Investigating the origin of Ultra-low velocity zones

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Seismic tomography has revealed two, large low shear-velocity provinces (LLSVPs) in the lowermost mantle beneath the central Pacific and Africa. These LLSVPs have been hypothesized to be caused by the presence of large-scale compositional reservoirs. Seismic studies have also detected much smaller-scale ultra-low velocity zones (ULVZs) in the lowermost tens of kilometers of the mantle, on the core mantle boundary. However, the origin of ULVZs is still controversial, and it is unclear whether ULVZs are caused by partial melting within hottest regions of LLSVPs, or whether they are caused by chemical heterogeneities that are compositionally distinct from LLSVPs.

Here, we perform high-resolution, 3D thermochemical calculations to investigate the morphology and distribution of ULVZs and the interaction between LLSVPs and ULVZs. We find that if ULVZs have different composition than LLSVPs, they will preferentially accumulate into discontinuous patches with variable size and shape along the edges of LLSVPs (although some may be temporarily located within the central regions of LLSVPs). However, if ULVZs are instead caused by partial melting within the hottest regions of the LLSVPs, they would be located inboard of LLSVP margins, where temperature is highest. Our results thus suggest that ULVZs along the edges of LLSVPs are caused by chemical heterogeneity, while ULVZs located inboard of LLSVP margins may be better explained by partial melting of LLSVP material.