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Potential field anomalies as a tool for imaging the inner structure of volcanic islands: the case of La Gomera (Canary Islands)

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Ocean islands volcanoes are the result of the complex alternation of constructive (intrusion and effusion of volcanic rocks) and destructive (erosion, caldera formation, flank collapse) processes. The reconstruction of the volcanic history of an ocean volcano is not a simple task, especially regarding the early phases of growth, because those products are buried beneath the more recent structures. In addition, several aspects about the growth of volcanic islands, such as the formation of rift zones or the occurrence of giant landslides, still remain unclear. Potential field studies can supply additional constraints for a more complete model of the inner structure of volcanic islands, since gravity and magnetic anomalies reveal density and magnetization contrasts linked to the different volcanic structures present within the whole volume of the volcanic edifice. In particular, modeling of magnetic anomalies can provide us with fresh information about the chronology of the different magmatic stages by comparing the observed magnetic polarities with the Geomagnetic Polarity Time Scale.

La Gomera is one of the lesser-known islands of the Canary Archipelago. Several characteristics make it different from the other Canaries, such as the absence of Quaternary volcanic activity and the outcrop of the so-called Basal Complex, which represents the submarine stage of growth, with an age estimated in 20 Ma. In this island, two main subaerial edifices have been identified: the Old Edifice (10.5-6.4 Ma) centered in the northern part, which grew in two stages separated by the occurrence of several flank collapses and was characterized by a southward migration of the volcanic activity, and the Young Edifice (5.7-4 Ma), built in the central and southern part of the island and characterized by the emission of more evolved magmas.

The number of papers published in the last few years demonstrates that the interest on this island has been renewed. In particular, a recent study showed correlation between the sources of the gravity field and the volcanic units associated with the growth of La Gomera island, being the main gravity source a deep high density structure related to the first submarine growth stage, the Basal Complex. Moreover, this model provided the original location and morphology of the Old Edifice from the distribution of positive density contrasts and identified other gravity field sources associated to several feeding systems of this stage of volcanism. The shallowest sections gave some insight into the internal structure and morphology of the Vallehermoso caldera and the migration of the volcanic activity towards the southern area of the island.

In 1993 the Spanish National Geographic Institute carried out an aeromagnetic survey of the Canary Islands. Over La Gomera and its surrounding marine are, flight lines were flown at an altitude of 2000 m above the sea level following the N-S direction with a distance between lines of 5 km. In this work we study, model and interpret this data set. The magnetic anomaly map of La Gomera reveals a main magnetic source characterized by a normal polarity centered over the northern part of the island and a reversely-magnetized minor source to the south. We have analyzed these anomalies using different inversion methods specifically adapted to the characteristics of volcanic environments. By applying an equivalent source linear inversion, we have estimated the direction of the total magnetization vector. Then, we have used several inversion methods in order to image the inner structure of La Gomera. For instance, we have applied a linear method for the purpose of identifying lateral magnetization contacts, and a non-linear method aimed at obtaining a 3-D description of deep intrusive bodies, in which constant magnetization values characterize the main sources and are fixed “a priori”. This second approach has been implemented using a genetic algorithm, following the method previously used in the gravity modeling.

The obtained magnetic models are interpreted in light of the previous geological knowledge of La Gomera.

The main magnetic source can be related with an intrusive body located beneath the northern part of the island and extending to the north in the marine area. The location and size of this body is coherent with the geometry of the high-density structure identified through the gravity study. We interpret this structure as the mafic core of the island, confirming the theory that the early growth of the island was shifted to the north of the present subaerial edifice. In addition, the location of magnetic contacts is interpreted and correlated with surface geological features, such as the northeast marine volcanic rift and the Vallehermoso caldera. Finally, a comparison between the gravity and magnetic models is presented and discussed.