Seismic Activity preceding and during the 1983 Volcanic Eruption in Grímsvötn, Iceland

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ABSTRACT
The eruption of Grímsvötn in May–June 1983 was preceded by increased earthquake activity. The premonitory activity began in December 1982 – March 1983 and increased gradually in April and May. The earthquakes originated under the SE rim of the Grímsvötn caldera and are interpreted as being caused by brittle failure of the crust above and around an inflating magma chamber. An intense earthquake swarm ($M_{\text{max}} = 4.0$) occurred in the same area on May 28, presumably related to the failure of the magma chamber walls and subsequent migration of magma towards the surface. The eruption is inferred to have begun shortly after the swarm ceased or about the time, when continuous volcanic tremor was first recorded on the nearest seismograph between 11:47h and 12:00h on May 28. The tremor was most intense in the first 12 hours and then gradually diminished until it disappeared early on June 2. It came in bursts of several minutes duration, separated by longer periods of more uniform background tremor. If the tremor amplitude is taken as an indicator of extrusion rate, the eruption was most vigorous during the first 26 hours. The several km high eruption columns observed in the last two days of the eruption thus probably reflect the reduced water pressure on the magma, when the volcanic orifice approached the surface of the caldera lake, rather than high extrusion rate. Earthquake activity was very low in Grímsvötn during the eruption and remained so for three months afterwards, probably indicating the relaxed stress state around the deflated magma chamber. The 1983 eruption demonstrates that small eruptions can occur in Grímsvötn without causing or being triggered by jökulhlaups, and without being noticed from the inhabited lowlands. Eruptions are, however, likely to be detected by the seismograph network in SE-Iceland. The absence of any abnormal seismic activity in Grímsvötn prior to 1983 and since at least 1971 indicates that no eruptions occurred during this time, in particular not during the jökulhlaups of 1972, 1976 and 1982.

INTRODUCTION
The eruption of May 28 – June 2, 1983 is the first confirmed eruption in Grímsvötn after the large increase in seismograph coverage of Iceland that began in the early seventies. The eruption was preceded by a significant increase in seismic activity for about three months and an intense earthquake swarm on the day of the presumed outbreak. Characteristic volcanic tremor was also recorded during the eruption. In this paper we document the seismic observations and discuss them in context with the "Grímsvötn problem" , i.e. the intriguing interplay between volcanic, geothermal and glacial processes at work in Grímsvötn. The direct observations of the eruption are summarized by Gröndahl and Johannes-son (1984) who also present chemical analyses of the eruptive products and discuss their constraints concerning the magma system. Geothermal and glaciological aspects are discussed by H. Björnsson and H. Kristmannsdóttir (1984).

The Grímsvötn volcano with its 6–8 km wide caldera is situated beneath the Vatnajökull ice sheet, and is one of a group of central volcanoes that appears to characterize the structure of this part of the volcanic rift zone. A powerful geothermal area, presumably fed by a shallow magma chamber (Björnsson et al. 1982), makes Grímsvötn unique among these subglacial volcanoes. The geothermal heat in the caldera melts the glacier ice from below and forms a caldera lake dammed by the ice. The lake level rises steadily until a critical level is reached. The water is then released under the glacier, the lake is partly drained and a burst of water up to 6–7 km$^3$ in total volume issues from the glacier, flooding the