Shear Wave Splitting in the Great Basin Solves the Elevation Problem: It Was a Simple Plume-like Upwelling All Along

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The Great Basin has an average elevation of 2 km. The average crustal thickness of 32 km does not explain this high elevation, hence the mantle appears to be anomalously buoyant. Around 16-17 Ma, an outpouring of flood basalts erupted throughout the northern Basin and Range, including a linear progression of felsic volcanism from McDermitt volcano in northern Nevada toward the northeast and northwest to the current locations of Yellowstone and Newberry, respectively. Published tomographic images show a low-velocity zone beneath Nevada at ~350 km depth, although the images do not reveal fine structure. Receiver functions suggest a low-velocity zone atop the 410 km discontinuity in northern Nevada that pinches out beneath eastern Nevada.

In Walker et al. (2005) we present new teleseismic shear-wave splitting data from six IRIS broadband seismic stations deployed along the axis of the SRP from 6/2000-9/2001. We show the first-order anisotropy signal is explained by a single layer of anisotropy with a horizontal fast axis. Considering the lithosphere is quite thin in the Great Basin and the lack of correlation between fast directions and geologic fabrics at the surface, it is likely that the anisotropy is located in the asthenosphere. We quantitatively modeled our station fast directions, as well as splitting fast directions from numerous other stations throughout the Basin and Range. We find that they are best explained by a lattice preferred orientation of olivine due to horizontal shear along the base of the plate associated with the gravitational spreading of buoyant plume-like upwelling material beneath eastern Nevada into a southwestward flowing asthenosphere (with respect to a fixed hotspot reference frame). This parabolic asthenospheric flow (PAF) model for the Great Basin easily explains the observed high elevations, high mantle buoyancy, low-velocity anomaly beneath eastern Nevada, high heat flow, and depleted geochemistry of some erupted basalts. An upwelling model may also be consistent with the results of turning-ray waveform and receiver-function modeling, which suggests the low-velocity zone atop the 410-km discontinuity beneath the northern Basin and Range does not exist beneath eastern Nevada. The lack of Pliocene-Recent major volcanism in eastern Nevada suggests that a significant amount of the buoyancy flux is due to compositional buoyancy. This model also implies that existing upwellings beneath Yellowstone and Newberry are not responsible for the high elevations we observe in the Basin and Range today.
