Links Between Sediment Consolidation and Cascadia Megathrust Slip Behavior

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At sediment-rich subduction zones, megathrust slip behavior and forearc deformation are tightly linked to the physical properties and in situ stresses within underthrust and accreted sediments. Yet the role of sediment consolidation at the onset of subduction in controlling the downdip evolution and along-strike variation in megathrust fault properties and accretionary wedge structure is poorly known. Here we use controlled-source seismic data combined with ocean drilling data to constrain the sediment consolidation and in-situ stress state near the deformation front of the Cascadia subduction zone. Offshore Washington where the megathrust is inferred to be strongly locked, we find over-consolidated sediments near the deformation front that are incorporated into a strong outer wedge, with little sediment subducted. These conditions are favorable for strain accumulation on the megathrust and potential earthquake rupture close to the trench. In contrast, offshore Central Oregon, a thick under-consolidated sediment sequence is subducting, and is likely associated with elevated pore fluid pressures on the megathrust in a region where reduced locking is inferred. Our results suggest that the consolidation state of the sediments near the deformation front is a key factor contributing to megathrust slip behavior and its along-strike variation, and it may also have a significant role in the deformation style of the accretionary wedge.

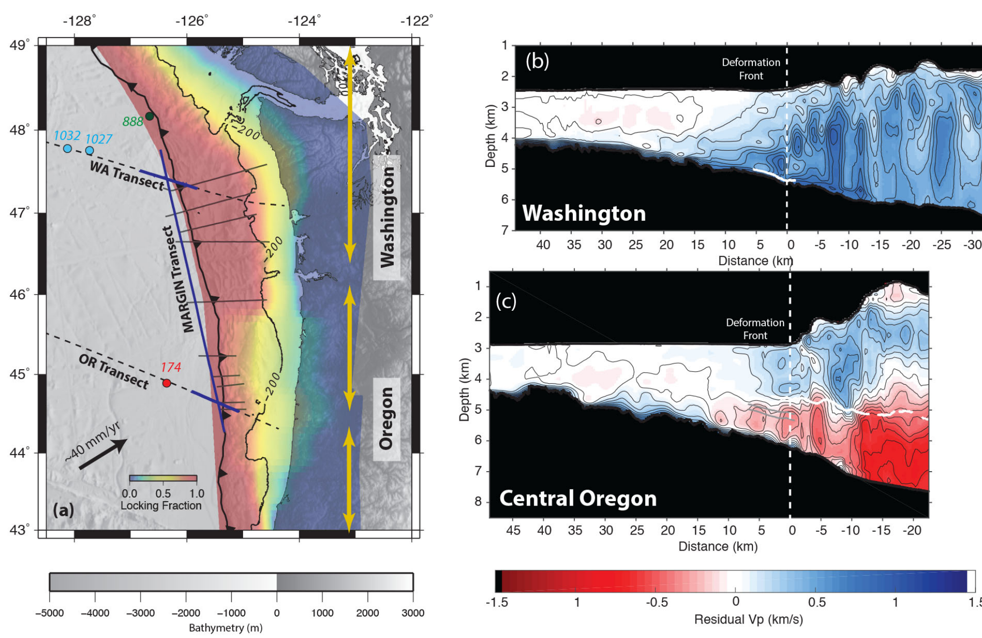

Figure 1

Figure 1 Paleo-earthquake rupture segments and current megathrust locking status of Cascadia subduction zone, and residual Vp structures offshore Washington and Central Oregon. (a) Regional map of Cascadia subduction zone superimposed by extent of paleo-earthquake rupture segments (thick yellow bars) and current megathrust locking fraction. Accretionary wedge is bounded by deformation front (barbed thick black lines) and 200 m depth contour (thin black line). Dashed black lines show seismic transects from Ridge-to-Trench experiment, with data subset used in this study in thick blue lines. Thin grey lines show previous published seismic transects from which underthrust sediment thickness is compiled. Colored circles denote locations of DSDP/ODP drilling sites. Convergence vector is represented by black arrow. (b, c) Residual Vp relative to predicted normal consolidation Vp profile.