# Structural Analysis and Basal Sheer Stress in Cascadia: Implications for the Up-dip Limit of the Locked Zone

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## Abstract

Apart from the tsunami inversion of the most recent quake on the Cascadia margin dating to 1700 AD, there are few clues as to seismic moment and distribution of slip on the thrust plane during past events. Consequently, current estimates of the margin's locked zone parameters rely largely on hypothesized thermally defined limits and the inversion of geodetic data to constrain elastic half-space dislocation models. However, in the absence of geodetic data from the margin's offshore accretionary wedge, these models are unable to discriminate between different up-dip limit geometries and have generally adopted an upper limit that is coincident with the toe of the wedge. We present a preliminary analysis of structural data from the Cascadia forearc that addresses relative changes in basal shear stress across the continental margin and provides a unique constraint on the geometry and location of the up-dip limit of the locked zone. Using new, margin-wide 100m-gridded bathymetry and multiple seismic reflection profiles, the upper slope angle of the accretionary wedge, the basal dip, and the resultant wedge taper of the margin were determined. Ranging from 5.4° to 6.5°, the taper was determined to be relatively constant from toe to shelf-break in S Oregon, N California and off Vancouver Island. From central Oregon to NW Washington, however, wedge taper was shown to exhibit significant variability within two distinct domains: 1) 2.5° taper from the toe to 10-50 km shoreward, and 2) 6.0°- 6.5° taper from the maximum concavity of the outer wedge to the shelf-break. With wedge taper determined, and using typical values of internal friction and fluid pressure, relative changes in basal shear stress were then assessed. For S Oregon, N California and Vancouver Island, there is no discernible change in basal shear stress. The maximum stress is both constant across the wedge and generally coincident with the toe of the slope, approximating the elastic half-space models' assumed location for the up-dip limit of the locked zone. However, from central Oregon to NW Washington, there is a pronounced step change in the relative magnitude of basal shear stress at the point of maximum topographic concavity. Depending on the internal friction and fluid pressure values applied, basal shear stress increases down-dip as much as 8-fold between the two taper-defined domains. The relative change in basal shear stress across Cascadia's accretionary wedge was additionally determined from an assessment of fold spacing and inter-limb angle variation. This assessment supported the presence of a significant increase in basal shear stress well landward of the deformation front in Oregon and Washington, and was consistent with the presence of high pore fluid pressures in the first taper domain suggested by landward vergent thrusts. Assuming that increased basal shear stress, manifest in structural character over many seismic cycles, reflects increased plate coupling, then the up-dip limit of the locked zone in Cascadia may be proposed to be coincident with the deformation front at its north and south extremes but offset 10-50 km shoreward of the deformation front from 44.3°N to 48.1°N, providing an important parameter for assessing past and future slip geometries and dynamics.

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