SAGA GEOPARK

JARÐVANGUR

SAGA JARÐVANGUR GEOPARK

AFFILIATED ORGANISATIONS

SÓKNARÁÆTLUN VESTURLANDS

BORGARBYGGÐ

Snorrastofa

ICELAND GEOPARK FORUM
KATLA | REYKJANES | SAGA

HÁSKÓLINN Á BIFRÖST
BIFRÖST UNIVERSITY

LANDBÚNAÐARHÁSKÓLI ÍSLANDS

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SAGA Geopark Project - Iceland

CONTENTS

A IDENTIFICATION OF THE AREA

A.1. NAME OF THE PROPOSED GEOPARK

The proposal presented herein concerns the establishment, in Borgarfjördur district in western Iceland, of a geopark of international stature under the name of 'Saga Geopark'. The geographic area to be included in the proposed geopark stretches from a lowland region with flourishing agriculture to the country's highlands. More precisely it will be located at the edge of the volcanic rift zone in SW Iceland, which is characterised by diverse subglacial and intra-glacial volcanic formations. Among the interesting aspects of the area is its extensive geothermal activity and the various uses that people have made of the available geothermal resources ever since the country was settled in the 8th century. Once established, the geopark will include the largest low/medium enthalpy geothermal area in Iceland as well as the world's largest boiling hot water spring, Deildartunguhver.

The name Saga Geopark has strong connections with ancient history, not least that of Reykholt farm where Snorri Sturluson, the most famous writer of sagas in Iceland, lived and worked in the 13th century. In addition, the noun 'saga' as used in modern English has the meanings "a long and complicated story with many details", "a long and complicated series of events" or "a long story about past heroes from Norway and Iceland". The first two meanings also relate to the geological history of the proposed Saga Geopark, which can be described as a "long and complicated geological saga with many details and series of events". The geopark will cover a total area of 2,270 km2.

A.2 LOCATION OF THE PROPOSED GEOPARK

Saga Geopark will be located in Borgarbyggd Municipality, covering almost half of its geographical territory but harbouring only 10.2 per cent of its population or 360 out of 3,535 inhabitants. The main town in the municipality, Borgarnes, is within one hour's driving time from the capital, Reykjavík, and thus within its labour market area referring to "Iceland 2020 – governmental policy statement for the economy and community". The geopark area is separated from Reykjavík by a distance of about 130 km, and from the inter-national airport in Keflavík by a distance of less than 200 km. The main road connecting north and south Iceland runs a few kilometres west of the area. The geographical location of the proposed Saga Geopark is shown on the map in Figure 1.

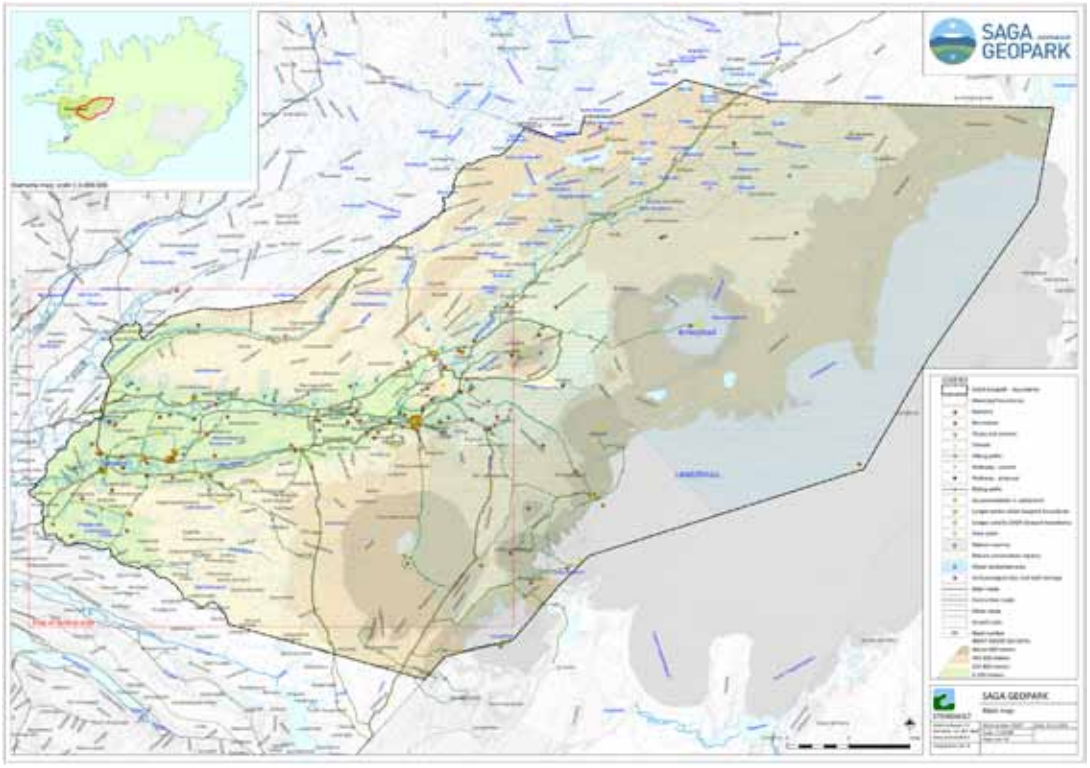

Figure 1: Geographic location of the Saga Geopark project in west Iceland. Geographical coordinates for 11 well-defined benchmarks along the boundary of the proposed Saga Geopark are listed in **Table 1**.

Benchmark No	Place name	N: deg min sec	W: deg min sec
1	Nordtunga	64 45 42.6	21 20 53.9
2	Örnólfsdalssandur	64 47 00.5	21 05 31.1
3	Kjararárdalur	64 52 29.0	20 49 11.5
4	Hlídarvatn	64 57 09.2	20 25 41.2
5	Hundavötn	64 56 13.0	19 47 35.5
6	Baldjökull *(NE Langjökull)*	64 52 03.2	19 49 13.9
7	Langjökull *(central part)*	64 40 17.8	20 06 31.5
8	Geitlandsjökull	64 36 14.7	20 34 23.6
9	Thórisjökull	64 32 29.8	20 41 51.7
10	Hrúdurkarlar	64 31 40.8	20 48 43.5
11	Lundarháls	64 33 34.4	21 13 09.0

Table 1: Geographical coordinates for well-defined benchmarks along the boundary of the proposed geopark.

A.2.1 ACCESSIBILITY

Four roads lead into the proposed geopark, two of which are connections from the main highway between north and south Iceland. These are marked 'A' and 'B' in Figure 1. From the south, a third road passes along the volcanic rift zone and across the borderline at point D, and then continues over the mountain pass between the two glaciers Langjökull and Ok. From the north, the fourth road crosses the central highlands of Iceland and the unpopulated highland in the northern part of the planned geopark. This road, which is only passable during the summer using bigger four-wheel drive vehicles, is marked 'C' in Figure 1. The colours used on the map indicate elevation above sea level. Green areas are less than 200 m above sea level, light brown between 200 m and 400 m, medium brown between 400 m and 600 m, and dark brown higher than 600 m. The glaciers are shown in dark grey colour.

A.3 SURFACE AREA, PHYSICAL AND HUMAN GEOGRAPHY CHARACTERISTICS OF THE PROPOSED GEOPARK

A.3.1 THE PHYSICAL TERMS

Borgarfjördur district is mostly lowland with a few moors to the east and northeast. The proposed Saga Geopark includes four valleys (*dalur* in Icelandic): Flókadalur, Reykholtsdalur, Kjarardalur and Örnólfsdalur. To the east of these valleys is found a range of glaciers (*jökull* in Icelandic): Thórisjökull farthest to the south, then Langjökull and Eiríksjökull. Three other important locations within the proposed geopark are Hvítársída, Hálsasveit (Háls on map), and Húsafell, all of which are home to thriving farming and tourism activities. The lowest point within the area is situated close to Kleppjárnsreykir at about 10 metres above sea level, while the highest one is the top of Eiríksjökull at 1,675 metres. Water runs from the glaciers, both above and below ground, forming streams and rivers sliding down the valleys. The main rivers (á in Icelandic) are Hvítá and Reykjadalsá. The latter flows down Reykholtsdalur in multiple bends and is one of Iceland's best known curved rivers. A considerable number of lakes and ponds lie within the proposed geopark. The largest concentration of lakes is found in the moorland (*heidi* in Icelandic) Arnarvatnsheidi, offering many fishing opportunities. The area around Húsafell farm and mountain Strútur has a number of bountiful springs with pure cold water. Throughout the region there are clear signs that glaciers once covered the whole country. The chief evidence consists of moraines, sediments and glacially eroded rock hills. Such hills present a smooth surface on the side once facing the flow of ice, because of higher eroding pressure. The lee side is steeper where the glacier has plucked blocks from the bedrock. These hills are sometimes referred to as 'whalebacks' because of their resemblance to the back of a whale.

The main lava fields (*hraun* in Icelandic) within the proposed geopark are Geitlandshraun, which once flowed from the Geitland Crater, and Hallmundarhraun, which originated from a crater west of Langjökull and west and north of Eríksjökull. The lava that formed the latter field flowed all the way south to the beautiful waterfall (*foss* in Icelandic) called Hraunfossar. Some of Iceland's largest caves (hellir in Icelandic) are found in Hallmundarhraun: Surtshellir, Stefánshellir and Vídgelmir. Areas with geothermal activity are widely found in Reykholtsdalur, Hálsasveit and Húsafell, including several hot springs (*hver* in Icelandic) such as Árhver and Deildartunguhver—the world's largest boiling hot water spring.

The easternmost part of the proposed geopark, that is to say closest to the three glaciers, is almost barren gravel. Arnarvatnsheidi is a vast wetland interspersed with drier patches covered with mossy vegetation. Grassland and farmland dominates in the four valleys, while wetland and moss are found on the moors separating the valleys. The main woodland areas are found near Húsafell farm and mountain Strútur.

A.3.2 CLIMATE

The climate of the lowlands, which are flourishing agricultural regions, is generally very different from that of the highlands, where no permanent human settlement thrives due to harsh climatic conditions. In the plains, the geographic location and the geology of the environment create conditions conducive to warm summer days. Húsafell is known for its pleasant climate and in the summer can often boast the highest daytime temperatures in Iceland. Mean precipitation is low compared to the neighbouring regions. Borgarbyggd and vicinity are one of the country's least snowy areas, although the prevailing conditions can cause a lot of drifting snow in the winter. Despite the relatively warm summer days, the average temperatures of the proposed area are lower than closer to the coast, for example in Reykjavík, due to its inland location and proximity to the highlands.

A.3.3 HUMAN GEOGRAPHY CHARACTERISTICS

The number of registered inhabitants in Borgarbyggd Municipality increased by 7.9 per cent between 1998 and 2015, compared to a total population growth in Iceland of 17.2 per cent in the same period . As already mentioned, about 10.2 per cent of the municipality's population, or 360 persons, were living in the proposed geopark area in 2013. Although not registered formally as residents, people staying for weeks or months in one of the 300 holiday homes spread around the area add to this number in the summer. The region is classified as a rural area and in general exhibits the same demographic characteristics as similar regions in other parts of the world, in that it has a decreasing and aging population. There is reason to believe that these demographic characteristics are on average more pronounced within the proposed geopark area than in the municipality as a whole. Based on official statistics, the number of children (between 0 and 16 years of age) in Borgarbyggd Municipality dropped by 34 per cent between 1998 and 2014, whereas the total number of children in Iceland grew by 2 per cent in the period 2000 to 2011 . The average age of the municipality's inhabitants rose by 4.7 years between 1990 and 2012 compared to an increase of 3.7 years in the country as a whole . However, there are some positive signs with regard to the number of children living in the proposed geopark area, given that the developing tourism industry has drawn a number of young families into the area in recent years.

An opinion poll conducted among the population in Borgarbyggd Municipality in 2014 revealed that the majority of people were very satisfied with their living conditions, the most frequently mentioned contributing factors being the proximity to an untouched natural environment and the quietness of the surroundings. Low salaries and lack of varied employment opportunities are two of the negative factors that influence how satisfied people are with living in Borgarbyggd .

According to the Regional Development Plan for West Iceland, the educational level in the region is rather low. Despite the multitude of educational opportunities available, including two universities and a number of high schools and lifelong learning centres, studies have shown that there is a need to boost education, not least with reference to the fact that the number of people having completed only basic education is quite high.

A.3.4 LAND USE

The Master Plan for Borgarbyggd municipality for the period 2010–2022 defines land use within the area of the proposed Saga Geopark as follows:

a. Most of the land is reserved for agriculture and general cultivation. According to the Master Plan, one of the goals for the agricultural and general cultivation areas "should be the registration and labelling of cultural heritage, archaeological and historical sites with the aim to promote cultural tourism".

b. Hiking and riding trails are included in the land use of the proposed geopark. The Master Plan lays down several goals for such trails, including that "a coherent system of riding trails should be created" and "hindrances for hikers around rivers and waters shall be remedied where possible"—these being just two of the goals for hiking and riding trails found in the plan.

c. Tourism is defined as a separate land use category in the Master Plan. Within the proposed geopark area, a number of sites have been designated as suitable for accommodation, shopping and general services.

d. Borgarbyggd Municipality comprises five towns or villages, including three small villages within the area of the proposed geopark: Kleppjárnsreykir (50 inhabitants), Reykholt (50 inhabitants), and Húsafell (30 inhabitants) (see Figure 1). The last two double in size during the summer with the arrival in the villages of seasonal staff working in the tourism industry and doing farming/greenhouse work.

A.4 ORGANISATIONAL AND MANAGEMENT STRUCTURE OF THE PROPOSED SAGA GEOPARK

4.1 LAUNCHING THE PROJECT—ORGANISATIONAL STRUCTURE 2013–2015

A preparatory committee to advance the Saga Geopark project was initially set up in 2013. The proposed geopark was registered as a legal entity on 1 March 2013 and thus became eligible for financial support from international and regional funds. The preparatory committee is a temporary body with a well-defined role, which consists in completing the first phase of the process of creating a geopark. A managing committee is to be established at the beginning of 2016 as a more permanent organisational body.

4.2 PRESENT ORGANISATION

The entity currently leading the project—the preparatory committee—is composed of members from different sectors of the community and led by an independent chair. With the assistance of an independent agency, the chair and the committee have elaborated a thorough and detailed work plan, highlighting the work currently taking place to create a 'de facto' geopark and preparing for the submission of the present dossier. They have also been responsible for executing various plans and activities decided on by the preparatory committee in the period in question.

In August 2013, Patrick McKeever of UNESCO visited the region on the invitation of the preparatory committee. He stayed for three days, travelling all over the region to familiarise himself with its features. The following year, the chair of the preparatory committee attended the 6th International Conference on Global Geoparks held in Stonehammer, Canada, in September.

The preparatory committee is composed of:

- 2 members representing Borgarbyggd Municipality;
- 1 member representing the West Iceland Marketing Office;
- 1 member representing Snorrastofa;
- the rector of Bifröst University;
- the rector of Hvanneyri University;
- 5 members representing the local community;
- a geologist responsible for the geology report and advisory activities;
- a financing expert from KPMG;
- an independent chair.

4.3 FUTURE MANAGEMENT STRUCTURE

The majority of those currently on the preparatory committee are expected to remain as members of the future management committee alongside new representatives. The structure of the organisational bodies will be improved to reinforce the management of the proposed Saga Geopark. The new organisational structure will be as shown below:

FUTURE MANAGEMENT STRUCTURE

Description and role of the future management structure of Saga Geopark

(as shown in the organogram at the bottom of the previous page).

General committee

The mayor of Borgarbyggd and the managing director of the West Iceland Marketing Office will constitute a body having a final power of decision in matters concerning the proposed geopark. They will be authorised to approve project and business plans, sign documents on behalf of the Geopark in accordance with those plans, and act as legal representatives vis-à-vis local, regional and international parties.

Managing committee

The managing committee will serve the operational needs of the geopark project and prepare and implement its overall strategy for the coming years, in collaboration with subcommittees. The managing committee will ensure the viability of the proposed geopark's operations by entering into a financial agreement with Borgarbyggd Municipality providing for an annual contribution toward the project. Other financing will be dealt with project by project.

