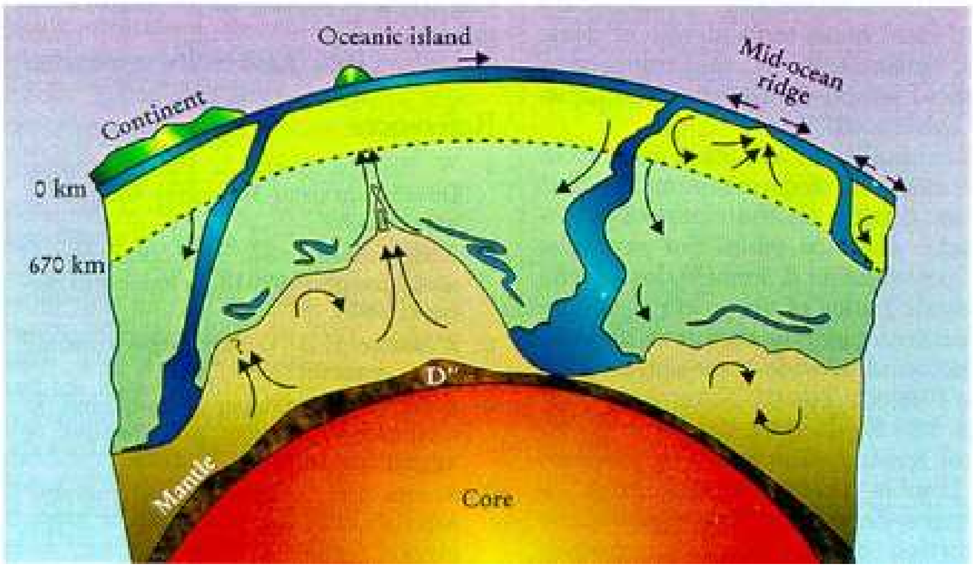

Figure 1.1: Illustration representing compositionally layered mantle convection (from Kellogg et al. (1999)).

The subducting slabs of former oceanic crust come to rest on the interface between the two reservoirs. Eventually, this material heats up and recycles to the surface in the form of mantle plumes. In their ascent, plumes are able to entrain some of the deep mantle material, affecting their chemical signature (Christensen and Hofmann (1994)).

1.3 Previous work

The model of compositional layering has become increasingly popular in recent years. In a simple 2-D numerical study, Kellogg et al. (1999) found that compositional layering is dynamically stable on a Gyr time scale, using an excess compositional density of ~ 4 % ($B_0 = 0.9$). Hansen and Yuen (2000) investigated a similar model using the more complete extended-Boussinesq formulation as well as temperature and depth-dependent viscosity and depth-dependent thermal expansivity. These aspects tend to stabilise compositional layering and hence a value of $B_0 = 0.5$ was sufficient for long-term stability. In this model, where long-term secular cooling was included, the deep mantle reservoir first forms a continuous layer, but transforms into isolated piles later. In the 3-D models of Tackley (2002), $B_0 = 0.3$ gives long-term stable layering with large topography. Also, variations in seismic wavespeed were predicted and compared with seismological studies. It was concluded that separate piles of deep mantle material are more consistent with the seismological constraints, than a continuous layering is. In addition to these numerical model studies, analogue laboratory experiments of Davaille (1999) confirm the dynamic stability of compositional layering, including thin plumes rising from the upper surface of the dense layer.

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