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The influence of convective vigour on phase change induced layering at 660 km in early Earth's mantle

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Since its discovery, the endothermic phase change in olivine mineralogy from ringwoodite to ferropericlase and perovskite at 660 km depth (660) has been a candidate for inducing some degree of layering in Earth's mantle. A layered mantle would provide a mechanism to isolate portions of the lower mantle chemically. Layering could also reduce the secular cooling rate relative to whole mantle convection. Thus layering would resolve a number of paradoxes in the understanding of the deep Earth. The problem with this interpretation is that seismology provides a convincing case for whole mantle convection at the present. However, it is widely accepted that the Earth as a whole was hotter in the past and that the mantle had a higher Rayleigh number (Ra) as a result. It has been suggested in previous modelling work that for a given Clapeyron slope at 660, higher Ra increases the propensity to layering. The conceptual model for this is that higher Ra leads to thinner plume-like upwellings, which are then of insufficient strength to break through the restoring force provided by the negative Clapeyron slope of the phase change. The suggestion has been made that at ancient Ra, the mantle may have been layered about 660 and that this layering has at some more recent time broken down.

This phenomenon is investigated through an ensemble run of 3D spherical mantle models. A parameter space mapping of 660 Clapeyron slope negativity (ranging from -20 to -2 MPa/K) and Rayleigh number (ranging from 1.56E+03 to 7.79E+06) is examined. Results suggest that the mantle may have been at least partially layered in the past. The implications of this are discussed, as is the nature of the temporal transition from phase induced layering to whole mantle convection.