Geophysical Research Abstracts, Vol. 7, 04221, 2005
SRef-ID: 1607-7962/gra/EGU05-A-04221

Plume fluxes from seismic tomography

Guust Nolet (1), Shun-ichiro Karato (2) and Raffaella Montelli (1)

(1) Dept. of Geosciences, Princeton University, (2) Dept. of Geology and Geophysics, Yale University

We use mantle plume images from finite frequency tomography and the Stokes equation to obtain a quantitative estimate of the heat and volume flux across several well resolved plume sections in the lower mantle. A major finding is that the heat flux through the plumes exceeds what can be accomodated within the constraints of the terrestrial heat balance unless the buoyancy of the hot material is reduced by a denser component such as iron, or the inferred temperatures are reduced through the presence of water, or the viscosity is very high ($> 10^{23}$ Pa s). With high probability, the observed buoyancy fluxes at the Earth's surface do not represent the full flux at depth.

To deal with the large uncertainties in the values of physical parameters in the Earth we randomly generate 560,000 different Earth models and reject those models that are incompatible with observed buoyancy fluxes. The remaining model histograms represent marginal probability density functions. We introduce a new parameter, the flux loss factor ω_B, the fraction of the deep plume flux represented by the observed buoyancy flux at the surface. ω_B, the iron enrichment ΔX_{Fe} and the viscosity η are the three most influential parameters in our analysis. The maximum likelihood value we obtain is 0.8×10^{23} Pa s for the dynamic viscosity near the top of the lower mantle; the iron enrichment and the flux loss factor are much less sharply defined but show a preference for values near limits imposed by independent factors: 0.4% for the iron enrichment ΔX_{Fe}, and near 0.2 for ω_B. Such low values for ω_B imply that much of the upward material flux into the upper mantle is carried by plumes. Only the strongest plumes rise more than 1 cm/yr and the maximum heat flux carried by the plumes is of the order of 1 W/m^2, comparable to the highest heat fluxes observed at the surface. These estimates carry a considerable variance and should be considered in the context of the full marginal probability density functions that we present.