

Reflection signature of seismic and aseismic slip on the northern Cascadia subduction thrust

Mladen R. Nedimovic, Roy D. Hyndman, Kumar Ramachandran, George D. Spence & Thomas M. Brocher

Lamont-Doherty Earth Observatory of Columbia University, 61 Route 9W, P. O. Box 1000, Palisades, NY, 10964-8000, USA

Pacific Geoscience Centre, Geological Survey of Canada, Sidney, BC, Canada

School of Earth and Ocean Sciences, University of Victoria, Victoria, BC, Canada

U.S. Geological Survey, Menlo Park, California, 94025, USA

At the northern Cascadia margin, the Juan de Fuca plate is underthrusting North America at about 45 mm/yr. The downdip extent of coupling between the two plates is difficult to determine because the most recent great thrust earthquake, thought to have been in 1700, occurred before instrumental recording. Thermal and deformation studies indicate that, off southern Vancouver Island, the interplate interface is presently fully locked for a distance of ~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 use reflection data from four acquisition campaigns, carried out from 1984 to 1998, to show that there is a change in the reflection character on seismic images from a thin sharp event (< 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. Our results imply a wider zone of coupling than currently proposed and possibly suggest a somewhat greater megathrust seismic hazard at inland cities.

More accurate mapping of locked seismogenic zones requires calibration of the reflection method at a subduction zone that has experienced megathrust earthquakes with the rupture extent defined by aftershocks and geodetic data. 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.