Mixing of Differentiated Oceanic Crust in a Convecting Mantle with Depth and Temperature Dependent Properties

Einat Lev and **Bradford H. Hager**

Department of Earth, Atmospheric and Planetary Sciences, MIT, Cambridge, MA

The mixing of materials in the Earth's mantle is directly controlled by the style of convection, which is not fully understood. Geochemical and petrological studies of mantle-derived rocks reveal a wide variety of compositions, which implies a convection pattern capable of preserving distinct chemical reservoirs, often identified as layers convecting separately (e.g. Allègre, 1997). However, recent seismic tomographic studies resolve subducted slabs well into the lower mantle, arguing for a whole-mantle convection regime (Kárason and van der Hilst, 2001).

In this project we study the evolution of compositional heterogeneities created by recycling a differentiated oceanic crust, a popular approach for reconciling geochemical and geophysical observations (Lassiter, 1998). We focus on two major parameters likely to control the fate of a subducting slab - the thickness of the basaltic crust and its composition, both of which affect the slab's buoyancy. We utilize two-dimensional cartesian finite-element models (Zhong and Zuber, 2000) and investigate the eventual depth of subduction and the pattern of the chemical heterogeneity introduced by it into the mantle. In our models, the thermal expansivity and the density contrast between the compositional components vary with depth, and the viscosity depends exponentially on both depth and temperature. We find that the thickness of subducted crust, specifically its thickness relative to that of the surface thermal boundary layer, indeed changes the resulting structure of the mantle. We also include two mineralogical phase transitions, at 410- and 660- km depth. The inclusion of mineralogical phase transitions is found to have profound consequences for the behavior of the model, as it alters the shape of the subducted slab and its initally layered structure.

References:

Allègre, C. J., Limitation on the mass exchange between the upper and lower mantle: the evolving convection regime of the Earth, Earth and Planetary Science Letters, 150, 1-2, 1997.

Christensen, U. R., and A. W. Hofmann, Segregation of subducted oceanic crust in the convecting mantle, J. Geophys. Res., 99(18), 19,867–19,884, 1994.

Lassiter, J.-C., and E. H. Hauri, Osmium-isotope variations in Hawaiian lavas: evidence for recycled oceanic lithosphere in the Hawaiian plume, Earth and Planetary Science Letter, 164, 483-496, 1998.

Kárason, H., and R. D. van der Hilst, Tomographic imaging of the lowermost mantle with differential times of refracted and diffracted core phases , JGR, 106(15), 6569–6588, 2001.

Zhong, S., and M. T. Zuber, Crustal compensation during mountain-building, GRL, 27, 3009–3012, 2000.