Reviewed research article

Seismic activity in Iceland during 2004

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Abstract — *Using seismological data from the Icelandic Meteorological Office, this article summarises inland and offshore earthquake activity in Iceland during 2004. About 12,000 earthquakes were recorded during the year. The largest earthquake had a body-wave magnitude of 4.5 and it occurred on 25 September 80 km offshore from the southwest tip of the Reykjanes Peninsula. Two intense earthquake swarms occurred on the Reykjanes Ridge; one in April and the other in September. The largest swarm on the Reykjanes Peninsula comprised 1500 earthquakes; it occurred in July and was concentrated beneath the Fagradalsfjall mountain. Activity in the Ölfus-Hengill region paralleled that of the previous three years, with the largest earthquake attaining a local moment-magnitude (M_{lw}) of 4.2. In the South Iceland Seismic Zone, residual aftershocks occurred on the faults produced by two local M_w=6.5 earthquakes in June 2000. Two earthquake swarms were observed northeast of Langjökull in a region where earthquakes are uncommon. Earthquake activity within the western flank of the Katla volcano showed strong seasonality, peaking during the autumn as observed for decades. An earthquake swarm took place within the Katla caldera, including a M_{lw} 3.9 earthquake on 02 July. Seismic activity at Grímsvötn increased significantly from mid 2003 until late 2004. On 01 November, a swarm of over 180 earthquakes were recorded at Grímsvötn; at the height of this swarm, a volcanic eruption began, lasting for a week. A public warning was issued one hour ahead of the eruption. Additionally, 29 icequakes were located in Skeiðarárjökull during a jökulhlaup from Grímsvötn that began two days before the November eruption. Throughout 2004, many earthquake swarms happened in the Tjörnes Fracture Zone; the largest swarm was located at the mouth of Eyjafjörður and comprised 600 events. Swarms of similar intensity are commonplace in this region.*

INTRODUCTION

Background and aim

Seismicity in Iceland has been monitored over the last 15 years by the national seismic network, SIL, which has been operating automatically since June 1991 (Jakobsdóttir *et al.*, 2002). During this time, over 230,000 events have been recorded and processed daily to provide nearly continuous information about stress conditions in the Icelandic crust. Additionally, the near-real-time data has proven invaluable for predicting and monitoring hazardous events, such as volcanic eruptions and jökulhlaups.

The main aim of this article is to summarize the seismicity during 2004 and compare this year's seismicty to that of previous years. We will give an overview of earthquake activity in selected areas, starting on the Reykjanes Ridge in the southwest, following the plate boundary to the Tjörnes Fracture Zone in the north.

The *SIL* seismic network

The *SIL* (South Iceland Lowland) seismic network consists of 44 three-component, digital stations, located mostly around the tectonic plate-boundary, where seismic activity is highest (Jakobsdóttir *et al.*, 2003) (Figure 1). In December 2004, three new stations were established in the Kárahnjúkar area, north

