The Icelandic plume: Removing crust from the mantle

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Our understanding of the uppermost mantle beneath Iceland has benefited from several regional tomographic studies. They all image a pseudo-cylindrical low velocity anomaly extending through the upper mantle to the maximum depth of resolution. However, in such studies the resolution degrades below ~400 km depth, making it impossible to determine the source depth of the low velocity anomaly. Also, the use of teleseismic body-wave arrivals alone results in a loss of resolution in the upper ~75 km of the model due to the near parallel nature of the rays at shallow depths.

In an effort to improve resolution of the uppermost mantle we first determine crustal structure using surface waves from local events. We then combine data from the PASSCAL-HOTSPOT and ICEMELT experiments with that from the permanent SIL network in Iceland to generate a teleseismic arrival-time dataset. The crucial step to improving resolution in the uppermost mantle is the removal of crustal travel times from the teleseismic dataset using our crustal model. This prevents the smearing of crustal velocity anomalies (which are significant) into the uppermost mantle. In addition to the corrected teleseismic body-wave dataset, we compile phase velocity information from teleseismic Love waves in an effort to recover some of the vertical velocity structure lost in the determination of relative body-wave arrival times.

The resulting tomographic images (see figure) show a low velocity cylinder extending from at least 400 km up to ~200 km. Its maximum P- and S-velocity anomaly are -2% and -4% respectively, similar to that seen in previous studies. However, the use of crustal corrections, and the inclusion of surface wave data, result in a very different structure above ~200 km to that previously observed. The vertical cylinder is replaced by a predominantly horizontal low velocity anomaly, which extends beneath all of Iceland. Within this horizontal anomaly we find regions of relatively high P- and S-velocity beneath central Iceland, directly above the core of the deeper low velocity anomaly. These observations are consistent with a low velocity mantle plume extending from greater than 400 km depth up towards the surface. Above ~200 km, plume material collects below the lithosphere, forming a horizontal region of low velocity - a plume head. The presence of relatively high velocities within the plume head, beneath central Iceland, may be the result of the extensive mantle melting necessary to generate the 46 km thick crust above.

Vertical W-E cross-section through our S-velocity model ICEMAN-S.