Geophysical Research Abstracts
Vol. 17, EGU2015-9610, 2015
EGU General Assembly 2015

Imaging magma plumbing beneath Askja volcano, Iceland

Tim Greenfield and Robert S. White
Bullard Laboratories, University of Cambridge, Cambridge, UK (tg286@cam.ac.uk)

Volcanoes during repose periods are not commonly monitored by dense instrumentation networks and so activity during periods of unrest is difficult to put in context. We have operated a dense seismic network of 3-component, broadband instruments around Askja, a large central volcano in the Northern Volcanic Zone, Iceland, since 2006. Askja last erupted in 1961, with a relatively small basaltic lava flow. Since 1975 the central caldera has been subsiding and there has been no indication of volcanic activity.

Despite this, Askja has been one of the more seismically active volcanoes in Iceland. The majority of these events are due to an extensive geothermal area within the caldera and tectonically induced earthquakes to the northeast which are not related to the magma plumbing system. More intriguing are the less numerous deeper earthquakes at 12-24km depth, situated in three distinct areas within the volcanic system. These earthquakes often show a frequency content which is lower than the shallower activity, but they still show strong P and S wave arrivals indicative of brittle failure, despite their location being well below the brittle-ductile boundary, which, in Askja is $\sim$7km bsl.

These earthquakes indicate the presence of melt moving or degassing at depth while the volcano is not inflating, as only high strain rates or increased pore fluid pressures would cause brittle fracture in what is normally an aseismic region in the ductile zone. The lower frequency content must be the result of a slower source time function as earthquakes which are both high frequency and low frequency come from the same cluster, thereby discounting a highly attenuating lower crust.

To image the plumbing system beneath Askja, local and regional earthquakes have been used as sources to solve for the velocity structure beneath the volcano. Travel-time tables were created using a finite difference technique and the residuals were used to solve simultaneously for both the earthquake locations and velocity structure. The 2014-15 Bárðarbunga dyke intrusion has provided a 45 km long, distributed source of large earthquakes which are well located and provide accurate arrival time picks. Together with long-term background seismicity these provide excellent illumination of the Askja volcano from all directions.

We find a pronounced low-velocity anomaly beneath the caldera at a depth of $\sim$7 km. The anomaly is $\sim$10% slower than the initial best fitting 1D model and has a Vp/Vs ratio higher than the surrounding crust, suggesting the presence of increased temperature or partial melt. The body is unlikely to be entirely melt as S-waves are still detected at stations directly above the anomaly. This low-velocity body is slightly deeper than the depth range suggested by InSAR and GPS studies of a deflating source beneath Askja. Beneath the main low-velocity zone a region of reduced velocities extends into the lower crust and is coincident with deep seismicity. This is suggestive of a high temperature channel into the lower crust which could be a pathway for melt rising from the mantle.