Reviewed research article

The seismic structure of Iceland

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Abstract — *We review here the contributions that seismology has made toward our understanding of Iceland, the best-studied of ridge-centered hotspots. Iceland is the subarial part of the Greenland-Iceland-Faeroe Ridge, a band of thickened basaltic crust, 25–30 km, stretching across the North Atlantic that represents the product of hotspot volcanism from the early Tertiary to present. Crustal thickness increases from 11 km on the Reykjanes Ridge section of the Mid Atlantic Ridge south of Iceland, to 35–40 km in central Iceland, and then decreases to 9 km on Kolbeinsey Ridge to the north. The correlation of crustal thickness, topographic elevation and gravity indicate that the crust is in isostatic equilibrium. Crustal seismic velocities are comparable to those in normal oceanic crust, except that Oceanic Layer 3, thought to represent gabbroic cumulates, is disproportionately thick. Judging from the generally low shear wave attenuation observed almost everywhere in Iceland, the crust is mostly subsolidus, although tomographic imaging of both shear velocity and* V_P/V_S *ratio indicate that hotter conditions occur in the lower crust along the neovolcanic zones (the expression of the Mid Atlantic plate boundary in Iceland). Actual basaltic melt has only been observed in shallow (2–3 km) crustal magma chambers located beneath central volcanoes, where it causes local zones of intense shear wave attenuation and delayed P wave arrival times. These magma chambers are often underlain by seismically-fast domes thought to represent gabbroic cumulates. While the crust must contain plumbing systems that deliver melt from the asthenospheric mantle to these shallow magma chambers, they have not been observed. Much of the crust, especially outside the neovolcanic zones, appears to be underlain by a 30–50 km thick mantle 'lid' of seismically-fast, relatively cool (subsolidus) mantle lithosphere. The mantle beneath this lid is dominated by a cylindrically-shaped zone of low seismic velocities (both compressional and shear) that has a diameter of 100–200 km and is centered beneath the Vatnajökull region of southeastern Iceland. Regional tomography indicates that this feature extends down to at least 350 km. Measurements of seismic anisotropy, which provides information on mantle-flow directions, provide some evidence for mantle upwelling in this region, but the pattern of flow does not have the radial pattern expected of simple upwelling. Instead, mantle flow appears to be channeled in some way by structures associated with the plate boundary. Whether the low velocity anomaly represents a deeply-rooted plume beneath Iceland is currently hotly-debated. The key issue of whether the low-velocities extend to depths deeper than 350 km has been addressed with global tomography, but results appear equivocal: some authors see little evidence in the global tomography for it extending deeper than the bottom of the transition zone (670 km), but others see it connecting with larger-scale low-velocity features in the lower mantle.*