The main activities of the managing committee will be:

- To safeguard and protect the unique geological heritage of the Geopark in the interest of future generations;
- To maintain an active and ongoing information agenda with a view to promoting greater understanding among the local population of the region's geological, cultural and historical heritage, thus enhancing their 'sense of place', among other things;
- To improve access to and improve the infrastructure of selected geosites and other remarkable cultural and historical sites within the proposed geopark, enhancing the public's awareness of their heritage;
- To build bridges between the natural and cultural sagas in order to obtain a better understanding thereof and to create a new storyline;
- To support the educational agenda with reference to the geopark's goal of education and enlightenment for all ages;
- To promote tourism in connection with local economic activities;
- To work closely with the Global Network of National Geoparks on learning efforts and of similar goals;
- To make every effort to underpin and secure the existence of Saga Geopark as an independent and sustainable organisation.

The managing committee will elect a chair early in 2016. The person in question will be responsible for day-to-day activities, for the execution of projects in partnership with other personnel, and for ensuring the flow of communication between the different subcommittees.

Academic and advisory subcommittees

The proposed geopark will work closely with the two universities in Borgarbyggd Municipality: the Agricultural University of Iceland and Bifröst University, drawing on the strength of the academic knowledge of the staff on board and on mutually beneficial projects, as well as by encouraging scientific studies and research. The rectors of both universities have been members of the preparatory committee from the beginning and are expected to continue as members of the forthcoming management committee. Projects will be developed on an ongoing basis in the domains of academic strength and local and international cooperation of each university. Each project will be financed independently, for the most part through partial contributions provided by municipal, local and/or external partners. Other advisors will provide specialised advice on issues relating to culture, the environment, geo-conservation, etc.

Saga Geopark partners

The proposed geopark's organisational bodies will cooperate with the various stakeholders, in particular those who are active within the geopark area itself. This will include locals working in sectors such as agritourism and those specialising in the production of food and other comparable products, as well as economic operators running guesthouses, hotels or artistic residencies, and local artists focusing on specialised projects centred around the geopark's philosophy and ideals. Finally, plans call for collaboration with the local school and kindergarten to enhance the children's awareness of the geopark and its unique features.

A.5 APPLICATION CONTACT PERSON

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B GEOLOGICAL HERITAGE

B.1 GENERAL GEOLOGICAL DESCRIPTION OF THE PROPOSED SAGA GEOPARK

Iceland—a phenomenon on rifting plates and on top of a mantle plume

Iceland is located at the intersection of the Mid-Atlantic ridge and the Greenland-Iceland-Faeroes ridge. The former lies on the diverging plate boundary of the American and the Eurasian plates. The spreading direction is N100°E. The Greenland-Iceland-Faeroes ridge is the trail of a mantle plume located beneath Iceland which has been active since the opening of the North-Atlantic some 60 Ma ago (Figure 1). The plume is now situated below central east Iceland, within the eastern branch of the volcanic rift zone which crosses Iceland from southwest to northeast. The existence of a mantle plume is supported by a seismic anomaly and by a major Bouguer gravity low centred above the proposed plume. The mass deficit must presumably be sought both in the thin elastic crust and in the underlying updoming asthenosphere. An anomalously low P wave velocity of 7.0–7.6 km/s and an attenuation of S waves has been observed in the mantle beneath Iceland, indicating partial melt. This anomalous mantle terminates abruptly near the insular shelf south of Iceland where normal oceanic crust and lithosphere is found. Based on magnetic anomalies to the north and south of Iceland the spreading rate in the island's vicinity was initially estimated to be about 1.2 cm/y in each direction, (Figure 1). Repeated regional GPS measurements have delivered similar values.

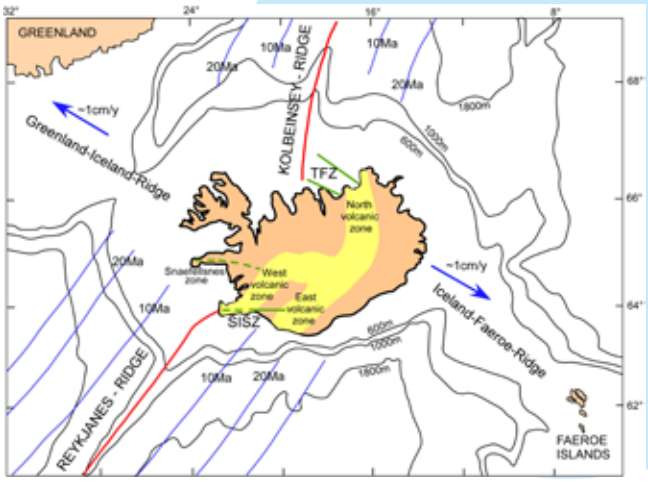


Figure 1: Iceland is an elevated plateau of volcanic basalt in the North Atlantic, situated at the junction between the Mid-Atlantic-Ridge (MAR) which characterizes the plate boundaries of the American and the Eurasian plates and the elevated Greenland–Iceland–Faeroes Ridge. The Reykjanes Ridge southwest of Iceland and the Kolbeinsey Ridge to the north are segments of the MAR. The spreading rate is around 1.2 cm/y, indicated in the figure by blue arrows. Magnetic anomalies (blue lines) indicate increasing age, in millions of years (Ma), of the ocean bottom with increasing distance from the rift axes.

Figure 1 also shows, in yellow, the volcano-tectonic rift zones crossing Iceland from the southwest to the northeast. The rift zone has two branches in south Iceland (East Volcanic Zone, EVZ and West Volcanic Zone, WVZ) and one in the north (North Volcanic Zone, NVZ). The South Iceland Seismic Zone (SISZ) in the south and the Tjörnes Fracture Zone (TFZ) in the north are transform zones which connect the volcanic rift zones to the respective segments of the MAR. Along the Snæfellsnes peninsula in west Iceland there runs an old transform fault which some 7 Ma ago connected the now extinct segment of the MAR, lying west of Iceland, with the WVZ. The Snæfellsnes transform zone is still volcanically active. Numerous eruptions have occurred there during Holocene, and earthquakes up to magnitude 5.5 have been measured in the eastern part, close to the WVZ and the proposed SAGA Geopark.

Tectonic earthquakes are due to relative movements of the North American and Eurasian plates. The biggest tectonic earthquakes in and around Iceland occur in the transform zones in the south (SISZ) and in the north (TFZ) where they can reach a magnitude of at least 7 (Richter scale). Earthquakes occurring in the spreading volcanic zones are less violent and usually do not exceed magnitude 5 (Figure B.2.2) This is due to the fact that the elastic crust is only 5 to 10 km thick in the volcanic rift zones and the temperature gradient is high. In the transform zones (TFZ and SISZ) the elastic crust is thicker, about 10 to 15 km, and the temperature gradient is lower, creating the conditions for greater stress build-up and larger earthquakes.

General geological description of Iceland—inner structure of major volcanoes

The volcanic zones in Iceland are segmented into several discrete volcanic systems, see Figure 2. Most of them include a central volcano characterized by a topographic high constructed in numerous volcanic eruptions and an associated fissure swarm with a graben structure intersecting the central volcano. Close to the central volcano the fissure swarms are characterized by eruptive fissures and further away by non-eruptive faults and ground fissures. The fissures extend far beyond the area of surface volcanism being the subsurface expression of dyke swarms (Sæmundsson, 1974, 1977, 1978).

Figure 2: Simplified geological map of Iceland. The yellow area crossing the island from the southwest to the northeast indicates the volcano-tectonic zone with an Upper Pliocene bedrock younger than 0.8 Ma. The green areas show Late Pliocene and Upper Pleistocene bedrock, 0.8–3.3 Ma old. The blue areas in the east and north-west indicate Tertiary bedrock increasing in age up to 16 Ma with increasing distance from the volcanic zones. Unfilled circles represent volcanic systems, and arrows crossing a circle indicate the direction of the associated fissure swarms. Filled red circles indicate primitive olivine-tholeiitic lava shields. 'WVZ', 'EVZ', and 'NVZ' are the axial rift and volcanic zones. The Snæfellsnes peninsula, in the west, is home to an old transform zone which, about 7 Ma ago, linked the MAR to a volcanic rift zone in west Iceland. The dotted circle in east central Iceland indicates the major central gravity low and the proposed location of the mantle plume beneath the island. (Based on Sæmundsson, 1978.)

The North Volcanic Zone contains a total of five volcanic systems, and the associated fissure swarms are arranged en échelon along the NVZ. Tension builds up continuously within the volcanic zone through the east-west drifting of the plate. The highest tension on the plate boundaries mounts in the particular fissure swarm that has been at rest the longest. When the tension reaches a critical value, magma starts to flow into a shallow crustal magma chamber and, from there, further into the fissures of the fissure swarm. A major rifting episode takes place in the NVZ once every 100 years but only one volcanic system is activated at each time. The latest rifting/volcanic episode started in 1975 and lasted until 1989. During that episode 11 eruptions took place, a 100 km stretch of the fissure swarm was activated, and the maximum widening of the fissure swarm was 9 m.

The WVZ contains four volcanic systems and presents a lower rift velocity of only around 0.5 cm/y.

Geothermal areas are an integral part of most of the central volcanoes. Sometimes subsidiary geothermal systems occur at volcanic foci on the fissure swarms, well away from the central volcanoes. The chemical composition of lavas exhibits a wide range in most of the volcanic systems (Jakobsson, 1979). Acid volcanism is confined to the central volcanoes, rocks of intermediate composition occur around the centre, but only basalt is erupted in the fissure swarms. These features indicate shallow magma chambers at a depth of about 3 to 10 km beneath the central volcanoes, where the magma ascending from the mantle evolves and changes in composition through time related reactions.

Structure of the volcanic rift zones—Volcanic systems

Figure 3 shows a schematic cross section of a typical volcanic system in the Icelandic volcanic rift zones. A volcanic system of this type is active for several hundred-thousand years, but as time passes it drifts out of the active volcanic zone and becomes inactive. In the wake of this, new systems are created at the crest of the rift axes. Intermittent seismic activity with episodes lasting several days or weeks is typical for the volcanic systems in Iceland, and demonstrates and delineates active fissure swarms in the area (Figure 7).

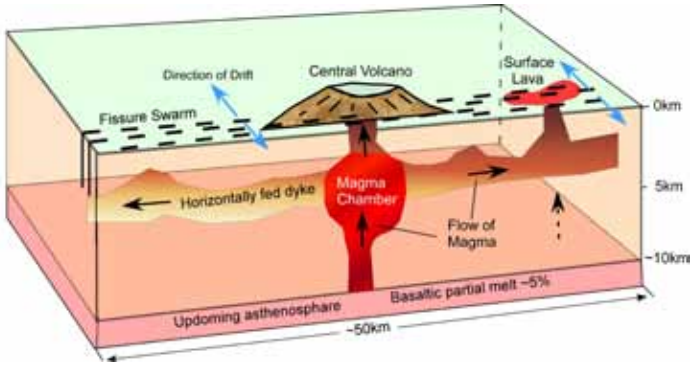


Figure 3: A central volcano is the core of the volcanic system and is characterized by a topographic high constructed in numerous volcanic eruptions. The central volcano is intersected by a 5 to 10 km wide and up to 100 km long fissure swarm. Fissure swarms usually have a typical graben structure with steep dip-slip faults on both sides and open tensional fissures in the subsided central part.

In addition to volcanic systems, see Figure 3, other types of volcano exist in the rift zones of Iceland, namely large monogenetic lava shields and table mountains, which are composed of primitive olivine-tholeiites indicating a deeper mantle magma source than that found beneath volcanic systems. Some of the volcanic shields are composed of picrite, suggesting a still deeper source. The lava shields are only found in the WVZ and the NVZ. Most of the lava shields were formed during the last glacial period and during a short time interval after it ended. Volcanoes of this type are created in a single huge eruption which can last for several decades. The eruptions often start on a short fissure but activity soon concentrates on one crater. If such an eruption occurs during an interglacial period (subaerial eruption) and lasts for decades, a regular cone-shaped lava shield is created. See Figure 4 showing the mountain Ok, a typical shield volcano (also called volcanic shield) within the proposed Saga Geopark in the WVZ.

Figure 4: The shield volcano Ok was created in a monogenetic olivine-tholeiitic eruption taking place near the end of the last glacial period.

If such a major eruption occurs beneath ice several hundred metres in thickness during a glaciation period, the lava melts the ice and creates a lake at the bottom of the ice layer. If the depth of the water exceeds 200 m the lava flows as pillow lava and piles up a mountain made of pillows. When the mountain reaches a certain critical height with lower water pressure, the lava starts to explode in the water and various hyaloclastite formations are created from the lava and from ash falling from the air. If the mountain reaches the surface of the glacial lake and the eruption manages to isolate the eruptive vent from the water, lava can start to flow in the same way as on dry land. The resulting mountain is called a stapi ("steep-sided mountain") in Icelandic, whereas the English term is 'table mountain' or 'tuya'. Figure 5 is a schematic depiction of the creation of an Icelandic stapi mountain below a thick ice sheet.

It must be noted that in Iceland both shield volcanoes (volcanic shields), like Ok, and subglacial stapi-type mountains, like Eiríksjökull, are the result of monogenetic eruptions from a single crater which last decades or sometimes more than 100 years. Hence, they are different from shield volcanoes such as those found on the Hawaiian Islands, which are stratovolcanoes erupting frequently over millions of years.

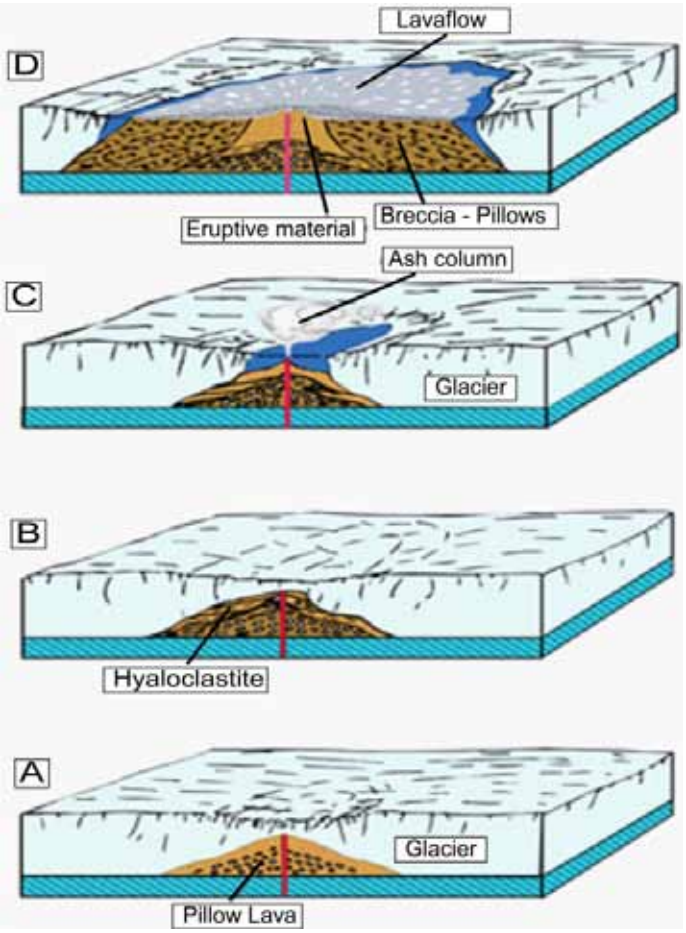


Figure 5: Icelandic stapi mountain formed beneath a thick glacier. Lava erupts through a single vent for decades, or even hundreds of years. In the first phase pillow lava forms. In the second phase various hyaloclastites are created. In the third phase lava is flowing on dry land. See further explanations in the text. The first scientist to explain the formation of a stapi through a subglacial eruption was the Icelandic geologist G. Kjartansson (1943). He used the name stapi for this type of mountain. The drawing is originally from Jones (1968), and is shown here with some modifications.

Figure 6: Eiríksjökull in the proposed SAGA Geopark is the largest stapi (table mountain) in Iceland. Its volume has been estimated to be about 40 km3. If that is true, this was the largest eruption during Holocene in Iceland.

The Prestahnúkur volcanic system

Smaller eruptions taking place beneath a thick glacier usually do not penetrate all the way up through the glacier. As a result, the lava is in contact with the melt water at all times. In the beginning, some pillow lava may form, followed later by various types of hyaloclastite, which may contain layered ash, and exploded pieces of lava. All the erupted material is glued together into a solid rock in the water heated by the lava, and takes on a brown colour from oxidation.

Hyaloclastite formations have no regular structure and are easily eroded by flowing water. If the eruption is confined to one crater an irregular mountain is formed. If the eruption takes place on a long fissure a hyaloclastite ridge is built up beneath the glacier. Such ridges often have several high peaks (tindar in Icelandic) protruding above the main craters where the production of lava was greater than at other points along the eruptive fissure.

