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Stability and Structures of Primordial Reservoirs of Dense Material in the Lower Mantle: Numerical Models and Comparison with Seismological Observations

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Seismological observations indicate that large compositional anomalies are present in the lowermost mantle. Recent numerical studies also show that the large reservoirs of primitive dense material can survive Earth's mantle convection, and be maintained at the bottom of the system for a long period of time. Previous numerical studies in 3D Cartesian geometry have pointed out some of the important parameters that control the stability and the shape of these dense reservoirs. These include buoyancy ratio, thermal and chemical viscosity contrast, and the role played by phase change at 660 km.

Here we extend this study to 3D spherical geometry. In this study, we explore the influence of the buoyancy ratio (B), which measures the density contrast between dense and regular material of the mantle, thermal and chemical viscosity contrast (Rmhu_T, Rmhu_C), and the volume fraction of the dense material (X). In additional, we explore the role played by the ringwoodite to perovskite (at 660 km depth) and perovskite to post-perovskite (in the lowermost mantle) phase changes. Our results indicate that: 1) Buoyancy ratio is the most important parameter controlling the stability of the reservoirs of dense material. With a small buoyancy ratio, the initial layer of dense material is swept up and quickly mixes with the regular material. With a large buoyancy ratio, the initial layer of dense material remains stable, inducing strong layering at the bottom of the mantle. With an intermediate buoyancy ratio, the dense reservoirs form and remain in the lowermost mantle for a long time. 2) Thermal viscosity contrast also strongly influences the stability and structures of the dense anomalies. Large thermal viscosity contrast results in long-wavelength structures, while small contrasts result in primitive dense material being swept up by mantle convection. With intermediate thermal viscosity contrasts, the volume fraction of dense material modifies the stability and the shape of the dense reservoirs. 3) A chemical viscosity contrast between $10^{(-2)}$ and 10^{2} does not influence the stability of the reservoirs but modifies their shapes. The topography of the reservoirs increases with increasing Rmhu_C. 4) The phase transition at 660 km acts as a filter for dense material, which penetrates above the transition with more difficulty. In the lowermost mantle, the post-perovskite phase is stable at the bottom of cold downwellings but not in the reservoirs of dense material, which are hotter than the surrounding mantle.

REFERENCES

Trampert, J., F. Deschamps & P. J. Tackley, 2004: Probabilistic tomography maps significant chemical heterogeneities in the lower mantle, Science, 306, 853-856.

Deschamps, F. & P.J. Tackley, 2008:Searching for models of thermo-chemical convection that explain probabilistic tomography I Principles and influence of the rheological parameters. Phys. Earth Planet. Inter., 171, 357-373.

Deschamps, F., & P.J. Tackley, 2009:Searching for models of thermo-chemical convection that explain probabilistic tomography II – Influence of physical and compositional parameter. Phys. Earth Planet. Inter., 176, 1-18.