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Constraints on the structure of Maio Island (Cape Verde) by a three-dimensional gravity model: imaging partially exhumed magma chambers

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SUMMARY

We propose a 3-D gravity model for the volcanic structure of the island of Maio (Cape Verde archipelago) with the objective of solving some open questions concerning the geometry and depth of the intrusive Central Igneous Complex. A gravity survey was made covering almost the entire surface of the island. The gravity data was inverted through a non-linear 3-D approach which provided a model constructed in a random growth process. The residual Bouguer gravity field shows a single positive anomaly presenting an elliptic shape with a NW–SE trending long axis. This Bouguer gravity anomaly is slightly off-centred with the island but its outline is concordant with the surface exposure of the Central Igneous Complex. The gravimetric modelling shows a high-density volume whose centre of mass is about 4500 m deep. With increasing depth, and despite the restricted gravimetric resolution, the horizontal sections of the model suggest the presence of two distinct bodies, whose relative position accounts for the elongated shape of the high positive Bouguer gravity anomaly. These bodies are interpreted as magma chambers whose coeval volcanic counterparts are no longer preserved. The orientation defined by the two bodies is similar to that of other structures known in the southern group of the Cape Verde islands, thus suggesting a possible structural control constraining the location of the plutonic intrusions.

Key words: Inverse theory; Gravity anomalies and Earth structure; Oceanic hotspots and intraplate volcanism; Crustal structure; Africa; Atlantic Ocean.

1 INTRODUCTION

Within-plate ocean islands are the result of long-lived (10^6–10^7 yr) magmatic activity giving rise to highly complex buildings whose emerged part usually corresponds to a very small proportion (usually <5 per cent) of the total volume of the insular volcanic edifice. Geology and volcanostratigraphy give us information about the shallow distribution/structure of the different formations/lithologies based on the direct observation of the emerged outcropping rocks. However, the determination of the underground structure of a volcanic edifice requires the use of indirect geophysical methods like gravity and magnetic field modelling or seismic tomography. Despite its propensity to non-unicity problems, the gravity data required to determine a 3-D subsurface mass/density distribution is relatively easy to acquire. Thus, it is widely used to study the internal structure of ocean islands (e.g. Minshull & Brozena 1997; Malengreau 1999; Montesinos *et al.* 2005; Gottsmann *et al.* 2008; Camacho *et al.* 2009; Montesinos *et al.* 2011).

The Cape Verde archipelago has been the subject of geophysical surveys using seismic, gravimetric and magnetic techniques to study the mechanisms responsible for the Cape Verde rise (e.g. Dash *et al.* 1976; Ali *et al.* 2003; Lodge & Helffrich 2006; Pim *et al.* 2008; Wilson *et al.* 2010). The only geophysical study made with the purpose of resolving the internal structure of each individual islands was carried out in the 1960s (1961–1968) and consisted of a land gravity survey covering all islands of the archipelago (Mendes-Victor 1970). However, these readings are sparse, and only allow for a very rough interpretation of the underground structures. Despite the existence of a complete report of Mendes-Victor's campaigns, it was not possible to accurately identify and locate the stations measured on Maio Island due to a lack of precision in the coordinate records. Hence, data sparseness, in addition to the lack of location