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Dynamic model of intrusion of magma and/or magmatic fluids in the large-scale deformation source of the Campi Flegrei caldera (Italy).

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The Campi Flegrei (CF) caldera is located in a densely populated area close to Naples (Southern Italy). It is renowned as a site of continual slow vertical movements. After the last eruption in 1538, the caldera generally subsided until 1969 when minor uplift occurred. In the early 1970s this uplift became significant ($\sim$1.5 m max). A further large uplift episode occurred from 1982 to 1984 ($\sim$1.8 m max), and subsequently smaller uplift episodes have occurred since then.
Amoruso et al. (2014a,b) have recently shown that the CF surface deformation field from 1980 to 2013 can be decomposed into two stationary parts. Large-scale deformation can be explained by a quasi-horizontal source, oriented NW to SE and mathematically represented by a pressurized finite triaxial ellipsoid (PTE) $\sim$4 km deep, possibly related to the injection of magma and/or magmatic fluids from a deeper magma chamber into a sill, or pressurization of interconnected (micro)cavities. Residual deformation not accounted for by PTE is confined to the Solfatara fumarolic area and can be mathematically explained by a small (point) pressurized oblate spheroid (PS) $\sim$2 km below the Solfatara fumarolic field, that has been equated with a poroelastic response of the substratum to pore pressure increases near the injection point of hot magmatic fluids into the hydrothermal system. A satisfying feature of this double source model is that the geometric source parameters of each are constant over the period 1980-2013 with the exception of volume changes (potencies).
Several papers have ascribed CF deformation to the injection of magmatic fluids at the base of the hydrothermal system. All models predict complex spatial and temporal evolution of the deformation pattern and consequently contrast with the observed deformation pattern stationarity. Also recently proposed dynamic models of sill intrusion in a shallow volcanic environment do not satisfy the observed CF deformation pattern stationarity.
We have developed an analytical dynamic model of intrusion of magma or injection of supercritical fluids in the PTE. Propagation is governed by a Navier-Stokes equation for magma intrusion and modelled as creeping flow in porous media (Darcy's law) for supercritical fluids injection. In both cases the ground deformation pattern is constant over time.
Using Finite Element Modeling, we also show that the presence of a viscoelastic shell surrounding the PTE amplifies ground deformation, with no appreciable effect on the ground deformation pattern.
Thus, our model satisfies the observed CF deformation pattern stationarity both using a purely elastic medium or allowing for stress relaxation close to the PTE, caused by the rock temperature.

Amoruso et al. (2014a), J. Geophys. Res., 119 (2), 858-879
Amoruso et al. (2014b), Geophys. Res. Lett., 41 (9), 3081-3088