Elasticity of iron-rich silicate in Earth's D" layer

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Earth's D" layer represents the lowermost 130 to 300 km of the silicate mantle just above the core. Regions with ultra-low seismic velocities have been observed at the base of the D" layer where this boundary layer comes in contact with the liquid, Fe-rich outer core. In a series of laser-heated diamond anvil cell experiments simulating the ultrahigh pressure-temperature conditions of the core-mantle boundary, we observed using synchrotron x-ray techniques that a large amount of Fe can be incorporated into the post-perovskite (ppv) silicate phase, and that this can significantly change its properties relative to the pure $MgSiO_3$ endmember. We determined the aggregate compressional and shear wave velocities of this Fe-rich silicate at high pressure and found that ppv with up to 40 mol % $FeSiO_3$ can explain the properties seismically observed in ultra-low velocity zones in Earth's D" layer.

Another intriguing feature of the D" layer is its seismic anisotropy, manifested in shear-wave splitting, the origin of which is an area of active, unresolved debate. We observed sizable elastic anisotropy in a sample of Fe-bearing ppv. We used a novel composite x-ray transparent gasket to contain and synthesize ppv in a panoramic diamond-anvil cell along with oblique x-ray diffraction geometry to observe the anisotropic lattice strain and [100] or [110] slip-plane texture at 140 GPa. We deduced the elasticity tensor (c_{ij}), orientation-dependent compressional wave velocities, polarization-dependent shear wave velocities, and the velocity anisotropy of the silicate ppv. The results indicate that with sufficient preferred orientation, the elastic anisotropy of this phase can account for the observed shear-wave splitting in Earth's D" layer.