



## TENTATIVE LIST SUBMISSION FORMAT

Mennta- og vinnuáhringarmálaráðuneytið	Ab: RHP	(B)
27. FEB. 2013		
Tilv.: MMR	11040177	
Db:	30-639	

STATE PARTY: ICELAND

DATE OF SUBMISSION: 27.2.2013.

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NAME OF PROPERTY: Torfajökull Volcanic System / Fjallabak Nature Reserve

State, Province or Region: Iceland,

Latitude and Longitude, or UTM coordinates: 63°56'N 19°03'W

### DESCRIPTION:

The Torfajökull area is approximately 600 km<sup>2</sup> rhyolite massif at an altitude of 600-1200 meters above sea level in the south central Icelandic highlands. It covers the Torfajökull volcanic system along with the southern tip of the Bárðarbunga volcanic system to the north. The landscape is spectacular, mountainous, screes are abundant and the effects of volcanic activity are highly dominant. Craters, lava and hyaloclastite characterise the northern part of the area, but light coloured rhyolite the Torfajökull caldera to the south. The high-temperature geothermal field associated with Torfajökull is the largest and most powerful in the country and the terrain inside the caldera is typified by immense geothermal activity. Fumaroles and hot springs are widespread and steam plume visible in many places. These conditions create different habitats for the biota that is diverse, especially when taking into account the high elevation. The conservation value of the area is indisputable and a part of the Torfajökull area, the Fjallabak Nature Reserve (446 km<sup>2</sup>), has been protected since 1979 and is a popular place for tourism and hiking.

The Fjallabak Nature Reserve lies at the boundary of two different volcanic zones, a rift zone and a flank zone. Eruptive formations in the nature reserve pertain mostly to the Torfajökull volcanic system in the South Iceland flank zone. However, craters and lava in the north and northeast parts of the reserve relate to the fissure swarm of the Bárðarbunga volcanic system, which stretches out to the southwest from the middle section of the rift zone. These two volcanic systems are dissimilar in many respects. The Bárðarbunga volcanic fissure swarm is a part of the rift zone and only ejects basaltic magma. The Torfajökull volcano has no clear volcanic fissure swarm, displays limited divergence and the bulk of the volcanic material is rhyolite. In the middle of the volcano is a large, elliptical caldera which is about 16 km from west to east and about 12 km from north to south. Little is known about the age of the caldera but it is likely to be about 500,000 years old.

For a long time, there has been very little volcanic activity in the eastern and southern sections of the caldera, as the landscape clearly indicates. The erosive forces, mostly glacial rivers, have shaped the landscape which is characterised by deep ravines and gullies with sharp edges between them. The whole eroded area is extremely colourful. In the western and northern parts of the caldera, the landscape is characterized by greyish and black rhyolite lavas. The terrain in the northern part of the reserve, north of Landmannalaugar, has a different and darker appearance than that of the area within the Torfajökull caldera. The volcanic formations in this area belong to the Bárðarbunga volcanic system. Alluvial plains and basaltic lava cover nearly all of the flat land. Huge black and red tephra craters rise out of the lava, together with sporadic hyaloclastite ridges.

In the northern part of the reserve, an exceptional phenomenon can be observed: the crustal extension that accompanies eruptions in the Bárðarbunga volcanic system has extended into the Torfajökull area and set off volcanic eruptions within the caldera. Eruptions have then happened simultaneously in both volcanic systems, rhyolite at Torfajökull and basalt in the Bárðarbunga volcanic fissure swarm. At the junction of the volcanic systems, i.e. in the vicinity of the caldera edge, a blend of these two types of

magma is typically seen, i.e. basalt and rhyolite in the same lava. During the Holocene, eruptions have occurred up to 11 times in the Torfajökull area, all eruptions being in the western and northern parts of the area. Eruptions have occurred at least six times concurrently at Bárðarbunga and Torfajökull, two of which have happened since Iceland was settled.

The largest and most powerful high-temperature geothermal area in the country lies within the Torfajökull area. The geothermal activity is very diverse and there are many rare geothermal phenomena. The most important distinctive feature of the geothermal activity in the Torfajökull area is the presence of so-called "boiling pans". "Boiling pans" are shallow, boiling thermal pools with a sand or gravel bottom. An even, constant boil or gas flow is present through much of the pool. Mudpots and mud pools are also present almost wherever geothermal activity is found. Fumaroles are fairly widespread while sulphur mounds and altered ground are common. Steam vents and fumarolic salts in hot ground are widely distributed. In the hot spring areas silica and calcium carbonate deposits are common and microbial growth is evident. Diverse and unique thermophilic bacteria and archaea are found at the geothermal area at Torfajökull.

