Geophysical Research Abstracts, Vol. 9, 04044, 2007
SRef-ID: 1607-7962/gra/EGU2007-A-04044

Faulting Related Initiation and Growth of Compaction Localization in Porous Sedimentary Rocks

W. Zhu

Department of Geology and Geophysics, Woods Hole Oceanographic Institution, USA
(wzhu@whoi.edu / Fax: 1 508 457-2183 / Phone: 1 508 289-3355)

Generation and maintenance of high pore pressure in active tectonic environments critically depends on permeability, a dynamic physical parameter that is sensitive to pressure, temperature and stress. Experimental studies have shown that permeability can be significantly modified under hydrostatic or non-hydrostatic stresses. Under relatively low confinement and temperature, rocks fail by brittle faulting. In the brittle faulting regime, deformation is mainly localized in shear bands, which are usually developed at high angles to the maximum compression direction. Dilatancy and strain softening are usually accompanied by permeability enhancement. During an earthquake cycle, shear localization can provide conduits for pore fluid discharge. With increasing confining pressure and temperature, compaction localization develops in compactant porous sandstones. In the compaction localization regime, deformation is localized in compaction bands. These compaction bands, developed under relatively high confinements, are morphologically different from shear bands developed under low confinements. When a rock fails by compaction localization, an array of discrete bands or diffused zones are observed sub-perpendicular to maximum compression. It is demonstrated that the development of compaction bands generally induces significant permeability reduction and provides hydraulic barriers for pore pressure excess.

In many geological settings, different modes of strain localization coexist. An intriguing question is, at conditions where an intact porous rock fails by compaction localization, what type of dynamic hydromechanical behavior should we expect if the rock has a pre-existing fault? To address this question, we performed a set of two-step experiments. First, we deformed a suite of samples of porous Bentheim sandstone samples at an effective pressure, P_{eff}, of 5 MPa until shear localization developed in each. Next, we reloaded each sample and deformed it at effective pressures P_{eff} of 5-200 MPa.

At 5 MPa the samples showed stable sliding along the pre-existing shear-band. With the increasing confining pressure, compaction localization occurred in the pre-faulted rocks. The compaction bands generally initiated at the pre-existing fault and gradually developed into a series of bands that intersect the fault. The experimental data also indicate that the presence of shear localization can be very effective in enhancing the local stress and activating various failure modes. The interaction between the shear localization and compaction localization significantly alters the pore structure and thus plays an important role in pore pressure excess and earthquake generations in seismogenic zone.