Investigating melting induced mantle heterogeneities in plate driven mantle convection models

Observations from geochemistry and seismology continue to suggest a range of complex heterogeneity in Earth's mantle. In the deep mantle, two large low velocity provinces (LLVPs) have been regularly observed in seismic studies, with their longevity, composition and density compared to the surrounding mantle debated. The cause of these observed LLVPs is equally uncertain, with previous studies advocating either thermal or thermo-chemical causes. There is also evidence that these structures could provide chemically distinct reservoirs within the mantle, with recent studies also suggesting there may be additional reservoirs in the mantle, such as bridgmanite-enriched ancient mantle structures (BEAMS). One way to test these hypotheses is using computational models of the mantle, with models that capture the full 3D system being both complex and computationally expensive.

Here we present results from our global mantle model TERRA. Using our model, we can track compositional variations in the convecting mantle that are generated by self-consistent, evolving melting zones. Alongside the melting, we track trace elements and other volatiles which can be partitioned during melting events, and expelled and recycled at the surface. Utilising plate reconstruction models as a boundary condition, the models generate the tectonic features observed at Earths surface, while also organising the lower mantle into recognisable degree-two structures. This results in our models generating basaltic oceanic crusts which are then brought into the mantle at tectonic boundaries, providing additional chemical heterogeneity in the mantle volume. Finally, by utilising thermodynamic lookup tables to convert the final outputs from the model to seismic structures, together with resolution filters for global tomography models, we are able to make direct comparisons between our results and observations.

By varying the parameters of the model, we investigate a range of current hypotheses for heterogeneity in the mantle. Our work attempts to reconcile the many proposed current ideas for the deep mantle, giving additional insight from modelling on the latest observations from other Deep Earth disciplines.