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Relation of dynamics with sceismic anisotropy in the lowermost mantle

Tatsuto Okamoto[1], Ikuro Sumita[2], Tomoeki Nakakuki[3]

[1] Earth Science, Kanazawa Univ, [2] Earth Sci., Kanazawa Univ., [3] Dept Earth Planet Syst Sci, Hiroshima Univ

Recent seismological observation has revealed the presence of a laterally varying shear-wave anisotropy in the lowermost mantle.
The anisotropy can be interpreted to reflect the dynamics and its evolution in the lowermost mantle.

The goal of this study is to relate the seismic structure of the lowermost mantle to its evolution.
Here, we use a 2-D numerical model of thermal boundary layer instability at the base of the mantle incorporating a strongly temperature dependent viscosity.

First, we confirmed three convection regimes: the small viscosity contrast regime which is plume-dominant convection regime, the stagnant lid regime characterized by small-scale convection in the hotter layer and non-convective layer in the colder one, the transitional regime between former regime and latter one.
These three regimes agree with the results of Solomatov (1995).

From our calculations, we find that the stress level at the lowermost mantle is insufficient to cause lattice-preferred orientation.
Therefore, we assume that the alignment of melt is the cause for anisotropy.

Next, we calculate the deformation of partial melt that is entrained into the plume.
We find that the melt is strongly deformed from stretching.
The aspect ratio of the melt incrementally increases as the melt is transported from the bottom boundary layer, through the conduit and then to the plume head, becoming as large as 100.

Finally, we compute the seismic wave velocity and its anisotropy traveling horizontally across the lowermost mantle made of deformed partial melt.
We find that the vertical anisotropic structure consists of 3 layers:

1. a 0.4% anisotropic layer (SH is faster than SV) traversing through the plume head,
2. a nearly isotropic layer traversing through the plume conduit,
3. a 10% anisotropic layer (SH is faster than SV) and an ultra low velocity zone at the base.

We suggest that this vertically anisotropic structure can be used to constrain the evolution of the instability in the lowermost mantle.