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Temperature-dependent non-linear rheological models of plate spreading in Iceland

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The Mid-Atlantic Ridge system is exposed above sea level in Iceland, which provides a natural laboratory to study plate spreading and corresponding surface deformation. Extensive GPS geodetic measurements reveal the style of extension in Iceland. Such observations have been fit to kinematic models with an opening dislocation in an elastic halfspace or stretching elastic-viscoelastic modeling. Most of these models use either elastic rheology or a rheology where relation between stress and strain is linear. However, in reality Earth's rheology may be non-linear and strongly temperature dependent. Here we aim to fit plate spreading models considering these effects to observed style of spreading in Iceland. For this purpose we have carried out finite element modeling considering temperature-dependent non-linear rheology. Two-dimensional symmetric thermo-mechanical coupling models are performed where rheology follows dislocation creep considering a subsurface temperature. The models stretch as to reproduce plate spreading. The rheology in the model corresponds to that of olivine as it is the major mineral in the upper mantle and, laboratory experiment of olivine and numerical modeling are similar. We consider both to so called wet and dry olivine rheology. Temperature distribution in models take into account thermal studies in Iceland. We apply high temperature (700 ºC) at varies depth (1–15 km for Eastern and 1–10 km for Northern Volcanic Zones). We also perform kinematic elastic dislocation dike opening models to compare temperature dependent rheology models. Wet and dry mantle rheology models give more or less similar results compare to two profiles. Horizontal displacements predicted by the models are compared to observed horizontal displacements from GPS observations along two profiles in the Northern and Eastern Volcanic Zones of Iceland. The best fit temperature-dependent rheology models, minimizing residuals between observations and model predictions provide an estimate for depth to 700 ºC temperature. It is 11–13 and 5–6 km for Eastern and Northern Volcanic Zones, respectively. Beneath the Northern Volcanic Zone the suggested average temperature gradient is $\sim$140 ºC/km whereas it is relatively cooler for Eastern Volcanic Zone as temperature gradient is $\sim$60 ºC/km at the rift axis.