Cross-section electrical resistance tomography of La Soufrière of Guadeloupe lava dome

Nolwenn Lesparre[1], Bartłomiej Grychtol[2], Dominique Gibert[3], Jean-Christophe Komorowski[3], Andy Adler[4]

[1]Institut de Radioprotection et de sûreté Nucléaire, Fontenay-aux-Roses, France, nolwenn.lesparre@irsn.fr
[2]German Cancer Research Center, Heidelberg, Germany
[3]Institut de Physique du Globe de Paris, Sorbonne Paris Cité, Univ Paris Diderot, Paris, France.
[4]Carleton University, Ottawa, Canada

Abstract: The electrical resistivity distribution at the base of La Soufrière of Guadeloupe lava dome is reconstructed by using transmission electrical resistivity data obtained by injecting an electric current between pairs of electrodes on opposing sides of the volcano. The data are inverted to perform a slice electrical resistivity tomography (SERT). The resulting image shows the presence of highly conductive regions separated by resistive ridges.

1 Introduction

The La Soufrière volcano has an active eruptive history. Future eruptions are possible, and could have large impacts on surrounding communities. Various scenarios are possible: collapse, phreatic eruption, magma ascent [1]. To give early warning, multi-parameter monitoring is conducted by the local volcano observatory (IPGP/OVSG). Complementary geophysical studies are then necessary to obtain a view of the inner structure of the volcano in order to better understand the monitoring data. The present study aims at contributing to the knowledge of the lava dome interior by performing a slice electrical resistivity tomography (SERT) obtained by inverting an electrical resistivity data set. The data set considered here was acquired with a transmission tomography configuration in order to probe the innermost regions of the lava dome [2].

2 Methods

Data were acquired at 62 electrodes attached to a 945 m long main cable. One of the cable extremities was connected to an auxiliary long wire in order to place an electrode on the opposite side of the lava dome. Both the remote electrode and one electrode plugged onto the main cable were used to inject an electric current forced to cross the innermost parts of the volcano. The main cable was moved to successively occupy three circular segments surrounding La Soufrière lava dome to form an almost closed loop. The elevations of the electrode loop vary between 1146 and 1337 m with an average of 1270 m, *i.e.* about 200 m bellow the summit.

We performed a SERT to reconstruct the conductivity distribution in a cross-section limited by the ring of electrodes. The SERT was implemented by defining the unknown conductivity distribution σ_{2d} on a coarsely meshed 2D cross-section. σ_{2d} was subsequently used to construct the full 3D conductivity distribution σ_{3d} necessary to solve the forward 3D finite element model. This was achieved by using a coarse-to-fine matrix that maps the conductivity σ_{2d} of each element of the cross-section onto each of the elements of the 3D model.

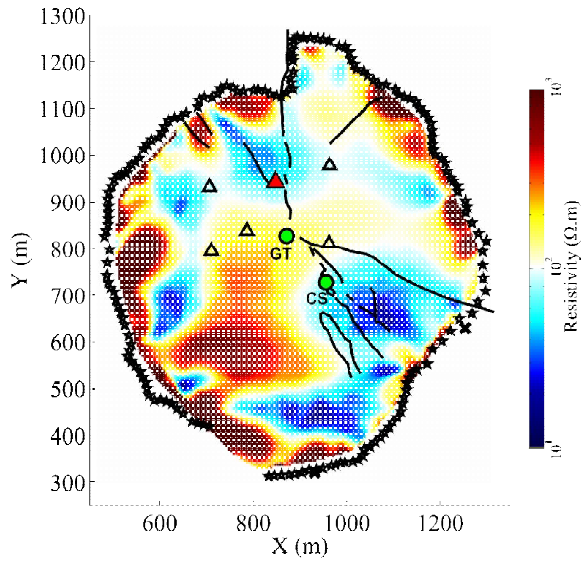

Figure 1: Reconstruction of the electrical resistivity at the dome base. Stars represent the electrodes location. Main geological structures are reported such as fractures (black lines), peaks (triangles) and acid ponds (green circles). The summit of La Soufrière is in red.

3 Discussion

The reconstructed resistivity cross-section shows that the interior of the lava dome contains three main conductive domains and one resistive structure (Fig. 1). Considering the resistivity values of these structures together with the densities obtained by cosmic muon radiography [3] we interpret the conductive regions as reservoirs filled with unconsolidated material and conductive hydrothermal fluids. This description is coherent with the activity observed during the successive phreatic eruptions that occurred since the creation of the lava dome 500 years ago.

Similarly, the resistive region is interpreted as a massive lava body that vertically extends through the whole height of the lava dome and which seems to constitute a barrier that, up to now, blocked eruptive activity on the south-west flank of the volcano.

References

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