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Ground displacement associated with hydrothermal fluid circulation

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Ground deformation is traditionally interpreted as being induced by volume change of a discrete source in an elastic or viscoelastic half-space. However, hydrothermal fluids may play an important role, mainly due to temperature and pore pressure acting on porous rocks. Examples of fluid-induced deformation are know from geothermal field exploitation, but significant evidences of thermo-fluid-mechanical interactions also come from episodes of caldera unrest. In this case, the identification of mechanisms causing ground displacement bears important consequences for hazard evaluation. Aim of this work is to evaluate mechanical effects associated with the circulation of hydrothermal fluids. We first simulate heat and fluid flow through a generic hydrotermal system, fed by a deep source of magmatic fluids. Then, we simulate the effects of an increased magmatic degassing and calculate the resulting deformation of the porous rock. We use a mathematical model, based on a system of distributed equivalent forces and on the linear theory for fluid-saturated, porous and thermoelastic media. Vertical ground displacement is first calculated for a homogeneous porous medium, and then taking into account heterogeneous hydraulic and transport properties of rocks. Results show that increased magmatic degassing can cause a vertical deformation of the same order of magnitude of the minor uplift observed at the Phlegrean Fields caldera (Italy). Results also show that deformation may follow complex pattern and it is affected by heterogeneity of rock properties.