Geophysical Research Abstracts,
Vol. 10, EGU2008-A-05441, 2008
SRef-ID: 1607-7962/gra/EGU2008-A-05441
EGU General Assembly 2008

Experimental Measurements of Permeability Evolution during Triaxial Compression of Initially Intact Crystalline Rocks and Implications for Fluid Flow in Fault Zones

T.M. Mitchell (1,2) and D.R. Faulkner (2)

(1) Now at Graduate School of Science, Department of Earth and Planetary Systems Sciences, Hiroshima University, 1-3-1 Kagami-yama, Higashi-Hiroshima city, 739-8526, Japan, (2) Rock Deformation Laboratory, Department of Earth and Ocean Sciences, University of Liverpool, 4 Brownlow Street, Liverpool, Merseyside, UK (tom-mitchell@hiroshima-u.ac.jp)

Detailed experimental studies of the development of permeability of crustal rock during deformation are essential in helping to understand fault mechanics and constrain larger scale models that predict bulk fluid flow within the crust. The strength, permeability and pore fluid volume evolution of initially intact crystalline rocks (Cerro Cristales granodiorite and Westerly granite) under increasing differential load leading to macroscopic failure has been determined at water pore pressures of 50 MPa and varying effective pressures from 10 to 50 MPa. Permeability is seen to increase by up to, and over, two orders of magnitude prior to macroscopic failure, with the greatest increase seen at lowest effective pressures. Post-failure permeability is shown to be over 3 orders of magnitude higher than initial intact permeabilities and approaches lower the limit of predicted in situ bulk crustal permeabilities. Increasing amplitude cyclic loading tests show permeability-stress hysteresis, with high permeabilities maintained as differential stress is reduced and the greatest permeability increases are seen between 90-99% of the failure stress. Pre-failure permeabilities are nearly seven to nine orders of magnitude lower than that predicted by some high pressure diffusive models suggesting that, if these models are correct, microfracture matrix flow cannot dominate, and that bulk fluid flow must be dominated by larger scale structures such as macrofractures. We present a model, based on our data, in which the permeability of a highly-stressed fault tip process zone in low-permeability crystalline rocks increases by more than 2 orders of magnitude, while stress reduction related to the onward migration of the fault tip close damage zone cracks, and some permeability is maintained due to hysteresis from permanent microfracture damage.