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

J.-L. Got¹, A. Carrier¹, D. Marsan¹
¹Institut des Sciences de la Terre, Chambéry, France

Key words Seismicity, deformation, damage, volcano.

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 overpressure in the reservoir; 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).