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Upper mantle anisotropy beneath the High Lava Plains, Oregon, USA: Linking mantle structure and dynamics to surface tectonomagmatism

Maureen Long (1), Lara Wagner (2), Matthew Fouch (3), and David James (4)

(1) Department of Geology and Geophysics, Yale University, New Haven, CT, USA (maureen.long@yale.edu), (2) Department of Geological Sciences, University of North Carolina, Chapel Hill, NC, USA, (3) School of Earth and Space Exploration, Arizona State University, Tempe, AZ, USA, (4) Department of Terrestrial Magnetism, Carnegie Institution of Washington, Washington, DC, USA

The High Lava Plains (HLP) of southeastern and central Oregon (USA) comprises a young (< 15 Ma), bimodal volcanic province that exhibits an age progression in silicic volcanism towards the northwest, along with widespread basaltic volcanic activity. The age progression is oblique to plate motion and approximately mirrors that of the Yellowstone/Snake River Plain volcanism to the east. A variety of models have been proposed to explain the recent volcanic history of the region, including the Steens and Columbia River flood basalt episodes at ∼17 Ma and the subsequent evolution of the HLP. These models invoke the rollback and steepening of the Cascadia slab, interaction between the subduction-induced flow field and the inferred Yellowstone plume, the influence of basal lithospheric "topography," significant lithospheric extension, or a combination of these processes. In order to investigate the geometry of mantle flow beneath the HLP and to test models for the origin and evolution of the HLP province, we combine constraints on upper mantle anisotropy from SKS splitting and surface wave analysis using data from ∼160 broadband stations of the HLP seismic experiment and the USArray Transportable Array (TA). Stations in the region exhibit significant SKS splitting, with average delay times at single stations ranging from ∼ 1.0 sec to ∼ 2.7 sec. Nearly all observed fast directions are approximately E-W, which argues for well-organized contemporary mantle flow in an E-W direction beneath the HLP. The E-W fast splitting directions are consistent with constraints on azimuthal anisotropy from surface wave analysis, but are inconsistent with models that invoke plume-driven flow along the strike of the HLP. We observe significant lateral variations in average splitting delay times, with a region of particularly large dt (> 2 sec) that delineate a region in the heart of the HLP province and another region of large delay times just to the north of Newberry Volcano. There is a notable spatial correlation between stations that exhibit large delay times and the location of Holocene volcanic activity. We discuss several possible models that may explain lateral variations in uppermost mantle velocities and anisotropy strength and the relationships between these variations and recent tectonomagmatic activity.