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3-D Heterogeneous Elastic Crustal Structure for Deformation Models in the Hengill Area, SW Iceland

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Crustal deformation in volcanic areas relates ground motions, measured by geodetic techniques, to physical (e.g. pressure or volumetric) changes of magmatic sources below the surface. These measurements contribute to studies of ongoing processes at the source of possible unrest, and are thus key for hazard assessment in active volcanic areas around the globe. However, such assessments often rely on geodetic-based models with quite simplistic assumptions of the physical structure of the volcanic complex. Particularly, constant values of elastic parameters (e.g. Poisson's ratio and shear moduli) are commonly used for entire active volcanic areas, thus overlooking the spatial effects of lithological properties, depth-dependant compression and temperature variations on those parameters. These simplifications may lead to inaccurate interpretation of the location, shape, and volume change of deformation sources.

In this study we ask how the 3-D heterogeneities of the elastic crustal structure beneath the Hengill volcanic system, SW Iceland, affects models of deformation sources in the area. The Hengill area hosts two active volcanic systems (Hengill and Hrómundartindur), and two high-enthalpy geothermal power plants (Nesjavellir and Hellisheiði), which provide thermal and electrical power to Reykjavík, the capital of Iceland, only 30 km away. To retrieve information on the spatial heterogeneities in the shear moduli and Poisson's ratio beneath the Hengill area, we first estimate the 3-D shallow density structure of the area using results from regional and local gravimetric surveys. We implement this structure, along with seismic tomographic studies of the SW Iceland, in a Finite Element Model to solve, using forward models, for the 3-D heterogeneities in the shear moduli and Poisson's ratio beneath the Hengill area. Furthermore, we discuss the difference between static and kinematic elastic moduli, which is important when building deformation models from seismic tomography. The new 3-D inferred elastic model is then used to re-estimate parameters for different sources of deformation causing uplift and subsidence in the area in the past decades. This study shows the importance of accounting for heterogeneities in the crustal elastic structure to estimate with higher accuracy the sources of deformation in volcanic areas around the world.