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Anisotropy and Phase Transition as Cause for D'' Reflections

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Using recordings of seismic events that sample the deep mantle, we can test different hypotheses of mantle processes and the state of minerals, such as subducted lithosphere, anisotropy, and the post-perovskite phase transition. Especially seismic reflections from structures in the D'' region, the lowest 200-400 km of the Earth's mantle, can provide information on the velocity contrasts in this region. Studying the waveforms and polarities of the D'' reflections in P and S-waves we can distinguish between different possibilities that cause the observed structures, such as phase transitions, aligned material or thermal anomalies. In this study we use recordings of seismic events that sample the D'' region with P and S-waves from events in South America recorded in North America and in a second region events from the Northwest Pacific recorded at European stations and Hindu Kush events recorded in Canada. This provides possible reflections off D'' in two different regions but both regions are characterized by fast seismic velocities in tomographic model. In both regions, more than one discontinuity is observed, consistent with a model in which perovskite changes to post-perovskite and back to perovskite at a deeper level. But the polarities of reflections in both tomographically fast regions differ and can therefore help to further discriminate the cause for the observed reflections. In one region, we find positive S-velocity contrasts but negative P-wave velocity contrasts for the D'' reflector. This is again consistent with a post-perovskite phase transition. In the second fast velocity region we detect positive P- and S-wave velocity contrasts in two orthogonal paths crossing in the lowermost mantle indicating a different scenario for the structures in D''. One possible explanation to reconcile observations in both regions is a phase transition and with 10 percent of alignment in the post-perovskite phase. Other isotropic and anisotropic models are tested but cannot fully explain the range of observations we find in the data.