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From fissure to fault: A model of fault growth in the Krafla Fissure System, NE Iceland

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Current models of fault growth examine the relationship of fault length (L) to vertical displacement (D) where the faults exhibit the classic fault shape of gradually increasing vertical displacement from zero at the fault tips to a maximum displacement (Dmax) at the middle of the fault. These models cannot adequately explain displacement-length observations at the Krafla fissure swarm, in Iceland's northern volcanic zone, where we observe that many of the faults with significant vertical displacements still retain fissure-like features, with no vertical displacement, along portions of their lengths. We have created a high resolution digital elevation model (DEM) of the Krafla region using airborne LiDAR and measured the displacement/length profiles of 775 faults, with lengths ranging from 10s to 1000s of metres. We have categorised the faults based on the proportion of the profile that was still fissure-like. Fully-developed faults (no fissure-like regions) were further grouped into those with profiles that had a flat-top geometry (i.e. significant proportion of fault length with constant throw), those with a bell-shaped throw profile and those that show regions of fault linkage. We suggest that a fault can most easily accommodate stress by displacing regions that are still fissure-like, and that a fault would be more likely to accommodate stress by linkage once it has reached the maximum displacement for its fault length. Our results demonstrate that there is a pattern of growth from fissure to fault in the Dmax/L ratio of the categorised faults and propose a model for this growth. These data better constrain our understanding of how fissures develop into faults but also provide insights into the discrepancy in D/L profiles from a typical bell-shaped distribution.