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### **Justification of Outstanding Universal Value:**

(Preliminary identification of the values of the property which merit inscription on the World Heritage List)

The Torfajökull volcano is an outstanding example of a rhyolite volcano in an extensional, oceanic setting. It presents an unequalled opportunity to study the generation of continental silicic crust within oceanic basaltic crust. The abundance and diversity of rhyolitic formations produced during volcano-ice interactions is unmatched by any other volcanic province. This includes a number of well-formed rhyolitic tuyas (table mountains). The interaction between the Torfajökull volcano and the Bárðarbunga volcanic fissure swarm is exceptional. Crustal extension and basaltic fissure eruptions in Bárðarbunga have repeatedly triggered eruptions of rhyolite and mixed rocks at Torfajökull.

The extensive geothermal system at Torfajökull exhibits exceptionally diverse geothermal surface features, including thunderous fumaroles, mudpools, solfataras, hot springs, "boiling pans" and carbonated springs. Thermophilic bacteria and archaea are diverse and unique.

The Torfajökull volcano presents an extraordinary landscape of exceptional natural beauty and aesthetic importance. The remarkably diverse landforms arise from a combination of volcanic, geothermal, glacial and fluvial processes. Abundant rhyolitic hyaloclastites and breccias have suffered widespread geothermal alteration resulting in a brilliantly colourful landscape, mixing yellow, pink, green, red, brown, black, blue and white colours. The area is among the most popular touristic sites in Iceland.

### **Criteria met** [see Paragraph 77 of the *Operational Guidelines*]:

(Please tick the box corresponding to the proposed criteria and justify the use of each below)

(i)    (ii)    (iii)    (iv)    (v)    (vi)    (vii) X    (viii) X    (ix)    (x)

#### **Criteria vii.**

The area contains remarkably diverse landforms resulting from a combination of volcanic, geothermal, glacial and fluvial processes. Geothermal alteration is widespread resulting in a brilliantly colourful landscape, mixing yellow, pink, green, red, brown, black, blue and white colours.

#### **Criteria viii.**

The Torfajökull volcano is an outstanding example of a rhyolite volcano in an extensional, oceanic setting. It presents an unequalled opportunity to study the generation of continental silicic crust within oceanic basaltic crust and provides an outstanding opportunity to study on-going geological processes. The abundance and diversity of rhyolitic formations produced during volcano-ice interactions is unmatched by any other volcanic province. This includes a number of well-formed rhyolitic tuyas. The interaction between the Torfajökull volcano and the Bárðarbunga volcanic fissure swarm is exceptional. Crustal extension and basaltic fissure eruptions in Bárðarbunga swarm have repeatedly triggered eruptions of rhyolite and mixed rocks at Torfajökull. The extensive geothermal system exhibits exceptionally diverse geothermal surface features, including thunderous fumaroles, mudpools, solfataras, hot springs, "boiling pans" and carbonated springs.

**Statements of authenticity and/or integrity.** [see Paragraphs 78- 95 of the *Operational Guidelines*]:

A part of the Torfajökull area is the Fjallabak Nature Reserve and has been protected under the Nature Conservation Act since 1979. The area placed on the tentative list embraces the whole of the volcanic site. There has not been any physical alteration of landscapes or other features in the area and the only development are few rough roads leading to the main touristic sites and hiking paths. The area is intact and maintains its integrity and its unique landscape, geological formations, geothermal activities and the colourful appearance.

**Comparison with other similar properties:** (The comparison should outline similarities with other properties on the World Heritage List or not, and the reasons that make the property stand out)

The Torfajökull area is a unique and outstanding volcanic region associated with the Mid-Atlantic Ridge. Comparison with three other sites on the World Heritage List; Yellowstone National Park, Volcanoes of Kamchatka and Tongariro National Park, shows that Torfajökull has some similar geological features, but is the only site placed on oceanic crust at a mid-ocean ridge. Volcanism at Volcanoes of Kamchatka and Tongariro National Park is the result of subduction of an oceanic plate beneath a continental plate. Volcanism at Yellowstone National Park is the result of a hot spot in an intra-plate continental setting. Torfajökull has lava fields and subglacial formations of rhyolite and basalt, whereas andesite is the main magma type in Kamchatka and Tongariro. The amount and variety of subglacially formed hyaloclastite ridges and tuyas (table mountains) and the exceptional interaction of different tectonic styles and magma compositions sets the Torfajökull area apart from the others. The extreme diversity of landforms, volcanic manifestations and geothermal features at Torfajökull make the area unique.

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