Geophysical Research Abstracts
Vol. 12, EGU2010-14516, 2010
EGU General Assembly 2010

Geophysical Observations Supporting Research of Magmatic Processes at Icelandic Volcanoes

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Magmatic processes at volcanoes on the boundary between the European and North American plates in Iceland are observed with in-situ multidisciplinary geophysical networks owned by different national, European or American universities and research institutions, but through collaboration mostly operated by the Icelandic Meteorological Office. The terrestrial observations are augmented by space-based interferometric synthetic aperture radar (InSAR) images of the volcanoes and their surrounding surface. Together this infrastructure can monitor magma movements in several volcanoes from the base of the crust up to the surface.

The national seismic network is sensitive enough to detect small scale seismicity deep in the crust under some of the voclanoes. High resolution mapping of this seismicity and its temporal progression has been used to delineate the track of the magma as it migrates upwards in the crust, either to form an intrusion at shallow levels or to reach the surface in an eruption. Broadband recording has also enabled capturing low frequency signals emanating from magmatic movements. In two volcanoes, Eyjafjallajökull and Katla, just east of the South Iceland Seismic Zone (SISZ), seismicity just above the crust-mantle boundary has revealed magma intruding into the crust from the mantle below. As the magma moves to shallower levels, the deformation of the Earth‘s surface is captured by geodetic systems, such as continuous GPS networks, (InSAR) images of the surface and – even more sensitive to the deformation – strain meters placed in boreholes around 200 m below the Earth‘s surface. Analysis of these signals can reveal the size and shape of the magma as well as the temporal evolution.

At near-by Hekla volcano flanking the SISZ to the north, where only 50% of events are of M>1 compared to 86% of earthquakes in Eyjafjallajökull, the sensitivity of the seismic network is insufficient to detect the smallest seismicity and so the volcano appears less active and deep seismicity has not been detected. Improved seismic station density may improve the resolution of deep processes. Due do Hekla‘s continued expansion, the concentration of the continuous GPS network has been increased around Hekla and a strain meter will be installed by the volcano in 2010. The increased density of geodetic observations is expected to increase the resolution of the depth, volume and geometry of the magma chamber. Before the volcano’s latest eruption in 2000, the increased seismicity and deformation signal recorded by the nearest seismic station and strain meter (at 15 km distance) enabled a public warning to be issued of the impending eruption 30 minutes prior to eruption. The additional instrumentation around Hekla is expected to extend the previous advance warning time.