Mass flux across the lower–upper mantle boundary: Vigorous, absent, or limited?

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ABSTRACT
Understanding of the style of mantle convection and determining the mass flux across the upper–lower mantle boundary is dependent on several critical questions, including whether the mantle is chemically stratified, where the boundary between chemically distinct mantle regions lies, what the compositions of these mantle regions are, to what depths slabs subduct, and what mechanism of mass and heat transfer is used. Answers to these questions are expected in geochemical and geophysical data. Many geochemical observations that have been interpreted as evidence for vigorous mass flux from the lower mantle and the core via plumes to the upper mantle (e.g., He-Sr-Nd-Pb-Os isotopic ratios in oceanic basalts) can be interpreted as involvement of recycled lithospheric material without lower-mantle plumes. Geophysical observations provide no strong constraints on penetration of slabs deep into the lower mantle. Deep slab penetration, if any, could occur during agglomeration of supercontinents. Most subducting slabs remain in the upper mantle or at the boundary between the upper and the lower mantle. The primary mechanism of convection in the upper mantle is cooling from above. However, ancient slabs can become buoyant after radiogenic heating if they contain sufficient sediments bearing radioactive elements. These heated slabs will rise, contributing to upward convective flow. Mass flux between the upper and the lower mantle is either absent or highly limited, but further studies are required to resolve this question.