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InSAR derived source geometries of two recent intrusive events in the Eyjafjallajökull volcano, Iceland, and their relation to the tectonic setting

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Significant surface deformation on the flanks of Eyjafjallajökull, a stratovolcano situated in a volcanic flank zone in south Iceland, has been observed in a series of more than 150 interferograms. The total time span of the data is 1992-2000, but the observed deformation can be shown to originate from two distinct intrusion events into the roots of the ice-cap covered volcano. Eyjafjallajökull erupts infrequently, with only two known eruptions in historic time (last 1100 years). However, since 1991 seismic activity has been increasing, and two seismic unrest episodes related to magmatic intrusions occurred in 1994 and 1999. Associated crustal deformation was recorded by dry-tilt, GPS and InSAR. We apply a two-step inversion method to model the deformation recorded in InSAR images, and relate the derived source geometry to the tectonic setting of the volcano.

During the 1994 unrest period, the centre of deformation was situated beneath the ice-cap, but deformational fringes reach well beyond the icecap on the southern slopes of the volcano. The affected area exceeds 300 km^2 in total, with up to 15 cm of displacement. Seismicity was restricted to the northern volcano slope. A variable opening horizontal sill intrusion at 4.6 km depth is our preferred model. The intrusion volume was 0.017 km^3.

The 1999 dataset provides opportunity to examine the spatio-temporal evolution of the intrusion. The total deformation amounts to more than 20 cm. Four interferograms cover the whole time-span, and five others cover different periods of the 1999 intrusive event. The centre of deformation does not coincide with the 1994 centre, and is seen to migrate through time. A horizontal sill model with variable opening is preferred, at

6.3 km depth.

The Eyjafjallajökull volcano may, unlike many of the active volcanic centers in Iceland, be regarded as a cold structure, with no residing magma chamber at shallow depth. The low eruptive activity of the system further supports this theory, as well as the variations in the location of maximum ground deformation recorded not only between distinct intrusive events, but also during the 1999 event, as the source of deformation cannot be due to pressure increase within a stationary magma chamber.

The pressure required to create a point source within a cold crust is on the order of 40 GPa, exceeding the tensile strength of the elastic host rock by more than four orders of magnitude, whereas a horizontal, plane circular sheet intrusion similar to the ones in our study only requires an overpressure only on the order of 4 MPa. Sill intrusions may be an important internal growth process occurring in the Icelandic flank zone volcanoes, thereby contributing to their considerable topographic relief.