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High-precision mapping of seismicity in the last decades at Bárdarbunga volcano, Iceland

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Bárdarbunga volcano is one of Iceland‘s most active and hazardous volcanoes. Its location inside the Vatnajökull ice cap and completely covered by the glacier, gives rise to multitude of hazards and also makes it difficult to monitor with modern Earth- and space based monitoring networks. Therefore, much of its unrest and activity has not been well recorded in the past. Seismic monitoring, however has been gradually improving over the last decade, with a significant improvement in sensitivity in the last two years through the FUTUREVOLC supersite project. The largest earthquakes (M>5), presumably associated with unrest episodes have been detected nationally and teleseismically since the 1970s, with under 20 such events recorded between then and the beginning of 2014. The mechanisms of these events have all been represented by a CLVD source.

Before 2014, the last M>5 event occurred at the end of September 1996. This event was accompanied by significantly increased microseismicity, which was recorded on the national seismic network, SIL as well as on the temporary nation-wide Passcal network, HOTSPOT. This microseismicity was located with high-precision, relative methods and showed propagation of the seismicity from the NE corner of the caldera and along the rim to the SE corner. A few days later, well located microseismicity started on a NNE-SSW lineament south of the caldera, which later becamoe the location of the Gjálp eruption. Because of the sparse network at the time, propagation of the seismicity from Bárdarbunga to the Gjálp fissure could not be unequivocally determined.

In 2006 seismic activity in all the volcanoes in western Vatnajökull started to increase and this increase was greatest in Bárdarbunga and the fissure swarm extending NE from the caldera towards Kistufell. This heightened regional unrest culminated in the Grímsvötn eruption in May 2011, after which the seismicity at all volcanoes suddenly dropped. In 2012 the activity started rising again, so that in early 2014 the activity in Bárdarbunga was reaching the seismicity level of 2011. Relative location of this seismicity shows that the earthquakes are confined NE of the caldera rim and extending N and NE towards Kistufell. Furthermore, a deep vertical channel starts to appear SE of the volcano. Activity in this channel was maintained until 2014, with a number of deep earthquakes located there in May 2014, but in August 2014 it stopped.

On 16 August 2014 an intense seismic swarm started at Bárdarbunga, inside the caldera and NW of it towards Kistufell. On the first day the activity propagated out of the caldera to the SW to the location of the vertical channel. There, the seismicity took a sharp turn and started propagating NE. This activity continued over the following two weeks, finally extending outside the northern margin of the glacier and ending in an eruption at Holuhraun; first a small, short-lived one on 29 September and then a second sustained eruption two days later. This eruption, which is still on-going at the time of writing, has produced a volume of over 1 km3 of lava and released large amounts of SO_2 and CO_2 gases. High-precision locations of the propagating seismicity delineates multiple linear segments, which have been modelled as lateral dyke propagation from the caldera to the eruption site (Sigmundsson et al, 2014). At the same time as the dyke was propagating, activity at the caldera started again, producing over 70 events of M>5, which can be modelled by negative CLVD mechanisms, and hundreds of microearthquakes around the caldera rim. The distribution of seismicity along the southern caldera rim is fairly linear and near vertical, while the event distribution along the Northern rim appears to dip towards north.

In light of the recent dyke propagation to Holuhraun, the Gjálp event will be reexamined to search for deterministic signs of lateral propagation from Bárdarbunga towards the Gjálp fissure.

Sigmundsson etal., 2014. Segmented lateral dyke growth in a rifting event at Bárðarbunga volcanic system, Iceland. Nature. doi:10.1038/nature14111.