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

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The Hengill area

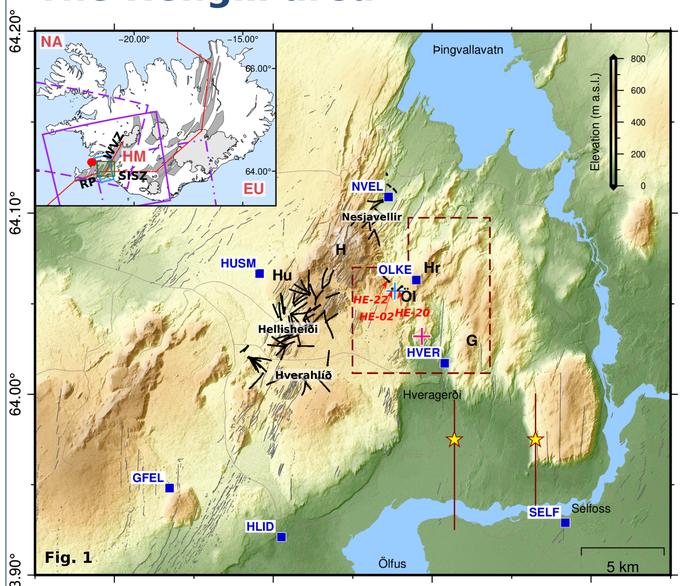


Fig. 1: Elevation map of the Hengill (H), Hrómundartidur (Hr), Grensdalur (G) volcanic complexes, SW Iceland (green square in inset). The blue squares indicate the location of GPS stations. Figure extracted from Ducrocq et al. *in prep.* The Elevation map is modified from the Arctic DEM (Porter et al. 2018, modified by the National LandSurvey 2020)

- Triple juction: Reykjanes Peninsula (RP), South Iceland Seisimc Zone (SISZ) and Western Volcanic Zone (WVZ; Fig. 1)
- Two active volcanic systems (Hrómundartindur and Hengill. Last eruption ~2000 years ago.

Shallow sources of deformation

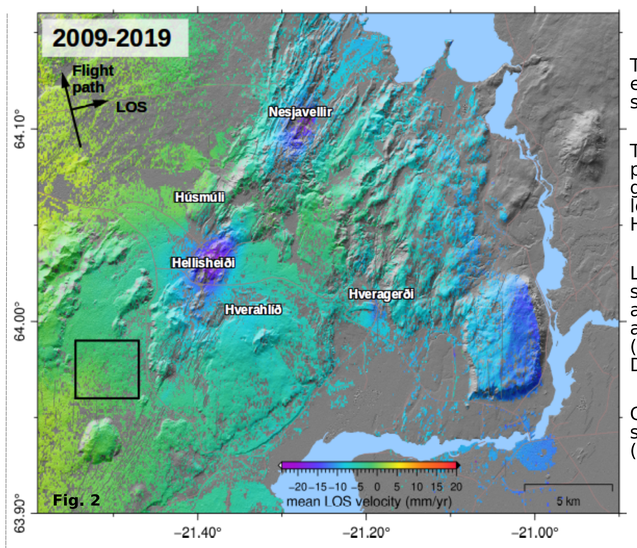


Fig. 2: Mean line-of-sight (LOS) InSAR velocities over the Hengill area, SW Iceland, between 2009 and 2019 (shown with the color scale) from TerraSAR-X satellite track T41. The deformation is plotted relative to average of motions in the area outlined by the black box. The black arrows indicate the flight path and line-of-sight (LOS) of the TerraSAR-X satellite for track T41. Figure and legend extracted from Ducrocq et al. (2021)

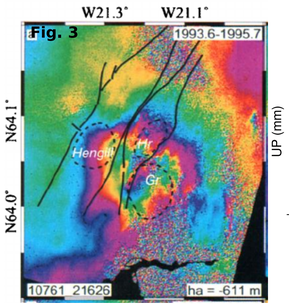
The area hosts active high-enthalpy geothermal systems.

Two geothermal power plants are harnessing the geothermal energy in two localities: Nesjavellir and Hellisheiði.