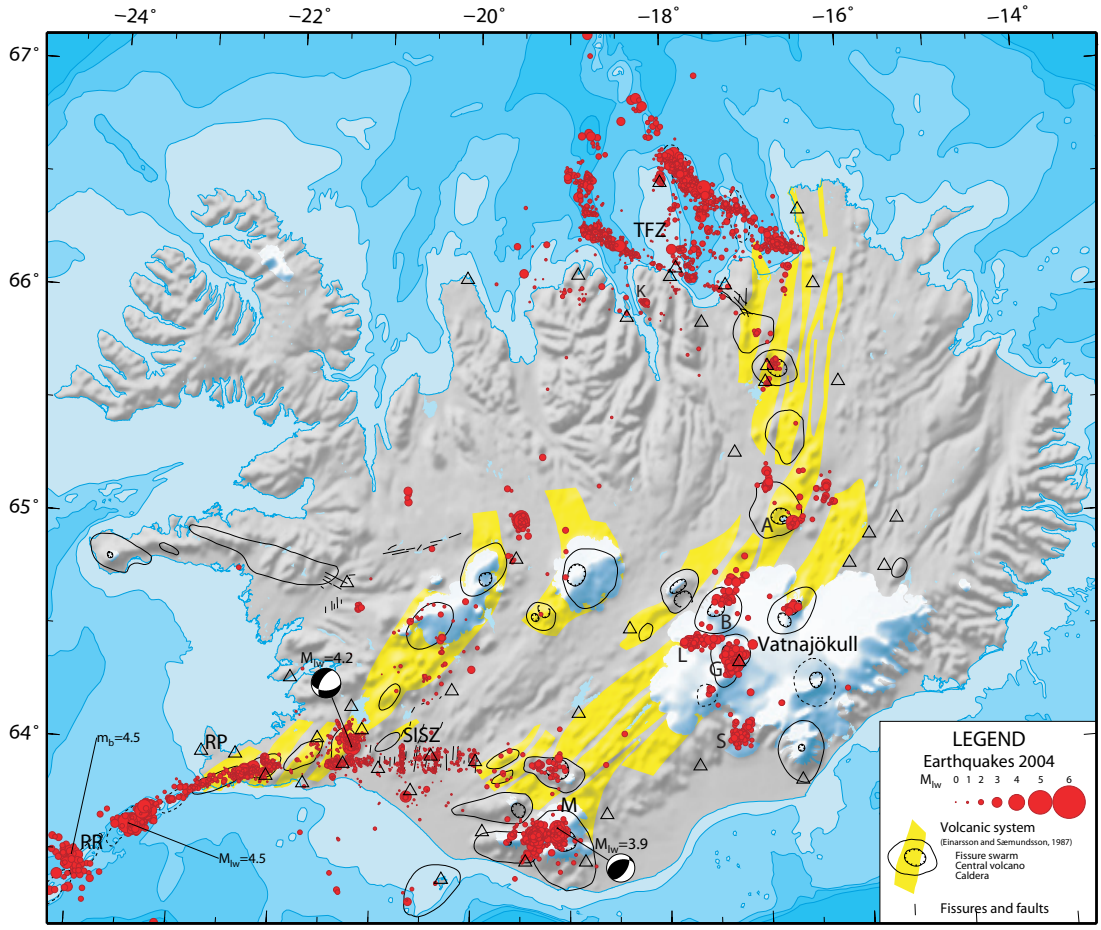

Figure 1. Seismicity in Iceland in 2004. Earthquake epicenters are only plotted for events recorded at at least five stations and with $M_{lw} \geq 0$. Main tectonic features are shown. RR denotes the Reykjanes Ridge, RP the Reykjanes Peninsula, SISZ the South Iceland Seismic Zone, WVZ the Western Volcanic Zone, TFZ the Tjörnes Fracture Zone, M the Mýrdalsjökull ice cap, L Lokahryggur, G Grímsvötn, S Skeiðarárjökull, B Bárðarbunga and K Kaldbakur. Black triangles denote *SIL-stations*. *– Jarðskjálftavirkni á Íslandi 2004. Skjálftamiðjur eru einungis teiknaðar fyrir skjálfta sem mældust á að minnsta kosti fimm stöðvum og með $M_{lw} \geq 0$. Svartir þríhyrningar tákna SIL-stöðvar.*

of the Vatnajökull ice cap (Jakobsdóttir *et al.*, 2005). These stations are sited near to the reservoir of a hydroelectric plant and they are intended for monitoring seismicity induced by the filling of the reservoir. Additionally, the stations have lowered the detection threshold of the *SIL* system for earthquakes beneath northwest Vatnajökull and the Askja caldera.

SEISMIC ACTIVITY

Over 12,000 earthquakes were detected during 2004; this figure is similar to the yearly number of events recorded between 2001 and 2003 (Þorbjarnardóttir and Guðmundsson, 2003; Þorbjarnardóttir *et al.*, 2003; Guðmundsson *et al.*, 2004). Likewise, the total

energy released by earthquakes in 2004 was comparable to the annual energy release since 2001. Additionally, 315 icequakes and 275 confirmed explosions were detected. The largest event recorded had a body-wave magnitude m_b=4.5 (USGS/NEIC, 2005). It occurred 80 km offshore on the Reykjanes Ridge (RR) in September, followed by a short-lived swarm that lasted only ten hours. The earthquake was not felt due to its distance from land. Although no hazardous earthquakes occurred, the dataset indicates heightened activity in some regions.

Reykjanes Ridge and Reykjanes Peninsula

Reykjanes Ridge and Reykjanes Peninsula Besides the m_b 4.5 earthquake in September, another event of similar magnitude occurred during a short-lived swarm in April, located 40 km offshore on the Reykjanes Ridge. In addition, numerous small swarms took place throughout the year on the ridge. Since 1997, seismic activity has increased steadily on the Reykjanes Ridge (RR). Interestingly, only a few earthquakes have been observed since 1997 in the 20 km wide gap between the active areas at Eldeyjarboði and Geirfugladrangur (see location of RR in Figure 1).

No major earthquakes have occurred on the Reykjanes Peninsula, since a magnitude 5 event occurred in Krísuvík in August 2003 (Vogfjörð *et al.*, 2004). The most intense activity in 2004 was in July, when nearly 2000 events were observed in the Fagradalsfjall mountain, west of Krísuvík (Figure 2). The activity began on 11 July beneath the western slopes of the mountain and earthquakes migrated eastwards for the next week on a series of N-NNE striking faults, where the largest events of the swarm also occurred (M_{lw} ∼3.5; local moment magnitude, Slunga *et al.*, 1984; Rögnvaldsson and Slunga, 1993). On 18 July, the activity subsided, but then increased again in the western part of the area two days later; at this time, the activity was mainly concentrated on an approximately 3.5-km-long, NE-striking fault (green events in Figure 2). Earthquakes are common near to Fagradalsfjall and swarms of similar intensity occurred in 1998 on the same NE-striking fault, and again nearby in 2000. Furthermore, Fagradalsfjall is highly fractured and a series of N-NE striking surface faults and fissures have been mapped in the area (Clifton, 2004).

Hengill and the South Iceland Seismic Zone

At the western margin of the South Icelandic Seismic Zone (SISZ), in the Hengill-Ölfus area, seismic activity was slightly higher during 2004 and 2003 as compared to 2002 and 2001. But the present regime pales in comparison to the period 1994-1998; during this time, magma intruded into the Hengill region, resulting in sustained earthquake activity (Rögnvaldsson *et al.*, 1996; Vogfjörð *et al.*, 2005a). The largest earthquake observed in the Hengill-Ölfus area in 2004 was a M_{lw} 4.2 event that occurred at Dalafjall, 3 km NW of the town Hveragerði (Figure 3). This location is near the center of crustal uplift, caused by the intrusion (Feigl *et al.*, 2000). The earthquake was felt widely in southern Iceland (Table 1).

Following the two M_w=6.5 earthquakes in June 2000, seismic activity in the SISZ increased greatly (Hjaltadóttir and Vogfjörð, 2005b). Since 2000, activity has decreased significantly and in 2004 only moderate seismic activity was observed, with neither large swarms nor large events detected. A number of aftershocks were located on the two June-2000 faults. Small swarms occurred at the southern and northern ends of the 21 June Hestvatn fault, and one event of magnitude 2.5 occurred on the 17 June Holt fault at the end of June. The largest event in the SISZ, M_{lw} 3.2, occurred in Áshverfi, south of the main transition zone (Á in Figure 3). It was followed by a short-lived swarm, located at depths between 9 and 10 km, which is significantly deeper than the 4–8 km commonly observed in the SISZ (Hjaltadóttir and Vogfjörð, 2005a). Except for the heightened activity in 2000, earthquakes seldom occur in Áshverfi, but these source depths are common in this area.

