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Reconstruction of the entire rift architecture of Theistareykir Fissure Swarm (northeast Iceland): integration between extensive UAV and field surveys

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Reconstructing the origin and kinematics of structures along active rifts is essential to gain a deeper knowledge on rifting processes, with important implications for the assessment of volcanic and seismic hazard. Here we reconstruct the architecture of an entire rift, the 70-km-long Theistareykir Fissure Swarm (ThFS) within the Northern Volcanic Zone of Iceland, through the collection of an extensive amount of 7500 quantitative measurements along extension fractures and normal faults, thanks to the integration between Unmanned Aerial Vehicles (UAV) mapping with centimetric resolution through Structure from Motion (SfM) techniques and extensive field surveys with classical methods. Quantitative measurements, collected across a wide area during several campaigns, comprise strike, opening direction and amount of opening at extension fractures, and strike and offset values at faults, along 6124 post-Late Glacial Maximum (LGM) and 685 pre-LGM structures.

The extent of the area covered by our data allowed us to pinpoint differences in the structural architecture of the rift. From south to north: i) extension fractures and faults strike ranges from mainly N10°-20°, to N00-10°, to N30-40°; ii) the opening direction starts from N110°, reaches N90-100° in the center and amounts to N125° in the northernmost sector; and iii) the dilation amount is in the range 0.1–10 m, then 0.1–9 m and it finally reaches 0.1–8 m. We explore such differences as due to the interaction with the WNW-ESE-striking Husavik-Flatey transform fault and the Grímsey Oblique Rift (Grímsey lineament), and to the structural inheritance of older NNE- to NE-striking normal faults. The reconstruction of the stress field resulting from such data allows the interpolation of the σ_{hmin} values, through the unpublished software ATMO-STRESS, prepared in the framework of the EU NEANIAS project, in order to plot and examine the strain field.

Furthermore, mechanisms of rift propagation and the relation between magma systems are here investigated through the analysis of 281 slip profiles of the main Pleistocene-Holocene faults. Our data show a mechanism of along-axis propagation of the rift outward from the volcano: in fact,

north of the volcano, 75% of the asymmetric faults propagated northward, whereas south of the volcano 47% of the asymmetric faults propagated southward. This can be due to the combination between the development of faults following lateral dyke propagation outward from the magma chamber, and faults nucleation near the volcano as a consequence of the different crustal rock rheology produced by a higher heat flux.