Figure 7: Hádegisfell-sydra east of Geitlandsjökull within the proposed SAGA Geopark. A typical hyaloclastite mountain piled up during a subglacial eruption, presumably during the last glaciation event.

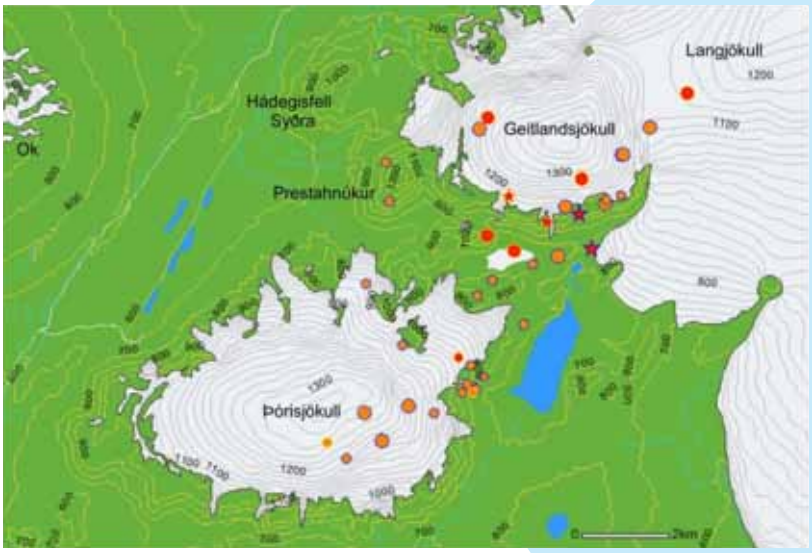


Figure 8: An earthquake swarm occurring in the Prestahnúkur volcanic system on 24 November 2014. Intermittent seismic activity, lasting several days or weeks at a time, is typical for the volcanic systems in Ice-land and demonstrates and delineates active fissure swarms in the area. Most of the surface of the Prestahnúkur volcanic system is hidden beneath the glaciers.

Figure 9: The centre of the active volcanic system in the proposed SAGA Geopark is close to the mountain Prestahnúkur shown in the figure. It is mainly composed of silicic subglacial extrusives (rhyolite) characteristic for the central volcanoes. There are a few warm springs in the area containing carbonated water. The light colour of Prestahnúkur is typical for the rhyolite, although it is partially due to geothermal alteration. The rhyolite is formed in the crust close to an upper crustal magma chamber through the re-melting of altered basaltic rock mixed with water.

Geology of the proposed Saga Geopark area

The geology of the SE part of the proposed SAGA Geopark is, in the same way as the central and youngest part of Icelandic volcanic zone, dominated by subglacial and interglacial volcanism occurring more recently than 0.8 Ma ago. This interaction of ice and fire lasting some 3 Ma during the ice age is one of the processes that make the geology of Iceland unique. Several postglacial lava flows less than 11,000 years old are found in the area. The youngest one, and also the largest, is Hallmundarhraun, which dates from about 940 CE. It contains some of the largest lava tubes (caves) in the world. The best known cave is Surtshellir (Black's Cave, hellir being the Icelandic word for cave), which is about 2 km long. Other big caves are Vídgelmir, Stefánshellir, Kalmanshellir and Hallmundarhellir. The area is home to a number of large monogenetic lava shields and table mountains, composed of primitive olivine-tholeiites indicating a deeper mantle magma source.

The lava shields are created during interglacial times while a similar eruption during a glacial period creates a stapi mountain ('table mountain'). Subglacial fissure eruptions form elongated ridges of hyaloclastites. Detailed mapping and dating of lavas in the extinct Húsafell central volcano, which was active about 3.2–2.4 Ma ago (the first 0.8 Ma of the ice age), shows that a total of eight glacial events took place during this time. This translates into approximately one glacial event happening every 100,000 years (Sæmundsson and Noll, 1974). The NW part of the Saga Geopark is dominated by Quaternary lavas, 0.8–3 Ma old, closest to the active rift zone, and Tertiary basalts older than 3 Ma further to the west and north.

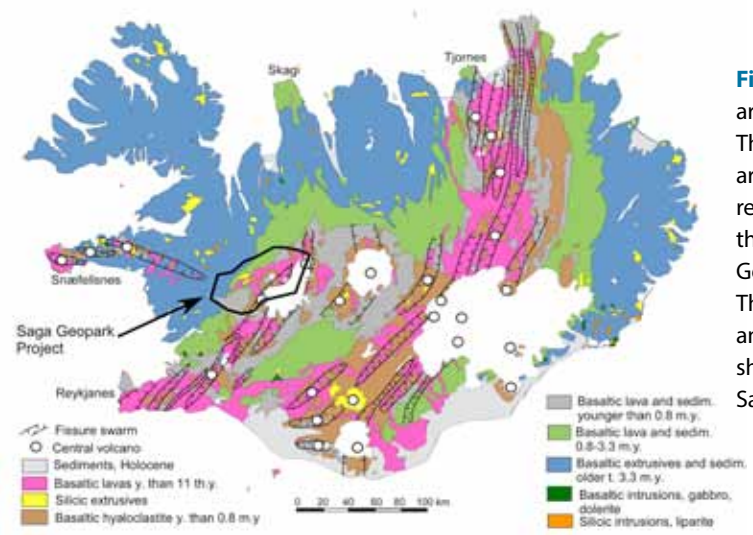
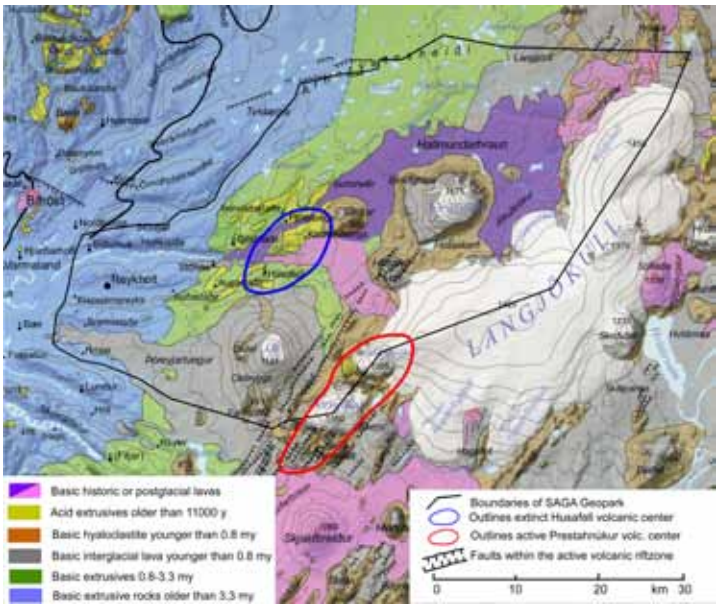


Figure 10: Geological map of Iceland. The pink, grey and brown areas indicate the volcano-tectonic zone younger than 0.8 Ma. The green area shows bedrock 0.8–3.3 Ma old, and the blue area indicates Tertiary rock with age up to 16 Ma. Unfilled circles represent central volcanoes. Heavy black lines mark the outlines of the associated fissure swarm. The outlines of the proposed SAGA Geopark are shown at the edge of the volcanic zone in SW Iceland. The axial rift zones are flanked by Quaternary volcanic formations and, further to the east and west, by Tertiary flood basalts as shown in this figure (Sæmundsson, 1978, 1979; Jóhannesson and Sæmundsson, 1998).

Figure 11 contains a geological map of the proposed Saga Geopark showing the main features in bedrock geology. The extinct Húsafell central volcano is delineated by a blue boundary. The Prestahnjúkur central volcano (Figure 9) is marked with a red boundary. It is the only presently active volcanic system within the proposed Saga Geopark. The centre of the central volcano is most likely to be found between Geitlandsjökull and Thórisjökull and includes the mountain Prestahnjúkur, which is made of acidic rocks and geothermally altered rocks. There are some minor warm springs in the area, with temperatures about 15°C to 20°C, containing carbonated water. About once a year, earthquake swarms indicative of small rifting events are detected in the area (Figure 8). These earthquakes are small and occur on lines with a direction NNE–SSW parallel to the faults and fissures in the West Volcanic Zone. All of this demonstrates that the Prestahnúkur area is an active volcanic centre.



By mapping the stratigraphy in all the various canyons of the SAGA Geopark Project, it has been possible to trace and map all glaciation and deglaciations events during the first 1 My of the Ice Age.

Figure 11: Simplified geological map of the proposed SAGA Geopark. The pink, grey and brown areas indicate the volcano-tectonic zone younger than 0.8 Ma. The green area shows bedrock 0.8–3.3 Ma old, and the blue area indicates Tertiary bedrock with age up to 10 Ma. Heavy black lines mark faults in the active fissure swarm. Modified from Sæmundsson (1978) and Jóhannesson and Sæmundsson (2009).

Nature of geothermal fields

There are numerous geothermal fields in Iceland. They have been divided into two categories based on the nature of the heat source and the temperature at depth. These categories are, first, high-temperature geothermal systems (HT) with temperatures of about 200°C to 300°C at a depth of around 2 km, and, second, low-temperature geothermal systems (LT) with temperatures lower than 150°C at 2 km depth (Bödvarsson, 1983). In Iceland, all HT systems are associated with central volcanoes within the volcano-tectonic zones. The heat sources are shallow magma chambers or cooling intrusions in the roots of the central volcanoes. The LT systems are nearly all found outside the active rift zones, within the older Quaternary and Tertiary areas. They are created by local circulation of groundwater in confined faults and fissures, which in some cases extend down to a depth of at least 3 km. The horizontal dimensions of these convection systems are relatively small, amounting to a few hundred metres. The convection of the water mines the heat from the lower part of the system and carries it up to the upper part, close to the surface. Hence, LT systems have a relatively low temperature gradient. The water of both the LT and the HT systems is of meteoric origin and no juvenile component has been found. The LT water is very low in dissolved solids, usually between 200 ppm and 300 ppm, and its pH is relatively high, 9–9.5, due to water-rock interaction with the fresh basaltic reservoir rocks. This water may be used directly for cooking, bathing, washing and domestic heating. The HT water is heated up to a temperature of 300°C to 400°C or more, and hence contains much higher quantities of dissolved solids. It also contains some dissolved volcanic gases, like CO2, H2S, H2 and CH4, from the heat source, as well as SO2 and HCl which mix with the ground water, thus forming acidic corrosive fluids which create fumaroles and mud pools at the surface.

The temperature of the hot water in the LT systems is determined by the maximum depth of the water circulation and by the surrounding temperature gradient (Bödvarsson, 1983). The longevity of these systems depends on the tectonic activity required to reopen the circulation channels which are gradually being closed by precipitation of secondary minerals from the water (Björnsson et al., 1987, 1990). Very few LT systems exist on the European plate in east Iceland. Most of them are located west of the plate boundaries, a fact which indicates a much more tectonically active crust in that area is than east of the plate boundaries (Björnsson et al., 1990). The LT systems can be regarded as confined local disturbances in the general heat flow from the mantle below. Outside the LT systems, the temperature gradient in wells is linear down to at least some 1.5 km, which is the depth of the deepest gradient holes drilled so far.

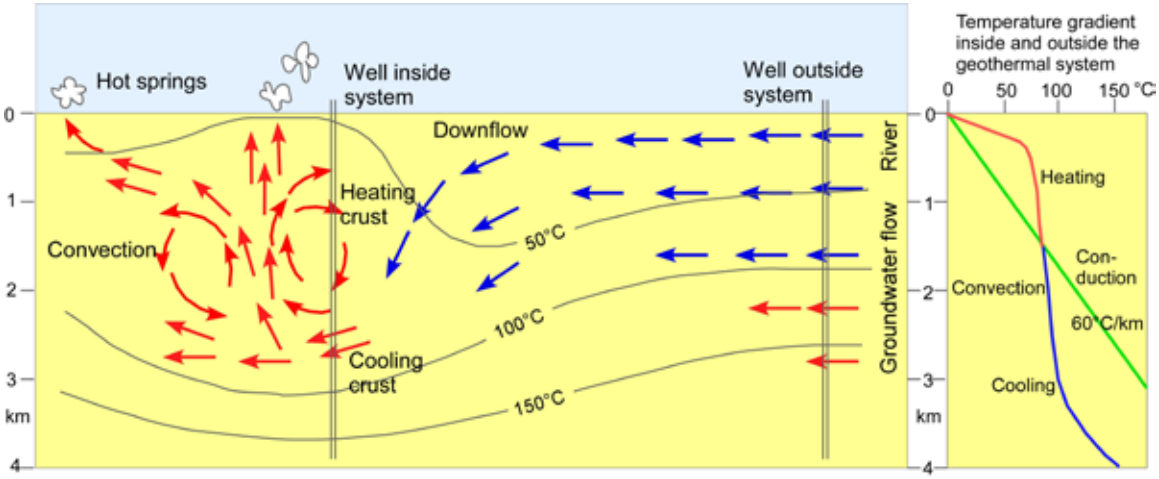


Figure 12: A schematic model of a typical Icelandic low- or medium-temperature geothermal system. Local convection of groundwater in near vertical faults and fissures transports heat from the lower part of the crust to the upper part. The right section of the figure shows a typical temperature gradient of 60°C/km outside the volcanic zone and outside geothermal systems, as well as the typical temperature profile inside a geothermal field. In the latter, the lower part of the crust is abnormally cool and the upper part abnormally hot. This model has been called the heat-mining model. (Modified from Björnsson et al. 1990.)

In order to keep the convection and the heat mining process going, a heat source is needed. Bödvarsson assumed that the water circulates in fissures and cracks at the boundaries of dikes and in faults. The fissures are closed below certain depths because of lithostatic pressure. He proposed further that the cold water percolating down along the fissures of the geothermal system serves to cool the rocks at the bottom, and that the contraction of the rock due to the cooling opens the fissure further down. Thus, the water continuously comes in contact with new hot rocks and the fissures migrate downwards. He named this process convective downward migration. The power of a geothermal system depends on the velocity of the downward migration, and this velocity in turn depends on the temperature gradient of the area and the ratio between horizontal stress and vertical stress at depth. Bödvarsson points out that this model does not contradict the fact that the water in the geothermal systems is originally rain water falling in the highlands. This water does not need to flow at great depth; instead it can simply flow in permeable layers close to the surface or in rivers down to the lowlands. A schematic model of a typical Icelandic LT geothermal system is shown in Figure 12.

No true high temperature geothermal fields are found within the proposed SAGA Geopark. The only indication of one is the occurrence of acidic rocks and some hydrothermal alteration within the active central volcano Prestahnjúkur in the SW part of the Geopark area. However, many low temperature geothermal sites exist in the western part of the area, especially in Reykholtsdalur, which forms part of the largest low temperature geothermal field in Iceland.

Utilization of geothermal energy

Figure 13: Snorralaug at Reykholt farm in Borgarfjördur, west Iceland, restored in 2004. One of the few con-structions preserved in Iceland from early mediaeval times. Similar pools have been commonly in use in Iceland since the settlement in the 9th century. They were both used for washing and bathing and played an important role as entertainment and information centres where people from several farms gathered, socialized and discussed the latest events.

One of the most interesting natural phenomena within the proposed SAGA Geopark is the area's extensive geothermal activity and the various uses to which geothermal energy has been put since the early Middle Ages, in other words since the settlement of Iceland in the 8th century. Geothermal research has been ongoing in the area since 1960, and production has been slowly increasing. The oldest space heating system in Iceland was revealed by archaeological excavations of ruins at Reykholt farm in Borgarfjördur, dating from the 13th century. The hot pool of Snorri Sturluson, the most famous writer of sagas in Iceland, also from the 13th century, still exists (Figure 13). In the modern era, the first geothermal heating system in Iceland was installed in Reykholtsdalur in 1907. Numerous remains of early geothermal utilization are found all over the area, and these are now being recorded and efforts made to preserve them. In the early 1980s the largest hot

spring in the world, Deildartunguhver (hver in Icelandic designating a boiling hot spring), which is located in the area and which delivers some 200L/s of boiling water, was partly exploited for a municipal district heating system for two towns in west Iceland, Akranes and Borgarnes. The hot water pipeline is about 70 km long. In Húsafell in Borgarfjördur a big resort has been built up around a separate geothermal field. Most farmhouses in this part of Iceland are heated by natural hot water.

Part of the preparation and planning of the Geopark is to assemble geothermal data from the area, as well as to collect and interpret new data. The Reykholt area is the largest low/medium enthalpy geothermal area in Iceland. Including this area in an internationally classified and acknowledged Geopark creates a unique opportunity to disseminate knowledge about the nature and economic importance of sustainable geothermal utilization to the general public.

