MAGMA CHAMBERS AND INTRUSIONS IN ICELANDIC CRUST – CONSTRAINTS FROM VOLCANO GEODESY

Freysteinn Sigmundsson (1), Erik Sturkell (2), Rikke Pedersen (1), Andy Hooper (3), Halldór Geirsson (4), Páll Einarsson (5), Benedikt G. Ófeigsson (1), Þóra Árnadóttir (1), and Judicael Decriem (1)

1. Nordic Volcanological Centre, Institute of Earth Sciences, University of Iceland; 2. University of Gothenburg, Sweden; 3. Delft Technical University, Netherlands; 4. Icelandic Meteorological Office, Iceland; 5. Institute of Earth Sciences, University of Iceland

Abstract

Extensive crustal deformation studies have been conducted at Icelandic volcanoes for over four decades, utilizing levelling, electronic distance measurements, GPS geodesy, satellite radar interferometry (InSAR), and other techniques. The measurements have revealed a number of persistently deforming areas at central volcanoes, interpreted as a consequence of pressure variations in magma chambers, and more episodic deformation in relation to separate intrusions. In the Northern Volcanic Zone, deformation due to pressure variations in shallow magma chambers at the Krafla and Askja central volcanoes at about 3 km depth is well resolved. Pressure in both of these has been decreasing for the last two decades. At both Krafla and Askja volcanic systems, geodetic data have been interpreted in terms of additional sources at a depth of 16-22 km, although other interpretations cannot be excluded. In 2007-2008 a clear geodetic signal was recorded in relation to formation of a deep oblique sheet under Upptyppingar and Álftadalsdyngja, below the brittle-ductile transition. At Vatnajökull, the best-resolved magmatic deformation signal relates to inflation/deflation cycle of the Grímsvötn volcano, despite only a single observation site at Mt. Grímsfjall. The observations are explained by flow of magma in and out of a shallow magma chamber under the central part of the Grímsvötn caldera complex. Additionally, deformation of the Bárðarbunga volcanic system has been recorded, in relation to the 1996 unrest and Gjálp eruption. In South Iceland deformation data indicates pressure variations in magma chambers under Katla at a depth of a few kilometres. Analysis and inversion of InSAR data resolve a deep magma chamber under Hekla with a centre depth in the range of 15-20 km. At Eyjafjallajökull, two separate sill intrusions occurred in 1994 and 1999, and a new unrest episode began there in 2009. In SW-Iceland, the best-resolved magmatic signal is related to pressure increase under the Hrómundartindur volcanic system 1994-1999, interpreted as a result of magma accumulation. The seismic signatures associated with the observed inflation and deflation of magma chambers and the intrusions is highly variable, but combined interpretation of seismic and geodetic data, together with other available data, provides a powerful approach to understand unrest periods at volcanoes.