pore pressurizations reactivated the fault and triggered stable sliding or stick slip depending on stress boundary conditions and pore pressure increase rate. Slow pore pressurization (0.05MPa/sec) induced frictional stable sliding, while sending a fast pore pressure pulse (from 0 to 80 MPa in two seconds) induced stick slip events (with an associated stress drop of 50 MPa). Amplitude of the slip depended on whether deviatoric stress was maintained constant or not. During fast pressurization of the fractured specimen, very few premonitory AE's occurred. However, a large numbers of "pore-pressure induced" afterchocks were observed. Time during which activity peaked seemed to depend qualitatively on the amount of slip which was accompanied, again, by low frequencies in the acoustogramms.