Geophysical Research Abstracts
Vol. 12, EGU2010-7226-1, 2010
EGU General Assembly 2010

Megathrust Earthquakes and Sediment Input to the Subduction Channel

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HABITATS OF GREAT MEGATHRUST EARTHQUAKES: Great megathrust earthquakes (Mw8.5 or higher) most commonly (∼65%) nucleate along subduction zones (SZ) bordered by laterally continuous (more than 500 km), sediment-flooded trenches. Examples include: south-central Chile (1922, Mw8.5; 1960, Mw9.5), eastern Alaska (1964, Mw9.2), Sumatra (2004, Mw9.1), Cascadia (1700, Mw9.0), Colombia (1906, Mw8.8), Sumatra (1883, Mw8.8), west-central Aleutian (1965, Mw8.7), central Aleutian (1986, Mw8.7), Sumatra (2005, Mw8.6), and Nankai (1707, Mw8.5). All known megathrust events greater than Mw9 ruptured at sediment-charged SZs (Alaska, S.C. Chile, Sumatra).

Sediment entering high-seismicity SZs is typically a 1-3-km-thick wedge of trench-axis turbidite beds overlying a 0.3-2-km-thick sequence of hemipelagic or abyssal turbiditic deposits that accrued seaward of the trench. Most commonly, laterally-continuous turbidite wedges are built by down-axis flowing turbidity currents sourced from mountainous and/or glaciated drainages (e.g., SE Alaska, Cascadia, Southern Andes, Himalaya). Great rupture events also occur at SZs receiving little sediment, for example Kamchatka (1952, Mw9.0), Kuril Islands (1963, Mw8.5) and north Chile SZs (1868, Mw9.0). These SZs exhibit evidence of upper plate thinning, subsidence, and truncation effected by frontal and basal subduction erosion. They also have a SC filled with ∼1 km or more of debris in transport toward the mantle.

WORKINGS OF THE SUBDUCTION CHANNEL (SC): Beneath the submerged forearc, the SC functions to transport subducted ocean floor sediment and tectonically eroded forearc debris toward and ultimately into the mantle. The SC is the lowest structural unit containing upper plate crustal material and the seismogenic zone runs along the SC's upper boundary. It has long been conjectured (e.g., Ruff, 1989; PAGEOPH, v. 129. Nos 1/2) that a laterally uninterrupted, sediment- or debris-charged SC serves to smooth the surface of interplate slip to set up conditions for lengthy, high moment-release ruptures. Maximum slip is commonly concentrated beneath a locally thinned, upper plate crust underlying prominent forearc basins. These structures, in positive feed back, are likely deepened co-seismically by enhance basal subduction erosion. The removed material presumably lowers the effective stress on the decollement and sets up conditions for follow-on events of high, co-seismic slip. The SC also works tectonically to underplate the base of the inner submerged forearc and induce co-seismic uplift at high-angle reverse faults.

SEISMIC CONSEQUENCES OF SUBDUCTION ZONE FEEDING: Observations imply that subducted bathymetric ridges and seamounts act to both nucleate seismic rupture and also arrest lateral rupturing. Thick sections of sedimentary and erosional debris entering the subduction channel appear to act differently and favor (1) continuation of rupture, (2) large slip beneath forearc basins, and (3) propogation of slip upward at outer-forearc splay faults and nearshore reverse faults to generate both local and trans-oceanic tsunamis. The potential for nucleation of great megathrust earthquakes along thickly sediment SZs, no matter the rate or lower plate underthrusting, obliquity of convergence, or crustal age, must be set high. Similarly, seismogenic risk for highly erosional SZs little perturbed by subducting relief must also be set high.