Geophysical Research Abstracts
Vol. 14, EGU2012-2464-1, 2012
EGU General Assembly 2012
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Quantification of magma ascent rates from collapsing domes: image, thermal and seismic monitoring at Volcán de Colima, Mexico

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Volcán de Colima, Mexico, is an active andesitic volcano. Its current eruptive phase started in 1998 and has been characterised by dome growth, of variable speed, interrupted intermittently by explosive eruptions. Since November 2009, the growing dome has been overflowing the western crater rim, generating rockfall events. Due to this, the rate of magma ascent, a crucial parameter for volcano monitoring and hazard assessment, could no longer be quantified easily. In the present study, we show alternative approaches to quantify the magma ascent rate for the period between January and December 2010. During this period, no significant volume increase of the dome was measurable because magma influx has been constantly compensated by rockfalls. We used a three-fold approach to calculate the volume of individual rockfalls through the detailed analysis of 1) high resolution images, 2) infrared images and 3) seismic signals related to rockfall events that were not associated with an explosive event. The high-resolution images were taken shortly before and after an event and investigated for noticeable differences. The size of the missing boulders was calculated. Infrared images were taken every two seconds from a common location and larger events showed a correlation between the volume of a rockfall and the surface temperature of the freshly exposed surface. The seismic energy associated with the rockfalls was calculated and shown to be correlated with the rockfall volume. By using those three approaches, it was possible to calculate the magma extrusion for the investigated period. Changes were revealed in rockfall activity, rockfall volume and averaged extrusion rate. We found that the extrusion rate was not constant but varying between 0.01 and 0.02 m3 s-1. We found that each one of these independent methods represents a reliable tool to constrain the growth rate of domes that are repeatedly collapsing partially. The correlation between the three approaches is very good, meaning that it is possible to calibrate the seismic records associated with the rockfalls (a continuous monitoring tool) to permit volcano monitoring and hazard assessment of the rockfalls.