



Forecasting the volcanic eruption in Grímsvötn, November 2004

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On November 1st 2004 an eruption started in the sub-glacial volcano Grímsvötn in Vatnajökull, Iceland. This eruption had both long term, intermediate and short term precursors. Since the last eruption of Grímsvötn in 1998, GPS measurements show that the southern rim of the caldera was moving both vertically and horizontally, which was interpreted as magma accumulating at depth. From July 2003 an increase in seismic activity in Grímsvötn was observed. In August, 20-30 min. long tremor bursts with a dominant frequency of 1-3 Hz indicated increased geothermal activity in Grímsvötn. In September, periodic bursts of 2-8 Hz tremor started to be visible and steadily became stronger. Two weeks before the eruption, seismic activity escalated again, starting with small earthquakes (M_L1) that gradually became larger (M_L2). As a result of these observations the National Civil Protection and co-operating scientists at Institute of Earth Sciences were notified that an eruption or a jökulhlaup might be expected soon. On Thursday, October 28th, ice quakes in the outlet glacier Skeiðarárjökull suggested that a jökulhlaup was starting. The flood reached the edge of the glacier early on Saturday. During the weekend the water level continued to rise and a tremor due to the flowing water was visible at the nearest seismic stations. On Monday morning, November 1st, a sequence of earthquakes occurred in Grímsvötn, the largest, at 06:51 UTC, was of magnitude 3. Already in 1953 the famous Icelandic volcanologist Sigurður Þórarinnsson suggested that a jökulhlaup might trigger an eruption. Therefore special attention was given to this increase in seismic activity and the aviation authorities were made aware that an eruption might be imminent. At this point no volcanic tremor was visible. However at 19:30 UTC, a new sequence of earthquakes started and at 20:10 UTC volcanic tremor was apparent, although it was still dominated by earthquakes. At 21:50 UTC, earthquakes were hardly distinguishable and volcanic tremor was intensifying. At that time, it was clear that an eruption was in progress.