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Seismic constraints on temperature and melting at the Lithosphere-Asthenosphere Boundary in the Southwestern United States

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The Lithosphere-Asthenosphere Boundary (LAB) demarcates the transition from a conductive thermal lid to a convecting asthenosphere below. The Southwestern United States presents an intriguing natural laboratory for investigating the processes at play in this critical boundary: intraplate volcanism is abundant and geochemical and geophysical analyses suggest the presence of a sub-lithospheric layer of partial melt. It has been suggested that a change in mantle strength at the top of the melt-bearing layer helps to create the LAB, indicating that melt stability is an important factor in understanding lithospheric dynamics. The mechanism, or interplay between mechanisms, that govern the LAB has implications for geodynamic modeling as well as for understanding the long-term evolution of lithosphere and volcanism. The analysis presented here is based on seismic observations of surface waves and converted body waves, which are used to determine 1-D profiles of shear wavespeed (Vs) throughout the Southwestern United States, from the surface to 300 km depth. The LAB is determined from the depth location of negative Vs gradients within the mantle. From the Vs profiles, we estimate temperature within the upper mantle, using two different geophysical interpretive toolkits. These toolkits each predict geophysical properties via forward-modeling of temperature, melt fraction, and/or compositional state, and assumptions made within the forward-modeling can yield large discrepancies in interpreted temperature. We leverage temperatures derived from geochemical thermobarometry as a constraint to guide our choice of method and attenuation parameterization. From this workflow, we report inferred temperature at and below the gradient inferred to be the LAB, and evaluate the relationship of these temperatures to the mantle adiabat and the peridotite solidus. Temperatures are near the solidus in portions of the lithospheric mantle, particularly in the Basin and Range province, suggesting that melting does play a role in defining the LAB, but not in every location. Moreover, the prevalence or absence of partial melt appears to be connected to regional variations in deformation style, surface heat flow, and topography. Finally, we note that additional constraints on hydration state and composition of the lithosphere, as well as the geometry and distribution of partial melt, will improve the workflow presented here.