Mýrdalsjökull

The Katla volcano, located under the Mýrdalsjökull ice cap, has been under constant observation since 1999 when a jökulhlaup issued from Sólheimajökull (Sigurðsson *et al.*, 1999; Roberts *et al.*, 2003) and a new cauldron formed in the ice cap (Guðmundsson *et al.*, 2000; Vogfjörð, 2002). Other existing cauldrons within the caldera deepened (Guðmundsson *et al.*, 2000), suggesting a widespread increase in geothermal activity in the volcano. Seismicity under the ice

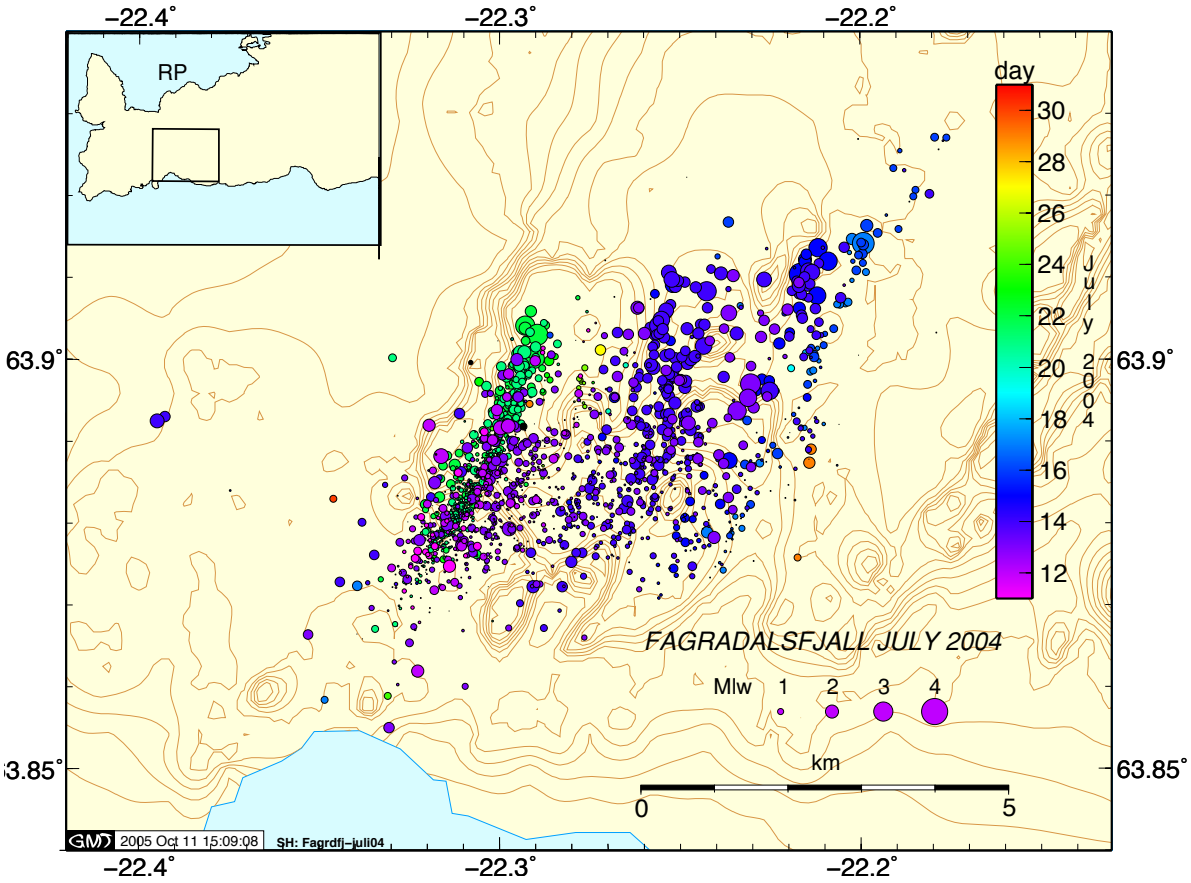

Figure 2. The July 2004 swarm in Fagradalsfjall, RP. The earthquakes are colour coded according to age. – *Smáskjálftahrina í Fagradalsfjalli í júlí 2004. Skjálftarnir hafa mismunandi lit eftir því hvenær í mánuðinum þeir urðu.*

cap is mainly concentrated in two locations, west of the caldera, in western Goðabunga, and within the caldera. Earthquakes in Goðabunga have shown a seasonal pattern for the last four decades, with increased activity between late summer and December (Einarsson and Brandsdóttir, 2000). In 2001 seismic activity increased substantially and remained high throughout the year (Figure 4). Continuous GPS measurements south of the caldera and campaign measurements at the northern caldera rim have also shown uplift and outward displacements from the caldera, further supporting magma accumulation in the volcano (Geirsson *et al.*, 2005; Sturkell *et al.*, 2003). Soosalu (2004) argued that the concentrated and shallow activity at Goðabunga might indicate an intruding cryptodome beginning to propagate toward the base of the ice cap in 1999. At the end of 2004, activity decreased again and now shows similar intensity as before 2001 (Figure 4). An event of magnitude 3.9 occurred in the caldera during a swarm in June and July (Table 1). The earthquake was felt in Langidalur, Þórsmörk, a few km west of the ice cap. Similar to Goðabunga, seismicity in the caldera has decreased.

