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

Chiara Lanzi (1), Vincent Drouin (2), Siqi Li (1), Freysteinn Sigmundsson (1), Halldor Geirsson (1), Gylfi Pall Hersir (2), Kristjan Agustsson (2), Sigrun Hreinsdottir (3), Asgrimur Gudmundsson (4)

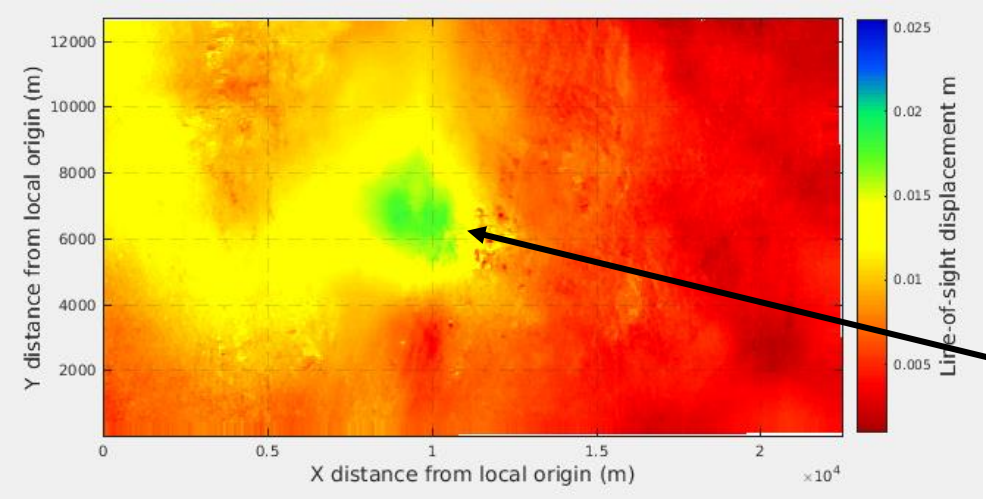
(1) Nordic Volcanological Center, Institute of Earth Sciences, University of Iceland
(2) ISOR – Iceland GeoSurvey, Reykjavik, Iceland
(3) GNS Science, Lower Hutt, New Zealand
(4) Landsvirkjun, Haaleitisbraut 68, 103 Reykjavik, Iceland

UNIVERSITY OF ICELAND
FACULTY OF EARTH SCIENCES

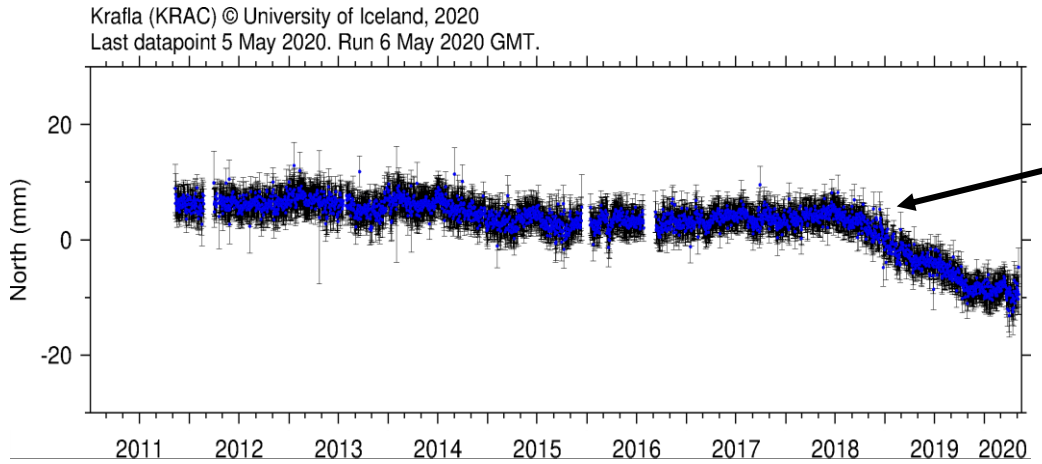
Photo by Michael Ryan, 1984 (USGS)

