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Tectonics of the lower mantle II: mineral physics constraints

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The last decade has seen significant advances in the seismological observation of the lowermost mantle, with our understanding of the D" region significantly increasing in complexity. At the same time mineral physics constraints on this region have vastly improved: (1) increases in computing power allow us to simulate the elastic, chemical and transport properties of geologically reasonable compositions of the major phases at finite temperature, (2) laser-heated diamond anvil cell experiments at the high-pressures and temperatures of the core-mantle-boundary have become standard, along with the increasing diversity of possible *in situ* measurements and (3) high-pressure rheological measurements are now possible. The discovery of the post-perovskite phase has gone a long way to explain much of the complexity of D". The layered nature of the SiO_6 units in post perovskite results in strongly anisotropic elastic properties as well as activating dominant slip on the (010) plane. This means that post-perovskite can match the observed seismic anisotropy in D" with a dominantly horizontal basal mantle flow.

However, post-perovskite is a strange beast; while it might look like a layer structure for elastic properties, transport properties are decidedly not constrained by the SiO_6 layers. Here I describe latest results on its mass transport properties.

Experiments on analogue $CaIrO_3$ suggest: (1) Textures developed during transformation under non-hydrostatic stress are similar to textures developed in the diamond cell in $MgSiO_3$ and $MgGeO_3$ and that subsequent deformation rotates this transformation textures into a [100]{010} deformation texture. (2) There is a weakening of 1 order of magnitude (or more) as perovskite transforms to post-perovskite and even after the transformation is complete post perovskite remains weak.

Ab initio simulations on $MgSiO_3$ show that the chemical diffusivity in post perovskite is highly anisotropic, with $\sim$ 8 orders of magnitude of anisotropy between the fast $<100>$ and slow $<010>$ directions, and that the fast direction is substantially faster than any direction in perovskite. For deformation in the dislocation creep regime this means that post perovskite will be weaker than perovskite, consistent with the experiments.

I will discuss the implications of this weakening for the dynamics in, and seismic observations of, the D" region.