Non-eruptive Uplift and Subsidence episodes beneath the Hengill Triple Junction, SW Iceland

Cécile Ducrocq\textsuperscript{(1)}, Halldór Geirsson\textsuperscript{(1)}, Thóra Árnadóttir\textsuperscript{(1)}, Daniel Juncu\textsuperscript{(2)}, Bjarni R. Kristjánsson\textsuperscript{(3)}, Gunnar Gunnarsson\textsuperscript{(3)} and Vincent Drouin\textsuperscript{(4)}

\textsuperscript{(1)} Nordic Volcanological Center, Institute of Earth Sciences, University of Iceland, Iceland
\textsuperscript{(2)} COMET, University of Leeds, Leeds, UK
\textsuperscript{(3)} Reykjavík Energy, Reykjavík, Iceland
\textsuperscript{(4)} Iceland GeoSurvey, Iceland

Picture credits: O. Lamb. View from Þingvellir (NW of Hengill) towards the SE.
The Hengill area:

→ Triple junction between the North American plate, Eurasian plate and Hreppar Microplate. (Plate boundaries (Fig.1) from Árnadóttir et al. 2009)

→ Host 2 active volcanic systems: Hengill and Hrómundartindur. The last eruption dates from 2000 years ago.

→ 2 geothermal plants (Hellisheiði and Nesjavellir) currently produce a total of ~ 400 Mth and ~ 400 Mwe.

Geophysical state of knowledge:


→ Subsidence sources: 2 shallow (< 3km) sources of subsidence linked to the areas of extraction in the 2 geothermal plants (Juncu et al. 2017) seen in Fig. 2.

→ Large earthquakes (~ Mw 6) recurrent in the area. The last ones occurred in 2008 in the East of the Hengill volcanic complex (Fig.2).

→ Deep-seated subsidence (~6km depth) in the area (Juncu et al. 2017) since 2006.
2017-2018 Uplift episode from GNSS

Figure 4 (on the left): Determination of the Uplift amplitude and time span from the North, East and Vertical component of the continuous stations OLKE and HVER (see Fig. 3 for locations).

The time series were generated using the GAMIT/GLOBK package (Herring et al. 2015) in the ITRF14 reference frame.

For each component of each station, the linear and seasonal signal were estimated and removed. This was done in order to remove the effect of the plate motions, and subsidence from geothermal production in the Hengill area (see in Fig. 2).

This figure shows the different data spans (InSAR and campaign GNSS (Fig. 3)) used in the study of the 2017-2018 uplift episode.

We observe some shallow subsidence W of Hengill (source < 3km) likely to be linked to the geothermal production in the Hellisheiði power plant.

Legend:
- Estimated source location of the 2006-2017 subsidence episodes (Juncu et al. 2017)
  - Depth: ~7 km
  - Contraction rate: ~2.4 x 10^6 m^3/yr
  - Volume change: ~4.6 Mm^3

- Estimated source location of the 1993-1999 uplift episode (Feigl et al. 2000)
  - Depth: ~7 km
  - Inflation rate: ~3.9 x 10^6 m^3/yr

Key Questions:

What drives these uplift and subsidence episodes?
Are the sources of these episodes related?
Are their origin magmatic or hydrothermal in nature?
Conclusions

GNSS and InSAR studies:
→ 2017-2018 Uplift lasted close to 6 months – as seen from the OLKE and HVER Global Navigation Satellite systems time series – with a maximum estimated amplitude of ~ 1.7 cm.

→ Joint GPS and InSAR inversion shows a deep source (~7 km) between the Hrómundartindur and Hengill active volcanic systems. These sources are located within the brittle-ductile boundary of the area.

→ Close location of the deep-seated sources suggests a relation between these uplift and subsidence episodes.

Other Geophysical/Geological data sets:
→ No significant increase in seismicity rate.

→ Borehole (Fig. 2) temperature measurements (max 1500 m b.g.l.) between 2015 – 2018 do not show consistent and significant temperature changes.

These uplift and subsidence episodes can be explained by:
→ Inflation/Contraction of a magmatic source at depth?
→ Hydrothermal fluids migration? Heat mining?
→ Degassing (subsidence) and trapped fluids (uplift)?
→ The interaction of all or some of the above processes?

Currently in the field. If you are interested in the subject or have any questions, please send me an email at cad7@hi.is. Your input would be very appreciated.
References mentioned:


Acknowledgement:

This work is supported by the Iceland Research Fund: Grant number 174377-015. Sentinel-1 data is provided by the European Space Agency. The intermediate TanDEM-X digital elevation model was provided by DLR (German Space Agency) under project IDEM_GEOLO123. TerraSAR-X data is provided by DLR (German Airspace Agency) through the Icelandic Volcanoes Supersite project, supported by the Committee on Earth Observing Satellites (CEOS). GMT software (Wessel and Smith, 1991) was used to produce the figures. Many thanks to Sveinbjörn, Steini and previous fellow PhD students for collecting the GPS campaign data, and Sigrún Hreinsdóttir (GNS, New Zealand) for the help and advices on the GPS data processing.