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Imaging the deep interior of Piton de la Fournaise

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Constraining the location of hydrothermal systems in active volcanoes is a fundamental step in assessing several geological hazards, like phreatic explosions, phreato-magmatic eruptions, and also flank collapses. On Piton de la Fournaise, signs of hydrothermal activity are elusive and restricted to weak low-temperature summit fumaroles. Until now, only SP mapping focused around the terminal cone and a few tens of direct current electrical and transient electromagnetic soundings attest to the presence of hydrothermal activity, spatially correlated with the summit collapse structure. These electrical resistivity soundings are of very low resolution and the lateral and the deep extension of the hydrothermal system remains poorly constrained. We will investigate the extension of the Piton de la Fournaise's hydrothermal system by a multi-disciplinary approach on a 3.8-km-long E-W cross-section across the Enclos Fouqué caldera, coupling Electrical Resistivity Tomography (ERT) with fine (every 5 meters) self-potential (SP), ground radar (Ultra GPR) and magnetic measurements. The combination of these methods will give information both on the internal structure of the edifice and fluid flow circulations. Our team has long experience in this domain and performed the first large-scale ERT experiment on an active volcano in the world, at Stromboli volcano, and obtained a high resolution ERT profile reaching up to 450 m depth. On Piton de la Fournaise, we deployed the same equipment (ABEM Lund imaging system SAS4000 and ES1064), but with a pole-dipole configuration consisting of a remote electrode 7 km away from the profile. It allowed reaching high-resolution ERT at depth down to 900 m, doubling the investigation depth compared to previous ERT made elsewhere through active volcanoes. A clear transition appears on the ERT, SP and magnetic profiles, revealing the influence of the hydrothermal system below the western part of the summit crater. No shallow sliding plane has been evidenced but this transition could be the upper part of a deeper one, at the origin (and controlling) the eastern flank instability.