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A unitary physical model for the long- and short-term deformation field revealed at Tenerife volcanic island

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Tenerife, the largest volcanic complex among the Canary Islands (Spain), is the result of the coalescence of several shield volcanoes. Different hypotheses about the origins of Tenerife have been proposed over the past decades. Among the several theories, the most debated ones propose a hotspot or mantle plume, a region of compressional block faulting, a rupture propagating from the active Atlas Range. Moreover, several authors have analyzed the geodynamic and tectonic processes affecting the Tenerife volcano and, more in general, the Canary Islands. The main results propose a complex interaction between the sub volcanic and regional structures at the Myr timescale, which produced a large flexure of the oceanic lithosphere, as confirmed by seismic and gravimetric studies. Recently, space - based geodetic observations based on Differential Synthetic Aperture Radar Interferometry (DInSAR) and GPS measurements revealed, in the 1992–2005 period, a deformation pattern characterized by a broad subsidence with maximum velocities of about 4 mm yr-1 .

In order to define a unitary physical model of deformation processes at Tenerife volcanic island, we investigate the relationship between these long-term and short-term deformation processes. We first carried out a standard dimensionless fluid dynamic analysis (FDA) to discriminate the deformation style of Tenerife and found that, at million year timescales, basement flexure mainly controls its long-term structural evolution. Secondly, to highlight the driving forces of the short-term deformation process, we simulated a numerical FDA based on finite element models that include topography as well as vertical and lateral material heterogeneities. Our results show that the recent surface deformation is mainly caused by a progressive sagging of the denser (less viscous) core of the island onto the weaker (but more viscous) lithosphere. Moreover, over periods comparable to the hypothesized age of loading of the oceanic crust beneath Tenerife, this tendency would result in a total flexure of about 3–4 km, which is in agreement with independent estimations based on geophysical analyses. Our study shows that a unitary physical model may explain both the deformation recorded in deep geological structures and the current active ground deformation processes occurring at the Tenerife volcanic island.