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High resolution digital elevation modelling from TLS and UAV campaign reveals structural complexity at the 2014 Holuhraun eruption site

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Fissure eruptions are commonly linked to magma dikes at depth, associated with deformation that is described by subsidence and lateral widening at the surface. The structure formation associated with such fissure eruptions, however, is barely preserved in nature because of the rapid erosion and/or difficult access to these areas, which is why, so far, normal fault displacements are commonly assumed for this type of fractures. At the 2014 Holuhraun eruption sites, the largest fissure eruption in Iceland since almost two centuries, evidence is increasing that the developing structures are related to pre-existing topography, reactivation of earlier fractures and possible complexity in the opening mode of the dike. In an attempt to investigate the Holuhraun structures in greater detail, a fieldwork mapping project combining terrestrial laser scanning (TLS) and unmanned aerial vehicle (UAV) based aerophoto analysis was realized. From this data, we generated a locally high resolution digital elevation model and a structural map that allow for identification of kinematic indicators and assessing senses of fault opening, strike-slip movements, and complexities in fracture pathways. We identified fracture curvatures, step-overs and en-echelon type structures, and measured strike directions for single fault segments including the amount of opening and opening angles. We conjecture that local complexities in the fracture paths and fracture geometries are closely related to pre-existing geometric and mechanical heterogeneities. Moreover, we identified local changes in fracture trends and offsets close to eruption sites, which are possibly associated with geometrical changes in the feeding dike itself. Results have important implications for the development of surface structures at fissure eruption sites and underline that the structural memory is a very important factor in understanding the complexities of local fault structures above dike intrusions.