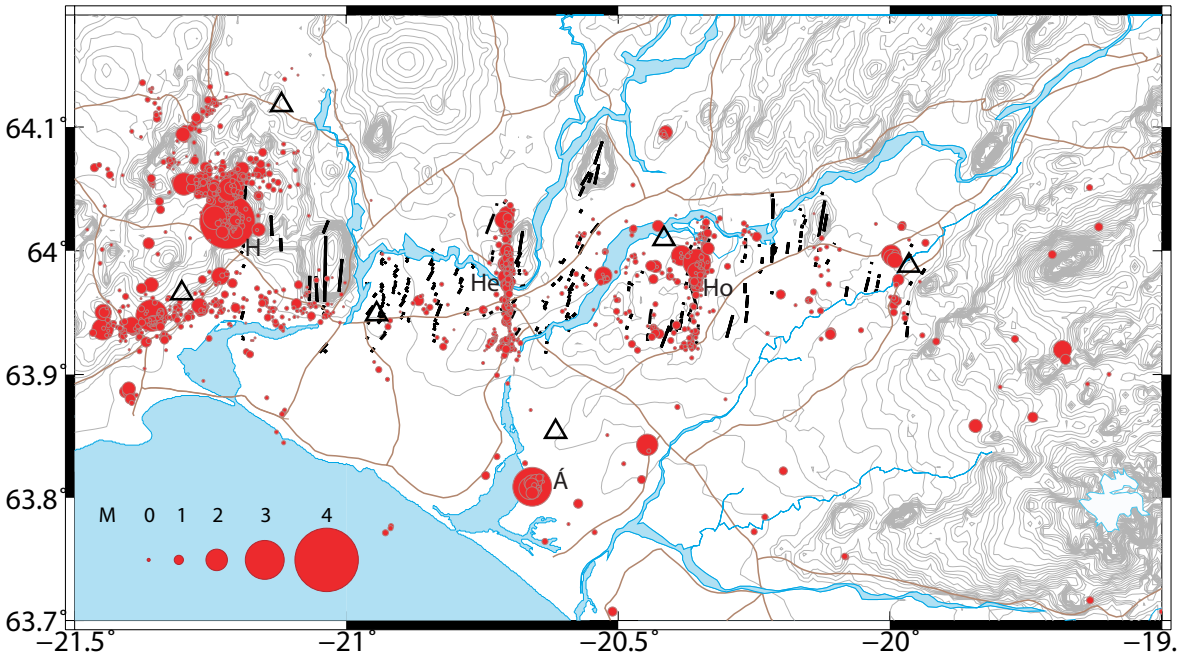

Figure 3. Earthquake epicenters in the SISZ. Á denotes Ásahverfi, He the Hestvatn fault, Ho the Holt fault and H Hveragerði. – *Jarðskjálftar í Suðurlandsbrotabeltinu.*

Vatnajökull and the November 2004 eruption of Grímsvötn

The Vatnajökull ice cap, located in south-eastern Iceland, overlies several active volcanoes and geothermal areas. Seismicity beneath the ice cap has increased since mid 2003 (Figure 5a). From August to October occasional pulses of seismic tremor, lasting roughly half an hour, were detected at station grf, located on Grímsfjall nunatak at the southern caldera rim (Figure 6). These pulses were interpreted as signs of increasing geothermal activity in the Grímsvötn caldera (Vogfjörd *et al.*, 2005b). Furthermore, GPS measurements showed that Grímsfjall had already surpassed the elevation level attained before the last eruption in 1998 due to magma accumulation (Sturkell *et al.*, 2005), indicating that an eruption was likely to occur soon.

Additionally, there were signs of an imminent jökulhlaup from Grímsvötn because the elevation of the caldera lake had risen to the highest level since the November 1996 jökulhlaup (Finnur Pálsson, *pers. comm.*, 2004). Considering this in connection with the increased seismicity, uplift and inferred geothermal activity, an eruption was considered very likely at Grímsvötn. Seismic activity increased further after mid-October and on 01 November three earthquakes of magnitude ∼3 occurred between 05:00 and 07:00 UTC in the caldera. Constant microearthquake activity followed throughout the day, but the events were all too small to locate until at 19:30 when a M_{lw} 2.5 earthquake occurred. By 20:00, earthquakes were occurring constantly. Furthermore, seismic tremor increased significantly around 20:00, suggesting the beginning of a volcanic eruption (Vogfjörd *et al.*, 2005b). Earthquakes from October to 01 November were relocated using a double-difference method to increase accuracy (Slunga *et al.*, 1995) (Figure 6). Their locations form a northerly striking cluster, about 1 km east of the eruption site. This result was also

Table 1: Felt earthquakes and explosions in 2004. (Reported explosions in the Kárahnjúkar construction area are not included). – *Fundnir skjálftar og sprengingar sem tilkynnt var um árið 2004.*

Date	Time	Latitude	Longitude	M_{lw}	Reported from
20040103	142323.602	63.96039	-22.09269	2.8	Reykjavík
20040107	232525.325	64.02415	-21.21860	4.2	From Hella to Hafnarfjörður
20040129	183125.494	63.87626	-21.39424	1.4	Þorlákshöfn*
20040702	035622.166	63.67758	-19.13190	3.9	Þórsmörk
20040713	211955.957	63.89701	-22.23038	3.1	Hafnarfjörður
20040829	154840.336	66.62667	-17.80493	3.5	Grímsey
20040910	131940.369	65.63834	-16.88615	2.2	Mývatnssveit
20040919	041619.956	63.80915	-20.65801	3.2	Hella, Hvolsvöllur, Ásahreppur
20041119	030611.840	66.24536	-17.88924	3.0	Akureyri
20041119	180521.195	64.67673	-21.61507	1.0	Munaðarnes*
20041130	235256.050	66.55811	-18.00205	3.1	Grímsey

