Magma dynamics at Campi Flegrei (Italy) as inferred by inert gas geochemistry

A. PAONITA[1], S. CALIRO[2] AND G. CHIODINI[2]

[1]Istituto Nazionale di Geofisica e Vulcanologia – Sezione di Napoli, Via Diocleziano 328, 80124, Napoli, Italy
[2]Istituto Nazionale di Geofisica e Vulcanologia – Sezione di Palermo, Via Ugo La Malfa 153, 90146 Palermo, Italy

In the last decade the Campi Flegrei caldera, sited in Neapolitan area (Italy), has showed clear signs of reactivation, including numerous episodes of ground uplift and correspondent seismic crises. A maximum ground uplift of 4 m occurred in 1984, followed by subsidence interrupted by three minor inflactions. In 2005 the ground started a new uplift phase which lasted up to 2013. These changes were parallelled by compositional variations of fumarolic effluents from La Solfatara crater (located in the centre of the caldera), an increase of the fumarolic activity as well as of soil CO_2 fluxes. We focus on the thirty years-long dataset of CO_2-He-Ar-N_2 fumarolic compositions from La Solfatara, which shows a continuous decrease of both N_2/He and N_2/CO_2 ratios since 1985, paralleled by an increase of He/CO_2. These variations are not consistent with processes of gas condensation in the local hydrothermal system, given that N_2/CO_2 and He/CO_2 should covariate, and with changes in the mixing proportions between magmatic and hydrothermal fluids, because both of them show similar chemical ratios in the CO_2-He-Ar-N_2 system. In order to interpret these peculiar features, we have applied the degassing model of Nuccio and Paonita (2001), after to have included the most recent updates for inert gas solubilities and the petrologic constraints for melt composition and reservoir pressure at Campi Flegrei. The model simulations for mafic melts (trachybasalt and shoshonite) show a surprising agreement with the measured data, whilst definitely excluding the involvement of acidic magmas in feeding the fumaroles. The long-time geochemical changes can be interpreted by both decompressive degassing of a ascending magma and mixing between magmatic fluids exsolved at various levels along the ascent path. The most intense episodes of inflation would occur when the gas supply to the sill-like reservoir comes from the 8 km-deep magma, although exsolved fluids by magma bodies at shallower depths contribute to the gas budget. Our work highlights that, in contexts where the presence of hydrothermal systems masks or deeply modifies the pristine magmatic signature of the reactive volatiles, the use of ratios among inert gas species can become the preferred method to achieve information on the magmatic systems.