



## Thermo-chemical convection and the nature of the deep mantle chemical heterogeneities

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In the past decade, the combination of seismological observations and mineral physics data has revealed the presence of large thermo-chemical heterogeneities in the deep mantle. However, the nature of the chemical heterogeneities remains a matter of debate, and two main origins have been explored, in particular by numerical models of thermo-chemical convection. First, chemical heterogeneities may result from the interaction between mantle convection and an initial reservoir of dense material, *e.g.* enriched in iron. The presence of a primitive, undepleted and isolated reservoir(s) hidden in the deep mantle has long been advocated by geochemists to be one of the sources of ocean island basalt. Recent models and geochemical data suggest that such reservoirs may result from the early partial differentiation of the Earth's mantle, or the recycling on an early crust. Our recent models of thermo-chemical convection, which consider the evolution of an initial layer of dense material, indicate that strong thermal viscosity contrasts play a major role in maintaining disconnected pools of dense material in the deep mantle, and that a negative Clapeyron slope at 660-km strongly reduces the flux of dense material from the lower to the upper mantle. The second main source of chemical heterogeneity is the recycling of oceanic crust entrained by slabs in the deep mantle. Models that include the production and recycling of MORBs indicate that the formation and shape of pools of dense material in the deep mantle depend on the buoyancy ratio of MORBs, on the Clapeyron slope of the post-perovskite phase transition, and on the core properties. When self-consistent mineralogy is included in models with spherical geometry, the MORBs segregate in the bottom of the system, and form a continuous layer around the core-mantle boundary that is locally disrupted by downwelling slabs. Individually, pools of primitive material and recycled MORBs do not fully satisfy the seismological observations. Thermo-chemical calculations that model the evolution of primitive reservoirs indicate that the present day distribution of the dense is perfectly correlated with that of the hot material, in contradiction with the thermal and chemical density anomalies seen by normal modes. On the other hand, high-pressure MORBs are seismically faster than the average pyrolytic mantle, and would therefore not explain the large low shear-wave velocity provinces observed at the bottom of the mantle. Very likely, the seismic velocity and density anomalies observed in the deep mantle originate from a combination of thermal anomalies and two or more chemical sources of chemical heterogeneities. In addition, the post-perovskite may play a significant role. In cold regions (*e.g.*, slab graveyards) perovskite may transform to post-perovskite at relatively shallow depths, whereas in hot regions (*e.g.*, plume sources) it may not transform at all. The next step is therefore to build thermo-chemical models of convection that combine two sources of chemical heterogeneity – primitive reservoirs and recycled MORBs – and account for the post-perovskite phase transition.