Geophysical Research Abstracts
Vol. 19, EGU2017-11542, 2017
EGU General Assembly 2017

Understanding how the shape and spatial distribution of ULVZs provides insight into their cause and to the nature of global-scale mantle convection

Allen McNamara (1), Mingming Li (2), Ed Garnero (3), and Nicole Marin (3)

(1) Michigan State University, East Lansing, United States (allenmc@msu.edu), (2) University of Colorado, Boulder, United States, (3) Arizona State University, Tempe, United States

Seismic observations of the lower mantle infer multiple scales of compositional heterogeneity. The largest-scale heterogeneity, observed in seismic tomography models, is in the form of large, nearly antipodal regions referred to as the Large Low Shear Velocity Provinces (LLSVPs). In contrast, diffracted wave and core-reflection precursor seismic studies reveal small-scale Ultra Low Velocity Zones (ULVZs) at the base of the mantle that are almost two orders of magnitude smaller than the LLSVPs. We hypothesize that ULVZs provide insight into the nature of LLSVPs, and the LLSVPs, in turn, provide clues to the nature of global-scale mantle convection and compositional state. However, both LLSVPs and ULVZs are observations, and it remains unclear what is causing them. Here, we examine several related questions to aid in understanding their cause and the dynamical processes associated with them. Can we use seismic observations of ULVZ locations to differentiate whether they are caused by compositional heterogeneity or simply partial melting in otherwise normal mantle? Can we use the map-view shape of ULVZs to tell us about lowermost mantle flow directions and the temporal stability of these flow directions? Can the cross-sectional morphology of ULVZs tell us something about the viscosity difference between LLSVPs and background mantle? We performed geodynamical experiments to help answer these questions. We find that ULVZs caused by compositional heterogeneity preferentially form patch-like shapes along the margins of LLSVPs. Rounded patches indicate regions with long-lived stable mantle flow patterns, and linear patches indicate changing mantle flow patterns. Typically, these ULVZ patches have an asymmetrical cross-sectional shape; however, if LLSVPs have a larger grain-size than background mantle, their increased diffusion creep viscosity will act to make them more symmetrical. Alternatively, ULVZs caused simply by partial melting of normal mantle are preferentially located significantly inboard of LLSVP margins and have relatively symmetrical cross-sectional shapes. These results can prompt new seismic studies to better constrain the cause and dynamic significance of multi-scale compositional heterogeneity in the Earth's mantle.