Geophysical Research Abstracts
Vol. 17, EGU2015-1981-1, 2015
EGU General Assembly 2015

Mantle compositional layering revealed by slab stagnation in the uppermost lower mantle

Maxim Ballmer (1), Jeroen Ritsema (2), Nicholas Schmerr (3), and Matthew Motoki (4)

(1) Earth-Life Science Institute, Tokyo Inst. Technology, Tokyo, Japan (ballmer@elsi.jp), (2) Dept. Earth and Environmental Sciences, University of Michigan, Ann Arbor, USA, (3) Dept. of Geology, University of Maryland, College Park, USA, (4) Dept. Geology & Geophysics, University of Hawaii at Manoa, Honolulu, USA

Seismic tomography reveals three different modes of slab sinking behavior. Some slabs segments (1) descend through the upper mantle to stagnate in the transition zone (e.g., Japan slab), others (2) sink into the deep mantle (e.g., Tethys slab), and yet others (3) sink through the upper mantle and transition zone to stagnate at ∼1000 km depth (e.g., Peru, Kermadec, Sunda and Nicaragua slabs) [Fukao and Obayashi, 2013]. Whereas stagnation in the transition zone is well explained by the supporting effect of the spinel-to-perovskite phase transition at ∼660 km depth (“the 660”), a scenario for equilibrium stagnation in the uppermost lower mantle, where no endothermic phase transitions occur, remains to be proposed. Here, we explore slab sinking behavior using two-dimensional numerical models. We show that slabs stagnate at 900∼1000 km depth if the lower mantle be intrinsically dense, for example due to enrichment in Si and/or Fe relative to Mg. A gradual and moderate compositional contrast across the 660 in a heterogeneous mantle is (at least locally) able to provide sufficient support for long-term slab stagnation. While such a contrast is expected to result from early-Earth processes (e.g., differential crystallization of the magma ocean), its maintenance over 4.5 Gyrs of mantle convection and stirring requires ongoing geodynamic mechanism(s) to sustain it. One such mechanism is stagnant slab disintegration, in which a superplastic slab that stagnates above or below the 660 undergoes convective instability to separate into its (enriched) basaltic and (depleted) harzburgitic components. As dense basaltic material and buoyant harzburgite tend to sink and rise, respectively, this mechanism sets up an efficient compositional filter across the transition zone. Thus, the fate of subducted slabs can sustain (disintegration) – as well as provide evidence for (stagnation at ∼1000 km depth) – relative enrichment of the lower compared to the upper mantle. Such an enrichment is sufficient to satisfy chondrite models for bulk-silicate Earth composition.