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The magmatic system beneath Torfajökull volcano, Iceland, through radar and seismic interferometric analysis

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Torfajökull is the largest silicic volcanic centre in Iceland lying at the intersection of the rift zone (Mid Atlantic Ridge) and the transform zone that connects to Reykjanes peninsula. It erupts infrequently, with only two eruptions in the last 1200 years, the latest of which was over 5 centuries ago. Yet, its active tectonic setting, persistent high and low frequency seismicity, deformation and geothermal activity within its large caldera (18x12 km diameter) indicate the continued presence of a long-lasting magma chamber. Here we speculate on possible geometry, size and depth of the Torfajökull magma chamber by using radar interferometry (InSAR) and seismic interferometry (SI).

Using InSAR time series analysis we detect a surface subsidence pattern at rates of up to ~13 mm yr^{-1} in the SW region of Torfajökull´s caldera, on-going since at least 1993. The subsidence rate is constant in time, and perhaps due to a cooling magma chamber. The data can be fit reasonably well using a model of a NE-SW oriented spheroidal body at ~5 km depth. As the deflating area correlates spatially with the area of geothermal activity, deflation may also be the surface response due to an active hydrothermal circulation.

To gain more insight into the geometry of Torfajökull's magmatic system and rock properties of the subsurface, we apply ambient noise seismic interferometry (SI) by cross-correlation of ambient noise. With this technique we can detect velocity variations, which can correspond to the edges of dikes or molten magma bodies. Our tomographic results give reliable results of velocity variations within a depth range of 2 km to 7.5 km. We find high velocity zones that we interpret as old dike intrusions. Low velocity anomalies (>5%), which usually indicate the presence of warmer material, are located on the southeast and southwest part of the volcano, outside the volcano caldera.

Finally we compare both InSAR and SI results. The hypothesis of a magma chamber under the subsidence area detected by InSAR does not seem to fit the tomographic results, as the expected edges of a magma body modelled by InSAR are not clearly identified by the SI results. If there is an established magma chamber within Torfajökull caldera this is likely to be bellow 7km depth.