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The Seismic Structure of the Mantle Wedge under Cascade Volcanoes, Northwestern U.S.A.

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For corner flow models to be correct, the mantle wedge of a subduction zone must have an unusual lithosphere-asthenosphere boundary, as the reduced viscosities from slab dewatering, melting, and relatively hot return flow must move the lithosphere-asthenosphere boundary close to the base of the crust of the overriding plate. This should be detectable with several different seismic probes. Under a number of the volcanoes of the Cascadia arc we have identified a characteristic seismic signature in individual station Ps receiver functions and in Ps CCP image volumes made from USArray Transportable Array and Flexible Array stations. In the mantle wedge, the CCP images and the RFs show a strong negative event just below the Moho, paired with a weak to moderate positive event between 50-70 km, and a strong slab event. At most of these volcanoes, a strong negative signal also appears between 15 and 25 km depth in the crust. The signature is particularly clear under Mt. Lassen and to a lesser degree under Mt. Shasta in data from FAME (Flexible Array Mendocino Experiment), where instruments were close to the volcanic centers. Random averages using all stations throughout the western U.S., and only stations in the Cascadia backarc region show that this signature is not common to the western U.S. as a whole, nor to the backarc region in particular.

Joint inversion of the Ps receiver functions and ambient noise and ballistic Rayleigh wave phase velocities (Porritt et al., 2011; Liu et al., 2012) for those volcanoes with the paired events provides 1D shear velocity profiles having common characteristics. A strong sub-Moho low velocity zone from 5 to 15 km thick gives rise to the paired negative-positive signals in the receiver functions. These mantle wedge low velocity zones, with velocities of $3.7 < Vs < 4.0$ km/s, are evident in 30 of the 39 stations we examined, with velocity minima occurring at $\sim$50-70 km depth. We speculate that this low velocity region is at the center or top of the corner flow beneath each volcano. The LAB is then either at or near the base of the crust, or below a thin lid. Directly beneath Mt. Lassen and Mt. Shasta, in the heavily instrumented Mendocino region, is a large, connected low velocity zone, that extends between the two volcanoes along strike. We interpret this as the locus of corner flow at the southernmost edge of Cascadia.

Cascadia stations not exhibiting this seismic signature have a different characteristic seismic structure: There is no abrupt velocity increase at Moho depths, instead Vs increases gradually from the lower crust to as deep as $\sim$70 km, forming a thick, relatively high velocity layer ($4.0 < Vs < 4.5$ km/s), with a correspondingly deeper LAB. This is predominantly seen in stations toward the back arc.

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