The Cascadia Subduction Zone Plate Roughness and Plate Boundary Amplitude Variations Constrained by Marine Seismic Data

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The Cascadia Subduction Zone is one of the few margins well-known for exceedingly low levels of recorded seismicity from the plate interface among global subduction zones. Due to the lack of historical seismicity and deep penetration seismic images, the properties of the megathrust and the transitions in slip behavior that bound the seismogenic zone are poorly constrained. The role of the geologic structures and properties of the subduction of the Juan de Fuca, Gorda, and Explorer plates could contribute to along-margin variations in slip that occurred during past earthquakes, inferred from paleoseismic studies, and in modern-day locking along the megathrust, derived from ongoing onshore geodetic studies. As part of the CAscadia Seismic Imaging Experiment 2021 (CASIE21), new multichannel seismic data were acquired aboard R/V *Marcus G. Langseth* using a 6,600 in^3 tuned air gun array and an ultra-long streamer throughout Cascadia to provide a regional-scale characterization of nearly the full Cascadia Margin, extending from the Gorda plate in the south to offshore Vancouver Island in the north. The CASIE21 project collected 18 primary dip lines spaced 50-75 km apart and oriented perpendicular to the margin from ~50 km seaward of the deformation front to the shelf, and several strike lines, including along the continental shelf to investigate segmentation near the possible down-dip limit of the seismogenic zone, and ~10 km west of the deformation front to sample the incoming plate structure and properties. The dataset was processed through pre-stack depth migration and produced both high-quality images and velocity models. The consistent processing steps for all the lines allow for a reliable interpretation of the amplitudes along the plate boundary and direct comparison between seismic lines. We interpret the top of igneous oceanic crust and the plate boundary fault throughout the margin. Removing a regional trend from these interpretations, we look at the high-frequency residuals to compare roughness of the two interpretations along the Cascadia Margin. Further, we extract the amplitude from the seismic data along these interfaces to compare their properties along the margin. The results highlight the complex interactions revealed from the structure of the shallow plate boundary fault and role of the incoming plate in Cascadia.

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