Figuring out the Forearc: Shoreline-Crossing Seismic Imaging in Cascadia

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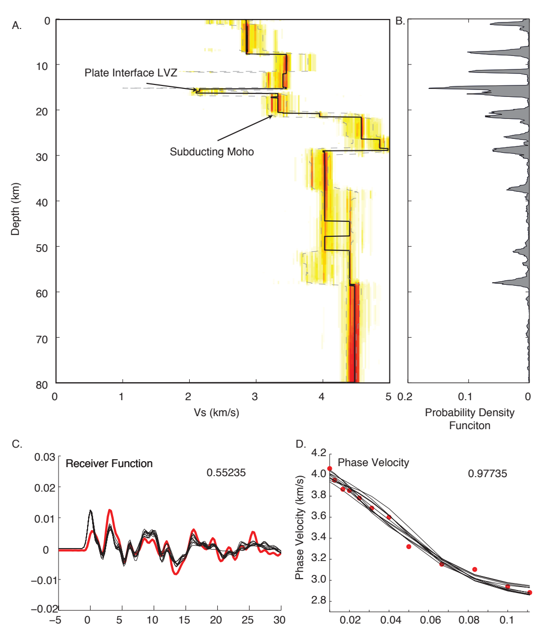
The forearc of the Cascadia subduction zone hosts a variety of tectonic behaviors, including the transition from locking along the plate interface to episodic tremor and slip and stable sliding downdip. Seismic imaging of plate interface and oceanic crustal structures in this region can provide constraints on their composition and hydrous properties, which in turn can influence their behavior along the megathrust. However, regional-scale imaging in the forearc is challenging due to its inherently amphibious nature; offshore data is essential to capture the structures underlying the full range of tectonic behavior from the deformation front to the volcanic arc. Here we present multi-scale seismic imaging results in the forearc of the Cascadia subduction zone using data from the recent Cascadia Initiative and Ridge-to-Trench experiments. Rayleigh wave phase velocities yield broad images of the entire shoreline-crossing forearc region, allowing investigation of along-strike heterogeneity as well as the transition from locking to episodic tremor and slip across the region. In a more focused area offshore Grays Harbor in central Washington, we use these phase velocities in a Bayesian joint inversion with receiver functions calculated from an ocean bottom seismometer to image detailed plate interface structure. We find evidence of an ~ 1 km thick low velocity region along the plate interface offshore within the broadly locked region. We also use onshore-offshore wide-angle reflection seismic data to investigate reflections from the plate interface, likely also due to this low velocity zone, and find there is along-strike variability in the updip extent of this feature. This indicates heterogeneity of the plate interface structure on a scale of tens of kilometers that may be related to variations in fluid pressures and subsequently seismogenic behavior along strike.



(a) Shear velocity model beneath the Cascadia forearc (OBS FN07) calculated from joint inversion of phase velocities and receiver functions. (b) Probability of an abrupt velocity interface at each depth. (c) Receiver function data (red) and example of ten synthetic accepted receiver functions (black). (d) Phase velocity curve (red circles) and example of ten synthetic phase velocity curves (black).