Brandon Schmandt's "Intermittent upwelling of hot lower mantle beneath Yellowstone"

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Abstract

There is long-standing debate as to whether hotspot volcanism is stimulated by narrow plumes of hot lower mantle buoyantly rising to the base of Earth's tectonic plates. Two types of seismic evidence particularly useful for identification of narrow hot plumes are deflections of near-horizontal discontinuities in seismic velocity that bound the mantle transition zone and three-dimensional variations in seismic velocity. Thus, a stringent test of the lower mantle plume hypothesis is identification of a narrow region where upward deflection of the 660 km discontinuity and low seismic velocities consistently indicate high temperatures.

Prior investigations of hotspots have yielded ambiguous or inconsistent results. The quality of seismic sampling near Yellowstone is now unrivaled among active hotspots as a result of Earthscope and other regional seismic deployments.

New seismic imaging finds a narrow ~15 km upward deflection of the 660 centered just northeast of Yellowstone caldera, which is consistent with images of low-velocity mantle extending across the 660. These results indicate a thermal plume, with a maximum excess temperature of ~240 K, rising from the lower mantle. Absence of depression of the 410 km discontinuity and irregular geometry and magnitude of the low-velocity anomaly indicate vertical segmentation of the high-temperature upwelling. This implies intermittent upward flux of hot lower mantle beneath Yellowstone.

Evolving buoyancy contrast of rising plume material due to mineralogical transitions near 660 km depth is a probable origin for pulsating plume flux and may contribute to temporal variations in hotspot magmatic productivity.