La Soufrière de Guadeloupe volcano large-scale electrical resistivity 3D imaging

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A three dimensional image of the electrical resistivity was constructed from data sets acquired across La Soufrière de Guadeloupe volcano. In a previous study, a 1D reconstruction was performed showing the large range of resistivity variations across the edifice highlighting its important heterogeneity. La Soufrière de Guadeloupe lava dome is indeed crossed by major radial fractures separating relatively unaltered massive andesite blocks. Some regions are also covered by ashes emitted during the last eruptions. Moreover, the dome is crossed by a hydrothermal system of acid fluids supplied by tropical rains. The hydrothermal field is revealed by fumaroles and hot springs present on and around the dome and an acid lake is boiling inside a deep pit at the summit. It is therefore highly pertinent to image the internal structures of the volcano, as this could provide information for models estimating the potential hazards in case of a future eruption.

As is often the case on volcanoes, the complex topography and lush vegetation of La Soufrière dome render some regions of the volcano inaccessible so the deployment of regular electrodes profiles is impossible. This lack of information causes classical methods of 3D electrical resistivity imaging to fail in the reconstruction process. Recently developed methods based on adaptive wavelet parameterization are also unfeasible due to the complexity of the topography.

We therefore developed an original parameterization of the volcano electrical resistivity with the objective to reconstruct the global structure of the edifice. A 3D finite element model is constructed to represent the volcano and simulate the measurements of a reduced data set. The selected data correspond to the more distant electrodes as they are more sensitive to the deeper part of the volcano. The image reconstruction is performed using the EIDORS suite allowing the development of specific parameterizations. The method used here is inspired from the pilot points method developed for hydrogeological purposes. The approach consists in determining the location of a reduced number of points highly sensitive to resistivity variations and limit the inversion at the selected pilot points. The inversion is repeated several times, increasing the number of pilot points and allowing for their movement.

The reconstructed 3D image reveals the main paths of fluids and allows to distinguish unaltered materials from highly altered rocks saturated by fluids. The resulting image is compared with density images obtained from gravity measurements and muon flux detection. Despite their sensitivity to a different physical parameter, the images show similar structures inside the volcano. Some conductive regions correspond well to less dense structures as showed by muon flux measurements, and so probably represent water-saturated altered rock, while some more resistive regions coincide with denser rock and could represent massive andesite.

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