

## Abstract

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With the ever increasing world population, more and more people live in the vicinity of a potentially active volcano. At any given time, around 20 of those are erupting. In the past decades advances have been made in forecasting volcanic eruptions. This work shows that by combining established monitoring techniques, more can be learnt about the ongoing volcanic processes at active volcanoes.

Volcanic processes vary from very fast persistent activity to extremely slow caldera unrest. Here, volcanoes at both ends of the spectrum were studied using micro-gravity techniques in combination with at least one other technique. Askja and Krafla caldera in Iceland represented the slow processes while Stromboli in Italy symbolized the processes in the faster part of the range.

At the rapidly deflating Askja caldera in Iceland, conventional micro-gravity techniques show a net micro-gravity decrease in the centre during 1988-2003. This net micro-gravity decrease is most likely caused by a combination of cooling and contraction of the shallow magma reservoir and magma drainage. Mogi point-source models are used to calculate an ongoing magma drainage rate of  $0.125 \text{ m}^3/\text{s}$  from 1988 to 2003. Tectonic forces are inferred to generate space in the ductile part of the crust allowing magma to drain to deeper levels.

InSAR data of Krafla caldera in Iceland (1993-1999) reveal, apart from the previously described rift zone and small concentric deflating features, a broad inflating signature 15 km north of Krafla mountain. This signal is, after extensive modelling, interpreted as magma accumulation at 21 km depth, close to the crust-mantle boundary. It

is a revelation that the effect of such a deep source can be observed at the surface using modern monitoring techniques. When magma in this reservoir reaches a critical pressure it will migrate to the shallow magma chamber from where it eventually may erupt. This agrees with the long periods of dormancy between rifting episodes.

Geodetic data from Krafla confirm that the area is still deflating. Interpretation of micro-gravity surveys is hampered by a geothermal power plant within the caldera whose operation affects the water mass balance. For the first time, micro-gravity data have been corrected for these effects and results show a net micro-gravity decrease from 1990 to 2003. This mass decrease is interpreted as a result of magma draining at a rate of 0.23 m<sup>3</sup>/s.

Observations at Askja and Krafla volcano suggest they each have a draining shallow magma chamber connected to a deeper magma reservoir. Analysis of InSAR data suggest the deeper Krafla reservoir is inflating. It is possible a pressure-link between these volcanoes exists along the ductile crust in Iceland.

Continuous micro-gravity may be used as a tool to understand conduit processes at persistently active volcanoes, such as Stromboli in Italy. My data show Low Frequency Oscillations possibly related to column height changes and High Frequency Oscillations related to volcanic vibrations caused by degassing events. However, more extensive data are needed to correct for instrumental drift.

Micro-gravity has proved to be a valuable tool in monitoring active volcanoes at either the slow or the fast ends of the spectrum. Micro-gravity data become even more powerful when combined with other techniques, which is feasible with the use of modern equipment.