Geophysical Research Abstracts,
Vol. 10, EGU2008-A-05863, 2008
SRef-ID: 1607-7962/gra/EGU2008-A-05863
EGU General Assembly 2008

From the trench to the seismogenic zone: Establishing links between, fluid pressure, low-T metamorphism, and fault stability

D. M. Saffer (1), R. Skarbek (1), H. J. Tobin (2), and A. W. McKiernan (1)

(1) Department of Geosciences, The Pennsylvania State University, University Park, PA , USA, (2) Department of Geology & Geophysics, University of Wisconsin-Madison, Madison, WI, USA (dsaffer@geosc.psu.edu / 814-863-7823 / 814-865-7965)

Fluid pressure within subduction zones profoundly affects fault strength and sliding stability through its control on effective stress. Quantifying the factors that control pore pressure development, its spatial distribution, and its relationship to observed fault mechanical behaviors is needed as a first-order test of conceptual models that suggest fluid content or pressure control the updip limit of seismogenesis. Here, we discuss our work on the well-studied Nankai and Costa Rican margins, with the aim of constraining fluid pressure from the trench to the uppermost seismogenic zone.

We use a combination of laboratory consolidation tests, porosity data from drilling near the trench, and porosity inferred from seismic reflection velocities to constrain in situ effective stress and pore pressure immediately beneath the megathrust, from the deformation front to $\sim$20 km downdip of the trench. As a second, independent approach to estimate pore pressure, we use a forward model of loading and pore pressure diffusion. We define sediment hydraulic and mechanical properties through extensive geotechnical testing of sediments from ODP Legs 190 (Nankai margin) and 205 (Costa Rican margin). We use constant rate of strain (CRS) consolidation experiments to define coefficient of consolidation (c_v), coefficient of volume compressibility (m_v), and permeability (k), at effective stresses from 0 - 90 MPa. Permeabilities derived from the CRS tests are supplemented by flow-through tests in which a hydraulic gradient is imposed across a sample.

Modeled pore pressures are in good agreement with those derived from consolidation tests, and from inferred and observed porosities. Our results show that high pore pressures and associated underconsolidation persist to tens of km from the trench, leading to low effective stress and potentially suppressing unstable slip in the updip region. At both margins, we also observe that drainage allows the zone of minimum effective stress to migrate down section, which may partly control downstepping of the décollement. Notably, the onset of drainage - and concomitant reduction in underconsolidation and increase in effective stress - are broadly coincident with the location of diminished seismic reflection amplitude, decollement downstepping, and the updip termination of coseismic slip. One key implication is that at both accretionary and erosional margins, drainage and the dissipation of fluid pressure are spatially correlated with the updip limit of the seismogenic zone. This is consistent with conceptual models in which the plate boundary transitions with depth from a fault with high water content that slips stably, to a relatively “dry” fault capable of failing seismically.