The Icelandic sagas and the Icelandic Annals contain a wealth of information about warm pools, similar to Snorralaug pictured in Figure 13. (The Icelandic word laug designates a warm spring having a temperature of roughly 20°C to 40°C.) These pools were mainly used for bathing and for washing clothes. It is well known from contemporary accounts that hot water was widely used in Iceland in the Middle Ages. By contrast, very little is known about the use to which geothermal water was put during early modern times—in the 15th to 17th centuries. Bathing culture had declined and only sparse information about two bathhouses exists, without any detailed description. In the 18th and 19th centuries, however, scientists started to become interested in geothermal activity.

Figure 14: Deildartunguhver is a hot spring about 10 km west of Reykholt. The spring has a natural flow of up to 200L/s of 100°C hot boiling water, making it the largest boiling hot water spring in the world. The water is pure groundwater with total dissolved solids of only about 300mg/L and can hence be used directly for cooking and bathing. About half of the flow is used for district heating in small towns and villages up to 70 km away. The spring itself is a major tourist attraction.

Several visitors came to Iceland to investigate the phenomenon. The most famous of these was the chemist Robert Bunsen who spent the summer of 1846 in Iceland collecting geothermal water and rock samples. He wrote several scientific articles about the nature of geothermal fields in Iceland, a work which lately has earned him the title 'father of geothermal research' (Björnsson, 2005). At this time no further progress had been made in the utilization of geothermal water in Iceland. Many farmers even considered hot springs to be a nuisance, merely spoiling good grazing land. In this period, most people in Iceland did not know how to swim and any type of bathing culture had disappeared.

It was not until in the late 19th century that fresh ideas and new knowledge about geothermal water were brought to Iceland. By that time, many people had spent time abroad and learned various trades and handicrafts, and new building materials were being imported. One of the most important of these was the cement used to make concrete. Cement made it possible to master the boiling hot springs, build water containers, and pipe hot water and steam into houses. It even became possible to build special houses of concrete with washing facilities, and to build kitchens with stoves made of concrete which were heated by 100°C hot steam from a boiling spring.

The use of geothermal water is of great importance for the Icelandic people and for the large numbers of tourists visiting the country every year, mainly during the summer months.

Half of the Icelandic population now lives in the capital Reykjavík and a number of neighbouring towns in SW Iceland. The area has about 20 outdoor swimming pools which stay open all year round. The heating systems are usually operated by the local communities. Almost all towns and villages in other parts of the country also have swimming pools, and geothermal district heating has been developed nearly everywhere that hot water has been found. This was not always the case. Around 1970 only 40 per cent of Icelanders had geothermal space heating. During the oil crisis of the early 1970s the government bought a new large drilling rig and hired all available geologists to start exploring geothermal fields and drilling for hot water. This major effort was very successful and resulted in a situation where already in 1980 some 75 per cent of the nation had geothermal heating. In 1990 this number had risen to 85 per cent and currently, in 2015, geothermal district heating warms 90 per cent of all houses in Iceland. It has been estimated that the total amount saved by the Icelandic nation through the use of geothermal water for space heating instead of imported oil was ISK 67bn in 2009, which is the equivalent of about USD 6,800 in that year alone for a family of four.

Within the proposed geopark area there are two official and several privately owned swimming pools. A spa is being built at Deildartunguhver.

Glaciers—Groundwater

Glaciers are an important part of the proposed Saga Geopark (glacier = jökull in Icelandic). Langjökull ('Long Glacier') is the second largest glacier in Iceland after Vatnajökull. It has a major ice sheet or ice shield at the top and numerous outlet glaciers running down to lower altitude. The southernmost part of Langjökull is called Geitlandsjökull, and south of it is a separate glacier called Thórisjökull (Figure 15). The last two glaciers are most likely major stapi volcanoes (table mountain, tuya) still covered by ice. One of the most majestic glaciers in Iceland is Eiríksjökull, which sits on the top of a major stapi volcano, see Figure 6. Smaller glaciers limited to a single mountain, like Eiríksjökull, are often called ice caps. Every glacier has a defined snowline, below which the annual precipitation melts during the summer. Above the snowline the precipitation accumulates and is compressed until the ice starts to move downhill because of gravity. The velocity of the ice is usually a few cm per day although it can be as high as one metre per day. The usual term for these moving glaciers is 'outlet glacier' or 'glacier tongue'. The Icelandic name is skridjökull ("crawling glacier").

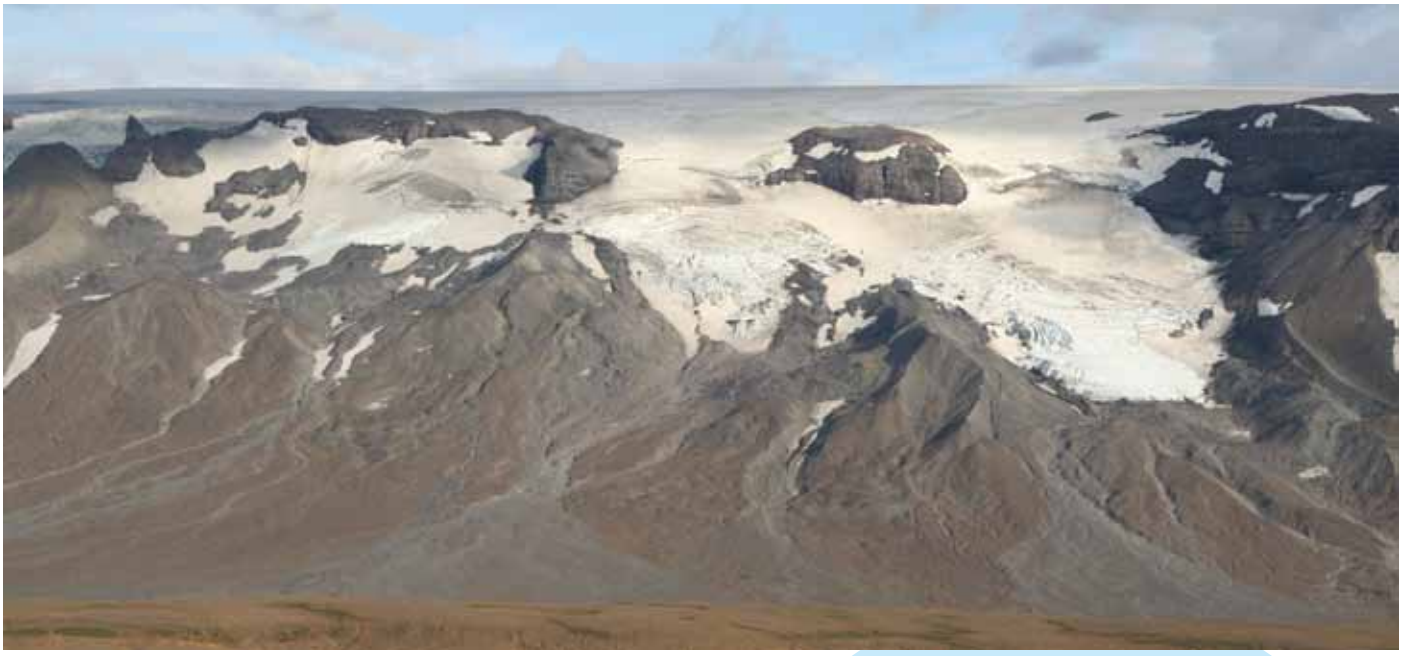


Figure 15: Outlet glaciers running down the west slope of Thórisjökull, a few km south of Prestahnúkur. Picture taken looking to the east from the highland road across Kaldidalur in the SE part of the proposed SAGA Geopark.

Lakes and rivers

All the glaciers within and near the border of the proposed SAGA Geopark have a considerable influence on the groundwater in the area. Huge amounts of water flow from the glaciers capping the highest mountains toward the surrounding lowland areas. The permeability of most of the rock formations in the area is very high, leading to a massive flow of groundwater. The multiple intermediate horizontal layers of ash and glacial sediments have high permeability. The existing faults and fissures are also highly permeable. Hence there is a steady, extremely high flow of groundwater from the highland toward the valleys and the lowland. Some of the water is stored temporarily in the multitude of lakes found in the northwest part of the proposed Saga Geopark, within the areas called Arnarvatnsheidi and Tvídægra, see Figure 11. This is one of the largest unspoiled lake areas in the whole of Europe with numerous small and big lakes connected by brooks and small rivers containing absolutely clean unpolluted water. The melt water from the glaciers originally contains fine clay and sand from the bottom of the glacier. This solid material is filtered from the water on its way from the glacier through the bedrock and the water reappears as absolute clean groundwater in springs and lakes only a few kilometres away from the glaciers.

Rivers in Iceland are often classified into three different types. Firstly we have the spring-fed river. The water in such rivers emerges from fresh water springs or from lakes, resulting in a nearly constant flow all year around. These rivers are most common in the high permeable areas close to the volcanic zones. The second type of rivers is the direct runoff river, which does not have a directly identifiable or well-defined origin. The water may come from small springs, from melting snow in the mountains and from rainwater. The flow rate varies from day to day with changes in the weather. The third type is a glacial river. This type of river emerges directly from beneath a glacier. The flow rate varies during the day, with more melt water being produced during the day than during the night. There is also a great difference in water flow between seasons.

The flow of glacial rivers is highest in the summer, when temperatures are higher and more melt water forms than during the winter. In summer, the glacial rivers carry large amounts of clay and fine sand which cause the colour of the river to become grey or even green. In the spring, glacial rivers may become brown-coloured due to the melting of snow. All these types of rivers are found inside the proposed SAGA Geopark. The river Hvítá has several interesting waterfalls. The

Figure 16: Two small creeks running into the main river Hvítá. Hvítá at this location gets its typical glacial colour from Geitá. Compared to the creeks, which appear black, Hvítá is nearly white. The difference in colour is explained by the fact that Hvítá carries light-coloured clay which renders it opaque. The creeks have clear water that makes it possible to see the black and grey stones at the bottom of the creek through the water, in turn making the water appear black compared to the white or light grey clay-coloured water.

most famous of these are Barnafoss (Figure 18) and Hraunfossar (Figure 17). Geitá is a typical glacial river coming from Geitlandsjökull. Nordlingafljót comes from Arnarvatnsheidi and is a mixture of a spring- or lake-fed river and a glacial river. The colour and the flowrate vary within the year. Hvítá is today mainly a spring-fed river where it originates between Eiríksjökull and Langjökull. The name Hvítá ('White River') indicates that when it was named, a few centuries ago, it had already acquired the colour of a glacial river. All of the rivers mentioned above come together near Húsafell farm to form one large river which carries the name of Hvítá all the way to the ocean. It is interesting to note that only half of the volume of Hvítá below Húsafell is running on the surface. The remaining half flows in subsurface channels or along permeable horizontal layers into the river.

Figure 17: Hraunfossar. The water in the falls is groundwater percolating down through the porous lava on the surface and flowing along an impermeable layer of ignimbrite (volcanic ash), and from there into the river Hvítá.

Figure 18: Barnafoss in Hvítá. The river has carved a small canyon into Hallmundarhraun along the hill to the right. The canyon contains a small natural stone bridge across the river.

B.2/B3 LIST AND DESCRIPTION OF GEOSITES–VALUE AND INTEREST

No.	Name	Short description	Value		Interest		
on			Internat.		Science		
map			National		Educate.		
	Icelandic /English		Local		Aesthetic		
I	Glaciers - Groundwater						
	Rivers - Waterfalls						
1	**Eiríksjökull/**	Stapi volcano - Ice Cap on the top	I		S	E	A
	Glacier of Erik	Vol. ~60km^3 - largest eruption in Holocene					
3	**Langjökull/**	Second largest glacier in Iceland	I		S	E	A
	Long- glacier	Easy access - Man made 300m ice tunnel					
4	**Geitlandsjökull/**	South-West part of Langjokull	I			E	A
	Goat-land-glacier	Stapi volcano - highest peak 1380m					
5	**Thorisjökull/**	Stapi volcano highest peak 1360m	N			E	A
	Glacier of Thor(ir)	Interesting outlet glaciers on west side					
2	**Ok (glacier)/**	Symmetric Shield volcano, end of the Ice Age	I		S	E	A
	Yoke(Eng.) Joch (Ger.)	Big top crater and lake - No real glacier now					
0	**Groundwater/**	Large production beneath the glaciers	N		S	E	

	Groundwater	Groundwater flow in high permeable rocks					
31	**Arnarvatnsheidi**	Largest unspoiled wetland area in Iceland /Europe	**I**		**S**		**A**
	Lake area	Numerous lakes and rivers, fishing possibility					
35	**Geitá/**	Glacial river coming from Geitlandsjokull	**I**		**S**	**E**	
	Goat-river	joining Hvitá close by Husafell					
36	**Hvítá (1)/**	Spring fead river from the area between	**N**		**S**	**E**	
	White river	Langjokull and Eiriksjokull					
37	**Norðlingafljót/**	Glacier water from northern Langjokull	**L**			**E**	
	North river	and spring fead water from lakes in the north					
36	**Hvítá (2)/**	Close to Húsafell the 3 main rivers listed	**N**			**E**	
	White river	abode, join into one mixed river named Hvítá					
11	**Hraunfossar/**	Fresh groundwater flows down through the porous	**I**			**E**	**A**
	Lava Waterfalls	lava and along impermeable ignimbrite into Hvitá					
11	**Barnafoss /**	Waterfall in Hvítá in a narrow canyon. A natural	**I**			**E**	**A**
	Children's fall	stone bridge crosses the river in the canyon					
28	**Skessukatlar/**	Up to 4 m deep erosion cauldrons in a	**N**		**S**	**E**	**A**
	cauldrons	now dry river bead of Hvita					
17	**Árbugður**	Meanders in direct run-of river Reykjadasá where it	**I**		**S**	**E**	**A**
	River bends/	enters the flat lowland in front of the river valley					
	meander						
II	**Lavas, craters, caves,**						
	sub glacial eruption						
8	**Hallmundarhraun/**	Large olivine tholeiit lava. The only historic one, ~940	**I**		**S**	**E**	**A**
	Helmond's lava	Contemporary poem exists, describing the eruption					
17	**Lava tubes**	World's largest lava tubes up to 3.5 km long	**I**		**S**	**E**	**A**
	caves	Total length of all caves is tenths of km					
9	**Surtshellir and**	Together 3.5 km long. Major archaeolog. monuments.					
	Stefanshellir/	Easy access except during the winter	**I**		**S**	**E**	**A**
	Blac's , Stefan's c.						
10	**Vidgelmir /**	Total length 1585 m and volume ~150.000 m^3	**N**		**S**	**E**	
	The wide big cave	Archaeological remains from the Viking Age					
		Guidance from land owner required					
49	**Kalmanshellir/**	About 4000 m longest in Iceland	**I**		**S**		
	Kalman´s Cave	Protected and closed for public access					
48	**Hallmundarhellir**	About 200 m long	**I**		**S**		**A**
	Hallmund's cave	Difficult access , far from roads					
34	**Geitlandshraun/**	Postglacial Lava. Crater in Geitland west of Langjokull	**N**		**S**		**A**
	Goat-land-lava	5 lava channels from crater. River Svarta flows in one					
27	**Tungan/**	Sub glacial volcanic ridge mainly made of acidic rocks	**I**		**S**	**E**	**A**
	Sub glacial Ridge	Light coloured rhyolite is dominating					
25	**Strútur**	Mountain piled up in sub glacial volcanic eruption	**N**			**E**	
		mainly hyaloclastite. Unique view from the top.					
26	**Strútur**	Deep and narrow canyons cut by glacial rivers into	**I**		**S**	**E**	**A**
	deep canyons	soft hialoclastite: Draugagil, Skógarhlíðargil, Stóragil					
40	**Hádegisfell syðra/**	Hyaloclastic mountain west of Geitlandsjökull	**I**			**E**	**A**
	Southern Noon hill	typical sub glacial eruption					

