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Investigating the mechanisms controlling the eruptive frequency at Hekla volcano, Iceland

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Hekla is one of the most frequently erupting volcanoes in Iceland with 18 summit eruptions during the past 900 years, the last one in February-March 2000. Before 1970 the average repose period between eruptions was of ∼60 years but since then Hekla has erupted four times, approximately every 10 years (in 1970, 1980-81, 1991 and 2000). Fifteen years have now passed since the last eruption, but no signs of unrest have yet been recorded. Did something change at Hekla since the last eruption in 2000?

There are many factors that may control the eruptive frequency of the volcano, such as changes in the state of stress around its plumbing system or variations in the rate of magma supply from depth. For example, Hekla is located in a very dynamic area, at the intersection of the Eastern Volcanic Zone (EVZ) and the South Iceland Seismic Zone (SISZ). We therefore investigate the effects on the magmatic system caused by seismic activity in the SISZ, in particular the stress changes produced by the post-seismic relaxation following two earthquakes that occurred in June 2000 along faults located only 35-50 km west of Hekla.

Since 2000 further stress changes may have also been caused by dike intrusions feeding the eruption of the neighboring volcano Eyjafjallajökull in 2010, or by changes in the rate of ice melting at the ice-caps in central and southern Iceland. In fact, previous studies have highlighted the possible influence of ice melting, and the consequent glacial isostatic adjustment of the crust, on the production of magma and its storage.

Furthermore, at Hekla, a direct correlation exists between the duration of the repose period, the volume of the eruption and its silica content. An almost perfectly linear correlation can be found between time and the cumulative erupted volume, as the sum of both lava flows and tephra, between 1104 A.D. and 2010. From this correlation we can infer a conservative constant rate of magma supply to the volcano of ∼0.013 km3/yr. At this rate, Hekla would have accumulated ∼0.2 km3 of eruptible magma since its last eruption in 2000. We use geodetic measurements of the surface deformation from interferometric synthetic aperture radar (InSAR) data to investigate the dynamics of magma supply and storage during the 2000-2014 time period. Preliminary results show that the volume change inferred from geodetic data and calculated assuming an elastic rheology for the crust, cannot account for the volume estimated using the long-term rate of magma supply. This may suggest a change in the supply rate during the past decade and/or a more complex rheology of the crust or of the magma that may reduce the amount of deformation measured at the surface.

Our study applies a multi-disciplinary approach that utilizes information gathered from the analyses of geodetic, seismic, geological and petrological data, in the attempt to increase the scientific understanding of the dynamics controlling the eruptive activity at Hekla. Our effort falls within the scopes of the FUTUREVOLC collaborative project of which this study is also a part.