Evidence for slab permeability-controlled tremor along the Cascadia margin

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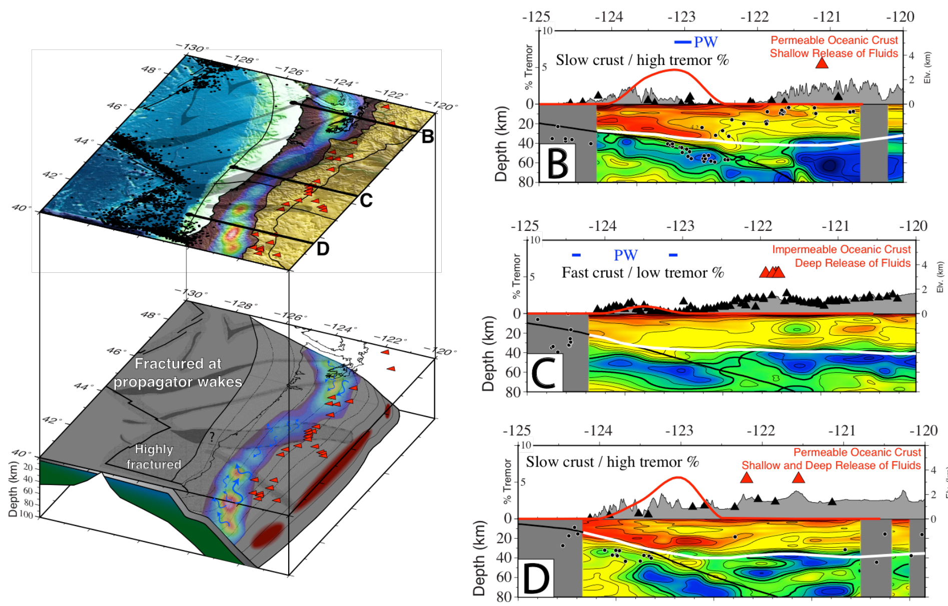
The dehydration of oceanic slabs during subduction is mainly thermally controlled and is manifested mechanically as intermediate-depth seismicity. In warm subduction zones, this dehydration also results in non-volcanic tremor, indicating relatively shallow slab dewatering. Along the Cascadia margin however, tremor density and intermediate-depth seismicity vary significantly from south to north despite little variation in the thermal structure of the Juan de Fuca Plate. To understand what controls these variations, we have constructed 3D vertical and horizontal shear-wave velocity models of the upper 80 km of the Cascadian margin through the joint inversion of Rayleigh- and Love-wave dispersion measurements and CCP-derived P-wave receiver functions. These models allow us to investigate variations in the seismic structure of the downgoing oceanic lithosphere and overlying mantle wedge, the character of the crust-mantle transition beneath the volcanic arc, and local to regional variations in crustal structure.



Along the southern and northern portions of the Cascadia margin, high seismicity rates in the subducting plate and high tremor density correlate with low shear velocities in the overriding plate's forearc and relatively little arc volcanism. The slow shear-wave velocities in the forearc crust likely represent crustal modification through fluid intrusion after being released from the downgoing slab. The seismic characteristics of these zones combined with rather sparse arc volcanism may indicate that the slab has largely dewatered by the time it reaches sub-arc depths. In contrast, the central portion of the subduction margin shows relatively low seismicity and tremor density, with relatively higher shear velocities in the forearc. This region also contains most of the young stratovolcano edifices in the Cascades, indicating that water may be retained in the slab to depths where it can feed arc volcanism. We find that deformation in the Juan de Fuca Plate prior to subduction correlates well with the lateral variations in tremor, seismicity, velocity structure, and possibly volcanism, indicating that both the permeability structure of the subducting plate and it's thermal state are important controls on the release of fluid at shallow depths.