Influence of thermochemical piles on topography at Earth's core-mantle boundary

Teresa Mae Lassak[a,*], Allen K. McNamara[a], Shijie Zhong[b]

[a] School of Earth and Space Exploration, Arizona State University, Tempe, AZ 85287-1404
[b] Department of Physics, University of Colorado, Boulder, CO 80309-0390

[*] Corresponding author. Tel./Fax: +1-480-965-8102.

Email address: Teresa.Lassak@asu.edu (T.M. Lassak).

Abstract

Numerous seismic studies reveal the presence of two large, low velocity anomalies beneath Africa and the central Pacific. Efforts to characterize these anomalies have yielded a variety of interpretations over the years, both isochemical and thermochemical. Previous interpretations have included large, isochemical superplumes, clusters of smaller thermal plumes, and doming thermochemical superplumes. A conceptual mantle model that is presently growing favor involves long-lived thermochemical piles. In anticipation that current techniques may yield better constraints on core-mantle boundary (CMB) topography, we investigate the relationship between CMB topography and thermochemical piles. Numerical modeling of isochemical convection illustrates a clear relationship between upwellings and downwellings to CMB topography in which downwellings lead to negative CMB topography and upwellings lead to positive topography. In our thermochemical models with piles, however, this relationship is not so straightforward. Despite their intrinsic density, a pile's effective density is significantly reduced by a density reduction associated with thermal expansion. As a result, thermochemical models tend to result in a much lower overall CMB stress/topography than do their isochemical counterparts. Our results suggest that, in general, thermochemical convection with temperature-dependent rheology does not lead to negative CMB topography beneath piles. As a result, observations interpreted as positive topography beneath proposed piles cannot be used to discriminate between isochemical and thermochemical mantle models.