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A tectonic model of the Askja caldera system based on FEM analysis

John Browning, Agust Gudmundsson, and Thorvaldur Thordarson

Royal Holloway, University of London, Department of Earth Sciences, Egham, United Kingdom
(john.browning.2012@live.rhul.ac.uk)

The Askja volcanic system lies on the boundary between the Eurasian and North American tectonic plates and is an example of a multiple caldera formed in an extensional regime. Askja is composed of at least three calderas, the last of which formed during an explosive eruption in A.D. 1875. The caldera floor has been subsiding almost continuously since 1983; total subsidence in this period is around 1.1 metres. Perhaps surprisingly, there has been no slip or movement on the caldera bounding ring-faults during this subsidence period. Various models have been proposed to explain this unusual signal. Previous models suggest two magma sources, one shallow at around 3 km depth and one much larger at around 16 km depth. In this model, subsidence is caused by depressurisation in both sources as a result of cooling contraction and crystallisation. In other models subsidence results from magma being squeezed out of the shallow chamber laterally; or somehow draining back into a deep seated reservoir.

In this study we examine the contribution of regional extension and structural discontinuities to the current subsidence of Askja caldera. Using a finite element numerical analysis, we ascertain the state of stresses at Askja caldera over time based on several different magma body geometries. We calculate surface displacements expected from extension around a shallow magma body, and place these findings in the context of Icelandic calderas. In addition we investigate the likely stress effects of the Askja caldera on the associated part of the Northern Volcanic Zone. The proposed model seeks to understand the volcano-tectonic conditions at Askja during caldera formation, as well as during rifting episodes. The models presented will be useful in assessing likely future rifting events and fissure swarm activity in Askja caldera, and neighbouring volcanoes.