GPS-mapping of geothermal areas in South Iceland

Phase 1: Reykjanes in Grímsnes, Þorlákshver and Laugarás in Biskupstungur. – An Overview –

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We report here the first results from a project to map systematically and in detail the geothermal areas in the Hreppar Block and the South Iceland seismic zone. The purpose of this effort is to relate the geothermal manifestations and individual springs to local structural features such as faults and fractures. The present state of the geothermal activity is also documented to provide a base of knowledge against which later changes can be determined.

As this work progresses and a wider coverage is obtained, we hope to reveal the geometric relationship of the geothermal activity to major structural features such as plate boundaries and volcanic systems.

Work of this type is greatly facilitated in recent years by the GPS-technology. Relatively inexpensive instruments can be acquired for mapping the structures at the resolution of 1-2 meters. Structures are mapped in the field by carrying GPS-receivers around them and storing the location data for later processing in the lab. Our choice of the method is influenced by the results of GPS mapping of earthquake fractures in the South Iceland Seismic Zone-SISZ (e.g. Einarsson et al., 2002) that proved to be successful for accurately locating fault structures and showing their general and local tectonic trends.

In this report we document the mapping results of geothermal areas near Skálholt in South Iceland. These areas are located within the Hreppar Block, a crustal block bounded in the west by the Reykjanes-Langjökull Rift Zone and in the east by the Eastern Rift Zone. In the south, it is bounded by the transform zone of South Iceland. This block is therefore separated from the two major plates, the Eurasian and North America Plates, by active rifts and a transform. Geothermal activity on the South Iceland Lowland and within the Hreppar Block is generally classified as low-temperature activity, with reservoir temperatures lower than 150°C, but surface spring temperatures up to the boiling point.

Our work is based on extensive earlier work in this region. The location, geochemistry, and discharge of the hot springs in Iceland was studied systematically in 1944 (National Research Council, 1944). Later studies of low-temperature geothermal areas in South Iceland include those of Ólafsson (1967) who measured the flow of springs and collected samples for chemical analysis, Stefánsson and Sæmundsson (1975) who reported on the geophysics and geology of the areas, and Torfason (2003) who described the general location of the springs and made a synthesis of data available to date.

We used the GPS technique to carry out surface mapping of geothermal manifestations in South and West Iceland in the autumn of 2004. Below is an overview of the outcome of the first campaign that concentrated on South Iceland. The mapping

is a part of the "*Bergsprungur í skjálftabeltum og gosbeltum"* Project. We selected an area to the north and west of Vörðufell, which includes the thermal areas of Reykjanes, Þorlákshver, a small zone by Hvítá, and Laugarás. Details of this first investigation will be presented in a BS report (SHG) at the University of Iceland, Faculty of Natural Sciences. A paper will follow (in preparation) where we interpret the GPS data with respect to our other results obtained from the Hreppar Block (Khodayar and Einarsson, 2002; Khodayar and Franzson, 2004), and to earthquake activity in the South Iceland Seismic Zone.

About 14 geothermal features were mapped in Reykjanes (Fig. 1). These are mostly pools with geothermal alteration, related vegetation, and steam appearing through the soil. Measured temperatures range from a maximum of 86,8°C to a minimum of 22,2°C. The springs form a general NNE trend, i.e. parallel to the rift structures. In detail the northerly and ENE directions dominate in Reykjanes.

The Þorlákshver system consists of two zones of equal importance, one to the west of the river Brúará with 22 mapped geothermal features, and the other to the east of the river with 54 features mapped. These are mostly pools, some fractures, and even hot points in streams that are made of the discharge of the surrounding hot springs. Geothermal manifestations appear here either through the soil or the sediments of the Brúará river. Some of these features are slightly off shore and may be hidden at a high water level. Measured temperatures range from a maximum of 94,1°C to a minimum of 12,5°C. The outline of the Þorlákshver system does not show a clear tectonic alignment despite a general northerly trend may be suspected from the organisation of the mapped zones. In detail, however, northerly, WNW, NE, and E-W tectonic directions are suggested in the geothermal manifestations of Þorlákshver.

Based on a characteristic algae growth and elevated temperature compared to the surrounding water of Hvítá, a single geothermal point was identified in emerging young sediments on the western shore of Hvítá. More manifestations may exist, but they could not be seen because of the high water level. This single point also may be easily hidden due to daily water level fluctuation.

