NON-LINEAR MAGMA-EDIFICE COUPLING AT GRIMSVÖTN VOLCANO (ICELAND)

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Continuous monitoring of seismicity and surface displacement on active volcanoes reveals important features of the eruptive cycle. In this work we analyzed high-quality GPS and earthquake data recorded at Grimsvötn volcano by the Icelandic Meteorological Office during its 2004-2011 inter-eruptive period. They show a characteristic pattern with an initial ~2 years exponential decay followed by a ~3 years constant inflation rate surface displacement, already observed on some other volcanoes. Such pattern was recently explained by a two-magma chamber model in a linear elastic edifice, with a constant magma inflow at the base of the conduit. Here we propose a one-magma chamber model, in a non-linear elastic damaging edifice, with incompressible magma and a constant pressure at the base of the magma conduit. We first modelled seismicity rate and damage as a function of time, and derived simple analytical expressions for the magma reservoir overpressure and the surface displacement as a function of time. We obtain a very good fit with the seismicity and surface displacement data, by adjusting only three phenomenological parameters. Reservoir overpressure was found to remain limited, quasi-constant during the constant inflation rate period, and to decrease during the pre-eruptive period. This decrease is controlled by the damage law. Magma flow was found to be constant during constant inflation rate period, and to increase during the pre-eruptive period. Magma flow variations are due to the non-linear variations of the reservoir volume, and not necessarily to variations of the pressure at the base of the magma conduit.

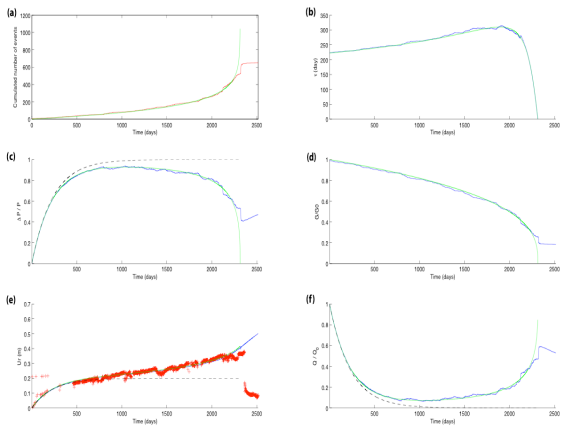

Figure 1. Model variables as a function of time from 1 December 2004 to 31 December 2011. Data are represented in red, Runge-Kutta (RK) numerical solution in blue, analytical solution in green, reference linear elastic solution in dashed black. a) Cumulated number of earthquakes (red: recorded by IMO seismic network; green: analytical model); b) characteristic time; c) dimensionless over-pressure in the réservoir ; d) normalized shear modulus; e) measured (at GPS station GFUM, red), modeled horizontal displacement, and reference linear elastic solution. f) magma flow rate (blue: from Poiseuille law and RK solution; green: from the analytical form).