TO Brownbag Seminar, Tuesday (10/02/2012)
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Geology of the Earthquake Source: Insights from exhumed heterogeneous fault zones on the spectrum of active fault slip styles

Over the last decade, a range of active faults slip styles - including continuous and transient aseismic creep, episodic tremor, and regular, low frequency and very low frequency earthquakes - have been inferred from seismic and geodetic observations. In subduction margins, these slip styles are observed predominantly along an up to 2 km thick shear zone in underthrust sediments along the subduction thrust interface.

If slip is accommodated within a layer of deformed sediments, slip style depends on the bulk rheology of this shear zone, which has a finite thickness and contains fault rocks of heterogeneous composition. In this case, intermingled lithologies within the subduction thrust interface may have different viscosity, frictional properties, and preferred deformation mechanism. For example, at subgreenschist facies metamorphic conditions, fine-grained phyllosilicate-dominated mudstones tend to experience viscous shearing flow by dissolution-precipitation creep, whereas coarse-grained quartz-dominated sandstones tend to act like competent, brittle volumes.

In the rock record, deformation of mixed lithologies is well represented in tectonic mélanges. In cases where relatively competent lenses (phacoids) of chert, sandstone, and basalt are distributed within a cleaved pelitic matrix, the matrix deformed predominantly by continuous deformation accommodated by dissolution-precipitation creep, whereas phacoids are commonly fractured. An anastomosing fault-fracture mesh, defined by slickenfibre-coated shear surfaces linked by quartz-calcite extension veins, cross-cuts the subgreenschist Chrystalls Beach Complex melange, New Zealand. The slickenfibre shear surfaces in this case developed along cleavage planes, and along matrix-phacoid contacts, and represent shear failure along pre-existing weak planes under high fluid pressure. Displacement along these shear surfaces is generally incremental, with slip of 10 * 100 *m in each increment. Overall, therefore, melanges deform by continuous deformation in the matrix, fracturing of phacoids, and shear failure along weak, overpressured planes.

As a rule of thumb, a matrix fraction equal to or greater than 20% appears to allow the shear zone as a whole to deform in a continuous style, although localized sliding may occur on numerous, small displacement shear surfaces. The hypothesis that follows is that the bulk rheology of a tabular fault depends on the ratio of competent to incompetent material, and that whether a fault creeps or slips episodically (at seismic rates) may be governed by the amount, size, and distribution of competent 'phacoids', and the presence or absence of weak, pre-existing planes that allow for frictional failure over large distances.