Limited Hydration of the Juan de Fuca, Gorda and Explorer Plates and its effect on the Intraslab Seismicity

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Using data collected offshore Nicaragua and Costa Rica, Ranero et al. (2003) showed that seismic reflection imaging may be a useful tool for determining the depth and extent of hydration of the oceanic lithosphere approaching a subduction zone. The water stored in subducting plates is released landward of the trenches through dehydration and is believed to strongly affect a number of processes of importance to natural hazard studies. The released water promotes partial melting responsible for arc magmatism and leads to dehydration embrittlement that is often considered to be the most plausible earthquake mechanism for intraslab events at intermediate depths of 50-300 km. Free water can also affect the physical properties of rocks at the megathrust by reducing the temperature at which transition from brittle to ductile deformation occurs, thus possibly having significant impact on the location of the downdip limit of seismogenic zones.

To study hydration processes at the Cascadia convergent margin, we compiled a database of all regional seismic reflection surveys (streamers 3 km or longer) done across the Juan de Fuca, Gorda and Explorer plates. Unlike at the Middle America trench, oceanic lihthosphere subducted at the Cascadia margin is young, warm, and descends at a relatively shallow angle. Bending-related normal growth faulting is sparser and subtler at the Cascadia margin but, surprisingly, it begins much further seaward of the trench than offshore Nicaragua and Costa Rica and the fault density is mostly uniform. Fault planes dip steeply and are challenging to image. Where fully imaged, these faults offset the sediments, cut across the crust to Moho and penetrate into the upper mantle. However, the depth of fault penetration into the mantle appears to be far less than at the Middle America trench, suggesting limited depth of hydration for the subducting plates at the Cascadia margin. The difference in the depth and extent of hydration at the Cascadia and Middle America margins seems to correlate well with the difference in the density and magnitude of intraslab seismicity observed at both margins. This limited depth of hydration of the subducting lithosphere at the Cascadia margin may restrict the maximum magnitude of the Cascadia intraslab earthquakes to about Mw=7.