# Hydrothermal fluid flow structures at Solfatara volcano, Somma-Vesuvius volcanic complex and Mt. Etna

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Solfatara (Campi Flegrei):

We present the first detailed 3-D Resistivity model of the Solfatara-Pisciarelli area, obtained from numerous ERT surveys during the "MED-SUV" Project. This inversion was performed by taking into account 44 000 ERT data points, as well as surface e-m resistivity measurements and the magneto-tellurics model from A. Siniscalchi et al. respectively as surface and bottom boundary conditions. The 3-D resistivity structure well matches with the $CO_2$ flux, temperature and self-potential variations at the crater surface. This model clearly highlights the main geological units of the area (Monte Olibano, Solfatara crypto-dome, layers of eruptive deposits), and the structures of hydrothermal fluids flow in the Solfatara crater. We particularly focus on the Fangaia liquid plume, and the feeding system of Bocca Nuova and Bocca Grande fumaroles. We also present the time-lapse resistivity variations measured on the eastern flank of Solfatara that show the dynamics of this active hydrothermal system.

Somma-Vesuvius:

Vesuvius is perhaps the volcano with the highest risk in the world threatening the 800,000 residents living on its slopes. In March 2014 an extensive field work was carried out in the framework of the "MED-SUV" Project. The aim of this survey was to identify the hydrothermal system and its fluid circulation dynamics as well as the structural boundaries associated to this volcanic complex. A high resolution deep Electrical Resistivity Tomography, 64 electrodes, 40m spacing, was performed along a NW-SE profile, 7km long, coupled with self-potential, temperature (30cm depth), and soil degassing ($CO_2$) with a step of 20m. ERT measurements were performed with a Wenner configuration and reached 500m depth. Inside Somma caldera, the resistivity cross-section of Vesuvius cone displays a conductive body (20-100 ohm.m) located beneath the present-day summit crater and interpreted as its hydrothermal system. This latter is also revealed by the characteristic "W" shape of self-potential signal showing with its minima a hydrothermal system of about

1,7km in diameter. The top of the hydrothermal system is at about 200-250m below the surface, except along four areas characterized by vertical rising of hydrothermal fluids up to the surface. These areas have been evidenced by temperature anomalies (increase of 6-13°C). The largest structure allowing this preferential fluid flow is the 1906s crater rim, while the two others temperature peaks are located close to the present-day fumarolic area. In the lower part of Vesuvius cone, outside of the hydrothermal system, it is possible to detect on both side of the edifice, a sub-vertical body of about 800-1000 ohm.m isolated by higher resistivity values (2500-3000 ohm.m). The more conductive body can be associated with a break in slope in the topography and also to higher $CO_2$ concentration. This structural boundary seems to fit with the 1631s crater rim.

Etna:

Between June and July 2015 a very deep ERT profile (Pole-Dipole configuration, 40m spacing between electrodes and a remote electrode located at ~10km from the acquisition points) has been performed in the framework of the "MED-SUV" Project. Self-potential (SP), soil gas concentrations ($CO_2$, $^{222}Rn$, $^{220}Rn$, He, $H_2$ and $CH_4$) and soil temperature (T) measurements were coupled to the ERT profile with a spacing of 20m (except for Rn: 40m). The NE-SW profile crossed Etnas summit craters in the middle of the 5720m ERT total length. Six roll along protocols of ¼ of the dispositive (600m out of 2520m tot) have been carried out and, for the first time, a high resolution DC ERT profile reached the noticeable investigation depth of 900m bgl. The results clearly evidence the central shallow hydrothermal system of Mt Etna with large positive SP anomaly, high values of T, $^{222}Rn$, $CO_2$, He, $H_2$ and $CH_4$, in the areas where the conductive bodies reach the surface in correspondence of the summit craters and the 2014 eruptive vents ($CO_2$, $^{222}Rn$ and T). Structural boundaries, such as the Elliptic Crater (EC), were highlighted by a sharp decrease of the SP inside the EC. The high activity of $^{220}Rn$ (Thoron), outside the EC, highlights shallow gas source. The resistive body identified just below the NE crater is probably due to the over-heated plume rising from the top of the shallow feeding system towards the surface.