Examining the role of chemical heterogeneity on the deep mantle seismic signature using 3D thermo-chemical mantle modelling

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It has been well established that at the base of the mantle sits two regions of anomalously low seismic velocities. These two regions have become known as the large low velocity provinces (LLVPs). Despite being well observed from studies using seismic tomography, our fundamental understanding of the cause of these regions remains in question. Geochemical observations suggest these LLVPs could be a source of distinct primordial material, providing reservoirs within the mantle to hold a variety of distinct chemistry. Detailed studies using various seismic waves also suggest LLVP densities varying from denser than the ambient mantle to more buoyant than the ambient material.

Previous work using computational models has shown the viability of both purely thermal models and thermo-chemical models which contain a primordial layer as potential routes for explaining the LLVPs. In our present study we investigate these two modes as well as an alternative third path; namely the generation of chemically distinct LLVP regions in the mantle through the accumulation of subducted material.

Using the 3D mantle convection model TERRA, we can interrogate these three modes of generating the observed seismic heterogeneity. Our models are able to generate compositional variation through self-consistent melting zones. By using the latest plate reconstruction models as a boundary condition our models are able to accurately mimic the surface processes at the plate boundaries, whilst also arranging the lower mantle into the typical degree two pattern that is analogous to the LLVPs. The results we present probe these modes of LLVP construction, providing additional insight into their formation and longevity.