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The May 2011 eruption of Grímsvötn

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Grímsvötn is the most active volcano in Iceland with >60 known eruptions in the last 800 years. Grímsvötn is located in the centre of the 8100 km2 Vatnajökull glacier and typically produces basalts in phreatomagmatic eruptions. Magma-water interaction occurs as the eruptions quickly melt their way through 50-200 m thick ice covering a subglacial caldera lake. Most of these eruptions have been relatively modest in size (0.01-0.1 km3 DRE) causing relatively minor fallout of tephra outside Vatnajökull. After a relative quiet second half of the 20th century, a period of increased volcanic activity in Grímsvötn started in the 1990s, with basaltic phreatomagmatic eruptions occurring within the caldera in 1998 and 2004. The 2011 eruption was therefore expected. It began at 19 UTC on 21 May. The plume quickly rose to 15-20 km, forming a 50-100 km wide umbrella cloud that was maintained until late on 22 May. Heavy fallout occurred in the districts 70-100 km south of the volcano, where periods of total darkness with drifting ash closed roads and caused distress to the local population. Wind directions and plume transport varied somewhat during the eruption. After 23 May, the eruption was relatively minor, with fallout mostly confined to the Vatnajökull glacier. The eruption ended on May 28. Most of the magma was erupted in the first two days. During this period strong northerly winds were dominant at low altitude, carrying the tephra towards south as a 2-4 km high cloud, while the top part of the plume first drifted eastwards and later northwards. Most of the fallout after the first few hours came from the low southwards drifting cloud while the high plume was white in colour and with apparently low concentration of ash leading to only minor fallout. This eruption falls into a class of events that seem to happen once every 100-200 years, with previous large historical eruptions including 1619 and 1873. Preliminary estimates indicate that the eruption produced 0.6-0.8 km3 of tephra, roughly corresponding to 0.2-0.3 km3 DRE. Fallout was detected outside Iceland in Jan Mayen, the British Isles and Scandinavia. Seven distinct phases can be identified in the proximal and medial tephra stratigraphy, showing that the activity alternated between dominantly phreatomagmatic and magmatic, with the most energetic phases producing basaltic pumice. The 2011 eruption of Grímsvötn demonstrates the ability of basaltic volcanoes to occasionally produce sustained magmatically driven large explosive eruptions. The dominance of fallout towards the south despite a high northwards drifting umbrella cloud demonstrates a complex interaction with the atmosphere not fully accounted for in common models of plume behaviour.