*Explosion/sprenging

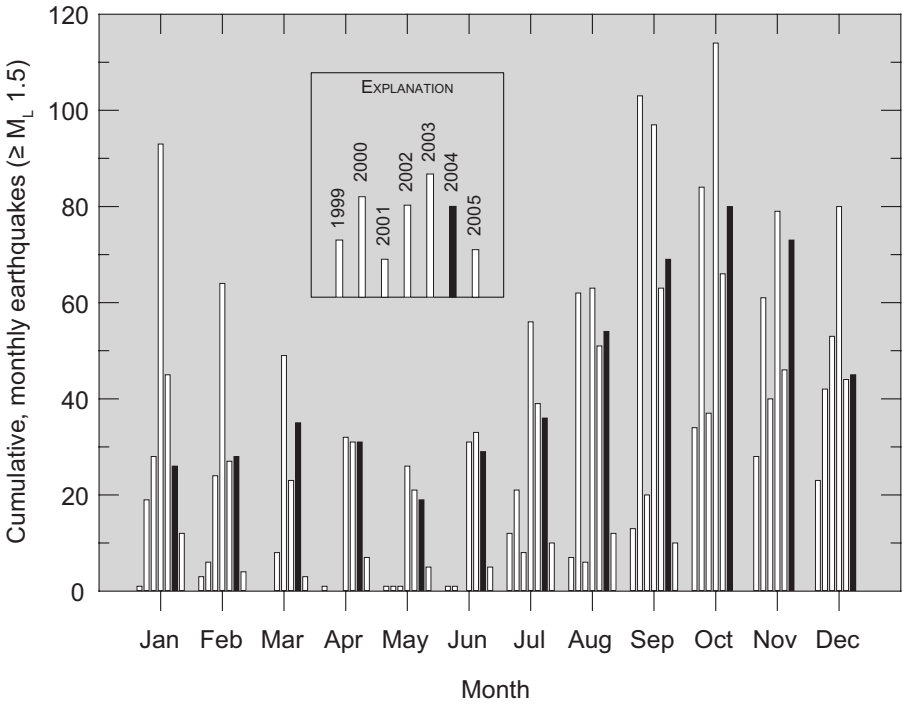

Figure 4. Monthly number of earthquakes ($M_L \geq = 1.5$) in the Katla volcano for January 1999-September 2005. – *Fjöldi skjálfta (stærri en 1,5) á mánuði í Mýrdalsjökli frá janúar 1999 fram í september 2005.*

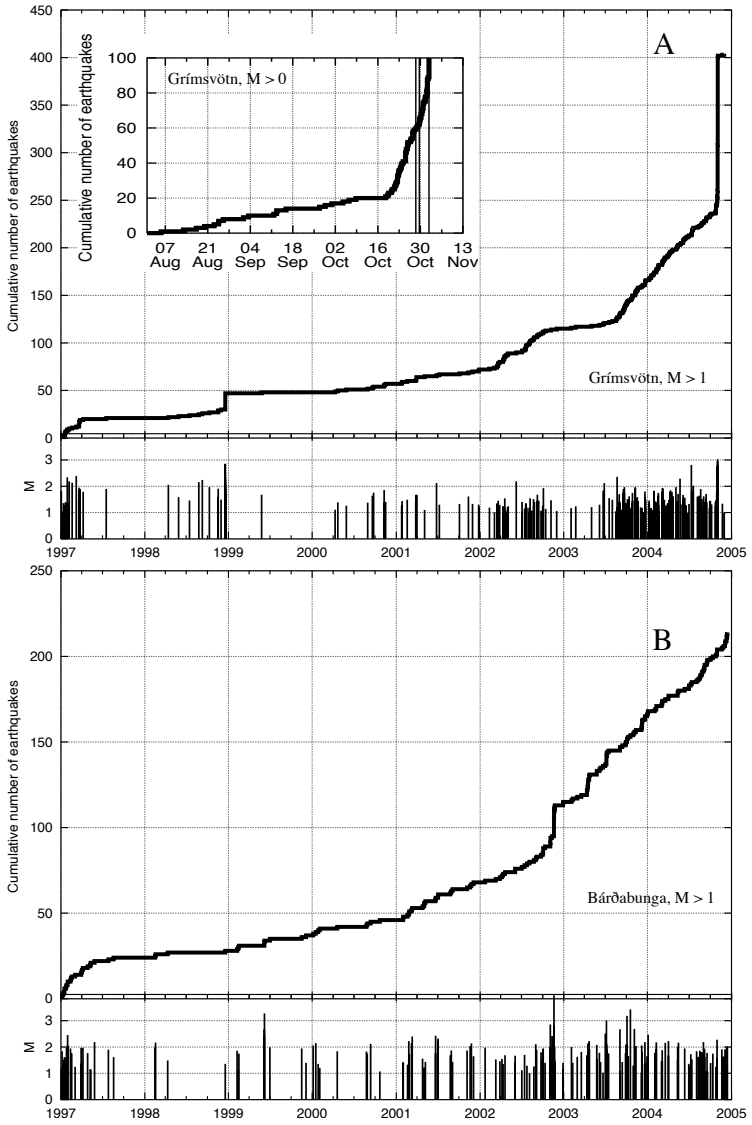

Figure 5. a) A graph showing cumulative number of earthquakes in Grímsvötn from January 1997 to December 2004 for $M_{lw} \geq 1$ and a magnitude vs. time plot below. The inserted figure shows the cumulative number of earthquakes for $M_{lw} \geq 0$ for a shorter period, i.e. from August until mid November 2004. The three vertical lines mark the detection of the water leakage from Grímsvötn at 28 October, the beginning of the jökulhaup at 29 October and the beginning of the eruption at 1 November. b) A graph showing cumulative number of earthquakes in Bárðarbunga from January 1997 to December 2004 for $M_{lw} \geq 1$, and a magnitude vs. time plot below.– *a) Uppsafnaður fjöldi skjálfta í Grímsvötnum frá 1997 til ársloka 2004 fyrir $M_{lw} \geq 1$, ásamt stærð skjálfta sem fall af tíma fyrir sama gagnasafn. Á innfeldu myndinni má sjá uppsafnaðan fjölda skjálfta fyrir $M_{lw} \geq 0$ frá ágúst fram í miðjan nóvember 2004. Lóðréttu línurnar þrjár sýna hvenær vísbendingar komu fram um rennsli úr Grímsvötnum 28. október, upphaf flóðsins þann 29. og upphaf gossins 1. nóvember. b) Uppsafnaður fjöldi skjálfta í Bárðarbunga frá 1997 til ársloka 2004 fyrir $M_{lw} \geq 1$, ásamt stærð skjálfta sem fall af tíma.*

verified by P-wave particle motion from a few earthquakes recorded at the grf seismic station.