41	**Hádegisfell nyrðra/**	Hyaloclastic mountain west of Geitlandsjökull	**I**			**E**	
	Northern Noon hill	typical sub glacial eruption					
6	**Prestahnúkur/**	Sub glacial rhyolite eruption near the centre of	**I**		**S**	**E**	**A**
	Precast mountain	an active central volcano. Some geothermal springs					
42	**Kroppsmúli**	South side of Reykholtsdalur by Kleppjarnsreykir	**N**			**E**	**A**
	Snældubjörg	Layered basalt 2,6-5,3 My old. Dykes and faults.					
III	**Geothermal springs**						
	and utilization						
14	**Deildartunguhver**	Largest boiling hot water spring in the world	**I**		**S**	**E**	**A**
	Spring in Deildartunga	Flow rate ~ 200L/s - Half of it used for house heating					
43	**Hurdarbak**	Two boiling springs. One used to cook and wash in	**L**			**E**	**A**
		a house build of concrete around 1900					
44	**Kópareykir**	Several boiling springs. Used to cook and wash and	**L**			**E**	**A**
		heat houses					
16	**Árhver (Vellir)/**	Boiling hot spring in the middle of the river Reykjadalsá	**N**			**E**	**A**
	River spring	Is reactivated about once every century by earthquakes					
15	**Snorralaug/Skrifla**	Skrifla is boiling hot spring at Reykholt. The hot water	**I**		**S**	**E**	**A**
	pool of Snorri	is piped in subsurface channel to the spa Snorralaug					
19	**Hringsgil**	Several small ~40°C warm springs in Hringsgil by	**N**			**E**	**A**
		Husafell. Outdoor pool will be build there for tourist.					
18	**Teitsgil**	Several small ~40°C warm springs in Teitsgil.	**N**			**E**	**A**
		There is a pool made of stones some 300 years ago					
45	**Áslaugar**	Several warm and boiling springs near the farm	**N**		**S**	**E**	**A**
		Stóri Ás. Production well used for space heating					
29	**Norðurreykir**	Numerous boiling hot springs. Used for space heating	**L**			**E**	**A**
		and for local industry and farming					
46	**Sturlureykir**	The first house in Iceland to pipe hot steam from local	**N**		**S**	**E**	**A**
		hot spring for cooking and later for house heating					
47	**Kleppjárnsreykir**	Local village using hot water for heating green houses,	**N**		**S**	**E**	**A**
		heating houses a school and a swimming pool					
IV	**Gil**	Canyons cut into various formations by glacial rivers					
	major canyon	at the end of the Ice Age					
18	**Selgil**	All this canyons play a major role in mapping and	**I**		**S**	**E**	**A**
		understanding the geological structure of the area.					
20	**Deildargil**	Various geological layers can be studied directly and	**I**		**S**	**E**	**A**
		the age measured on rock samples. This mapping has					
22	**Ásgil**	delivered a clear picture of the geological history,	**N**			**E**	
		especially the nature of the Ice Age which was					
23	**Rauðsgil**	characterized by 100Th years glaciation periods inter-	**N**			**E**	**A**
		ruptet by ice free periods of similar length. That means					
21	**Valagil**	that about 25-30 glaciation-deglaciatins events have	**I**		**S**	**E**	**A**
		occurred during the Ice Age. Students and tourists can					
13	**Bæjargil**	learn about the inner structure of the area and admire	**N**		**S**	**E**	**A**
		a unique landscape, rock formations, wonderful					
		waterfalls and hot springs in this unique canyons.					

B.4 LISTING AND DESCRIPTION OF OTHER SITES

SITES OF NATURAL, CULTURAL AND INTANGIBLE HERITAGE INTEREST AND HOW THEY ARE RELATED TO THE GEOLOGICAL SITES AND INTEGRATED INTO THE PROPOSED SAGA GEOPARK

No. on map	Name	Short description
14	**Reykholt**	The home of the most important writer of Icelandic Sagas, Snorri Sturluson (1179-1241)
31	**Arnarvatnsheidi**	Largest unspoiled wetland area in Iceland /Europe Fishing, bird watching, summer grazing for sheep
11	**Hraunfossar/Barnafoss**	The most visited place in the Geopark A strong relation to folklore of the area
9	**Surtshellir/Stefánshellir**	The longest cave in Iceland Archeological remains from the Viking age and folklore
10	**Vidgelmir**	Total length 1585 m and volume ~150.000 m^3 Archeological remains from the Viking age and folklore
26	**Draugagil**	Deep and narrow canyon in mt Strútur Relates to history of Snorri Björnsson of Húsafell
15	**Skrifla/Snorralaug**	Hot water from Skrifla was piped in subsurface channel to the spa Snorralaug. Making Snorri a pioneer in geothermal utilization
19	**Hringsgil**	Several small ~40°C warm springs in Hringsgil by Husafell. Outdoor pool will be built there for tourist.
18	**Teitsgil**	Several small ~40°C warm springs in Teitsgil. There is a pool made of stones some 300 years ago
13	**Bæjargil**	Blocks of basalt stones from Bæjargil used for building an open sheepfold by Snorri Björnsson. A 180 kg stone used as a door. A replica of the "Husafell stone" is used worldwide in strongman competitions
39	**Geitland**	Lava from Geitlandshraun was used to make millstones. Used in Borgarfjörður district.

B.4.1 REYKHOLT

In the 13th century, Reykholt was the home of the most important writer of Icelandic sagas, Snorri Sturluson (1179–1241). It is close to the geographic centre of the planned geopark and without doubt its main cultural centre.

Several places in Iceland are of particular significance for Icelanders with regard to their cultural heritage. Iceland was settled in the 9th century and the people established an Althing (parliament) in 930 at Thingvellir in SW Iceland. Thingvellir became the most important place in the country, the place where laws were adopted and legal disputes settled. The second most important location in Iceland with respect to cultural heritage is Reykholt farm, where the famous writer of sagas, Snorri Sturluson, lived in the 13th century. He was a lawspeaker at the Icelandic parliament, the Althing, author of the Prose Edda, a narrative of Nordic mythology; a book of poetic language; and Háttatal, a list of various verse forms. Without these works very little would be known about the old mythology and the complicated rules of the poetic language used in the Viking age. Snorri also wrote the history of the contemporary Norwegian kings and their ancestors back to the 8th century. Snorri was a very effective author and a clever scholar who collected all available written and oral information about the matter he was dealing with. He also demonstrated ingenuity in the

use of the natural resources available in Reykholt and on many other farms he owned. The farmhouse stood on a small hill, at the bottom of which was a boiling spring called Skrifla. Snorri had an underground tunnel dug from the spring and piped its steam into the house for heating and bathing. Water from Skrifla was also brought to his pool (Snorralaug) using another tunnel. Finally, access from the main building to the pool was provided through a tunnel containing a staircase, making it easy to use the pool day or night all year round. Considering all this, we may assert that Snorri was a pioneer in geothermal utilisation. Today, a research centre for mediaeval literature (Snorrastofa) is operated in Reykholt and every year provides several scholars with study facilities. Reykholt also houses an exhibition about Snorri and the period in which he lived, a lecture hall and a church. A festival with various art performances is held every year, and lectures are given on subjects both in the natural sciences and the humanities.

B.4.2 STURLUREYKIR

Sturlureykir is a farm located west of Reykholt. In 1907, the farmer piped steam from a boiling spring uphill and into the kitchen and used it for cooking. This may have been the first heating (cooking) system constructed in Iceland in the modern era. A few years later hot water was piped into the house for space heating. There exists some conflicting information about a public bath house close to the spring at Sturlureykir which is said to have been in use from ancient times and until the 18th century. Today, part of the farmland has been divided up and sold to individuals who have built holiday houses there, all of which are provided with geothermal water for heating and bathing.

B.4.3 SURTSHELLIR AND OTHER CAVES IN HALLMUNDARHRAUN

Hallmundarhraun is a lava field created by an eruption occurring in three craters near the edge of NW Langjökull about the year 940, as determined by tephrochronological mapping and radiocarbon dating. The eruption may have lasted for several months, and the lava destroyed and submerged several farms and changed the flow of the rivers Nordlingafljót and Hvítá. Rather peculiarly there exists a long poem, called Hallmundarkvida, which describes the eruption and the flow of the lava. The poem clearly dates from pagan times as it shows no Christian influence. The author (skald) is unknown, but most likely he was an eye witness living in the area. It is very interesting to have a written description of a volcanic eruption from the Viking age and to be able to compare it to modern day observations.

In recent years numerous caves within the lava field have been explored and mapped. Archaeological remains show that many of them have been used for human occupation for longer or shorter periods of time. This is true of Surtshellir, Vídgelmir and several other caves in Hallmundarhraun. In the ancient literature, entire sagas and other pieces of information found in various manuscripts contain accounts of outlaws living in Surtshellir. In addition, various folktales deal with giants, outlaws and ghosts in the region. The caves contain delicate geological formations which must be protected, and in some of them there are also archaeological remains which are in need of protection.

B.4.4 DRAUGAGIL

Draugagil ("Ghost Canyon") is a fissure up to 100 m deep and only few metres wide, cut by a glacial river close to the end of the Ice Age into the relatively soft hyaloclastite rocks of the mountain Strútur, which was created in a subglacial basaltic eruption during the last glaciation period. The fissure is so narrow that it does not enjoy full daylight at the bottom even on sunny summer days. It is characterised by beautiful pillow lava and lava intrusions (roses). Draugagil is an interesting cross section through a hyaloclastite mountain. Snorri Björnsson, at the time a priest in Strandir in the West Fjords of Iceland, became priest in Húsafell in 1757 and lived there until his death in 1803. It was commonly believed in Iceland that people from Strandir could perform witchcraft. In particular, they were thought to be able to fight ghosts and send them back below ground from where they could not trouble living humans. Many sick people sought Snorri's help, and he was usually able to find some cure. The folk belief was that Snorri sent the annoying ghosts to a special subterranean place which was either believed to be a special ghost cemetery near Húsafell farm or located in Draugagil.

B.4.5 HRAUNFOSSAR

Hraunfossar ("Lava Falls") is one of the most visited places in the proposed Saga Geopark. Clear groundwater percolates down through the porous Hallmundarhraun until it reaches an impermeable layer of red volcanic ash, called ignimbrite. The water flows along the dense ash layer until it enters the canyon where Hvítá flows. The contrast between the clear

groundwater and the grey or brown colour of Hvítá is impressing. The moss-grey surface of Hallmundarhraun, the black front wall of the lava, the low-growing birch trees, along with gravel and grass on the left bank combine in a wonderful mixture of colours.

B.4.6 BARNAFOSS

Barnafoss (Children's Falls) is in Hvítá, three minutes' walk from Hraunfossar. Here, the river flows in a narrow canyon where a natural stone bridge crosses the water. Older people in the area tell a story handed down from their ancestors according to which the waterfall was previously located a short distance further down the river, where another stone bridge then stood. The story is supported by the fact that the lava in this narrow canyon is subject to considerable erosion, causing the water-fall to migrate slowly upstream. According to a legend, Barnafoss got its name from two children who fell into the river when trying to get across it on the stone arch. Their mother then had the arch broken down in order to prevent further accidents. There are countless stories and folk tales of this type in Iceland. Uniting geology and landscape with history and folktales adds to the appeal of the geosites.

B.4.7 ARNARVATNSHEIDI—TVÍDÆGRA

Arnarvatnsheidi and Tvídægra in the northern part of the planned geopark is the biggest unspoiled wetland area in Iceland, and possibly in the whole of Europe. The area covers about 600 km2. Enormous amounts of groundwater flow from the glaciers Langjökull and Eiríksjökull, and the area is characterised by numerous big and small lakes connected by small creeks and rivers. Many of the lakes have good fishing (trout) and are open for fishing during the summer. The region is home to a great variety of birds and provides excellent summer grazing for sheep. A number of 'main roads' (horse tracks) connecting north and southwest Iceland used to pass through this area until the 19th century.

One major river, Nordlingafljót, flows to the south from here and joins Hvítá north of Húsafell farm. Nordlingafljót is a salmon river and fishing licenses are sold for the summer season.

B.48 NATURE BATHS (WARM POOLS)

Snorralaug is the most famous old pool within the planned geopark area, but is a manmade pool since the water is piped from the nearby spring Skrifla. However, many natural warm pools exist in nearly all regions of Iceland, especially where warm or hot springs are common. Using rocks and turf, farmers and travellers often built these pools next to, or even within, a warm spring. Everyone was free to use such pools for the purpose of relaxing, taking a bath or washing their clothes. Nowadays these pools are not used very much, with the exception of those located in the inner highlands, which are very popular. One such natural pool is found in Teitsgil/Selgil east of Húsafell farm. As the story goes, Snorri Björnsson, legendary priest and ghost-killer in Húsafell, built the pool in the 18th century as a bathing and washing facility. There are plans to restore the old bath and improve access to it for the guests of the planned geopark.

Hringsgil west of Húsafell harbours several warm springs with temperatures around 40°C within a large rhyolite intrusion at the bottom of the canyon. A new nature bath is to be built there for use by tourists taking a walk along this unique canyon.

B.4.9 ROCKS FROM THE PROPOSED SAGA GEOPARK

Stones and rocks originating in the proposed Saga Geopark area have been used for various purposes through the ages, both to create practical implements and to produce artwork.

a) At Húsafell farm there stands an old open sheepfold, built by Snorri Björnsson in the 18th century. A big slab of stone was used as a door to open and close the fold. According to legend, Snorri was in the habit of lifting the 180 kg stone which he then carried around the fold before replacing it in the opening. The stone is still in its place and everyone is welcome to test their strength by trying to lift it. The stone is a block of basalt taken from Bæjargil canyon.

b) Until about 200 years ago, every farm possessed a pair of millstones to grind the grain (all of which was imported at the time). Icelandic millstones were usually two flat stones of rough lava, one of which was fixed to a stationary support while the other was laid on top of it. The grain was crushed between the stones by rotating the upper stone. The best millstones were those that were flat but with a suitably rough surface. Rocks with vesicles of a certain size were considered the best. The best lava for millstones came from the lava field at Geitland and most millstones used at farms in Borgarfjördur district were taken from there.

C GEOCONSERVATION

C.1 CURRENT OR POTENTIAL PRESSURE ON THE PROPOSED GEOPARK

Tourism in Iceland has increased at an extraordinary pace in the past few years as shown in table C110. The figures in the table only refer to the number of foreign tourists travelling through Iceland's main international airport, thus excluding anyone arriving by other means, such as on ferries or cruise ships or through other airports. Forecasts call for the number of foreign tourist to Iceland to continue to increase in the coming years.

Number of foreign tourists travelling through Keflavík Airport		
Year	Number	Year-on year increase (%)
2015 (10)	1,108,986	
2014	997,556	23.6
2013	807,349	20.0
2012	672,773	18.9
2011	565,611	15.7

Table C1: Number of tourists travelling through Keflavík airport 2011–2015 (October)

A survey conducted for the Icelandic Tourist Board in 2014 shows that 36.5 per cent of all foreign visitors included west Iceland in their itinerary. They stayed an average of 2.11 nights, although nearly 8 per cent stayed more than 4 nights. The two largest professional groups with which these travellers identified themselves were 'artist/musician/actor' and 'vocational/technical'. The largest groups came from Britain and Scandinavia. The majority of those who visited west Iceland during their stay in Iceland responded having visited the country for the purpose of 'education and training', although many also visited for 'business/small meeting'. Like in previous surveys, 'nature/landscape' was most frequently mentioned as the most memorable experience of those who visited Iceland in 2014.11

The increasing number of tourists, both foreign and local, is bound to put an increased pressure on the natural environment and on other attractions in the proposed geopark. A newly published report commissioned by the Icelandic Tourist Board—"Tourism carrying capacity at eight popular tourist destinations in South and West Iceland, summer 2014" [Icelandic title translated here into English] 12 —is indicative of current and potential pressure to which the proposed geopark is exposed because it includes the popular tourist site Hraunfossar.

Grants allocated by the Tourist Site Protection Fund	
2015	
Snorralaug, Reykholt	5,500,000
SAGA Geopark – policy development	635,000
2014	
Hraunfossar – paths and security fences	2,950,000
2013	
Surtshellir – design of walking path through the cave	1,300,000
Snorralaug – design of signposts and installation	13,000,000
SAGA Geopark – policy preparation	1,265,000
2012	
Snorrastofa – design of signposts	3,000,000
Total	**ISK 27,650,000** (€ 194,677.00)

Table C2: Grants allocated by the Tourist Site Protection Fund to projects within the proposed Saga Geopark in the period 2012–2015.

The report concludes that there is a generally positive attitude towards Hraunfossar, its natural features and surroundings, but also that the existing infrastructure might be improved. Other sites within the proposed geopark have not been assessed in the same way, but there is reason to believe that a number of sites within the area would receive similar ratings as Hraunfossar. In this context it should be mentioned that the travel guide Lonely Planet recently named West Iceland as No 2 in the category "Best in Travel Regions 2016"13, a fact which will no doubt lead to increased tourist pressure in the area of the proposed geopark in the near future.

