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TITLE: Grímsvötn 2011 Explosive Eruption, Iceland: Relation between Magma Chamber Pressure Drop inferred from High Rate Geodesy and Plume Strength from Radar Observations

SESSION TYPE: Oral

SESSION TITLE: V41E. Constraining the Dynamics of Volcanic Jets and Plumes II

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ABSTRACT BODY: We demonstrate a clear relation between the vigor of an explosive eruption and inferred pressure change in a magma chamber feeding the eruption, based on near-field records of continuous GPS and ground tilt observations. The explosive mostly phreatomagmatic VEI4 eruption of the subglacial Grímsvötn volcano in Iceland, 21-28 May 2011, produced an initial plume reaching a height of about 20 km. Magma feeding the eruption drained from a shallow magma chamber under the Grímsvötn caldera. A continuous GPS site on the caldera rim sampling data at 5 Hz has allowed the reconstruction of the pressure drop history in this magma chamber. The pressure dropped at a fast rate about an hour prior to the eruption while a feeder dike formed. Throughout the eruption the pressure continued to drop, but decayed exponentially. These observations are compared to measurements of plume heights, based on C-band radar located 257 km from the volcano and a mobile X-band weather radar placed at 75 km distance from the volcano after the eruption began. The radar further away has height resolution steps of 5 km at the location of Grímsvötn above 10 km elevation, and the one closer has resolution steps of 2-3 km. The measurements reveal plume heights often above 15 km between 19:21 on 21 May and 17:35 on 22 May (local time same as GMT). Peak elevation values of about 20-25 km for about 30 minute intervals were observed a few times between 21:25 on 21 May and 06:40 on 22 May. The initial strong plume was followed by pulsating but generally declining activity. After 04:55 on 23 May the measurements indicate a fluctuating plume mainly below 10 km. In order to generate a continuous curve of plume elevation we average all available plume elevation information for each hour. The resulting plume height is then related to magma flow rate using an empirical formula from Mastin et al. (2009). Integrating these flow rates yields an estimate of accumulated volume of eruptive products calculated as dense rock equivalent (DRE). Despite large uncertainties on the inferred magma flow rate, the shape of the curve of inferred accumulated DRE and the pressure drop are similar. For this eruption, we see a clear link between the strength of an eruption plume and pressure change in the feeding magma chamber, measured by high rate ground deformation studies. Hence we can conclude that magma flow inferred from plume height correlates with the pressure change, which demonstrates the potential of real time high rate geodesy to foresee both onset and evolution of explosive eruptions and their plumes. The inferred volume change of the underlying magma chamber, modeled as a Mogi source, is about 5-8 times smaller than the suggested DRE volume from the integration of plume heights, which we relate to the effects of magma compressibility.

KEYWORDS: [8414] VOLCANOLOGY / Eruption mechanisms and flow emplacement, [8419] VOLCANOLOGY / Volcano monitoring, [1240] GEODESY AND GRAVITY / Satellite geodesy: results, [8488] VOLCANOLOGY / Volcanic hazards and risks.

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