Does Subslab Buoyancy Govern Segmentation of Cascadia's Forearc Topography?

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Cascadia's forearc topography varies systematically along-strike with the high-standing Olympic and Klamath mountains separated by the relatively low-standing Oregon Coast range. This topographic variability reflects long-term patterns of surface uplift and erosion, however, the underlying drivers of uplift and the mechanisms supporting present day topography are unclear. Here, we synthesize results from seismic imaging, observations of vertical deformation, and characteristics of the megathrust interface to infer that buoyancy in the subslab asthenosphere influences the development and stability of Cascadia forearc topography. The Cascadia subduction zone can be divided into northern, central, and southern segments. Northern and southern segments are characterized by rapid short- and long-term uplift rates, rapid erosion rates, shallower slab dip angles, and increased plate locking compared to the central segment. Similarly, tomographic images of the subslab asthenosphere show segmented low-velocity anomalies beneath northern and southern Cascadia. These low-velocity anomalies reflect localized upwellings and regions of excess buoyancy due to partial melt and possibly elevated temperatures (Bodmer et al., 2018). We propose that buoyant regions influence the integrated shear force at the megathrust by either shallowing slab dip — thereby increasing the area of the seismogenic zone— or increasing strength of the megathrust — for example, by increasing normal stress or the effective coefficient of friction. Either or both scenarios will locally increase the integrated shear force in the seismogenic zone, which has implications for long-term topographic development and the force balance sustaining high elevations. Because interseismic uplift, long-term uplift and erosion, and topography exhibit similar increases north and south, we infer that unrecovered interseismic strain leads to long-term deformation. Using inferred values for slab dip and plate coupling we predict first-order variations in Cascadia forearc topography. Our analysis suggests that lateral support for topography in Cascadia may be due to variations in the net shear force at the megathrust interface. Variations in subslab buoyancy may be critical to explaining forearc highs in this and other subduction systems.