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Contribution of 3D inversion of Electrical Resistivity Tomography data applied to volcanic structures

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The electrical resistivity tomography (ERT) method, initially developed for environmental and engineering exploration, is now commonly used for geological structures imaging. Such structures can present complex characteristics that conventional 2D inversion processes cannot perfectly integrate.
Here we present a new 3D inversion algorithm named EResI, firstly developed for levee investigation, and presently applied to the study of a complex lava dome (the Puy de Dôme volcano, France). EResI algorithm is based on a conventional regularized Gauss-Newton inversion scheme and a 3D non-structured discretization of the model (double grid method based on tetrahedrons). This discretization allows to accurately model the topography of investigated structure (without a mesh deformation procedure) and also permits a precise location of the electrodes. Moreover, we demonstrate that a complete 3D unstructured discretization limits the number of inversion cells and is better adapted to the resolution capacity of tomography than a structured discretization.
This study shows that a 3D inversion with a non-structured parametrization has some advantages compared to classical 2D inversions. The first advantage comes from the fact that a 2D inversion leads to artefacts due to 3D effects (3D topography, 3D internal resistivity). The second advantage comes from the fact that the capacity to experimentally align electrodes along an axis (for 2D surveys) depends on the constrains on the field (topography...). In this case, a 2D assumption induced by 2.5D inversion software prevents its capacity to model electrodes outside this axis leading to artefacts in the inversion result. The last limitation comes from the use of mesh deformation techniques used to accurately model the topography in 2D softwares. This technique used for structured discretization (Res2dinv) is prohibed for strong topography (>60 %) and leads to a small computational errors.
A wide geophysical survey was carried out on the Puy de Dôme volcano resulting in 12 ERT profiles with approximatively 800 electrodes. We performed two processing stages by inverting independently each profiles in 2D (RES2DINV software) and the complete data set in 3D (EResI). The comparison of the 3D inversion results with those obtained through a conventional 2D inversion process underlined that EResI allows to accurately take into account the random electrodes positioning and reduce out-line artefacts into the inversion models due to positioning errors out of the profile axis. This comparison also highlighted the advantages to integrate several ERT lines to compute the 3D models of complex volcanic structures. Finally, the resulting 3D model allows a better interpretation of the Puy de Dome Volcano.