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Physical modeling of hydrothermal fluid circulation and gravity changes at the Phlegraean Fields (Italy)

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An active hydrothermal system exists at the Phlegraean Fields caldera (Italy), and daily releases important amounts of carbon dioxide through diffuse degassing and feeds fumaroles inside the Solfatara crater. Recent bradyseismic crises and minor ground displacement have been accompanied by correlated changes in the composition of fumarolic gases. Such changes have been recently interpreted in terms of pulsating degassing of the deep source feeding the shallow hydrothermal system. Physical modeling of coupled heat and fluid flow through porous media has been performed in the past to test this working hypothesis (Todesco et al., 2003; Chiodini et al., 2003). The model applied describes the evolution of a shallow hydrothermal system fed by a deep (magmatic) source of hot water and carbon dioxide. Modeling results showed that alternating periods of strong and weak magmatic degassing are able to cause the observed CO_2/H_2O variation in discharged gas. A good match with observed data, however, can be also achieved with a different choice of degassing periods and gas composition (Todesco et al., 2004). The model has therefore verified the working hypothesis (i.e.: a pulsating degassing may induce the observed compositional variation), but it cannot univocally define the evolution of magmatic degassing. To better constrain the model, we need to compare modeling results with other, independent data sets.

The simulated evolution of the hydrothermal system involves changes in size and composition of the two-phase zone feeding surface manifestation. These changes imply variation in subsurface fluid density distribution that can be significant and can occur at very shallow levels, and can therefore induce detectable gravity changes at the surface. In this work we evaluated the gravity changes arising from the simulated evolution of the hydrothermal system. Calculated gravity signal is characterized by an

overall decline (-150 microgal over the simulated 20 years period), as the two-phase zone progressively enlarges and more gas enters the system. This trend is periodically interrupted when periods of increased magmatic degassing induce a mass increment and a corresponding gravity increase.

To compare the calculated gravity signal with measured data, we first need to isolate the contribution of the hydrothermal system to the overall gravity changes recorded at the stations, which also include effects due to elevation changes and to other possible mass changes at depth, possibly related to magma movements. Hydrothermal fluid contribution was estimated, after correction for elevation changes, from the difference existing between the gravity station right above the hydrothermal system (Solfatara), and the one at the caldera centre (Serapeo) where no surface emissions are present. Calculated gravity changes appear to justify most of the differences observed between gravity data at Serapeo and Solfatara. Gravimetric and geochemical data werethen jointly used to calibrate the model, by progressively adjusting model parameters in order to fit the observed evolution of gas composition and gravity changes, over the same time span. Preliminary results provide interesting insights on the interpretation of recent evolution of the Phlegraean Fields.