TEM at breathtaking heights: Imaging the shallow fumarolic system on Lastarria volcano, Chile

T. Vondenhoff[1], B. Blanco-Arrué[2], J. Roas[1], B. Tezkan[1], D. Diaz[3], Y. Liu[4] and P. Yogeshwar[1]
[1]Institute of Geophysics and Meteorology, University of Cologne, Germany
[2]LIAG Institute for Applied Geophysics, Hannover, Germany, Barbara.BlancoArrue@leibniz-liag.de
[3]University of Chile, Santiago, Chile
[4]China University of Geosciences, Wuhan

SUMMARY

Volcanic activities around the world pose significant threats to both human life and infrastructure, underscoring the importance of comprehending the underlying processes within volcanic systems. Furthermore, volcanoes can be a window to better understand subsurface processes on a larger scale. This study presents the results of transient electromagnetic (TEM) measurements conducted on Lastarria volcano in Chile, aimed at unravelling the subsurface dynamics that govern volcanic activity at shallow depth. The investigation employs TEM as well as 1D and 3D inversion techniques, focusing on the electrical conductivity variations at shallow depths (~250m) around a field of fumarolic vents emitting hot sulphuric gases. Additionally, electromagnetic induction (EMI) measurements were conducted to cover regions near the fumaroles where the TEM soundings were difficult due to altitude and terrain challenges.

Here, we present 1D inversion results derived using conventional Marquardt-Levenberg and Occam inversion techniques. The 1D models are stitched together as quasi 2D sections. Model parameter importances and equivalent modeling is used to assess model uncertainty. Alongside, we present 3D inversion results obtained with the recently developed Julia Package (3DTEMinv) for time-domain 3D inversion and modeling data. Subsequent to various grids and inversion parameter tests, the 3D inversion was used for two separate profiles including a total of 17 TEM soundings. We obtain interesting results, with a high agreement between consecutive stations for the 1D models and very consistent structures in the 3D imaging. The first significant discovery is a double conductive layer situated at shallow depths beneath the volcano's edifice, between 30 m and 60 m depth. The second noteworthy finding involves a deep-seated conductor, which adds a layer of complexity to the volcanic system. Unravelling the properties and implications of these shallow and deep conductors might be instrumental in comprehending the overall behavior of the fumarolic fields. Both structures could be confirmed by sensitivity modelling studies. Although the precise resistivity and thickness of the double-layer remains uncertain, its presence is evident, and the structure is robust. The depth and spatial extent of the deep conductor comes with a high uncertainty, since the sensitivity of the TEM method is greatly decreased below the shallow conductor. Still, this structure is required for a good data fit. Overall, the 1D and 3D results show a high level of similarity and are in good correlation with the surface manifestations and EMI mapping data. These results contribute to the understanding of magmatic-hydrothermal processes at Lastarria volcano.

Keywords: Lastarria Volcano, Transient Electromagnetics, 3D TEM inversion, Time-domain methods