Localized deformation signals (2-2.5 cm/yr) are associated with the main areas of fluid extraction (Fig. 2; Juncu et al. 2017; Ducrocq et al. 2021).

Geodetic studies estimated shallow contraction sources (<3 km; Juncu et al. 2017).

Deep-seated sources of deformation



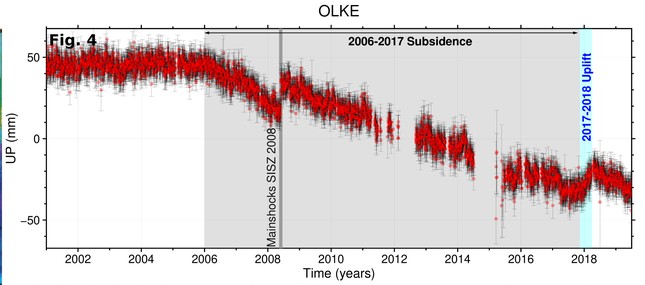


Fig. 3: InSAR interferogram of an inflation episode in the Hengill area, between 1993 and 1995. Extracted from the study of Feigl. et al (2000).
Fig. 4: Time series of vertical displacements at the continuous GPS station OLKE (location in Fig. 1). Figure extracted from Ducrocq et al. in prep.

The area is the locus of two uplift and subsidence episodes in the last 30 years (Fig. 3 and Fig. 4):

- inflation 1993-1999, Volume change: ~3.9 Mm^3/yr
- deflation 2006-2017, Volume change: ~2.4 Mm^3/yr
- inflation 2017-2018, Volume change: ~4.6 Mm^3
- ongoing deflation (2018 - onwards)

The sources from these inflation and deflation episodes are located near or within the brittle-ductile boundary of the area (6-7 km) depth.

Problem:

For complex geothermal, magmatic and tectonic regions, such as the Hengill area, constant and uniform values of elastic parameters may lead to inaccurate interpretation of location, shape and volume change of sources in deformation models. This is key for hazard assessments in active volcanic systems

Aim:

Estimating the elastic properties of the crust (G,ν) for improved deformation models of shallow and deep-seated sources.

Data sets

We are working on implementing :

- Topography (Arctic DEM, Fig. 1)
- Density model of the Hengill area (infered from gravity data sets available, e.g. Fig.5)
- Vp/Vs Seismic Tomography (Fig. 6; Hobé et al. 2021, personal communication)

The Finite Element Model will be built in COMSOL Multiphysics.

Gravity

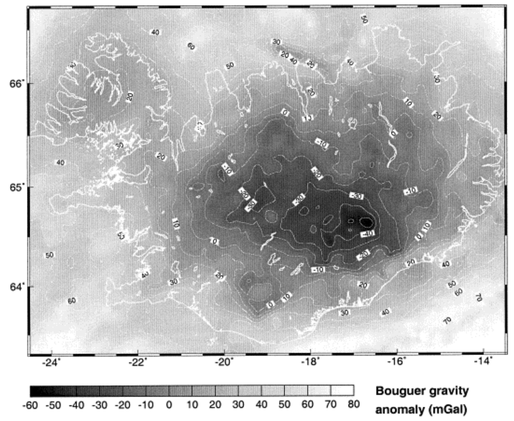


Fig 5: Map Bouguer gravity anomaly (Darbyshire et al. 2000 and references therein)

Vp/Vs Seismic Tomography

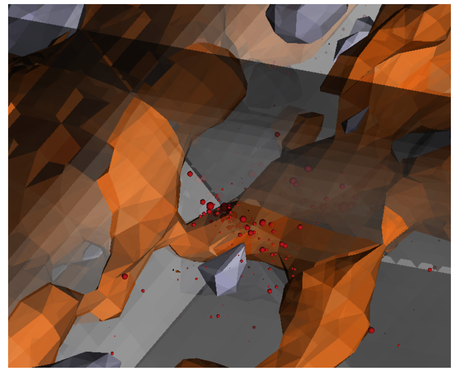


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Fig. 6: Time dependant Vp/Vs seismic tomography results (Hobé et al. 2021, personal communication)

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Collaborators:

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