Three-Dimensional interpretation of broadband magnetotelluric data at Fogo Volcano, Azores Islands

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The architecture of volcanic systems is essential to know as (1) it yields knowledge on evolution of the volcanic system, thus improving our capability to project future behaviour; (2) as it provides insights regarding geohazards (such as seismic activity, landslides, increased outgassing), crucial for mitigating risk to human population; (3) as it contributes to the assessment of potential for renewable energy resources. High electrical conductivity values are typically associated with volcanic-hydrothermal systems and the magnetotelluric (MT) method has proven to be successful in mapping such conductivity contrasts and constraining volcanic processes.

The Azores archipelago (Portugal) is formed by nine volcanic islands located in the North Atlantic Ocean where the American, Eurasian, and African plates meet at a triple junction. São Miguel Island is the largest of the archipelago and hosts three trachytic polygenetic volcanoes: Sete Cidades, Fogo (Água de Pau) and Furnas. Following our earlier MT studies at Furnas, 44 high-quality (to ~1000s) broadband MT sites were collected during 2018 across Fogo Volcano and the adjacent Congro region that is prone to seismic swarm activity.

Our MT studies comprised two avenues: generating geoelectrical models that provided new insights into this unique setting, and investigating and assessing new tools for the MT community.

(1) Fogo has a resistive core and we do not see a magma chamber beneath.

(2) Shallow conductive channels are observed beneath Congro and their presence have been tested and validated through forward modelling and additional sensitivity tests.

(3) The MT results can be used to map clay alteration, with the highly conductive zone on the northern flank of Fogo corresponding to the smectite zone. The alteration temperature distribution is consistent with the formation temperature recorded within the area.

(4) A potential new geothermal resource has been identified. An area north of Ribeira Cha, on the southern flank of Fogo has very similar characteristics of the Ribeira Grande geothermal system that is located on the northern flank. This area may be key in increasing the energy self-sufficiency of the island.
Depth slices through the final 3-D MT inversion volume will be presented.

The new MT processing code of University of Frankfurt was compared against two long-standing codes commonly used in the MT community and it proved to yield superior responses for every site and examples will be presented. See presentation in this session “FFproc - an improved multivariate robust statistical data processing code for the estimation of MT transfer functions” (Castro et al).

A novel approach exploiting the Jacobian matrix elements for the 3-D MT inversion strategy will be presented. The Jacobian matrix elements map the relationship between the model and model responses, thus portions of the model with low sensitivities infer that the sensitivity structure is algorithmically influenced more strongly by the regularisation term than by the data-fitting term. Our results will show that the computation of the Jacobian matrix (albeit computationally expensive) is a powerful tool in aiding interpretation.