The Tourist Site Protection Fund has allocated grants to several sites within the proposed geopark every year since 2012, the year of launch of the geopark project.

Other global factors that may put pressure on the proposed geopark area include climate changes, in particular the warming effect, which will continue to accelerate the melting of the glaciers, thus increasing the flow of some of the rivers. Some geologists even expect Langjökull glacier to disappear completely within 150 years.14

The increasing number of holiday homes in the region may end up causing pressure on the groundwater, although water preservation measures are now an integral part of the Borgarbyggd Municipality Master Plan (see below).

C.2 CURRENT STATUS IN TERMS OF PROTECTION OF GEOLOGICAL SITES WITHIN THE PROPOSED GEOPARK

C.2.1 INTERNATIONAL LEGISLATION AND DECLARATIONS

As a member of the European Economic Area (EEA), Iceland implements certain EU legislation with regard to the environment, such as that concerning integrated pollution prevention and control, the protection of air and water, waste treatment, etc.15

Iceland is also a member of the Ramsar Convention, an international treaty on the conservation and sustainable use of wetlands and the protection of water birds. Six sites in Iceland fall under the Ramsar Convention, including one in Borgarbyggd Municipality—just outside the proposed geopark area. According to a recent proposal by a group of experts and representatives of local authorities, an investigation should be launched to determine whether Arnarvatnsheidi—roughly the eastern part of proposed geopark—should be designated as a protected wetland under the Ramsar Convention. Arnarvatnsheidi is one of the largest, or possibly the very largest, contiguous wetland area over 400 metres in altitude in Europe.

C.2.2 NATIONAL LEGISLATION

C.2.2.1 Nature conservation

A number of Icelandic legislative and regulatory acts aim to protect the country's natural environment in general as well as specific natural sites. In November 2015 the Icelandic parliament— the Althing — unanimously adopted a new Nature Conservation Act which implements a large number of reforms, including clear protection goals and the application of various principles of environmental law, amongst them the precautionary principle and the question of how it should be applied. The general public's right to access is formally established, but the Act also contains detailed provisions on the possibility to restrict traffic based on the use that the land owners make of the area in question as recognised in the protection order. In addition, a transitional provision stipulates that work should continue on the provisions regulating the tourism industry, taking into account the principles of the right of public access, the interests of protecting the nature, and the need to manage natural resources as an inevitable consequence of the exploitation of the natural environment by the tourism industry.

The Nature Conservation Act specifies the following five protection categories for sites of natural interest in Iceland:16

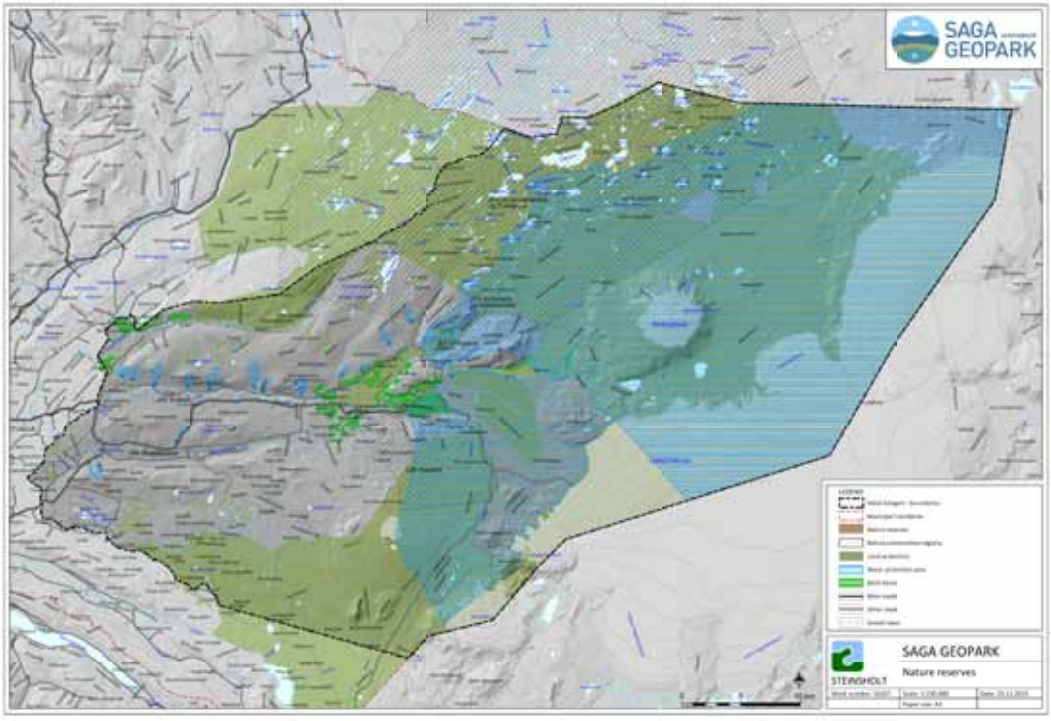
a) Nature reserves
b) Natural monuments
c) National parks
d) Country parks
e) Nature Conservation Registry

Several sites within the proposed geopark area have been protected under the Nature Conservation Act, see table C3:17

Site	Value	Protection category	Nature	Landscape	History	Art
Húsafellsskógur (forest)	Húsafell forest is an extensive birch forest which has become a popular recreation area. The combination of a location away from the sea and the proximity to springs and rivers adds to the specificity of the habitat. The size of the reserve is 436 ha.	Nature reserve	x	x		
Geitland (lava and sands)	The area is dominated by a vast lava and sand plain created by volcanic activity near Langjökull. Vegetation covers the land in many places. Large caves have been discovered in the lava fields. The size of the reserve is 12,281 ha.	Nature reserve	x	x		
Hraunfossar/Barnafoss (waterfalls)	Hraunfossar is a beautifully formed waterfall that emerges from under the Hallmundarhraun lava field and empties into the river Hvítá. Nearby, Barnafoss is surrounded by spectacular lava formations. The waterfall is known for its stone arches which the river has carved from the rock. The size of the reserve is 36 ha.	Nature reserve	x	x		
Kalmanshellir (cave)	A world-class natural phenomenon, Kalmanshellir is one of only a few caves on earth that exhibit spectacular and pristine lava formations. The objective of the protection is to prevent damage to these formations.	Nature reserve	x	x		

Reykjadalsá (river) and nearby geysers	Reykjadalsá is a calm river with lush vegetation which mostly stays open all the winter by reason of the warm water flowing into it from geothermal springs. This environment attracts ducks which use it as a winter station. The river's sinuosity lends it an unusual beauty. The sections having geothermal activity also have interesting flora and fauna.	Nature conservation registry	x	x		
Sudda	Pool surrounded with marshes. Unusually diverse wildlife. One of the few pools in Borgarfjördur which have not suffered damage.	Nature conservation registry	x	x		
Húsafell (farm)	Spectacular, varied scenery, expansive forests, pools and springs.	Nature conservation registry	x	x	x	x
Vídgelmir (cave)	A cave and adjoining lava field section in the land around Kalmanstunga farm. The cave is unusually large.	Nature conservation registry	x	x	x	
Surtshellir and Stefánshellir (caves)	Two caves and adjoining lava field section in the land around Kalmanstunga farm. Large lavatubes. Surtshellir is the largest and most renowned cave in Iceland.	Nature conservation registry	x	x	x	
Arnarvatnsheidi og Tvídægra (heath/moor)	Aquatic area of lakes Arnarvatn and Tvídægra. Fertile ponds, lakes, bays and rivers in the river basin of several rivers. Trout and birdlife.	Nature conservation registry	x	x		

Table C3: Nature reserves and nature conservation registries within the proposed Saga Geopark, cf. Act No 109/2015.



C.2.2.2 Archaeological and built heritage

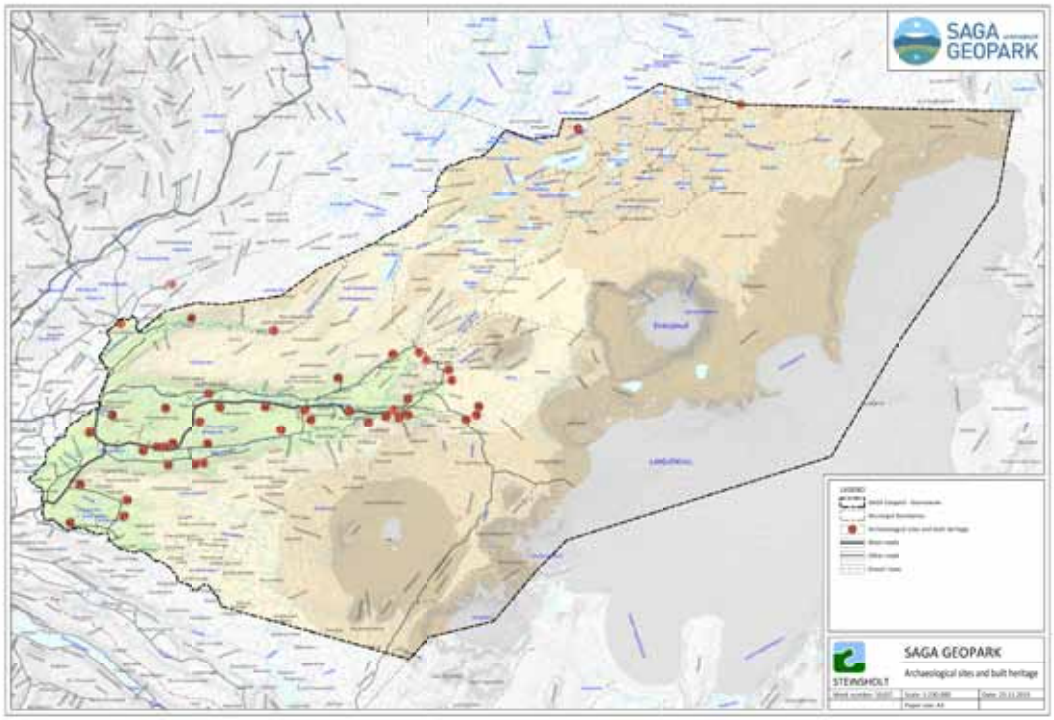
According to the Cultural Heritage Act, No 80/2012, archaeological heritage includes both archaeological artefacts and archaeological sites. Archaeological artefacts are those which are more than 100 years old, have been used by human beings or bear evidence of human intervention, and have been discovered in or on the earth or glacier or sea. Ships and boats dating to before 1950 are also considered to be archaeological artifacts. Archaeological artifacts can also be human or animal remains found in archaeological sites such as ancient mounds, cairns and graves.

Archaeological sites are any kind of remains of human settlement on land, underground, in a glacier, in sea or water that are man-made and more than 100 years old.

Built heritage

One of the roles of the Cultural Heritage Agency of Iceland is to protect the nation's built heritage. According to the Cultural Heritage Act, No 80/2012, buildings and other structures and their individual parts having heritage, scientific or artistic value are considered to be part of the nation's built heritage.

Archaeological sites	Value	Protection category	Nature	Landscape	History	Art
Breidabólstadur	Farm ruins	Archaeological heritage			x	
Reykholt	Snorralaug – old pool, ditch and piping	Archaeological heritage			x	
Afréttarland	Several farm ruins	Archaeological heritage			x	
Hofsstadir	Farm ruins and a stone	Archaeological heritage		x	x	
Húsafell	Several farmsteads and stones	Archaeological heritage		x	x	
Kollslækur	Farm ruins	Archaeological heritage			x	
Kalmanstunga	Several farmsteads and stones	Archaeological heritage		x	x	
Örnólfsdalur	Farm ruins	Archaeological heritage			x	
Gilsbakkakirkja	Old church — built 1908	Built heritage			x	
Reykholtskirkja	Old church — built 1886–1887	Built heritage			x	
Stóra-Áskirkja	Old church — built 1897–1898	Built heritage			x	



C.2.2.3 Planning Act

Under the Planning Act, No 123/2010, local authorities have the powers to establish water protection zones in their Master Plans. Water protection measures decided in such plans can be of two kinds: either measures provided for by laws and regulations applicable to existing wells, or water conservation measures which aim is to protect the least polluted water-rich areas, which are a resource in themselves, or areas which are likely to be used for abstraction of drinking water in the future.

	Water protection zones	Land type — Area size (in hectares)	Protection category
1	Kalmanstunga	Farm — 21 ha	Water protection
2	Fljótstunga	Farm — 31 ha	Water protection
3	Thorvaldsstadir	Farm — 62 ha	Water protection
4	Hallkelsstadir	Farm — 67 ha	Water protection
5	Kolsstadir	Farm — 19 ha	Water protection
6	Gilsbakki	Farm — 30 ha	Water protection
7	Bjarnastadir	Farm — 49 ha	Water protection
8	Kirkjuból	Farm — 40 ha	Water protection
9	Hvammur	Farm — 37 ha	Water protection
10	Haukagil	Farm — 123 ha	Water protection
11	Háafell	Farm — 65 ha	Water protection

	Water protection zones	Land type — Area size (in hectares)	Protection category
12	Sámsstaðir	Farm - 101 ha	Water protection
13	Thorgautsstadir	Farm — 100 ha	Water protection
14	Fródastadir	Farm — 47 ha	Water protection
15	Geitlandshraun	Lava field with surroundings — 23.610 ha	Water protection
16	Strútur	Mountain with surroundings — 1.544 ha	Water protection
17	Nordlingafljót and surrounding area	River with surroundings — 295 ha	Water protection
18	Arnarvatnsheidi and surrounding area	Moor with surroundings — 96.544 ha	Water protection
19	Síðumúli	Farm - 140 ha	Water protection
20	Breidabólsstadur	Farm - 42 ha	Water protection
21	Snældubeinsstadir	Farm - 51	Water protection
22	Hamrar	Farm - 29 ha	Water protection

Table C5: Water protection zones within the proposed Saga Geopark, based on Borgarbyggd Municipality Master Plan for 2010–2022.

Municipalities are also authorized to take action to protect the characteristics of heritage sites or areas of special historical, natural or cultural significance by putting them under to so-called "local protection" and including them in relevant development plans. Local protection is seen as a precautionary measure to be implemented while authorities await the opinion of the agency competent to assess the value for preservation of sites or old buildings. The Borgarbyggd Municipality Master Plan for 2010–2022 lists 2 geysers, 4 rivers, 4 areas and 15 buildings as enjoying local protection.

C.3 DATA ON THE MANAGEMENT AND MAINTENANCE OF ALL HERITAGE SITES (GEOLOGICAL AND NON-GEOLOGICAL)

Iceland has a number of legislation and policys to protect and maintane important geologial and non-geological sites. The Environmental Agency in Iceland is responsible for managing protected sites but in practice they are managed by the local municipalities, as is the case in Saga Geopark. On selected protected sites within the geopark a park ranger from the municipality operates during the summer months.

A complete listing on protection category can be seen in the following chapters: C.2.2.1, Nature conserve, C.2.2.2, Archaeological and built heritage, C.2.2.3, Planning Act.

All protected areas in Iceland are protected either by national or regional authorities are subject to planning regulations. Under the Planning Act, No 123/2010, there are three planning levels: regional, municipal and local and all plans covering the same area have to be consistent to each other.

The Icelandic administrative system is divided into two levels of government, central government (national) and municipailities (local). The local authorities has the responisbility to preper the planning regulations but the Ministry of Environment has supreme control over planning, with the assistance of the Planning Agency, and both municipal and regional plans are subject to the minister´s approval. Once approved by the minister, regional and municipal plans adopted by local authorities are legally binding.

Local level

Approved municipal plan is obligatory by all municipalities covering all land within its borders.

This plan covers the policy of the local authority regarding land use, transportation and service systems, environmental matters and the development of inhabitants during the period of at least 12 years.

Regional level

In Iceland there is no regional administrative level, but two or more municipalites can, at the initiative of the local authorities or the Planning Agency, preper a regional plan were the plan is to co-ordinate the policy of local authorities on development of inhabitants and land use over a certain period, at least a 12 year plan. A regional plan becomes legally binding when all involved have adopted the plan and the Minister has approved.

National level

On the national level there is no formal land use plannin, however the Planning and Building Act does, include a parapgrah about „plans and land use at national level" where it states that the Planning Agency shall have access to and preserve plans produced by public entities on land use, which apply for the whole country. This applies for example to plans for transportation, power structures, telecommunications and nature conservation.

D ECONOMIC ACTIVITY AND BUSINESS PLAN

D.1 ECONOMIC ACTIVITY IN THE PROPOSED GEOPARK

EMPLOYMENT OPPORTUNITIES IN SAGA GEOPARK.

