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D$''$ anisotropy and slip systems in post-perovskite

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The lowermost few hundred kilometres of the Earth's mantle—known as D$''$—form the boundary between it and the core below, control the Earth's convective system, and are the site of probable large thermochemical heterogeneity. Seismic observations of D$''$ show a large ($\sim$2%) increase in S-wave velocity and significant seismic anisotropy (the variation of wave speed with direction) are present in many parts of the region. On the basis of continuous regions of fast shear velocity (V_S) anomalies in global models, it is also proposed as the resting place of subducted slabs, notably the Farallon beneath North America. The $MgSiO_3$-post-perovskite mineral phase is the most compelling explanation for observations of anisotropy, though an outstanding question is how post-perovskite and other mineral phases may deform to produce this: different mechanisms are possible. With knowledge either of mantle flow or which slip system is responsible for causing deformation, we can determine the other with the seismic anisotropy which is created.

We investigate the dynamics at the CMB beneath North America using differential shear wave splitting in S and ScS phases from earthquakes of magnitude $M_\mathrm{W} > 5.5$ in South and Central America, Hawaii the Mid-Atlantic Ridge and East Pacific Rise. They are detected on $\sim$500 stations in North America, giving $\sim$700 measurements of anisotropy in D$''$. We achieve this by correcting for anisotropy in the upper mantle (UM) beneath both the source and receiver. The measurements cover three regions beneath western USA, the Yucatan peninsula and Florida. In each case, two different, crossing ray paths are used, so that the style of anisotropy can be constrained—only one azimuth cannot distinguish differing cases. Our results showing $\sim$1% anisotropy dependent on azimuth are not consistent with transverse isotropy with a vertical symmetry axis (VTI) anywhere. The same but with a tilted axis is possible (TTI) and would be consistent with inclusions of seismically-distinct material such as melt. TTI planes of isotropy dip south beneath Florida, southwest beneath western USA and southeast beneath Yucatan. However we test other slip systems in MgO, pv and ppv to determine if deformation in these phases can account for the observed anisotropy. The systems [100](010) and [$\bar{1}$10](110) in ppv are consistent everywhere; pv is not beneath Yucatan. If we assume a general downwelling and displacement of mantle material in the seismically fast D$''$, corresponding to the impingement of slab material, slip along [100](010) seems more likely. With a new breed of detailed mantle deformation models, or experimental evidence of which slip system dominates, seismic anisotropy may be used to map deformation in D$''$ and provide greater insight into Earth's convecting interior.