Discussion of

Lower mantle material properties and convection models of multiscale plumes

by

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25th December, 2006, Gillian R. Foulger

It has been remarked that the heating mode in the paper by Matyska & Yuen is not clear, and the figures give the impression that the mantle is assumed to have no radioactivity and that the 2D models are driven entirely by heating from below. Would the authors care to clarify the thermal boundary conditions, and the bearing any simplifying assumptions have on the contribution of core heat and the resulting Rayleigh number?

6th January, 2007, Ctirad Matyska & David A. Yuen

Our convection models are partly heated from within as we have used the dimensionless heat source term $R = 3$, which is equivalent to about 25% of the chondritic value. Moreover, with radiative thermal conductivity, there is a tendency for overheating in the lower mantle for a chondritic mantle. The bottom boundary is isothermal and thus a substantial amount of heat comes from below. This heating mode could be caused by a decrease of the core gravitational potential energy due to inner core formation, ohmic dissipation, and perhaps some radioactivity from potassium. Moreover, the core was heated during Earth formation and its cooling represents another source of heat, which flows from the core to the mantle. However, we did not compute cooling of the core, and thus the temperature of the bottom boundary does not change with time in our computations.

The surface Rayleigh number was set to 10^7; we note, however, the concept of Rayleigh number becomes vague in the presence of depth-dependent thermal expansivity, depth- and temperature-dependent viscosity, and radiative thermal conductivity. An "effective" Rayleigh number is much lower, especially at the bottom of the lower mantle, something like 10^5. The combined effect of the depth-dependent mantle material properties resulted in the creation of the lower-mantle superplumes with very low lateral temperature variations, followed by "classical" thin plumes emerging from the 670-km boundary.

References