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Using repeating earthquakes to reveal temporal behavior of caldera faults

Kristín Jónsdóttir (1), Félix Rodrigo Rodriguez (2), and Vala Hjorleifsdóttir (3)

(1) Icelandic Meteorological Office, EoS, Reykjavik, Iceland (kristinj@vedur.is), (2) National Autonomous University of Mexico, Mexico city, Mexico , (3) Reykjavik Energy, Reykjavik, Iceland

The Bárdarbunga volcanic unrest in 2014-2015 gave a rare insight into the behaviour of a caldera volcano. The volcano encompasses an 8x11 km wide oval caldera and is overlain by a glacier up to 800 m thick. The eruption (was) accompanied by a caldera collapse that triggered thousands of events with 80 earthquakes between M5-M5.8. A subsidence bowl up to 65 m deep was formed (observed?), while about 1.8 km3 of magma drained laterally along a subterranean path, forming flood basalt 47 km northeast of the volcano. The caldera collapse, monitored with a GPS inside the caldera, and the magma outflow, gradually declined until the eruption ended some 6 months later (27 February 2015). The seismicity continued to decline, both in the far end of the dyke as well as within the caldera for a few months after the eruption ended, interpreted as a relaxation process. However, half a year later (in September 2015) seismicity within the caldera started to increase again and has so far triggered over 30 earthquakes with magnitude M4-M5.

Here we present a seismic waveform correlation analysis where we look for similar repeating waveforms of caldera earthquakes. The analysis reveals a dramatic change occurring between February and June 2015. We find that the earthquake's polarity reverses sign completely already two months after the eruption seized and until this day the caldera is only triggering earthquakes with reversed polarity compared to the caldera collapse period. Moment tensor analysis of earthquakes with M>4.5 show that Bárðarbunga earthquakes are characterized by two main types of solutions; CLVD with vertical-P (seen worldwide during unrest) and the opposite CLVD with vertical-T (seen worldwide to occur before volcanic eruptions). The moment tensor analysis also confirms that before the eruption vertical-T solution were observed and during the caldera collapse the vertical-P solutions were observed. Solutions were reversed again after the unrest, or between 19 February 2015 and 2 March 2016 and since then, only vertical-T solutions are observed.

Our results suggest that caldera fault movements were reversed two months after the eruption and caldera collapse ended in 2015, months before the seismicity started to increase again. By analyzing small earthquakes with repeating waveforms, we can increase our temporal resolution of understanding the caldera faults movements. These data and their interpretation are helpful to improve our understanding of the current status of the volcano and, eventually, to perform a more accurate and reliable hazard assessment.