

Motivation

Volcanic activity in extensional geodynamic settings occurs in distinctive zones: within the rift (in-rift) on the rift shoulders (off-rift), and within extensional transfer zones (inter-rift). While in- and off-rift volcanism has been associated with the competition between tensional crustal stresses and gravitational unloading pressure produced by rift excavation, volcanism in inter-rift **zones** still remains unclear.

Hypothesis

Topographic highs connecting different rift segments may exert a local stress field by drawing magma trajectories toward inter-rift areas.

Study areas -



Rhenish Massif: - Between the Upper and Lower Rhine Graben (Fig. 1c). - Tertiary Volcanic Fields: Siebengebirge, Westerwald and Hocheifel. - Quaternary Volcanic Fields: Westerwald, East and West Eifel.

Virunga Volcanic Province: African Rift System (Fig. 1b-d). the between linked half-grabens.

Adda'do Magmatic Segment: volcano-tectonic Southern Afar (Fig.1b). - Ayelu and Abida: end of the magmatic segment. - Yangudi: axial centre of the rift.

Figure 1. (1a) Volcanism in the European Cenozoic Rift System (modified by Lustrino & Carminati, 2007). LRG, Lower Rhine Graben; URG, Upper Rhine Graben; ER, Eger Graben; LM, Limagne Graben; BG, Bresse Graben; MC, Massif Central. (1b) Volcanism in the East African Rift System (modified by Acocella, 2022). Blue boxes: study areas, vents are shown as triangles. Black dashed lines mark graben boundaries. (1c) Rhenish Massif. (1d) Virunga Volcanic Province (VVP). (1e) Adda'do Magmatic Segment (AMS). (1c-d-e) Hillshade from the Copernicus 90 m DEM.



What controls inter-rift volcanism?

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Figure 2. (1-5a) Frontal (1a-2a-5a), transversal (3a) and top (4a) views of the gelatine box (20 cm w., 40 cm I., 20 cm h.) prior to experiments. Blue rectangles: plastic plates (thickness 2.5 ± 0.1 mm) used to impose differential extension. Brown boxes: wooden moulds to reproduce the asymmetric (10 cm w., 14,5 cm., 1 to 4 cm h.) and symmetric (6 cm w., 14 cm l., 3 cm h.) rift topographies.

(1-5b) Top view of the holes at the bottom of the box used to inject air. Light blue, green and red are off-rift, in-rift and inter-rift injection starting points. Numbers indicate the air-filled crack trajectories starting and arrival (2.1-5c) points. (1-5c) Top view of the gelatine box after the experiments. Length of the blue arrows is proportional to the degree of extension. Line drawing of the moulds location in brown. Endpoints of the trajectories in red. (1-5d-e) Strike view of the air-filled crack trajectories on the left and right side of the box, respectively.





- Analogue experiments: tracking the propagation of air-filled cracks into gelatine by imposing differential tensile stresses and asymmetric/symmetric inter-rift topography boundary conditions (Fig. 2).

Discussion topographic high.



Figure 3a. Trajectories starting points distribution.

- Trajectories reaching the inter-rift area can start from any position close to the rift

- Trajectories arriving in-rift predominantly originate off-rift and vice versa.

What controls inter-rift volcanism? A new mechanism, Inter-rift unloading

Alongside the mechanism of across-rift gravitational unloading pressure, which directs magma originating from the rift centre to an off-rift location, inter-rift unloading is facilitated by mass redistribution.

This involves both loading within the inter-rift area (produced by the topographic high) and unloading within the rift itself (produced by the rift excavation), ultimately steering magma trajectories from the rift tips towards the inter-rift regions.

References

Lustrino, M., & Carminati, E. (2007). Phantom plumes in Europe and the circum-Mediterranean region. In Plates, plumes and planetary processes. Geological Society of America. https://doi.org/10.1130/2007.2430(33) Acocella, V. (2021) Volcano-tectonic processes. Springer International Publishing. https://doi.org/10.1007/978-3-030-65968-4



- Differential tensile stresses: air-filled crack trajectories tend to align perpendicular to least compressive principal stress (σ 3) and converge toward the centre of the box. - Inter-rift topography: air-filled crack trajectories progressively deflect towards the





- The spatial patterns of the air-filled cracks trajectories are consistent with the results of the DEM analysis of the three study areas.

