Can the transition zone test the Plate and Plume hypotheses?

Gillian R. Foulger

Dept. Earth Sciences, Univ. of Durham, Durham DH1 3LE, U.K.

g.r.foulger@durham.ac.uk

In recent years it has been recognized that the assumption that melting anomalies such as Iceland and Hawaii are fuelled by mantle plumes has by no means been proven. It has been proposed instead that they result from shallow processes associated with plate tectonics–the "Plate" model. The mantle plume model predicts that beneath melting anomalies, material with a temperature anomaly of 300 ± 100 K rises through conduits that extend from the core-mantle boundary to the surface. They must thus pass through both the 660-km and 410-km discontinuities. As a consequence, topographic anomalies are expected on the discontinuities, along with seismic wave-speed anomalies above, within and below the transition zone. The Plate model, in contrast, predicts that the structures and processes underlying melting anomalies are confined to the upper mantle, usually the shallowest parts. Structures may occasionally extend through the 410-km discontinuity and on into the transition zone, but rarely, if ever, deeper and through the 660-km discontinuity.

The 410-km discontinuity is depressed under some melting anomalies, but this observation is permitted by both the Plate and Plume hypotheses. In principle, the presence or absence of topography on the 660-km discontinuity is the most diagnostic indicator of whether or not downward-continuous, hot conduits exist. In practice, however, there are difficulties. It is unclear what the net Clapeyron slope is for the several mineralogical phase changes that occur in this region. Furthermore, the expected topographic anomaly may be too small to detect in practice, except for unusually well-instrumented cases. It has also not been clearly laid out what the effects of partial melt and compositional anomalies are on transition-zone discontinuity topography. It is thus at present unclear to what extent study of the 660-km discontinuity can test the mantle plume hypothesis.