

Modern technologies to decode historical eruptions: a multidisciplinary approach for understanding the 1947 and 1981 dyke intrusions at Mt. Etna

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Investigating events that occurred in the past can pose significant challenges, as further back in time we look, the more fragmented and imprecise the available data often becomes, especially in highly dynamic environments such as volcanoes.

Here we reconstruct the 1947 and 1981 dyke intrusions at Mt. Etna through a multidisciplinary approach combining different kinds of imagery with advanced processing techniques.

Starting from historical aerial photographs obtained from the IGM (Istituto Geografico Militare - Regio Aeronautica Italiana and Italian Aviation) we defined the geological-structural framework before and after the investigated events. In addition, an extensive field activity was carried out, including the acquisition of high-resolution UAV images and detailed geological-structural measurements, in order to quantitatively characterize the main parameters (e.g. strike and opening) of the structures preserved despite subsequent eruptions. Photogrammetric processing in Agisoft Metashape allowed the generation of high-resolution models, enabling detailed mapping and classification of volcano-tectonic structures (e.g. faults, open fractures and eruptive fissures).

To complement the historical surface observations and constrain the deep mechanics of these intrusions, we analyzed InSAR data from recent, analogous dyke emplacements. These modern deformation patterns provided a baseline for implementing different numerical model setups in COMSOL Multiphysics. By integrating the field-derived structural parameters of the 1947 and 1981 dykes with the geophysical insights from recent events, our models focused on the role of pre-existing fractures during dyke propagation and the stress-field changes induced by magmatic intrusions.

This multidisciplinary approach allowed us to identify the conditions that favor dyke propagation versus arrest, and to define the mechanism controlling lateral versus vertical propagation, with possible implications for hazard assessment and the resilience of communities living around Mt. Etna, as well as for volcanic edifices stability more broadly [Luppino et al., 2025a, b; Tibaldi et al., 2025].