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Tectonic evolution of the Geitafell Volcano, Southeast Iceland

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The Geitafell Volcano is an extinct Tertiary central (composite) volcano in East Iceland. Due to deep glacial erosion, the interior of the volcano down to the top of the extinct crustal magma chamber is exposed. This offers the unique possibility to study the infrastructure and tectonic evolution of a typical Icelandic central volcano.

The Geitafell Volcano consists of a succession of eruptive composite materials such as basaltic lava flows, hyaloclastites, and acid extrusives. In the core of the volcano, the upper part of an extinct crustal magma chamber is exposed and represented by several gabbro bodies. In direct contact with the chamber, there is a very dense swarm of inclined (cone) sheets. These were injected from the magma chamber when the Geitafell Volcano was active, at roughly 5 to 6 Ma (Fridleifsson, 1983).

In order to improve our understanding of the volcanotectonic evolution of the central volcano, we measured more than 500 inclined sheets and dykes, 400 mineral veins, and nearly 1100 joints in the Geitafell area. Analysis of the attitude of the inclined sheets shows that they have a circular strike distribution with a peak in N-S direction. Analysis of the joint and mineral vein systems in the gabbro bodies shows two main strikes, NNW-SSE and ENE-WSW. Most joints in the gabbros are cooling (columnar) joints that form when the outermost part of a gabbro body solidifies. The similarity in attitude of the joints and the mineral veins indicates that many cooling joints were subsequently used as pathways for geothermal fluids that circulated through the cooled outer envelope of the magma chamber. Furthermore, the attitude of 48 sheets that cut through the gabbros shows that some joints were used as pathways by the latest dykes and sheets to be injected from the chamber. These late-formed sheets passed through a cooled but still-hot envelope of the magma chamber on their way out to the main sheet

swarm. The sheets that dissect the gabbro envelope, however, are few in comparison with those in the high-intensity swarm at the margin of the gabbro pluton.

Remote-sensing studies and field observations suggest that the magma chamber in the core of the Geitafell Volcano was sill-like with a diameter of around 7 km. This geometry, together with data on the mechanical properties of the main layers that constitute the Geitafell Volcano, was used in numerical models to simulate the local stress field around the magma chamber. The results allow us to explain the intensity and attitude of the swarm of inclined sheets.

Numerical models were also run to understand the formation of the caldera in the Geitafell Volcano. Field observations by Fridleifsson (1983) suggest that the caldera of the Geitafell Volcano has a maximum diameter of 8-10 km. The numerical models suggest that doming of the deep-seated magma reservoir at the crust-mantle boundary below the sill-like crustal magma chamber may have triggered the formation of a caldera in the Geitafell Volcano.

Fridleifsson, G. O., 1983. The Geology and the Alteration History of the Geitafell Central Volcano, Southeast Iceland. Ph. D. thesis, Grant Institute of Geology, University of Edinburgh, 371 pp.