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Rift-zone formation by gravitational spreading on El Hierro: an experimental study

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Abstract: Rift zones on volcanic islands are characterized by abundant subparallel dike intrusions. The geometry of rift zones can give information about the volcanoes' magmatic and tectonic evolution, usually oriented parallel to the direction of the maximum compressive stress. On the Canary Islands, however, the consideration of purely magmatic and regional tectonic forces could not sufficiently serve with an explanation for the formation of the observed complex rift zone orientations.

We studied the rift system on the island of El Hierro that strongly affected the latest eruptive stage and probably induced four giant lateral collapses. The rift system of El Hierro has been previously proposed to be triaxial stellate, formed by fracturing as a result of central magmatic uploading. However, our re-examination of onshore dike orientations suggests a more complex geometry, described by two major rift axes, diverging arcuated from NE to the W, and from the NE to the S. Using scaled analogue experiments, we tested the hypothesis that this complex rift configuration is the result of gravitational spreading and buttressing of a compound edifice.

El Hierro is made up by three overlapping volcanic edifices that have successively formed. In early stages of volcano growth, a N-S topographic ridge was merging with a volcano in the N (the Tinor volcano). Later a third edifice grew to the west of this edifice (El Golfo volcano). All these volcanoes are situated on top of weak ocean sediments. According to this geometric configuration we mounted a sand ridge and an overlapping sand cone onto a viscous PDMS substratum. Gravitational spreading of both (ridge and cone) produced an extensional zone in between, being arcuated

from the NE to the S hence reflecting the rift axis between Tinor volcano and the submarine Southern Ridge of El Hierro. Then a second sand cone was mounted overlapping the former edifices in order to imitate the younger El Golfo volcano. New rift axis formed, being then arcuated from the W to the NE, and from the W to the S, while fracturing at the previous rift zone ceased. The final triangular geometry of the extensional zones well corresponds to the rift geometry of El Hierro displayed by dike orientations. The comparison of our analogue models with the real rift geometry suggests that the complex rift system of El Hierro is a consequence of gravitational spreading of successively growing and overlapping volcanic edifices, changing and adjusting with time.