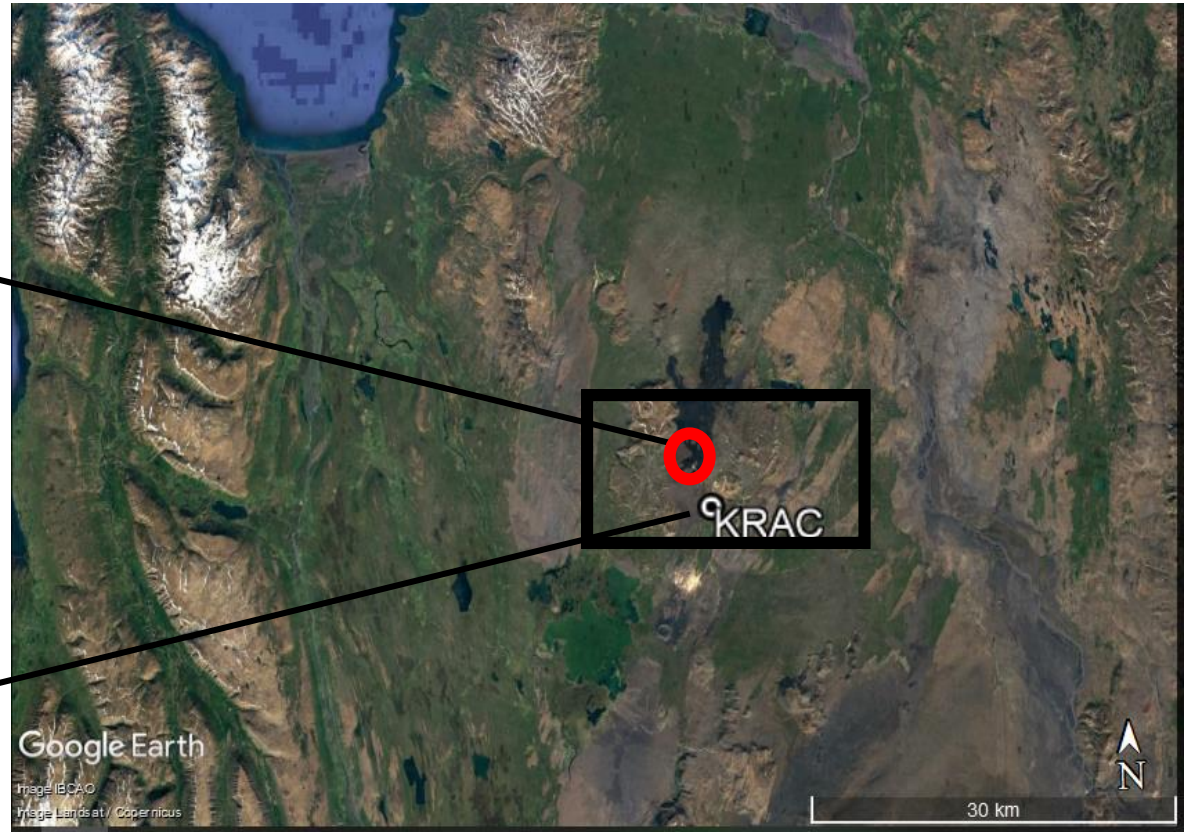
- The Krafla volcanic area in Northern Volcanic Zone of Iceland was characterized by deflation in the last few decades.

- In summer 2018, the volcano behaviour changed to inflation as observed both by Global Navigation Satellite System (GNSS, KRAC station) geodesy and Sentinel-1 satellite data, Interferometric Synthetic Aperture Radar (InSAR). Inflation since 2018 occurs at a rate of 10-14 mm/yr, centered in the middle of the caldera.



InSAR data, 2018-2019 time period

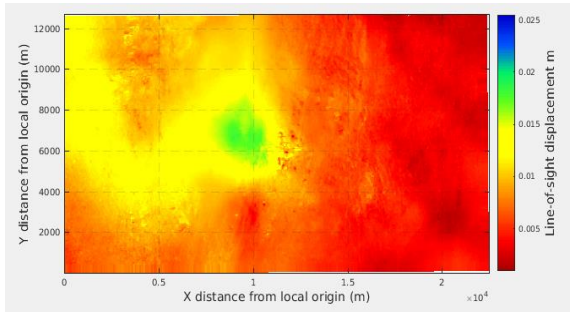




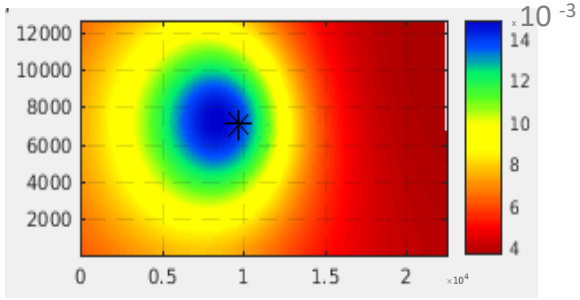
Analytical model: Mogi source

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.

