



Is composition a critical dynamical element of mantle convection?

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It is clear from observations of differentiation producing oceanic crust and depleted residue, and its ultimate subduction that compositional heterogeneity does exist in the mantle. An important question for mantle dynamics however, is how important is this composition?

Compositional variations have been attributed to be critical for explaining many dynamical aspects of mantle upwellings as evidenced in hot-spots, such as their relative fixity (Jellinek and Manga, 2004) and non-steady upwelling velocity (Lin and van Keken, 2005). They have also been attributed to causing peaks in magma production.

Our modeling work in spherical geometry shows that a wide variety of upwelling behaviour can be produced in models that have NO compositional variations and are only driven by thermal anomalies. The critical component of this family of models is a high, Earth-like Rayleigh number. Our models have also reproduced time varying magma production on a long time-scale in thermal convection models. The critical element is again a very high Rayleigh number, but this time combined with a realistic Clapeyron slope at the 660km discontinuity. Schubert et al., 2009, have also shown that composition is not required to explain some of the seismic signatures of mantle convection models either, including at the base of the mantle.

While, as stated initially, composition must play a role, we would argue that given that much of the supposedly 'non-thermal' behaviour can be explained by thermal models that the simplest current paradigm is to assume thermally driven convection. A further advantage of this class of model is that there are fewer degrees of freedom in comparing the geodynamics models with seismology, and therefore tighter tests will be possible. While there are other arguments for compositional variations close to the core-mantle boundary and in the upper boundary / lithosphere; tests from simpler models could help to refine and bound the degree of compositional variation required dynamically.