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Origin of three-armed rifts in volcanic islands: the case of El Hierro (Canary Islands)

Inés Galindo Jiménez (1), Laura Becerril Carretero (1,2), Joan Martí Molist (2), and Agust Gudmundsson (3)

(1) Spanish Geological Survey, Canary Unit, Las Palmas, Spain (i.galindo@igme.es), (2) Institute of Earth Sciences Jaume Almera, ICTJA-CSIC, Barcelona, Spain, (3) Department of Earth Sciences, Royal Holloway University of London, Egham, UK

Rifts zones in volcanic oceanic islands are common structures that have been explained through several theories/models. However, despite all these models it is as yet unclear whether it is the intense intrusive activity or the sector collapses that actually control the structural evolution and geometry of oceanic-island rift zones. Here we provide a new hypothesis to explain the origin and characteristics of the feeding system of oceanic-island rift zones based on the analysis of more than 1700 surface, subsurface (water galleries), and submarine structural data from El Hierro (Canary Islands). El Hierro's geological structure is primarily controlled by a three-armed rift-zone, the arms striking NE, WSW and S. Between the rift axes there are three valleys formed during huge landslides: El Golfo, El Julan, and Las Playas. Our results show: (1) a predominant NE-SW strike of structural elements, which coincides with the main regional trend of the Canary Archipelago as a whole; (2) a clear radial strike distribution of structural elements for the whole volcanic edifice (including submarine flanks) with respect to the centre of the island; (3) that the rift zones are mainly subaerial structures and do not propagate through the submarine edifice; (4) that it is only in the NE rift that structures have a general strike similar to that of the rift as a whole, and; (5) that in the W and S rifts there is not clear main direction, showing the structural elements in the W rift a fan distribution coinciding with the general radial pattern in the island as a whole. Based on these data, we suggest that the radial-striking structures reflect comparatively uniform stress fields that operated during the constructive episodes, mainly conditioned by the combination of overburden pressure, gravitational spreading, and magma-induced stresses. By contrast, in the shallower parts of the edifice, that is, the NE-SW, N-S and WNW-ESE-striking structures, reflect local stress fields related to the formation of mega-landslides and mask the general radial pattern. Thus, the rift zones on El Hierro are shallow structures that commonly capture and divert ascending magma towards different parts of the island but do not condition magma ascent at depth.