Finally, data from Laugarás indicate that this geothermal zone differs from the zones mentioned above for the following reasons. The 52 manifestations mapped in the Laugarás village show a clear N-S organisation. The manifestations, with one exception, are south of the Skúlagata street. Almost all geothermal manifestations have a temperature above 65,7°C and steam comes out of most of them. Most points are above 80°C, and the highest measured temperature is 96,4°C. A pipe or a cemented cap is set on top of a few of these springs, but in places the steam has broken the constructions and escapes from it. Other mapped points are either small pools with swampy sediments or less commonly, conspicuous deposits, algae, vegetation, and oxidation; or they are bubbling points in small streams that were created by the accumulation of the discharge of other hot points. The main system in Laugarás is located to the east of the pump house, but there could be more geothermal features to the west, in the conspicuous streams coming mainly out of the pipes from the pump house. The geothermal system of Laugarás consists of several N-S sub-areas that are shifted to the left when looking from the south to the north. This geometry is strikingly similar to the segmentations of the earthquake fractures in the South Iceland Seismic Zone. Inside of each sub-area, geothermal activity is dominantly aligned N-S, but WNW

and NE tectonic directions also seem to be present. Contrary to the other mapped zones, the Laugarás system is located on a conspicuous structure that is visible both in the field and on aerial photographs. This structure is primarily a N-S fault and displaces the lava and hyaloclastites ≥ 10 m down to the east. Whether a dyke is injected into this fault could not be identified in the field because to the south the fault zone is occupied by the geothermal field, and to the north it is covered by soil. Data from Laugarás suggests that reactivation of an old N-S fault during major earthquakes may be responsible for the geothermal activity here.

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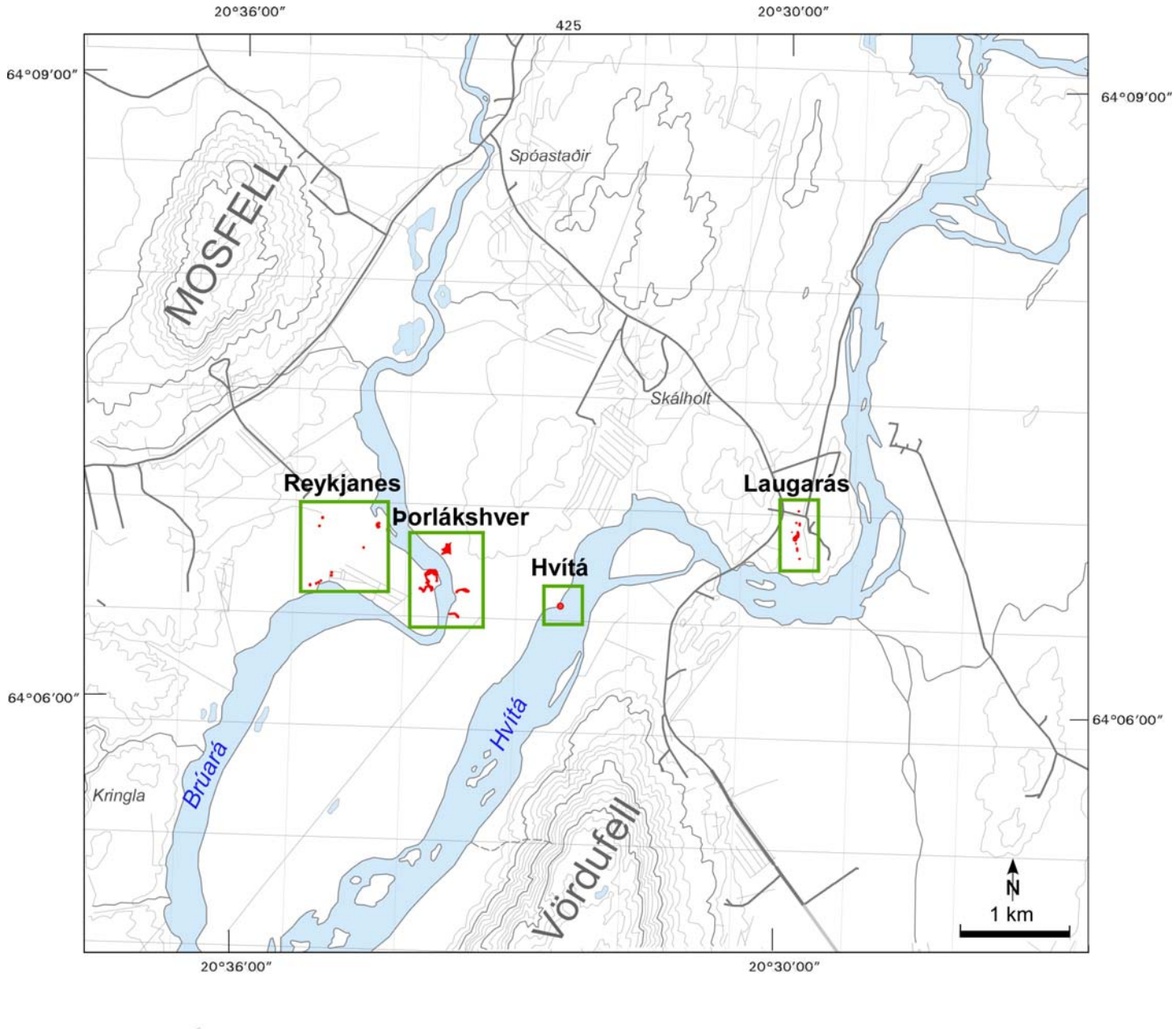

Fig. 1. Location of the geothermal zones mapped with the GPS.