Saga Geopark lies in Iceland's West Region and is a part of Borgarbyggd Municipality, one of 10 municipalities in the region. The West Region has a total population of around 15,400 people, 83 per cent of which live in its urban areas. Borgarbyggd has 3542 inhabitants, 360 of whom live within the area of the proposed geopark. The Geopark will share around half of its territory with Borgarbyggd, although only 12 per cent of the municipality's inhabitants live within the Park.

The Park lies within a rural area and the population is mostly farmers who increasingly participate in the growing tourism sector by offering accommodation and recreational activities on their farms or on land they own in the surrounding areas.

There are 64 farmsteads within the Park. Nearly half of the farmers (31) keep animals, cows, sheep, horses, pigs and goats, on eight farms the mainstay of the economic activity is greenhouse farming, and six are forestry farmers. Two farms generate electricity/warm water (for district heating) as their main economic activity. Finally, 11 farmsteads within the Park are not economically active. These are mostly owned by absentee owners who use them as second homes. Along with traditional farming, 14 farms are now engaged in tourism services, offering either accommodation, recreation or both.

Situated within the Park, the primary school at Kleppjárnsreykir serves 93 children and employs 32 staff, and Reykholt is a historic/cultural centre where around 60 people live and work. According to the latest figures, the unemployment rate in the West Region

as a whole is around 2 per cent, slightly below the national average of 2.4 per cent (Ministry of Welfare and Housing, 2015). The unemployment rate among people living within the Park is not known, but as this is a farming community, people are much more likely to be under-employed than having no work at all. Like many rural areas in Iceland, the population is ageing, the younger generations do not return after having left home for the purpose of obtaining an education.

Tourism

The geopark area is less than 100 kilometres away from the capital area and, because of its unique history and geology, has always been an important local tourist destination. There are 2,605 holiday homes in the West Region, including 1,090 in Borgarbyggd and 305 within the boundaries of the Park (Registers Iceland 2013). Some are privately owned, while others are owned by associations that rent them out to their members. In later years more options for accommodation have opened up as farmers in the area started offering home-stays at their farms. Three hotels operate within the Park: Fosshótel Reykholt, Hótel Á at Hvítársída, and the newly opened Hótel Húsafell. The Park also has three modern camping sites with full facilities: two at Húsafell and one at Kleppjárnsreykir. All three are heavily visited during the holiday season by both local and foreign visitors.

The West Region has participated in the recent tourist boom, which has resulted in an average annual increase in the number of visitors to Iceland of 9.3 per cent since 2000. Between 2013 and 2014, the increase was a full 23 per cent with over 1 million tourists visiting the country. Most stay in Reykjavík and the surrounding areas, with the West Region and the West Fjords seeing 12.9 per cent of all visitors coming to Iceland in the summer of 2014, and 6.9 per cent of foreign tourists visiting in the winter time that year (Tourism in Iceland in Figures, Icelandic Tourist Board 2014).

Almost 90 per cent of Icelanders travelled domestically in 2014. Of those, 14 per cent spent their holidays in the West Region. Many Icelandic families travelling within the country stay with relatives or friends, while 38 per cent stay in their own holiday homes and 31 per cent in holiday homes rented from various associations. Reykholt and Húsafell, both situated within the Geopark, are destinations for 11 per cent of Icelanders doing day trips in 2014 (Tourism in Iceland in figures, Icelandic Tourist Board 2014).

Education

The West Region enjoys an educational standard which is above the national average, with 41–45 per cent of the population having completed a university degree, compared to 31 per cent for Iceland as a whole. The percentage of the population that does not enter secondary education is steadily declining, dropping from 37 per cent in 2007 to 21 per cent in 2014 (Population Survey of the West Region (1), Iceland, 2014). This can partially be explained by the relative ease with which people living in the region can seek secondary and tertiary level education, given that the region is served by two secondary schools, in Borgarnes and Akranes, and two universities, Bifröst University and the Agricultural University of Iceland at Hvanneyri.

Jobs created by tourism

With tourism now becoming one of Iceland's biggest foreign currency earners, the number of jobs provided by that sector has multiplied. According to a June, 2014 estimate around 21,400 people were working in the tourism industry at that time (compared with 1,900 in heavy industry and 4,700 in fish processing) (Statistics Iceland, figures published in "Vidskiptabladid", 16 November 2015).

The Strategic Plan for the West Region (March 2013) contains a strategy on how to boost tourism in Borgarbyggd Municipality. The strategy calls for "making history visible" as a means of attracting more tourists to the region. This sits well with the overall objective of Saga Geopark, which focuses on Reykholt and Snorrastofa as well as the many and diverse geological sites and natural phenomena situated within the Park. In the plan, the following objectives to boost tourism have been selected for the region in next few years:

- To make history visible
- To create more jobs in culture-related tourism

- To increase off-season tourism
- To increase year-round jobs in the tourism industry
- To recruit the cooperation of landowners, municipalities and the Ministry of Environment in implementing the strategy

The strategic plan drawn up by the stakeholders for Saga Geopark rests on this wider-reaching planning document for Borgarbyggd, and has been incorporated into it. The Park and the municipality are thus moving forward as one to implement the strategic plan for Saga Geopark, in alignment with the global Geopark agenda.

Saga Geopark—Budget and financing for the period 2016–2019

			EUR		
Expenses	**2016**	**2017**	**2018**	**2019**	**Total**
Administration cost	40,800	45,000	49,500	54,400	189,700
Travel costs	5,200	5,600	6,200	6,800	23,800
Communication/exhibition, etc	4,300	4,700	5,200	5,700	19,900
Project – Drifting apart	6,300	3,100	3,100	-	12,500
Project information/knowledge	6,800	6,800	-	-	13,600
Project landscape/geology	71,000	71,100	49,800	35,600	227,500
Project Saga art/nature	3,600	2,900	2,900	-	9,400
Project Saga local products	-	-	2,900	2,900	5,800
Total (EUR)	138,000	139,200	119,600	105,400	502,200

			EUR		
Financing	**2016**	**2017**	**2018**	**2019**	**Total**
Borgarbyggð Municipality	24,900	24,900	24,900	24,900	99,600
International funds (Drifting Apart)	6,300	3,200	3,200	-	12,700
Private funding	37,100	42,600	35,500	28,500	143,700
Regional funds	35,500	32,900	19,000	14,900	102,300
Local Partners	30,600	30,600	30,600	30,600	122,400
Use of logo and miscellaneous sales	3,600	5,000	6,400	6,500	21,500
Total (EUR)	138,000	139,200	119,600	105,400	502,200

D.2 EVENTS, PROJECTS AND FACILITIES

D.2.1 Existing and planned facilities for the proposed geopark

The historical importance of the area, as well as its unique landscape which boasts hot water springs, glaciers and waterfalls, together with the relative proximity to the Capital, have long since made the Saga Geopark area a popular destination for the local population. With Iceland growing in popularity as a tourist destination, the area has also seen a growth in foreign visitors, West Iceland recently being named as one of the top-10 destinations in the world in 2016 by the Lonely Planet travel guide. Saga Geopark already has a number of cultural and natural sites that can be exploited to attract more visitors. This chapter gives an overview of these facilities and the investments planned for Saga Geopark to go forward.

Reykholt: One of the most remarkable historical sites in Iceland, in large part on account of the mediaeval scholar and author Snorri Sturluson, who lived there from 1206 until his assassination there in 1241. For many centuries, Reykholt has also been the site of a church and rectory, and of a country school between 1930 and 1997. Thousands of travellers visit Reykholt every year.

The cultural and mediaeval Centre Snorrastofa in Reykholt was founded in 1995 in memory of Snorri Sturluson. The institution receives visitors and hosts exhibitions on his life and career, and holds exhibitions. It runs a small shop offering Icelandic handicraft, art, and books on Icelandic culture. Snorrastofa also

organises concerts in Reykholt Church, renowned for its acoustics, and hosts the annual Reykholt Festival, a classical music festival held in late July.

The role of Snorrastofa is to promote and study mediaeval culture, local history and the works of Snorri Sturluson. Snorrastofa houses a conference and meeting space, guest apartments for visiting scholars, and a library, well-stocked with works on mediaeval culture, intended for scholarly and public use alike. Snorrastofa has initiated and participated in many international studies on literature, archaeology, geography and history, and has published books in these fields as well.

Currently Snorrastofa participates in the following international research projects:

- The Reykholt project – An international research project in the fields of literature, archaeology, geology and history.
- Reykholt and the European art of writing, a mediaeval research project.
- Aesthetics, an International Forum on the aesthetics of art.
- Nordic Mythology. The Reykholt Publishing House is preparing the publication of a book on Nordic Mythology, presenting all the main sources of, and various academic research into, that topic.

Snorrastofa and Saga Geopark have entered into a partnership to promote the Park within and outside of Iceland. Snorrastofa has a member on the board of the Saga Geopark committee, and has organised various lectures and talks relating to the history, geology and culture of the Geopark and the inhabitants' way of life. These talks have attracted members of the local population as well as visitors to the area. Below are some of the exhibitions, talks and lectures held at Snorrastofa in 2013–2015:

- The Painters at Húsafell
- Herding and angling on the Arnarfell heath
- Programme on Thorsteinn of Úlfsstadir
- The outlaws in Snjóöldufjallgardur in words and pictures
- Gilsbakki and Surtshellir, the upstate of Borgarfjördur in an international research programme
- The daughters of the valley; ten women in ten ages
- The mediaeval structures at Reykholt, a forum for scholars
- The saga of Snorri, an exhibition
- Pearls in Reykholtsdalur, a photo exhibition
- The distribution of farms in the area from the settlement of Iceland to current times
- Female storytellers in Borgarfjördur
- Ancient openings: An exhibition on archaeology digs in the area
- Ástrídur and Jósep of Signýjarstadir—a rural trader and a rural poet
- The entrepreneur Erlendur Gunnarsson of Sturlureykir and the harnessing of geothermal heat in Borgarfjördur
- An exhibition on the tombstones at Húsafell
- Fjalla-Eyvindur and Halla, heroes of the wilderness

Snorralaug: Also in Reykholt. A stone-lined pool fed by warm geothermal water, one of the oldest historic sites in the country.

The Art Centre at Húsafell: Húsafell is the home of the artist and sculptor Páll Gudmundsson. Páll works with materials found in the area. His stone sculptures and his stone harps, which he also plays, are internationally renowned. He also paints and makes musical instruments from materials found in nature, such as pan flutes made of rhubarb and flowers. The Art Centre at Húsafell is currently being expanded to include permanent exhibitions on the "painters and poets at Húsafell" (see D.3).

Fljótstunga Artist Residency: A farmstead within Saga Geopark. The residency hosts national and international artists and promotes connections to the Icelandic natural, cultural and art scene.

Kolstadir: A farmstead within Saga Geopark. Not currently an active farm but an art residency that hosts a music studio, painters and creative art.

Stedji Brewery: A microbrewery within the Geopark. Uses its own spring water to brew its beer.

Local food markets: Held two times a year, in December and July. Catering for both the local population and foreign visitors, the farmers sell local produce, vegetables from their greenhouses and other home-grown produce, as well as locally made handicrafts.

The rhubarb festival: Held in the spring when the rhubarb has grown to size. The locals gather and bring products made of rhubarb, a much-used plant in Icelandic households. Last year over 140 products were presented at the festival, which attracts visitors from all over the West Region and beyond.

Hallmundarhraun: A lava field formed in a giant eruption taking place close to Langjökull glacier around 930. The field is home to three large caves: Surtshellir/Stefánshellir and Vídgelmir. Surtshellir/Stefánshellir together measure 3,500 metres, thus forming the longest lava cave in Iceland. The Vídgelmir lava tube is the largest of its kind in Iceland with a volume in excess of 150,000 cubic metres.

Hraunfossar and Barnafossar: Two of the best known natural features in Iceland, these are two waterfalls on the Hvítá. Hraunfossar emerge from under the moss-covered lava and empty into the river after flowing down a series of rock steps, while Barnafoss, named after two children who fell to their deaths while crossing a narrow stone arch spanning the river, is found six kilometres upstream.

Langjökull ice cave: This enormous (300 m) tunnel with adjoining caves heads into Langjökull glacier at 1,260 m above sea level. The glistening, LED-lit tunnel opened in 2015 and provides information to visitors on how a glacier forms. It also houses a small chapel for those who want to tie the knot inside a glacier.

Deildartunguhver is Europe's most productive hot spring, splashing out 180 litres of 100°C hot water every second. Most of the water used for central heating in the towns of Borgarnes and Akranes is taken from this hot spring.

Krauma: These natural baths are under construction at Deildartunguhver. Using the natural warm water from the hot spring, Krauma will provide facilities for up to 140 guests with its various pools, saunas and rest rooms. A restaurant, serving locally-produced food, and a bar will be on the premises together with a souvenir shop. The facilities will open in 2016.

Háafell: The Icelandic Goat Centre: Home to the endangered Icelandic breed of goat. The farmers are working hard to save the stock from extinction. They also make products such as goat cheese, milk and meat, all of which can be bought at the farm.

Walking trails: The Park has many walking trails of varying degrees of difficulty, ranging from short, easy treks to very demanding glacier walks. Maps with marked trails for the area around Reykholt and Húsafell are available. A more comprehensive map of the whole geopark with marked trails will be published in 2016.

Horse-riding routes: Horse-riding is a growing sport in Iceland and the Icelandic horse is gradually becoming better known as a breed internationally. Several farmers in the geopark area breed horses, especially those in Reykjardalur. The Borgarbyggd Municipality Master Plan (2010–2021) incorporates planned riding trails both within and outside the Park, many of which already exist. Horse-riding trips are offered in the Park, suitable for beginners as well as experienced riders.

Bicycling trails: Mountain biking is becoming more popular in Iceland, and many travellers, both locals and foreigners, are taking biking trips as a part of their holidays and/or using a bike as their means of transport. The Park has many possibilities to cater for this. A guide to mountain biking has been published for West Iceland and includes information about trails in the Park.

Various leisure opportunities are available in and around Húsafell. The warm swimming pool with hot tubs is popular with families with children. There are also thematic walks in the summer and opportunities to go golfing or angling, to name a few of the options.

D.2.2 Future projects, events and facilities

Infrastructure: There is a need to strengthen the infrastructure of the area by identifying and defining more trails for hikers, bikers and horse riders. It is also necessary to renew the markings of some of the geo-sites, and mark any new trails identified. The paths will be defined using the knowledge of the local population and existing ancient pathways. The trails will be marked with signposts, and travellers will be able to access information on the trails both through electronic media and using more traditional maps.

Historical and cultural sites: One section of the Park lies in an agricultural area where people have lived for centuries. This leaves many visible ruins and other historical and cultural sites that can be explored. There are a lot of possibilities in making the history and culture of the area come alive by highlighting these sites and providing links to the past.

Ancient routes: A number of ancient routes connecting the northern and southern parts of Iceland, Kaldadalsvegur, Okvegur and Skagfirdingavegur, run through the Geopark. These were the most travelled highland routes for centuries and were shown as marked by vördur (cairns) in maps from 1944 (Geodætisk Institut 1944a; Geodætisk Institut 1944b). The routes will be revived as trekking, riding or biking paths where possible, and linked with geo-educational programmes, restoring the vördur wherever possible.

Communication: It is important that visitors have access

to detailed information on the geology, history and culture of the area in one place. To facilitate this a 'Geo-corner' will be set up in Reykholt as a place to exhibit and explain the geology and history of the Geopark area. Local food products will also be available in the Geo-corner.

Education: Well-informed guides are essential when it comes to meeting the expectations of visitors to the Park for information on history, the Icelandic sagas, and the complex natural phenomena found in the area. In this regard, preparations have begun to develop a curriculum for Saga Geopark guides in partnership with a local educational institute in the West Region (Símennt).

Children: One of the ideals behind the geoparks movement is strengthening the livelihoods of both the existing population and future generations. It is therefore important to educate children of all ages so as to stimulate their interest in their surroundings. This will be done by working with the local school to develop learning materials and organise field trips to some of the many important geological, historical and cultural sites within the Park. Snorrastofa will also play an important role in providing a historical context to life within Saga Geopark.

Local food: Local food production already exists within the boundaries of the Park. The farmers produce animal products, meat, milk and cheese. There is a considerable amount of greenhouse production using local geothermal heat, and this is the only place in the country where products from goats are available. Rising temperatures due to a warmer climate have also made the cultivation of wheat and barley possible in the region. Given the highly sustainable way that farming is conducted in the area, local food processing has a considerable potential to raise the income of the local population while at the same time making it possible for visitors to the Park to enjoy wholesome locally-produced food. The newly opened Food Lab in Borgarnes will facilitate this development by helping farmers to develop new food products through the provision of expertise and facilities. All food products originating in the Park will be marketed under the Geopark label.

