Investigation of Cascadia Segmentation with Ambient Noise Tomography

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Abstract

Along strike variation in the characteristics of subduction zone processes has been observed throughout the Cascadia Subduction Zone through analysis of arc magmas and the distribution of seismicity. We investigate links between these observations and subduction zone structure by imaging three-dimensional lithospheric scale shear velocity structure using ambient noise tomography (ANT). The crustal portion of the model is well resolved through typical ANT processing techniques. We expand the methodology to use longer period phase velocities in order to recover structure to ~120km depth. The resulting model, PNW10-S, represents structural information in terms of relative shear velocity in the crust and uppermost mantle. Crustal structure mirrors surface geology to ~10 km depth and then transitions to a structure that is dominated by the subducting slab. The subducting slab and overriding crust appear segmented into three parts with boundaries near 43°N and 46°N. This three-way structural segmentation is aligned with the variation in recurrence of episodic tremor and slip along the subduction zone (Brudzinski and Allen, 2007). Upper to middle crustal boundaries between the Klamath Mountains and Siletzia Terrane and between the Crescent Formation and Olympic Peninsula are also coincident with locations of increased occurrence of tremors raising the question of whether there is a link between the intensity of tremor activity and shallow (<10km) crustal structure. The slab-segment boundary at 43°N is a stronger feature than the northern segment boundary at 46°N and appears to be the continuation of the Blanco Fracture Zone separating the Gorda segment of the plate from the rest of the Juan de Fuca plate. The southern half of the arc system, south of 45°N, shows lower velocities from the surface to ~80 km depth relative to the northern portion of the arc. We propose this is due to clockwise plate rotation, which causes extension in the south, and results in increased melting. Along the arc, four broad low-velocity features are also imaged just below the Moho and centered at 42°N, 44°N, 47°N, and 49°N. We interpret these as ponding of melt just below the crust where differentiation can occur before further ascent through the crust.