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Rheologic controls on inter-rifting deformation of the Northern Volcanic Zone, Iceland

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Extensional rifts are characterized by significant lateral variations in crustal rheology, as lithospheric material cools and advects away from the rift axes. Nevertheless, most models used for modelling of crustal movements consist of horizontal layers with uniform properties.

We explore the role spatial variation of rheological properties play, in modifying the style of surface deformation due to plate movements at rifts, by comparing 2D and 3D finite element model (FEM) predictions to inferred inter-rifting surface deformation from Iceland's northern volcanic zone. Crustal deformation has been observed by satellite radar interferometry (InSAR) and GPS measurements. A de-coupling of the horizontal and vertical deformation components appears in the data. Extension is observed across the entire northern rift zone, whereas subsidence occurs in two distinct areas, corresponding to mapped fissure swarms, where major rifting took place in 1975-1984 and 1874-1876, respectively.

Our models indicate that the observed inter-rifting plate spreading deformation field is controlled by local rheological variations within the en echelon arrangement of fissure segments, and that a regional central ridge axes model does not apply. Uniform stretching across a plate boundary zone, where fissure swarms are weaker than the surrounding crust, and reflect the surface expression of the rift, reproduces the characteristics of the deformation field. The most realistic fissure swarm structure consists of a wedge of weak elastic material on top of a local ridge, where visco-elastic material locally reaches to a shallow depth.