After the beginning of the eruption, which lasted for six days, only 12 earthquakes were located at Grímsvötn through the remainder of 2004. Two days before the eruption, water began to drain from Grímsvötn, resulting in a jökulhlaup from Skeiðarárjökull (Harðardóttir *et al*., 2004). However, analysis of tremor signals from 28 October suggests that a leak was already established (Figure 5a). It has been suggested (Sigmundsson and Guðmundsson, 2004) that the pressure decrease over the magma chamber caused by the water leaking from Grímsvötn triggered the eruption. During the jökulhlaup, twenty-nine locatable icequakes were detected in Skeiðarárjökull (Vogfjörd *et al*., 2005b) and the glacier moved

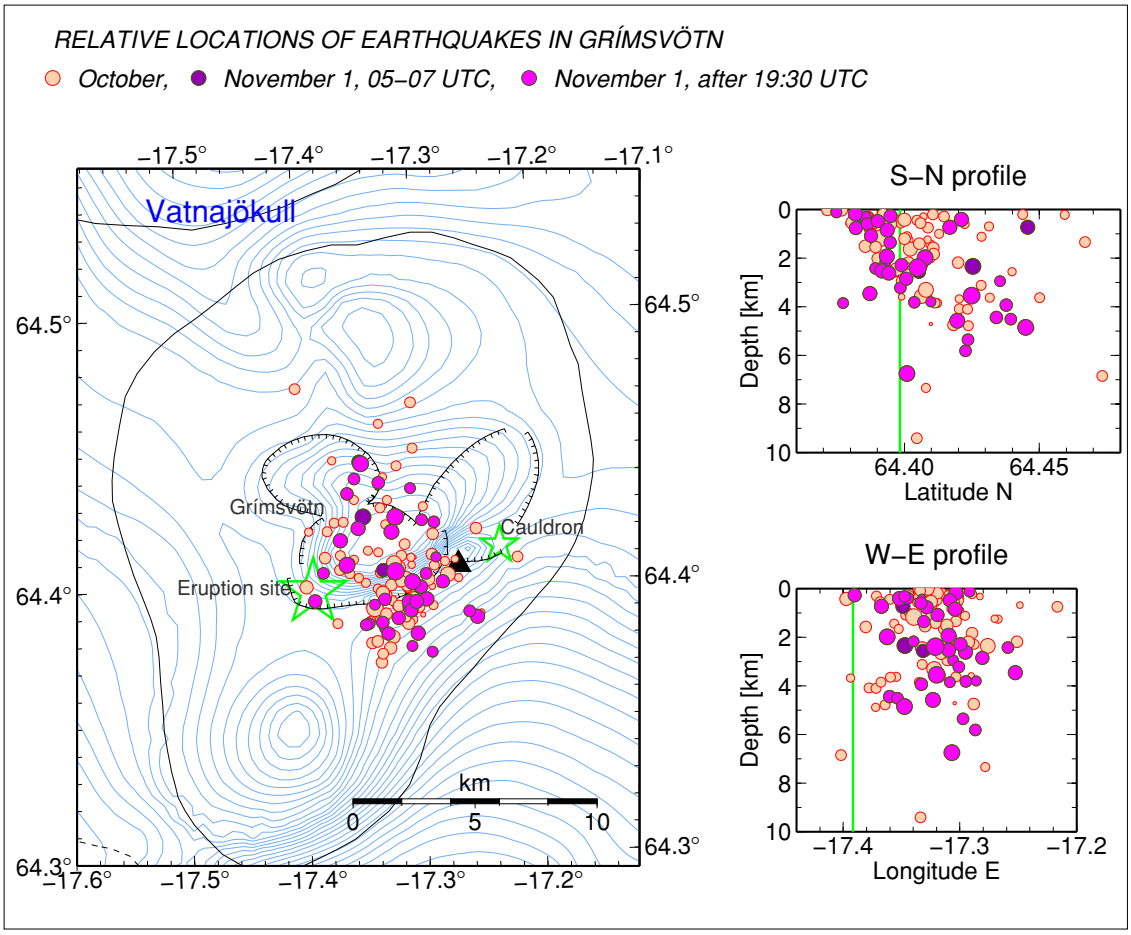

Figure 6. Relatively located earthquakes in Grímsvötn, preceding the eruption in November. Black triangle denotes the location of *SIL*-station *grf*, located on the caldera rim. – *Afstæðar staðsetningar skjálfta í Grímsvötnum frá miðjum október fram að gosinu sem hófst 1. nóvember. Svarti þríhyrningurinn sýnir legu SIL-stöðvarinnar grf á Grímsfjalli.*

approximately 5 m horizontally during the period of the flood (Roberts *et al.*, 2005). Furthermore, icequake swarms were observed in the glacier in connection with heavy rainfall and other jökulhlaups.

Approximately 70 earthquakes were located in the vicinity of Lokahryggur (L in Figure 1), but this was considerably less than the activity observed in 1996 and 1997, following the eruption 1996 at Gjálp. On the other hand, earthquake activity in Bárðarbunga has increased (Figure 5b), especially since 2002. The two main clusters of activity are located under the northern slopes of Bárðarbunga (Figure 1).

