Rheology and stress in subduction zones around the aseismic/seismic transition

*John P Platt[1], Haoran Xia[1], Schmidt William[1]

1. University of Southern California

Subduction channels are commonly occupied by deformed and metamorphosed basaltic rocks, pelagic and clastic sediments, which form a zone up to several km thick to depths of at least 40 km. At temperatures above ~ 350°C (corresponding to depths of >25-35 km) the subduction zone is aseismic, and much of the relative motion is accommodated by ductile deformation in the subduction channel. Microstructures in metagreywacke suggest deformation occurs mainly by solution-redeposition creep in quartz. Interlayered metachert shows evidence for dislocation creep at relatively low stresses (6-13 MPa shear stress). Lack of evidence for significant strength contrast with metagreywacke suggests that this is a reasonable estimate for the shear stress in the channel as a whole. Metabasaltic rocks deform mainly by transformation-assisted diffusional creep during blueschist facies metamorphism, which may require somewhat higher stresses. Quartz flow laws for dislocation and solution-redeposition creep suggest strain rates of ~ 10^{-13} sec^{-1} at 500°C and 10 MPa shear stress: this is sufficient to accommodate 30% of a 50km/m.y. convergence rate within a 5 km wide subduction channel.
The up-dip transition into the seismic zone occurs through a region where deformation is still distributed over a thickness of several km, but occurs by a combination of microcracking and solution-redeposition. This process requires a high fluid flux, released by dehydration reactions down-dip, and produces a highly differentiated deformational fabric with alternating mm-scale quartz and phyllosilicate-rich bands, and very abundant quartz veins. Bursts of dilational microcracking in zones 100-200 m thick may cause cyclic fluctuations in fluid pressure, and may be associated with episodic tremor and slow slip events. Shear stress estimates from dislocation creep microstructures in dynamically recrystallized metachert are ~12 MPa.

Keywords: Subduction zone interface, paleopiezometry, pressure solution, dislocation creep, tremor, slow slip