Geophysical Research Abstracts,
Vol. 10, EGU2008-A-06899, 2008
SRef-ID: 1607-7962/gra/EGU2008-A-06899
EGU General Assembly 2008

Geophysical signature of shallow magma chamber replenishment.

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The arrival of new magma batches into shallow chambers is commonly considered as one possible trigger of a new volcanic eruption, as in several cases including the Mount St. Helens eruptions in the eighties, the 1991 Pinatubo eruption, and at least some of the several eruptions in the history of Campi Flegrei. Magma movement at depth implies mass re-distribution, pressure changes, and pressure transients which translate into variations in the gravity field, shape and slope of the volcano flanks, and seismic signals registered at the surface. We have developed a numerical modelling framework which allows an evaluation of the type, magnitude, and time-space distribution of gravity, deformation, and seismic signals produced as a consequence of new magma arrival in a pre-existing chamber. Magma convection and mixing is modelled by solving the fundamental transient 2D mass, momentum and energy equations for compressible to incompressible multicomponent homogeneous magma carrying an H_2O+CO_2 gas phase in thermodynamic equilibrium with the silicate melt. Gravity changes are computed through time by integrating in space the contribution from any single computational node in the finite element domain. The time-shape distribution of pressure and deviatoric stress at fixed fluid flow boundaries is then used as the boundary condition for numerical simulations of the elastic dynamics in the heterogeneous rock system bounded by a free surface with real topography. Numerical simulations have been performed with reference to the Campi Flegrei volcanic system, by employing system conditions representative of the arrival of volatile-rich trachytic magma into a shallow phonolitic magma chamber. The complex dynamics of magma convection and mixing are illustrated in detail in a contribution submitted

to session GMPV-22. Depending on the width of the dyke carrying trachytic magma into the chamber, complex patterns of recirculation of the phonolitic magma within the dyke are possible, resulting in either negative or positive residual gravity changes with magnitude up to several tens of μgal. Ground oscillations occur over a spectrum of frequencies, with most energy concentrated at periods of several tens to >100 s, and secondary peaks at 5-10 s (Very Long Period) and 1-2 s (volcanic tremor) with waveforms similar to those typically registered in volcanic areas. The residual ground deformation shows patterns which nearly perfectly superimpose to those registered during bradiseismic events at Campi Flegrei. We suggest that the present numerical approach can be used in conjunction with inverse techniques to constrain the arrival of new magma batches at shallow depth, an event which may be associated to an increased hazard level at active volcanoes. The occurrence of ground oscillations with frequency around 0.01 Hz emerges as one possible relevant element for the set up of an early warning system at active volcanoes.