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Renewed Inflation of Krafla Caldera, Iceland, since 2018: Sensitivity of Ground Deformation to lateral variation in Earth structure and architecture of the magmatic system explored with the Finite Element Method

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The Krafla volcanic area in Northern Volcanic Zone of Iceland was characterized by deflation starting in 1989, suggesting a general pressure decrease and/or volume contraction at depth, which then exponentially decayed until having no significant deformation since around 2000. In summer 2018, the volcano behaviour changed to inflation as observed both by Global Navigation Satellite System (GNSS) geodesy and Sentinel-1 satellite radar interferometry (InSAR). Inflation since 2018 occurs at a rate of 10-14 mm/yr, centered in the middle of the caldera. No significant change in seismicity has occurred in the area in 2018, but seismic moment release ocurrs at a higher rate since middle 2019. Gravity stations in the area were remeasured in November 2019 for allowing comparison with earlier observations, and for providing reference for later studies. Initial modelling of the geodetic data is carried out assuming that the deformation is caused by a spherical source of pressure in an uniform elastic half-space. The result suggests that the deformation can be broadly explained by a single source of magma inflow at depth around 3.9-7.5 km, with the best-fit value around 4-4.5 km. We also apply the Finite Element Method (FEM) to additionally consider modification of the deformation field caused by Earth's elastic heterogeneities and the uncertain geometry and depth of the magma source. A set of FEM models are built with the COMSOL Multiphysics software in a 50x50 km domain where we test three different geometries of the source: a spherical source (radius 1000 km), a prolate ellipsoid, and an oblate ellipsoid (sill-like) source, at 2.5, 4.0 and 5.5 km of depth. We also build a model to test how the vertical and horizontal displacements may be influenced by different elastic properties (e.g. Young's modulus; about an order of magnitude different within a caldera boundary) for these sources. The results show that lateral variations in material properites can have a significant influence on ground deformation. Low-value Young's inside caldera boundaries compared to higher values outside caldera boundaries will in particular influence the vertical displacement: the vertical displacement is about half of of what it is the original modelling. The ratio of vertical to horizontal displacements will thus also be modified. This can in turn influence

the inferred magma source geometry as it depends on the displacement ratios. The outcome of our study will provide better constrain for the elastic properties in Krafla area, and help understand the magma intrusion rate in the area.