Unsolved problems in the lowermost mantle

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Many characteristics of D" layer may be attributed to the recently discovered $MgSiO_3$ post-perovskite phase. However, some features remain unexplained [1]. The seismically inferred velocity jump (up to 3% for both P- and S-waves) at the top of D" is too large in comparison to first principles calculations. The regional variation in seismic anisotropy may be consistent with the lattice-preferred orientation (LPO) of post-perovskite, but the prediction of its slip system is not straightforward and is controversial. The double phase boundary crossing in D" layer may be able to constraint a thermal structure near the base of the mantle. However, the experimental and theoretical determinations of the *P-T* conditions of post-perovskite phase transition include some ambiguity. There could be a strong chemical heterogeneity in D" that may play an important role in addition to the phase transformation. The chemical heterogeneity may be caused by the accumulation of ancient MORB crust. However, the seismic evidence for a basaltic layer in D" has never been reported yet. Separating the heterogeneities caused by phase transformation and chemical anomaly is a key to understand the nature and evolution of the lowermost mantle. The positive Clapeyron slope of the post-perovskite phase transition can readily induce boundary layer instabilities at the D" layer. Current tomographic images, however, show few but broad upwellings (two so-called “superplumes”). As a result of the proximity of this phase transition to the CMB, new physical mechanism, such as radiative thermal transfer, is necessary for the growth of large plumes from the highly unstable D" layer.

References

[1] Hirose, K., S. Karato, V. Cormier, J. Brodholt, and D. Yuen (2006), Unsolved problems in the lowermost mantle, *Geophysical Research Letters*, 33, L12S01, doi:10.1029/2006GL025691.