Events: Special events will be organised to boost the awareness of both the local population and visitors of what the area has to offer, whether in terms of geology, history or cultural sites. Every opportunity will also be used to promote the ideals of the geopark.

The 2016 Geopark festival week is already in the planning stages. To attract more visitors it will now be held in the spring in connection with the rhubarb festival.

A bicycle tournament will be held on 18 August 2016. The route will begin at Laugarvatn, pass through Kaldidalur and into Húsafell. The tournament is organised by the main off-road biking associations in Iceland, and will be a regular feature on the calendar of Saga Geopark.

D.3 ANALYSIS OF GEOTOURISM POTENTIAL OF THE PROPOSED GEOPARK

Background

The West Region in general and Borgarbyggd in particular already have sizeable local tourism, rooted in the 2,609 holiday homes registered in the region, 305 of which are situated within the Park. Húsafell Travel Service, situated within the Park, offers facilities such as a golf course, swimming pool, camping facilities, cottages for rent, a shop and a restaurant. These facilities were originally built to cater for the many holiday homes in Borgarbyggd and beyond, and now attract both Icelandic and foreign visitors travelling through or making Húsafell their destination. Húsafell and other farms within the Park are family friendly and offer recreational programmes for children in the summer. This makes the Geopark an ideal destination for families with children. The Park also aims to cater for geology enthusiasts and those interested in the sagas and the history and culture of Iceland. More adventurous visitors will also be able to find activities to their liking, such as horse-riding tours, or snowmobiling and dog sledding on Langjökull glacier.

Saga Geopark has a lot to offer the intended target groups in terms of existing attractions and activities. In order to expand geotourism in the area it is important to package the available potential in such a way as to appeal to these groups. Geotourism must be approached systematically and can be developed on three levels:

Basic level: Here we find activities that visitors can engage in on their own when visiting the Park: walking

and bicycling, horse riding, angling, visiting the permanent exhibitions at Húsafell, Snorrastofa and Reykholt, the geothermal swimming pools at Húsafell and Kleppjárnsreykir or the new Krauma nature baths at Deildartunguhver. Some of these activities are seasonal while others are open to visitors all year round, depending on weather.

Organised activities: These are activities offered by tour operators within or outside the Park. They can range from a single one-day event, such as visiting the ice cave in Langjökull, to a longer stay in the Park focusing on guided tours to specific areas. The themes for the tours should build on the three central themes that have been developed for the Park (see D.4.1.).

Highlights: Events celebrating the specific offerings of Saga Geopark should be organised. The Geopark Week, to be held in the spring of 2016, is one such event where the themes of the Park will be highlighted through a series of activities.

For the Saga Geopark concept to come alive it is important to ensure that all key players are familiar with it. The development of a curriculum to train geo-guides is underway, and it is anticipated that training can commence in early spring 2016. This training will be further developed and extended with the aim of reaching all front desk staff in the Park, as well as those offering accommodation and recreation, before the end of 2017.

Activities and events on permanent offer:

- Walking tours, guided and unguided (organised and basic)
- Bicycling tours, guided and unguided (organised and basic)
- Angling in Arnarvatnsheidi (organised and basic)
- Horse riding tours, ranging from shorter day trips with o r without a guide to multi-day guided tours catering for the more experienced riders
- Into the glacier—guided tours into the ice cave in Langjökull
- Guided tours into the caves Vídgelmir and Surtshellir
- Guided tours onto the glacier, snowmobiling, dog sledding
- Organised art events at Húsafell and Kolstadir
- Snorrastofa and Reykholt offer organised programmes all year round with lectures, concerts, and an annual classical music festival held in July

Planned activities 2016–2019:

- Construction of an exhibition centre showcasing the Icelandic horse at Skáney farm; to be operational in 2017
- Construction of an outdoor activity centre at Húsafell; a gateway to the Park with information on all that is on offer; to be operational in 2018
- Construction of Krauma, the natural baths at Deildartunguhver; to be operational in 2016.
- A permanent exhibition in Húsafell on the ancient tombstones cut by the ancestors of reverend Snorri Björnsson; with the collaboration of the National Gallery of Iceland; planned for 2016
- An art gallery at Húsafell, a permanent exhibition on the musical instruments made by Páll Gudmundsson and the "the painters and poets of Húsafell"; planned for 2017
- The local food and handicraft festival, held in spring and autumn
- The annual rhubarb festival, held in the summer
- The Geopark Week, to be held in the spring
- Ongoing organised tours within the Park

Objectives and anticipated results for 2019

The overall objective is to develop the area further as a tourist destination. This is to be achieved by building on the Saga Geopark concept which encompasses history, the sagas, culture, local food and the magnificent landscape. The Park's recognition as a member of the European Geoparks Network and, together with Katla Geopark and Reykjanes Geopark, of the National Network of Geoparks will open up the opportunity to participate in national and transnational projects to promote and strengthen the geopark concept nationally and internationally.

On the local level plans call for:

- The present formal cooperation with Borgarbyggd municipality to be strengthened and enhanced;
- All planned trails (walking, bicycling and horse-riding) to be marked with the relevant information;
- All planned brochures relating to the trails and themes of the Park to be published and made available for distribution;
- All operators and accommodations within the Park to be capable of providing professional information about the Geopark;
- The local population to continue to be informed on the development of the Park, enabling each individual to act as an ambassador for the Park;
- The Park to attract people wanting to build businesses based on the themes of the Park;
- The Park's share of visitors to Iceland to increase from the current 13 per cent (in season) and 7 per cent (off season) to 18 per cent and 12 per cent respectively;
- At least 7 to 12 year-round jobs and up to 40 seasonal jobs to be created in the next four years.

D.4 OVERVIEW OF THE SUSTAINABLE GROWTH OF GEOTOURISM AND THE ECONOMY, GEO-EDUCATION AND GEO-HERITAGE

The (aspiring) Geopark will contribute to the future growth and economic development of the West Region. The unique landscape within the Geopark and its abundant water resources, both hot and cold, combined with its rich history, make the Park an ideal destination for both local and foreign visitors. With the increasing number of visitors to Iceland, the Geopark will fill a need for an authentic experience that allows geological, historical and cultural sites to be protected and promoted at the same time. Being first and foremost a small scale farming community, the sustainable use of natural resources is of utmost importance to the residents. The Geopark should therefore be a place that embraces sustainability while at the same time developing a robust tourism industry.

4.1 GEOTOURISM AND THE LOCAL ECONOMY

Saga Geopark aims to develop sustainable geotourism with three central themes:

- The history and the sagas
- Art and Culture – painters and poets
- Local food and other locally made products

History and the legacy of the sagas are evident at every step within the Park. Reykholt and Snorrastofa (see D.2) will play a key role in promoting the historical and cultural aspects of Saga Geopark. The proposed links with Saga Geopark—through the 'Geo-corner', the educational programmes for children, and the lectures for the wider audience, will enhance the visibility of Reykholt and Snorrastofa, and at the same time Snorrastofa will be able to meet the needs of the Geopark for education and general information about the Park. This partnership has already borne fruit in that Snorrastofa has published a book, Hvítur jökull, snaudir menn ("White Glacier, Destitute People"), a historical account of life in the area, in cooperation with the Geopark committee, and bearing the Geopark logo.

The 'Art and Culture' theme is currently being developed. Historically, some of Iceland's best-known painters, writers and poets, notably the painters Ásgrímur Jónsson, Thorvaldur Skúlason and Júlíana Sveinsdóttir and the author Gudmundur Bödvarsson, used Húsafell and its surroundings as an inspiration, resulting in the creation of many of their finest works. To celebrate these artists and highlight their connection to the Park, an Art Centre is being set up in the Húsafell cluster where the lives and works of these artists and their relevance to the area will be highlighted. All of this, together with the works of Páll Gudmundsson and the contributions of Snorrastofa, will add to the strong profile of the Geopark as a haven of art and culture.

With the growing number of foreign visitors, the focus on and the demand for locally made food has increased in the entire country. In Saga Geopark, the farmers are well equipped to answer the call for locally processed food, as the area is already a producer of varied foodstuffs produced in a sustainable way (see also D.2.2). The possibilities created by the abundance of warm and cold water for food production and processing will be explored further by linking up to the newly established Matsmidjan ("Food Lab") in Borgarnes, which intends to support the processing and production of new foodstuffs in the region. The farmers in Saga Geopark are well aware of the many ways in which they can make their products more valuable by targeting the rapidly growing tourist market, and in so doing they contribute to the growth of the local economy.

Geo-education: The partnership between the Geopark, Snorrastofa and the local school will ensure the growth and vitality of the educational aspects of the Geopark ideology. Snorrastofa is firmly established as a cultural centre that regularly organises talks and lectures for wide audiences on the history and geology of Saga Geopark and its surroundings. In the future, the focus will be on educating school children and students living in the Park about their surroundings, in cooperation with the local school and Snorrastofa. Universities from all over the world will also receive a warm welcome.

Educating geo-guides is a priority for Saga Geopark. The Park's unique natural environment calls for a certain level of expertise on their part so as to make it possible for visitors to learn about and enjoy what they are exposed to in the Park. It is also important to keep the local population well informed about the history and geology of the Park, given that they are the ambassadors of Saga Geopark.

Geo-heritage: The geological heritage of the Park is generally well protected under the Nature Conservation Act. The geology of the area is of huge interest to researchers and there are ongoing short- and long-term research projects within the Park. Researchers from Brown University, Rhode Island, have conducted extended research on the cave Surtshellir and its use in the early settlement period (about 900 CE). The Geopark has collaborated with three Icelandic universities (the University of Iceland, Bifröst University and the Agricultural University at Hvanneyri) on research into various aspects of Saga Geopark. The results will broaden the knowledge base of the Park and will be disseminated and packaged for various identified audiences.

Syowa Station, one of five similar centres dedicated to the study of the northern lights, is situated on the farm Augastadir within the Park. It receives funding from the National Institute of Polar Research in Japan. The researchers are collecting ground-based network observational data, which are used to study the mechanisms of various auroral phenomena and solar wind-magnetosphere-ionosphere coupling.

D.5 POLICIES FOR, AND EXAMPLES OF, COMMUNITY EMPOWERMENT (INVOLVEMENT AND CONSULTATION) IN THE PROPOSED GEOPARK

Saga Geopark caters to a wide range of visitors. The Park sees itself as an attractive destination both for holiday home owners in the region, nature enthusiasts, and people interested in history and culture. It is already being promoted as a tourist destination through local, national and social media, brochures, tour operators, travel shows (West Norden, Mid Atlantic), and West Iceland, the official travel guide to the West Region. Last year, the

Park received the visit of 400 different tour operators and media people in connection with the opening of the Langjökull ice cave.

Saga Geopark cultivates links with the public administrative bodies in charge of tourism in the country, the Ministry of Industry and Innovation, and the Icelandic Tourist Board. It is also a member of the National Geoparks Network together with Katla Geopark and Reykjanes Geopark.

Saga Geopark is a member of the local network to promote tourism in the West Region. The new management committee for the Park is currently drawing up a communication plan for 2016–2017 that will promote the Park in a systematic way.

At the local level, the Geopark's preparatory committee includes a wide range of stakeholders who are well placed to promote the ideals of the Park through their work. The committee works with an independent project manager who is responsible for taking the project forward. Of the eleven members of the organising committee, six come from the local community—including farmers with a stake in the tourism industry, a local hotel manager, and the manager of Snorrastofa; two are local politicians in Borgarbyggd Municipality; one is the manager of West Iceland, the local tourist board; and finally the rectors of both universities in the West Region, Bifröst University and the Agricultural College of Hvanneyri, also sit on the committee.

A logo and a flag have already been designed for Saga Geopark and will be used to brand all its products.

All these representatives are deeply involved in the project of bringing Saga Geopark forward. They all have a stake in the project and can contribute to its progress in their respective capacities and act as ambassadors of the Park in their daily lives.

The advocacy for the Geopark in the local community through extensive meetings and information sharing that resulted in the Strategic Plan for the Geopark has already been covered (see D.2).

D.6. POLICIES FOR, AND EXAMPLES OF, PUBLIC AND STAKEHOLDER AWARENESS IN THE PROPOSED GEOPARK

Saga Geopark´s primary focus is to raise awareness of the geology and landscape which can be found within the area. Cultural history, art and local produce are equally important and are within the targeted focus.

To implement the awareness it is necessary to cater to a wide audience, the most important groups are the local people who live within the park and guests who come to visit either for a limited time or longer. On the broader spectrum the geopark philosophy has to reach national level by the cooperation between all the Icelandic geopark´s.

Saga Geopark has a good relationship with the local newspaper "Skessuhorn" published in the Borgarfjordur region. It has featured many articles about the geopark and is on their monthly "call list" for news and updates. There have been several articles in other national and tourism newspapers both in Icelandic, English and one in Chinese.

Other communication media is important, such as a website which will be fully developed in 2016 and will be linked to existing websites both in tourism as well as organisations in West Iceland. Social media like Facebook, Instagram etc. are used as a part of communication plan for the next years.

Education about the heritage in the area will continue with the cooperation with Snorrastofa the local schools and universities, to strengthen the "sense of place" with the locals, also to make them aware of the park and encourage to participate in the development and activities.

Organised activities and events such as varied guided tours, exhibitions and festivals as the geopark week for the first time in spring 2016 will further enhance the awareness of the geopark and will be a permanent feature in all planning. This will also help to the overall objective to develop the area further as a tourist destination.

E INTEREST AND ARGUMENTS FOR JOINING THE GGN/EGN

GLOBAL GEOPARK AS A HOLISTIC TOOL TO IMPROVEMENT

The remnants of the ice age have left their mark on the geography of Saga Geopark. These remnants, together with the multiple lava fields, rivers, lakes, glaciers, and hot springs which exist within a relatively restricted geographic area, bear clear witness to the shaping of the land through natural processes. This shaping by the forces of fire and ice, along with the later phenomenon of human activity, has led to the creation of a unique geological and culturo-historical heritage that both younger and older visitors will find it interesting to explore and learn about.

The geographical region concerned is sparsely inhabited, and making a living in other ways than through farming became possible only quite recently. A few years ago a number of municipalities in the area merged without this being accompanied by new economic developments. The exception to this is tourism, in which more and more people gradually have become active. Being accepted as a member of Global Geoparks Network would open up the possibility to introduce improvements in a variety of fields. The membership could be used as a tool of progress and development in many existing areas, and to create an integral vision of the elements which contribute to the community's cohesion.

The entire area could be restructured as the new Saga Geopark with the aim of attracting larger numbers of visitors, but also with a view to preserving vulnerable natural phenomena and geological and cultural remains for the enjoyment of generations to come. In this context, it will become necessary to provide the general public with increased information about different aspects of the heritage which is characteristic of the area, both with regard to what has already taken place, such as events connected with volcanic activity, and with regard to future events such as the melting of glaciers.

Saga Geopark is aiming for the reshaping of the area, and looks to the future on behalf of generations to come by applying to become a member of Global Geoparks Network. Ever since the idea was first discussed, the inhabitants of the area have worked diligently on coming up with ideas on how best to proceed to implement the Geopark ideology. The report presented herein is the result of that work, and Borgarbyggd Municipality participates fully in this process.

Although Saga Geopark will not cover the entire territory of Borgarbyggd Municipality, becoming a member of the Network would have enormous significance for the community. Its specificity will be enhanced by the fact that it is home to a UNESCO Geopark, and the tourism industry will also benefit. The membership will also provide challenges and encourage the further development of infrastructure, as well as the protection of remains of geological or cultural importance.

Other sectors than tourism will also receive a boost. Both on-farm production and other production sectors will have a stronger platform to grow. Joint marketing under the Geopark brand will provide an incentive for improvement and for increased cooperation. This will also make it possible to differentiate the products and to better support production processes.

The recognition of the Global Geoparks Network would without any doubt provide an economic boost to the entire region. Cooperating under the auspices of UNESCO is a sign of quality and suggests a professional approach. Membership would enable Saga Geopark to take advantage of the knowledge and experience of other geoparks, and we would be able to provide the same in return. Collaboration on specific projects would become easier with better access to international funding.

The central objective of Saga Geopark is to be a good representative of the UNESCO Global and the European Geopark Networks, and to promote geoparks both at home and internationally.

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