Improving constraints on multi-scale heterogeneity in the upper mantle

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Globally-averaged amplitudes of scattered coda waves suggest strong and pervasive heterogeneity throughout the uppermost mantle at lateral scale-lengths ranging from a few to thousands of km. The precise depth extent and root-mean-square velocity perturbation of this heterogeneous zone is poorly constrained owing to the linear tradeoff between these two quantities. Nonetheless, evidence from PKP precursors implies that small- and intermediate-scale heterogeneity throughout the lowermost mantle is, on average, at least a factor-of-ten weaker than that in the uppermost mantle.

Here we explore the possibility that the mantle is a self-similar mixture of basalt and harzburgite, in which case the dichotomy in heterogeneity strength between the uppermost and lowermost mantle may be due to the post-garnet phase transition at the base of the mantle transition zone, as the velocity contrast between basalt and harzburgite is thought to drop from about 10% to less than 1% across this boundary. To improve our understanding of the strength and scale of mid-mantle heterogeneity, we undertake a series of analyses including (1) characterization and modeling of coda-wave amplitude variation with event depth; (2) comparison with surface-wave phase-velocity maps to tighten constraints on uppermost mantle heterogeneity; and (3) determination of what fraction of root-mean-square heterogeneity comes from well-understood long-wavelength structure such as the continent--ocean function and the thermally controlled mid-ocean ridge system.

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