Geophysical Research Abstracts,
Vol. 11, EGU2009-13927, 2009
EGU General Assembly 2009

Subsurface mass migration at active volcanoes: what we learnt from the VOLUME project

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Movements of multiphase fluids beneath active volcanoes are generally detected at the surface in terms of changes in geophysical and geochemical observables. The prompt detection and interpretation of such signals thus represent a crucial step toward the short-term evaluation of volcanic hazard. Funded through the European 6th framework program, the VOLUME project joined 19 institutions from 6 EU and 5 extra-european countries under the common goal of improving our understanding of how subsurface mass movement manifests itself at the surface, in turn revealing the significance of such movements as precursors to impending eruptions. We integrated high-end experimental procedures with a robust modeling framework to address some of the most relevant issues of modern, quantitative volcanology. In particular, our studies focused on: (i) Unrevealing the complex interplay between hydrothermal and magmatic fluids in generating the observed geophysical / geochemical signals, (ii) Detailing the location, geometry and dynamics of magma pathways and storage zones (iii) Probing variations of the elastic parameters of volcanic media in response to stress changes induced by mass migration, and (iv) Developing a robust computational framework for forward-modelling the geophysical observables resulting from the dynamics of multiphase magmatic systems.
VOLUME activities developed at both european and extra-european volcanoes. We present here the most striking results obtained at two italian test-sites, namely Etna and Campi Flegrei, for which we had available data sets of unprecedented sensitivity and temporal resolution.
Results from Etna include a) mapping of the shallow plumbing system from Moment-Tensor inversion of broad-band seismic signal, b) the detection of deep magma intrusion from inversion of joint gravity-tremor anomalies; c) the measurement of changes in both elastic anisotropy and seismic velocity concomitant to the waning stage of the 2002 NE flank lava effusion; and d) highlights on the degassing process, through comparison of internal volume changes inferred from seismological inversions with gas volumes measured externally through continuous FTIR and COSPEC logging. At Campi Flegrei, we defined a conceptual framework for interpreting the temporal succession of geochemical and geophysical signals observed during the 2005-2006 mini-uplift episode. The source modelling of Long-Period sources and precise location of brittle-failure events, joint to a quantitative image of the spatial and temporal distribution of gaseous emissions, clarified the complex interplay between ascending magmatic fluids and the dynamics of the shallow, over-pressurised hydrothermal system. Taken all together, these results contribute to our understanding of the relationships relating the migrating magmatic / hydrothermal fluids, and the associated geophysical / geochemical tracers.