ROLE OF ANELASTIC RHEOLOGY IN VOLCANIC DEFORMATION MODELLING

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Analogical models of ground deformation in volcanic areas often show better agreement with observations than mathematical models assuming a perfectly elastic behaviour of the medium. In particular, extensive sand-box experiments show that, following an inflation episode at depth, strain localization takes place above the source, along fault-like structures, which play a fundamental role in governing the cumulative long term deformation of the medium. Owing to the low lithostatic pressure, to the widespread presence of fluids and to the low cohesion of volcanic material, shallow layers in a volcanic region are better described in terms of the modified Mohr-Coulomb constitutive relation. Deep layers, on the other side, are better described in terms of viscoelastic constitutive relations, owing to the high temperatures close to magma reservoirs. Taking into account the inelastic properties of the medium, it is possible to lower considerably the overpressure estimates inferred from elastic models and to reconcile inferred overpressure values with petrologic constraints.

In this study, we develop finite element models of ground deformation in volcanic areas, employing elastic and inelastic constitutive laws. The aim of the analysis is to elucidate how a heterogeneous structure of the medium (variations in rheologic parameters and pore pressure) affect the stress and strain distribution. The huge ground deformation (more than 1.5 m) observed at Campi Flegrei caldera (Italy) during 1982-84 is modelled in terms of an inelastic behaviour of the medium. The caldera is characterized by different mechanical (elastic and inelastic) properties with respect to the host rocks, due to the different formation and evolution. Axi-symmetric finite element models are developed, involving an overpressure source located at depth greater than the deepest limit of hypocenter distribution.

Models take into account gravity and the initial isotropic (lithostatic) stress state is
perturbed by the inflating source. The Mohr Coulomb failure criterion permits to take into account the lithostatic stress and the presence of fluids, respectively inhibiting and enhancing the plastic deformation. We simulate the influence of the caldera structure on the deformation field and the distribution of seismicity, interpreted as the plastic component of deformation. The surface deformation and the seismicity patterns observed during the unrest can be explained in terms of a considerably deeper source characterized by a lower overpressure with respect to the elastic modelling. Models are applied to other volcanic areas, which show typical evidence for inelastic properties of the medium.