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The 2010 inflation and deflation sources of Eyjafjallajökull: Magma flow, geochemical characteristics and evidence for intrusion triggering of the explosive summit eruption

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GPS and InSAR data spanning the 2010 eruptions and unrest at Eyjafjallajökull have been fitted to model interpreted in terms of two main deformation sources active in 2010. i) Complex intrusion under eastern flank, with sills at about 5 km depth, and dike extending upwards to the surface. ii) deflation source under the summit at about the same depth, modeled as a sill for the first 10 days of the eruption. These results can be compared to seismicity patterns, and geochemistry of the eruptive products.

Seismic activity in January and February 2010 suggests a magma upflow channel east of the summit fed the intrusive complex. Seismicity reveals that intrusion is likely to have grown in an incremental manner. Bursts of earthquakes occurred during incremental growth of the intrusion, in a temporally and spatially complex manner. From early March and until the beginning of the flank eruption major seismicity occurred on an E-W trending segment, in relation to progressive evolution of a dyke at depth and the opening of a narrow magma channel from it to the site of the flank eruption.

Flank eruption provides “a window” on the likely geochemical characteristics of the intrusion that evolved prior to the activity. This eruption produced olivine-and-plagioclase-bearing basalt with 45.9-46.3 SiO_2, having 8-9% MgO and euhedral phenocrysts assemblage composed of Cr-rich spinel, olivine in the range Fo87-71, and plagioclase with An81-76. Abundant vesicles and microlites characterize the groundmass, suggesting degassing-related crystallization. The interstitial glass composition is similar to the evolved FeTi-basalts of the neighbouring Katla volcano (MgO: 4.5-5.0%).

The explosive eruption was associated with pressure decrease in a “distributed” source under summit area of the volcano. Fine-grained tephra of benmoritic composition was produced. Three glass types are observed in the early tephra with SiO_2 concentrations of 49-51%, 60-61% and 69-70% that illustrates a mechanical magma mingling without enough time for homogenization before eruption. The geochemical results are interpreted in form of a binary mixing between fractionated basalt and a dacitic melt, possibly left-over from a preceding eruption at Eyjafjallajökull 1821-23 that produced dacite.

Just before the summit eruption, and during the flank eruption, subtle seismic activity was already detected at 10-12 km depth in a possible feeding channel to the summit eruption site. However, the main swarm indicating more pronounced magma transport towards this channel began at 5-8 km depth only 2-3 hours before the beginning of the eruption and soon earthquakes also occurred between 0 and 3 km depth (after a ML 2.3 event). This pattern agrees well with the model of deeper magma hitting a body of evolved magma at 3-5 km depth on 13 April.

The course of events at Eyjafjallajökull may show complexities typical for reawakening of moderately active volcanoes. Intrusions may lead to eruptions not only when they find their way to the surface; at Eyjafjallajökull our observation show how primitive melts in an intrusive complex active since 1992 catalyzed the explosive eruption of April-May 2010.