Geophysical Research Abstracts
Vol. 16, EGU2014-5204, 2014
EGU General Assembly 2014

Relations between electrical resistivity, carbon dioxide flux, and self-potential in the shallow hydrothermal system of Solfatara (Phlegrean Fields, Italy).

Svetlana Byrdina (1), Jean Vandemeulebrouck (1), Carlo Cardellini (2), Aurelie Legaz (1), Christian Camerlynck (3), Giovanni Chiodini (4), Thomas Lebourg (5), Jean Letort (6), Ghislan Motos (1), Aurore Carrier (1), and Pascale Bascou (1)

(1) ISTerre, Université de Savoie, IRD R219, CNRS, UMR 5275, F-73376 Bourget du Lac, France, (2) University of Perugia, Italy, (3) Sisyphe, Paris 6, UMR 7619, France, (4) INGV, Vesuvius Observatory, Naples, Italy, (5) Géoazur, UMR7329, France, (6) ISTerre, Grenoble UJF, CNRS, UMR 5275, France

In the frame of the Geo-Supersite Med-Suv project, we present the results of an electric resistivity tomography (ERT) survey, combined with mappings of diffuse carbon dioxide flux, ground temperature and self-potential (SP) at Solfatara, Phlegrean Fields, Italy. This ensemble of methods aims to image the hydrothermal system of Solfatara, understand the geometry of the fluid circulation, and precise the extension of the hydrothermal plume evidenced by Bruno et al. (2007). Solfatara is the most active crater of Phlegrean Fields, characterized by an intense carbon dioxide degassing, about 1500 T/day (Chiodini et al, 2005). Its main structures are Bocca Grande fumarole and several lesser fumaroles aligned along two normal faults, and Fangaia mud pool where the aquifer reaches the surface. Solfatara appears as a globally conductive structure, with resistivity in the range $1 - 100$ Ohmm. Comparison between spatial variations of resistivity and gas flux rate indicates that resistivity changes at depth are related to gas ratio content and the fluid temperature. Broad negative anomaly of self-potential in the inner part of Solfatara with a minimum in the area of the Bocca Grande suggests a significant downward flow of condensing liquid water. Our results delineate several distinct zones: 1) a vegetation-covered area, relatively undisturbed by a hydrothermal activity and characterized by a high resistivity (up to 100 Ohm-m) of the shallow layer (vadose zone), and low carbon dioxide flux. In this area, self-potential takes zero or positive values with little spatial variations. 2) In the central part, below a superficial vadose zone, a resistive layer ($20 - 100$ Ohm-m), between $30 - 100$ m depth, interpreted as a gas-saturated body, is systematically overlain by a conductive aquifer ($1 - 5$ Ohm-m). In this area, the self-potential displays a negative anomaly with an average value of -100 mV and the carbon dioxide flux is > 1000 g m^{-2}day^{-1}. 3) Close to Bocca Grande fumarole, the self-potential reaches its minimum (-160 mV), the CO_2 flux is extremely high (5000-20 000 g m^{-2}day^{-1}) and the aquifer is interrupted by a quasi-vertical structure (20 Ohm-m) representing in our interpretation a channel for a hot mixture of CO_2/vapour/condensing water; 4) Around Fangaia mud-pool, the resistivity model clearly identifies a very conductive plume ($1 - 5$ Ohm-m). The self-potential around Fangaia takes an almost constant value of ~ -90 mV; 5) The flanks of Solfatara crater are characterized by highest values of resistivity up to 500 Ohm-m and strong diffuse degassing. We also perform a 3-D resistivity model of Fangaia hydrothermal plume using 23 high-resolution Wenner-Schlumberger ERT profiles. Assuming that the shallow resistivity variations in the vicinity of the plume are mainly due to saturation variations, we propose a 2D axis-symmetric numerical model coupling Richards equation for fluid flow in conditions of partial saturation with the resistivity calculation as function of saturation only. The numerical model allows the estimation of the permeability of the shallow layers below Fangaia as 5×10^{-13} m ^{2}, which belongs to the upper part of the range of permeabilities given by laboratory studies for pyroclastic rock samples (Vanorio et al, 2002).