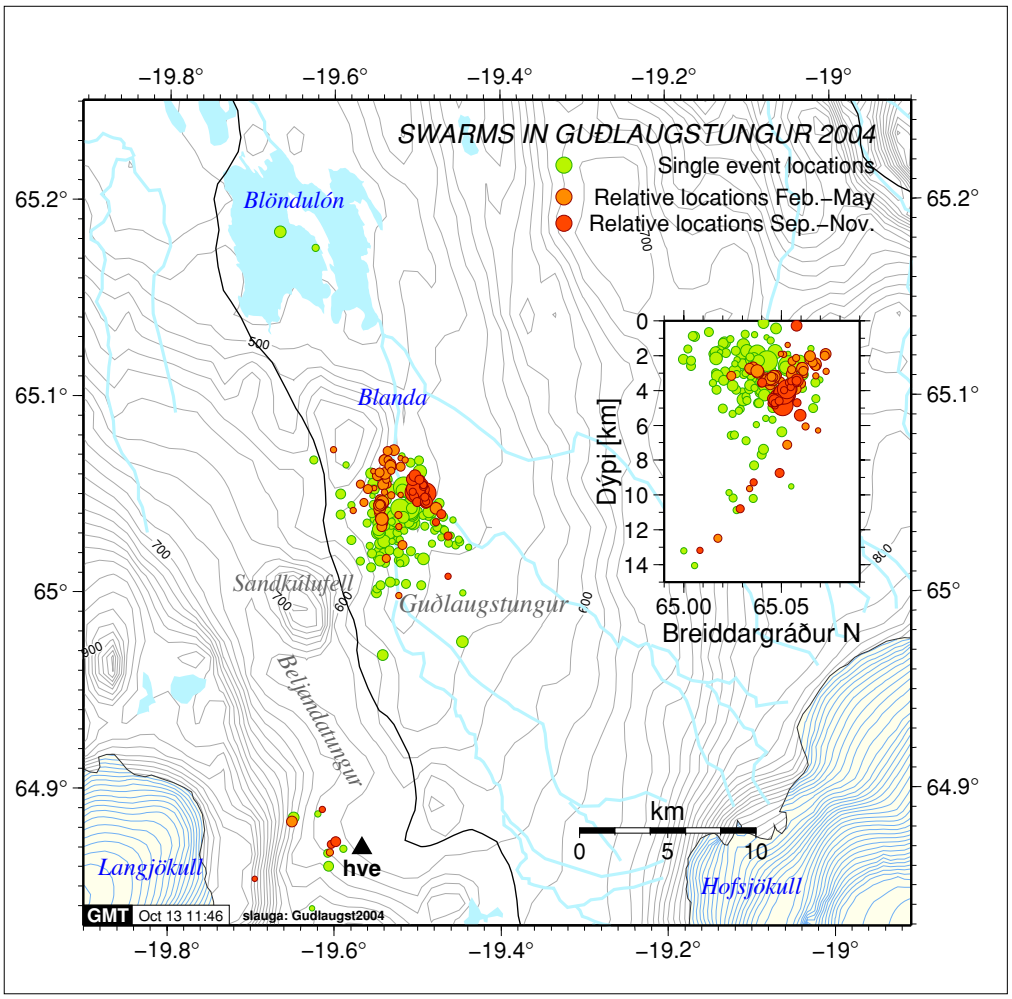

Figure 7. Single event and relative locations of earthquakes in Guðlaugstungur during February-November 2004. Black triangle denotes the *SIL* station hve at Hveravellir. – *Venjulegar og afstæðar staðsetningar skjálfta í Guðlaugstungum, febrúar-nóvember 2004. Svarti þríhyrningurinn sýnir staðsetningu SIL-stöðvarinnar hve á Hveravöllum.*

Guðlaugstungur

In March an earthquake swarm occurred near the glacial river Blanda, in Guðlaugstungur, about 20 km north of the geothermal area Hveravellir. A smaller swarm occurred 2 km further east in September. Seismicity is not very frequent in this area and earthquake epicenters located between 1995 and 2003 are mostly concentrated further south, i.e. west of Hveravellir. The March swarm started with a single event on 26 February, and it lasted throughout the next month. Around 50 microearthquakes were located, the largest reaching a magnitude of only 2.5. Only ten earthquakes were recorded in April, but no further activity happened until September, when roughly 70 events

were observed in a swarm, with the two largest events (M_{lw}=3.9) occurring at the end of September and the beginning of October. The earthquakes have all been relocated using a double-difference method (Slunga *et al.*, 1995) and are shown in orange in Figure 7. For comparison, the single event locations are plotted in green in the background. After relocation, the epicentral clusters revealed two distinct features. Hypocenters of the first swarm form a N-S lineament, while the hypocenters in the latter swarm are more concentrated in a dense cluster, which is elongated in a NNW direction. Most earthquakes are located at fairly shallow depths, between 1.5 and 5.5 km. Faults and fissures striking NE have been mapped on the surface in the vicinity of Hveravellir (south and east of hve, at approximately 64.85°–64.87°N) (Hjartarson and Ólafsson, 2005). North-westerly striking faults have also been observed, but they are less distinct. Furthermore, there are surface structures with a NNW strike in Beljandatungur, SW of Guðlaugstungur, similar to the apparent trend of the latter swarm, but none have been observed in the exact area of the seismicity.

The Tjörnes Fracture Zone

The Tjörnes Fracture Zone (TFZ) is a transform zone connecting the Northern Volcanic Zone to the ridge segments offshore. Seismicity in the TFZ is mainly concentrated on two WNW-trending lineaments, starting at the shore near the towns of Húsavík and Kópasker. The northern Grímsey lineament (GL) stretches as far as 110 km offshore to the northwest, while the southern Húsavík-Flatey fault (HFF) reaches 80 km to the WNW and then bends northwards (Figure 1).

In 2004 the largest swarm in the TFZ occurred in June on the HFF, at the mouth of the fjord Eyjafjörður, when around 600 earthquakes were located. The earthquakes, which were all small (M_{lw}<2.5), have been relocated, using the double-difference method (Slunga *et al.*, 1995). The event distribution shows a NW-striking lineament at a depth of 9–11 km. Seismic activity is very common in the area and the largest swarms recorded over the past few years occurred in 1997 and 2001. Several other smaller swarms also occurred on the Grímsey Lineament. None of the larger events (M_{lw} $\sim$3) occurring in 2004 were followed by further activity, which is unusual. They may have been caused by increased strain in the TFZ, which led to an earthquake of magnitude $\sim$5 (M_l; EMSC, 2005) in the centre of the GL in January 2005.

In November and December, two small swarms occurred under the mountain Kaldbakur in Eyjafördur (K in figure 1); a total of 65 earthquakes, all with M_{lw} $\leq$2.5. This is quite an unusual location and since the installation of the *SIL* system, only one swarm has been observed in its vicinity. It occurred in October, 1999, when 24 events were located $\sim$1 km east of the November 2004 swarm. Kaldbakur is situated on the Dalvík seismic Lineament (DL), south of the HFF (Rögnvaldsson *et al.*, 1998). This lineament has shown much less seismic activity than GL and HFF, although large earthquakes are known to occur on the DL, the most notable being the M_L 6.2 Dalvík earthquake in 1934.

