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Structural mapping and analysis of rifting events using UAVs in the North Volcanic Zone (Iceland)

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Volcano-tectonic events in extensional environments release over days or weeks tectonic strain deficit accumulated over several decades or hundreds of years.

Thanks to its position, on top of both an extensional plate boundary and a mantle plume, several volcano-tectonic events occur in Iceland, and they have relatively accurately reported since the first settlements in ~ 870 AD. The eruptions and graben formation observed during these events are related to magma transport in the crust, which also causes the reactivation of pre-existing structures.

However, the Earth's upper crust is classically modelled as homogeneous and fully elastic and not as a pre-fractured medium. This study aims to analyse the role of pre-existing crustal structures on the propagation of magma in extensional environments.

The 13 main Icelandic volcano-tectonic events, mostly concentrated in the North, East, and West Volcanic Zones, show a return period in the order of 200 years on average. The suggested cyclic nature of strain deficit loading and subsequent release is consistent with the stepwise nature of strain release at divergent plate boundaries: the crustal opening associated with dike emplacement during volcano-tectonic events is of the same order of magnitude of the strain deficit accumulated since the previous event in the same area.

On this basis, we identified structurally relevant and logistically accessible fieldwork areas in the North Volcanic Zone to perform detailed structural mapping based on UAV-drone imagery. In August 2019 we carried out a UAV survey in Fjallagjá, a graben ~15-20 m deep and ~1 km wide that extends parallel to Sveinagjá graben for ~18 km, in the Askja volcanic system. During the volcano-tectonic event in 1875 in Askja volcanic system, Sveinagjá graben was activated and it subsided 3 to 6 m.

The UAV is a fixed-wing with a ground resolution down to 1 $cm \cdot px^{-1}$ (flying at 100 m above ground), with an on-board PPK antenna. We installed a GNSS base, wich, in combination with the PPK correction, allows a centimetre-accuracy of the georeferencing of the drone images, with no need for aerial targets as GCPs. With this setup we managed to perform 21 flights, covering an area of ~15 km^2.

The processing of the drone images resulted in DEMs and orthorectified mosaics of the fieldwork area, allowing to perform a detailed morphological and structural analysis, looking at fracures, topography effects, and potential kinematic indicators. Specific attention is paid to obliquity between sets of structures. The aim is to reconstruct the paleostress history of this area of the plate boundary.

The use of UAV high-resolution mapping paves the way to an efficient broadening of the fieldwork area and makes available a near-field structural analysis dataset much wider than previously possible.