geoconvention
Calgary • Canada • May 15-17 2023

Geothermal mapping and remote sensing of thermal anomalies at Grændalur area, Hverageröi, SW Iceland

Patrick M. Kant[1], Ingibjörg J.[1], Sigurður G. Kristinsson[2], Gunnlaugur M. Einarsson[2], and Grímur B.[3]

[1] University of Iceland, Iceland
[2] Iceland GeoSurvey (ISOR), Iceland
[3] Warm Arctic, Iceland

Summary

This paper consists of geothermal mapping and identification of thermal anomalies using remote sensing in the Grændalur valley. This region is located in southwest Iceland, immediately north of the town of Hverageröi. It is located at the contact of the eastern margin of the Western Volcanic Zone (WVZ) and the South Icelandic Seismic Zone (SISZ). The area is seismically active, the most recent significant earthquake swarm occurred on May 29, 2008 with magnitudes of 6.3 and 5.5 between the towns of Selfoss and Hverageröi. The Grændalur valley is one of the areas in the Hverageröi region with intense geothermal activity. Geothermal mapping has been carried out in this area to map surface geothermal manifestations such as hot and warm springs, mud pools, fumarole, steam vents, steaming ground and structures. Remote optical sensors (Landsat and ASTER satellite images) were used to identify thermal anomalies in this area. The analysis of thermal anomalies made on daytime and nighttime satellite images from 2005 to 2020 has detected a new geothermal activity in the north near the center that would have certainly been created after the earthquakes of May 29, 2008. The thermal infrared (TIR) image taken with a TIR camera carried by a DJI Matrice 200 drone with a Zenmus XT thermal camera at 120 m height, was compared with temperature measurements taken directly on the ground after the flight to calibrate the TIR image for accuracy. The TIR image was used to identify and estimate the surface temperature of a geothermal manifestation whose accessibility was difficult. The surface temperature index of this geothermal manifestation is about 43°C.

Introduction

The Grændalur valley is one of the geothermal fields of the Hengill Central volcano and it is located about 6 km north of Hverageröi town. The Hverageröi town is located about 45 km southeast of Reykjavik, the capital of Iceland. The Grændalur valley is in the Southern Iceland Seismic Zone (SISZ) mainly in its western part which is in contact with the western flank of the active plate boundary between the North American and Eurasian crustal plates.

The geothermal activity in this valley is linked to the extinct Grændalur central volcano. This volcano has moved away from the center of the rift by the extension of the plate boundaries (Ingólfsson et al., 2008; Arnórsson, 1995a).

This study focuses on mapping surface geothermal manifestations and identifying thermal anomalies using thermal sensors. To do this, the description of the geothermal manifestation was made in situ, the manifestations temperature measurements were performed using a digital thermometer and the positioning of their sampling points was done by GPS. After field work, the

collected data were downloaded to a computer and edited by ArcGIS 10.6 software. The digital elevation model (DEM) was used to determine the geological structures of the area.

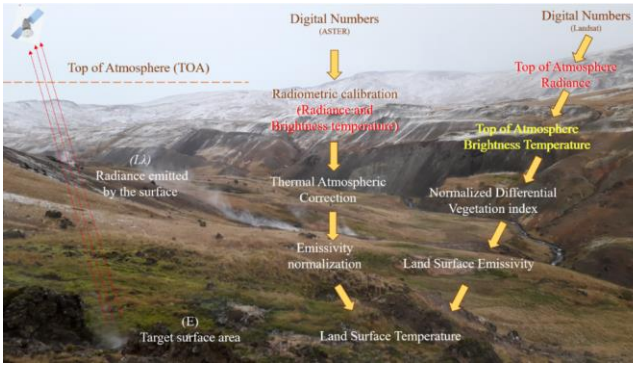

Figure 1: Data processing steps followed for thermal anomaly mapping retrieved by the satellite.

The identification of thermal anomalies was made using Landsat and ASTER images (Thermal infrared 'TIR' bands) covering the period from 2005 to 2020 (fig.1) and the thermal image taken by a camera carried on the drone. The collected data were downloaded to a computer and edited by ArcGIS 10.6, ENVI 5.3 and QGIS 3.16 software.

Results and Conclusions

The geothermal mapping of the Grændalur valley reveals the presence of geothermal manifestations follow NE-SW, N-S, E-W, and NW-SE oriented alignments that inform us about the direction of faults and fractures covered by the surface deposits.

The processing of TIR bands of Landsat and ASTER satellite images covering the period from 2005 to 2020 and the thermal image taken by a camera carried on the drone, allowed us to: identify the presence of a thermal anomaly that did not exist before the year 2008. This anomaly certainly appeared after the earthquakes of May 29, 2008 which had opened the door to a new geothermal manifestation and closed the door to others that existed in the area; identified and estimated at about 43°C the temperature index of a thermal anomaly existing in an area located on a steep slope in the southern part of the Grændalur valley from TIR images with high spatial resolution taken by a TIR camera carried on the drone at 120m high.

This study attests to the importance of geothermal mapping, which allows the study and mapping of geothermal manifestations and their correlation with geological structures for better understanding of the geothermal activity of a region. Also, it demonstrates the effectiveness of the analysis, processing, and use of combined techniques of extraction of TIR images from satellite space sensors at different resolutions, taken at different times and that of the TIR image taken from the TIR camera carried on the drone in a geothermal area. This combination allows to cover large areas and detect thermal anomalies provided by geothermal manifestations. These can provide information about a possible magma upwelling.

Acknowledgements

We would like to thank the Centre de Recherches Géologiques et Minières (CRGM) through the General Director Professor Kanda Nkula for granting us the opportunity that made this study possible. The project was funded by the GRÓ–Geothermal Training Program as part of a MS fellowship.

References

Ingólfsson Ó., Sigmarsson O., Sigmundsson F., and Símonarson L.: The dynamic geology of Iceland. *Jökull,* 58, (2008), 1–2.

Arnórsson S.: Geothermal systems in Iceland; structures and conceptual models I, high temperature areas. *Geothermics*, 24, (1995a), 561-602.