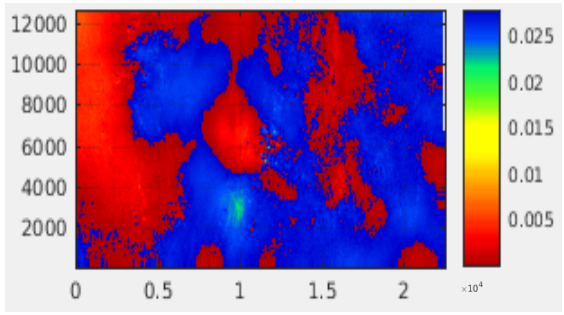
Data from track 147, Sentinel-1



Model

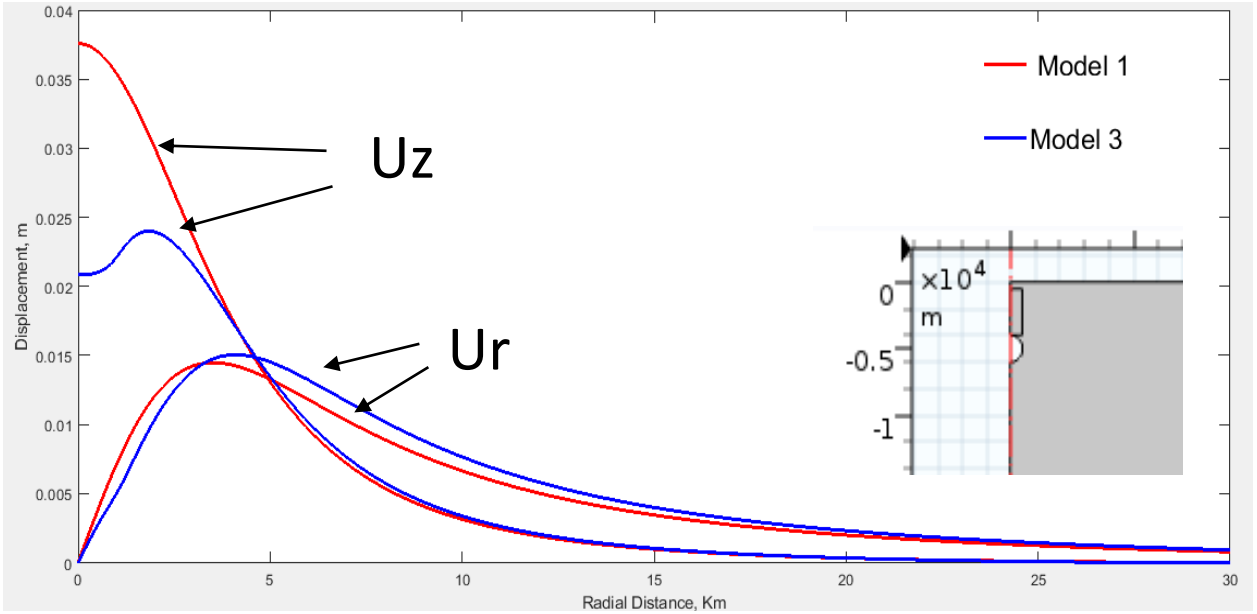


Residual



Source depth: 5.1-8.4 km (95% confidence interval)
Volume change: 1.4-3.7x 10^6 m^3 (95% confidence interval)
Inversion results from GBIS software (Bagnardi M. & Hooper A, 2018)

Finite Element axisymmetric model: ring fault and sphere source



Model 1: homogeneous, isotropic elastic domain with a pressurized spherical source;
Model 2: ring fault with free slip condition on the fault and sphere source (model in the picture);
Model 3: low Young' modulus value inside the caldera boundaries compared to higher value outside them.
The results show the vertical displacement is significant affected by the variation of the elastic parameter.

Conclusions

After decades of deflation, the deformation pattern in the Krafla (North Iceland) changed:

OBSERVATION →

- InSAR data from two tracks
- Continuous GPS instrumentation

Analytical approach:

MOGI MODEL

RESULT →

Source depth: 5.1-8.4 km (95% confidence interval)
Volume change: 1.4-3.7 x 10^6 m^3 (95% confidence interval)

Finite element approach:

RING FAULT AND SPHERICAL SOURCE

RESULT →

Influence of different elastic parameters is mainly seen on the vertical component.

FURTHER STUDIES: The outcome of our study will provide better constrain for the elastic properties in Krafla area about lateral variations and help to understand the magma intrusion rate in the area.