

Anatomy of a fumarolic system inferred from a multiphysics approach

*Marceau Gresse^{1,2}, Jean Vandemeulebrouck², Svetlana Byrdina², Giovanni Chiodini³, Philippe Roux², Antonio Pio Rinaldi⁴, Marc Wathelet², Tullio Ricci⁵, Jean Letort², Zaccaria Petrillo⁶, Paola Tuccimei⁷, Carlo Lucchetti⁷, Alessandra Sciarra⁷

1. Earthquake Research Institute, University of Tokyo, Tokyo, Japan, 2. University Grenoble Alpes, Univ. Savoie Mont Blanc, CNRS, IRD, ISTERre, Grenoble, France, 3. Istituto Nazionale di Geofisica e Vulcanologia, Bologna, Italy, 4. Swiss Federal Institute of Technology (ETHZ), Zürich, Switzerland, 5. Istituto Nazionale di Geofisica e Vulcanologia, Roma, Italy, 6. Istituto Nazionale di Geofisica e Vulcanologia, Osservatorio Vesuviano, Napoli, Italy, 7. Università Roma Tre, Dipartimento di Scienze, Roma, Italy

Fumaroles are a fundamental manifestation of volcanic activity that are associated with large emissions of gases into the atmosphere. These gases originate from the magma, and they can provide indirect and unique insights into magmatic processes. Therefore, they are extensively used to monitor and forecast eruptive activity. During their ascent, the magmatic gases interact with the rock and hydrothermal fluids, which modify their geochemical compositions. These interactions can complicate our understanding of the real volcanic dynamics and remain poorly considered. Here, we present the first imagery of a fumarolic plumbing system at Solfatara crater (Campi Flegrei Caldera, Italy), using three-dimensional electrical resistivity tomography and acoustic noise localization. We delineate a gas reservoir that feeds the fumaroles through distinct channels. Based on this geometry, a thermodynamic model reveals that near-surface mixing between gas and condensed steam explains the distinct geochemical compositions of fumaroles that originate from the same source. Such modeling of fluid interactions will allow for the simulation of dynamic processes of magmatic degassing, which is crucial to the monitoring of volcanic unrest.

Keywords: Fumaroles, Hydrothermal system, Electrical Resistivity Tomography, Multiphase Flow Modelling, Acoustic noise localization, Campi Flegrei caldera

