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Electrical resistivity tomography applied to a complex lava dome: 2D and 3D models comparison

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The study of volcanic domes growth (e.g. St. Helens, Unzen, Montserrat) shows that it is often characterized by a succession of extrusion phases, dome explosions and collapse events. Lava dome eruptive activity may last from days to decades. Therefore, their internal structure, at the end of the eruption, is complex and includes massive extrusions and lava lobes, talus and pyroclastic deposits as well as hydrothermal alteration.
The electrical resistivity tomography (ERT) method, initially developed for environmental and engineering exploration, is now commonly used for volcano structure imaging. Because a large range of resistivity values is often observed in volcanic environments, the method is well suited to study the internal structure of volcanic edifices.

We performed an ERT survey on an 11ka years old trachytic lava dome, the Puy de Dôme volcano (French Massif Central). The analysis of a recent high resolution DEM (LiDAR 0.5 m), as well as other geophysical data, strongly suggest that the Puy de Dôme is a composite dome. 11 ERT profiles have been carried out, both at the scale of the entire dome (base diameter of ∼2 km and height of 400 m) on the one hand, and at a smaller scale on the summit part on the other hand. Each profile is composed of 64 electrodes. Three different electrode spacing have been used depending on the study area (35 m for the entire dome, 10 m and 5 m for its summit part). Some profiles were performed with half-length roll-along acquisitions, in order to keep a good trade-off between depth of investigation and resolution. Both Wenner-alpha and Wenner-Schlumberger protocols were used.

2-D models of the electrical resistivity distribution were computed using RES2DINV software. In order to constrain inversion models interpretation, the depth of investigation (DOI) method was applied to those results. It aims to compute a sensitivity index on inversion results, illustrating how the data influence the model and constraining models interpretation.

Geometry and location of ERT profiles on the Puy de Dôme volcano allow to compute 3D inversion models of the electrical resistivity distribution with a new inversion code. This code uses tetrahedrons to discretize the 3D model and uses also a conventional Gauss-Newton inversion scheme combined to an Occam regularisation to process the data. It allows to take into account all the data information and prevents the construction of 3D artefacts present in conventional 2D inversion results.

Inversion results show a strong electrical resistivity heterogeneity of the entire dome. Underlying volcanic edifices are clearly identified below the lava dome. Generally speaking, the flanks of the volcano show high resistivity values, and the summit part is more conductive but also very heterogeneous.