CONCLUSIONS

1. Seismic activity in Iceland during 2004 was moderate in comparison to the number of events recorded between 2001 and 2003. Over 12.000 earthquakes were located, and 315 of these were icequakes located in Skeiðarárjökull in connection with jökulhlaups and heavy rainfall. In addition, 275 reported explosions were recorded, many of which were located in the Kárahjúkar construction area.

2. The largest recorded earthquakes occurred offshore on the Reykjanes Ridge in April (M_{lw}=4.5) and September (mb=4.5). Both events were a part of short-lived swarms, lasting between one and two days. No volcanic tremor was detected on the ridge in connection with the swarms, but seismicity has been increasing steadily on the ridge during the past few years.

3. Seismic activity in Mýrdalsjökull decreased substantially during 2004 and now shows similar intensity as observed before 2001.

4. Heightened seismic activity has been widely observed in northwest Vatnajökull since mid-

2003. Activity in Grímsvötn increased further after mid-October 2004 and culminated at the beginning of an eruption on 1 November. The eruption and preceding jökulhlaup from Skeiðarárjökull were successfully forecasted based on analysis of earthquake data, as well as results from GPS measurements and hydrological data.

5. Two earthquake swarms occurred about 20 km north of the geothermal area Hveravellir. Swarms of this intensity have not been recorded in the area before, but in 2000 earthquake activity was observed farther south, west of Hveravellir. After double-difference relocation, the two swarms form two distinct clusters, one striking N, the other striking NW. Mapped surface faults and fissures in the vicinity of Hveravellir show a NE strike, but signs of less distinct NW striking faults are also observed.

6. In the Tjörnes Fracture Zone, several earthquakes of magnitude 3 were detected, but were not followed by further seismic activity. This is quite uncommon and they may have occurred because of strain build-up in the transform zone, which led to an event of magnitude $\sim$5 in early January 2005.

Acknowledgements

This paper is based on data from weekly reports made by scientists from the Physics Department of the Icelandic Meteorological Office. The monitoring team in 2004 comprised Bergþóra S. Þorbjarnardóttir, Erik Sturkell, Gunnar B. Guðmundsson, Halldór Geirsson, Hjörleifur Sveinbjörnsson, Kristín S. Vogfjörð, Matthew J. Roberts, Sigurlaug Hjaltadóttir, Steinunn S. Jakobsdóttir, Vigfús Eyjólfsson and Þórunn Skaftadóttir. The team contributed to the operation of the *SIL* system and to the expansion of the earthquake database. Jósef Hólmjárn and Sighvatur K. Pálsson are responsible for maintaining the *SIL* stations and Reynir Böðvarsson and Ragnar Slunga are the main designers of the system. Most figures were made with GMT software (Wessel and Smith, 1998). Thanks to Gunnar B. Guðmundsson and Matthew J. Roberts for contributing figures. Matthew and Kristín S. Vogfjörð are also thanked for comments on an earlier version of the paper.

ÁGRIP

Jarðskjálftavirkni á Íslandi árið 2004

Í lok árs 2004 voru 44 jarðskjálftastöðvar í *SIL* jarðskjálftamælanetinu. Síðla árs bættust við þrjár nýjar stöðvar á virkjunarsvæðinu við Kárahnjúka, Brúarjökull (bru), Hvannstóðsfjöll (hva) og Vestari-Sauðahnjúkar (vsh), og hafa þær aukið næmni kerfisins norðan Vatnajökuls og í honum norðanverðum. Rúmlega 12.000 skjálftar voru staðsettir á árinu. Á Reykjaneshrygg hefur virkni farið vaxandi síðustu ár, og urðu þar nokkrar hrinur árið 2004, þær stærstu í apríl og september. Stærsti skjálfti ársins (m_b = 4,5) varð 25. september um 80 km SV af Reykjanesi. Á Reykjanesskaganum bar hæst hrinu í Fagradalsfjalli í júlí, en þar mældust um 1500 skjálftar á nokkrum dögum. Virknin byrjaði vestan í fjallinu og færðist austur, en enginn skjálfti náði stærðinni þremur. Nokkuð var um smáskjálfta í Ölfusi og á Hengilssvæðinu, en stærsti skjálftinn þar (4,2) varð skammt frá Hveragerði 7. janúar. Virkni var enn viðvarandi á Hestvatns- og Holtasprungum sem Suðurlandsskjálftarnir urðu á í júní árið 2000. Í Guðlaugstungum, norður af Hveravöllum, varð hrina í mars og önnur í september á svipuðum stað. Þar mældust yfir 130 skjálftar og voru þeir tveir stærstu 3,9 að stærð. Sjaldgæft er að skjálftar mælist á þessum slóðum. Í Mýrdalsjökli vestanverðum var virkni árstíðabundin líkt og verið hefur, en í öskju Kötlu kom hrina í júlí, þar sem stærsti skjálftinn var M_{lw}=3,9. Skjálftavirkni jókst í Grímsvötnum eftir mitt ár 2003. Virkni jókst enn upp úr miðjum október 2004 og náði hámarki sínu í upphafi eldgoss, sem hófst 1. nóvember og stóð í tæpa viku. Samfara hlaupinu úr Grímsvötnum, sem hófst þremur dögum fyrir gosið, mældust allmargir ísskjálftar í Skeiðarárjökli líkt og nokkrum sinnum á árinu í tengslum við smáhlaup eða úrhellisrigningar. Nokkrar hrinur smáskjálfta urðu úti fyrir Norðurlandi. Sú stærsta varð úti fyrir mynni Eyjafjarðar í síðari hluta júní, en þá mældust yfir 600 skjálftar. Einnig urðu litlar hrinur í ágúst um 25 km norður af Siglufirði og 15 km austur af Grímsey.

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