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Unravelling rift development: a key study from the Northern Volcanic Zone of Iceland

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Unravelling the kinematics, development and origin of the structures along a volcano-tectonic rift is of paramount importance for understanding plate separation, seismicity, volcanic activity and the associated hazards. Here, we focus on an extremely detailed survey of the Holocene deformation field along the Northern Volcanic Zone of Iceland, the northernmost point of emergence of the Mid-Atlantic Ridge. The study of this extremely dynamic rift is also useful for a better comprehension of how mid-oceanic ridges work. The study is based on extensive field and unmanned aerial vehicle surveys performed over the last four years, completed by about 6000 measures collected at 1633 sites on fault strike, dip and offset, and fracture strike, dip, dilation direction and dilation amount. The rift, named Theistareykir Fissure Swarm, is composed of N-S to NNE-SSW-striking normal faults and extension fractures affecting an area 8 km-wide and 34 km-long. The computed overall spreading direction is N111° averaged during Holocene times, with values of N125° to the north and N106° to the south. The kinematics is characterised by the presence of complex components of right-lateral and left-lateral strike-slip motions, with a strong predominance of right-lateral components along structures parallel and coeval to the rift zone. The surveyed 33 Holocene faults (696 sites of measurement) along the central part of the rift show two opposite directions of fault/rift propagation, based on fault slip profile analyses. We discuss the possible causes of these characteristics and analyse in detail the interaction of both faults and extension fractures with the WNW-ESE transform Tjornes Fracture Zone, and in particular with the parallel right-lateral Husavik-Flatey Fault in the central part of the rift, and the Grimsey Lineament to the north. We also assess the role of: i) repeated dyke intrusions from the magma chamber outward along the plate margin, ii) regional tectonic stresses, iii) mechanical interaction of faults, and iv) changes in the rheological characteristics of rocks.