Variation in b-value of caldera earthquakes during recent activity of the Bárðarbunga Volcano in Iceland

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Abstract — *The magnitude distribution of caldera earthquakes in the subglacial Bárðarbunga volcano in Central Iceland, characterized by the b-value, shows a systematic variation that is consistent with stress changes anticipated in the roof of an inflating magma chamber beneath the caldera. The b-value was 0.83 prior to the rupture of the chamber in August 2014 when a dike propagated laterally from the volcano to feed the eruption in Holuhraun. The b-value was relatively high following the collapse of the caldera, reflecting low stress in the magma chamber roof. Half a year later a decrease was observed in the b-value, concurrent with an increase in the seismicity, consistent with indications of recharging of the volcano magma chamber. The magnitude distribution was anomalous during the slow collapse of the caldera in association with the eruption. During this period the earthquake sequence appeared to consist of two populations, only one of which followed the conventional Gutenberg-Richter distribution. For a subglacial volcano, where geodetic methods are difficult to implement, the b-value of caldera earthquakes provides an important additional parameter for the monitoring of magma pressure variations.*

Key points

The Bárðarbunga volcano at the center of the Iceland Hotspot is re-inflating following a major eruption and caldera collapse in 2014–2015.

The magnitude distribution of caldera earthquakes is consistent with increasing stress in the caldera region.

The b-value of the caldera earthquakes provides an addition to the arsenal of useful monitoring parameters for this remote sub-glacial volcano.

INTRODUCTION

The Gutenberg-Richter relation log $\mathbf{N} = \mathbf{a} - \mathbf{bM}$ is one way of quantifying an earthquake sequence. Here $\mathbf{N}$ is the number of earthquakes of magnitude $\mathbf{M}$ and larger, $\mathbf{a}$ and $\mathbf{b}$ are constants. The slope of this linear relationship, the b-value, describes the relative frequency of small events versus that of large events and $\mathbf{a}$ is the logarithm of the number of earthquakes of magnitude 0 and larger. For ordinary tectonic areas the value of $\mathbf{b}$ is close to 1 and shows little change. For some areas, however, volcanic areas in particular, the b-value is significantly different from 1. The spreading segments of mid-oceanic ridges, e.g., have consistently higher b-values, as high as 2.6 (Sykes, 1970; Einarsson, 1986).

It is generally accepted, following Scholz (1968) and Wyss (1973), that the b-value is inversely dependent on the stress level in the seismically active volume. High stress level over a large area favors large events over small events, hence a low b-value. High b-value is expected in areas of low stress and heterogeneous crust, where small earthquakes are favored. This has led to numerous studies where the objec-