Mapping Great Earthquake Rupture Area

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At the northern Cascadia margin, the Juan de Fuca plate is underthrusting North America at about 45 mm/yr. Thermal and deformation studies indicate that, off southern Vancouver Island, the interplate interface is presently fully locked for a distance of some 60 km downdip from the deformation front. Great thrust earthquakes on this section of the interface, with magnitudes of up to 9, have been estimated to occur at an average interval of about 590 yr. Further downdip there is a transition zone from fully locked behavior to aseismic sliding, with the deep aseismic zone exhibiting slow slip thrust events.

We show that at the northern Cascadia margin there is a change in the reflection character on seismic images from a thin reflection package (< 2 km thick) where the subduction thrust is inferred to be seismogenic, to a broad reflection band (> 4 km thick) at greater depth where there is aseismic slip. This change in reflection character provides us with a new technique for detailed mapping of the maximum landward extent of great earthquake rupture. The landward edge of the locked zone on the northern Cascadia subduction thrust inferred by reflection imaging appears to lie some 25-30 km closer to the land than estimated from thermal and dislocation modeling, possibly suggesting a somewhat greater megathrust seismic hazard at inland cities.

Deep seismic reflection images from Alaska, Chile and SW Japan show a similar broad reflection band above the subduction thrust in the region of stable sliding and thin thrust reflections further seaward, perhaps suggesting that reflection imaging may be a globally important predictive tool for determining the maximum expected rupture area in megathrust earthquakes. The eastern Alaska-Aleutian subduction zone is an ideal setting for testing this hypothesis. In this region, recent megathrust earthquake rupture areas are defined by aftershocks, inversion of geodetic data points to strong lateral variations in coupling, and wide shelf area allows for a relatively inexpensive and full marine mapping of the locked and transition zones, and partial mapping of the slow slip zone.