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Potential building sites at Reykjanes with regard to natural risk

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POTENTIAL BUILDING SITES AT REYKJANES WITH REGARD TO NATURAL RISK

Five potential building sites of approximately 1 km^2 each have been identified on Reykjanes, based on geological and topograpical considerations. These sites are regarded as favourable for building power plants or factories exploiting the high-temperature geothermal resource there.

The Reykjanes geothermal field is about 2 km^2 in size at the surface. Resistivity measurements indicate that it is at least twice as large at depth. It is located in a 6 km broad active rift zone. Accordingly the risk factors involved in its exploitation are primarily volcanic and tectonic.
These include:
1) Fissure eruptions and lava flows.
2) Ashfall from eruptions off the coast.
3) Fault movements.
4) Earthquakes.

The first three of these will be defined briefly and assessed. The discussion is based on J. Jónsson's (1978) geological map of Reykjanes; M.A. Sigurgeirsson's studies of ash eruptions near Reykjanes (1992, 1995) and Orkustofnun reports on the geothermal field.

The general volcanic features of Reykjanes are as follows. In early Postglacial time, 8000-12,000 years ago lava shields were formed. Two small shields, Skálafell and Háleyjabunga are located to the SE of the geothermal field. To the north there is a larger shield, Sandfellshæð. The floor of the rift zone is covered by younger flows from fissure eruptions which have buried the shield lavas. The fissure eruptions occurred during the latter part of the Postglacial. They are confined to two NE-SW trending volcanic swarms within the rift zone, spaced about 1-1.5 km apart (Fig. 1). The eastern swarm has erupted three times at least, with the last eruption occurring about 3000 y. ago. The eruptive fissures of this swarm did not reach beyond the shore. The western volcanic swarm has erupted three times. It has been the more active in the geologically recent past, with an eruptive episode in the early 13th century and the next before some 1800 y. ago. Eruptive fissures of the western swarm extended into the sea which resulted in the production of ash instead of lava on their land part.

The age of the Postglacial eruptions is not well constrained backwards in time. There are written accounts of the 13th century episode. Chronologically known ash layers, mostly of distant origin, found in the soil covering the lavas indicate their approximate age. During the last few millenia at Reykjanes, and indeed the Peninsula as a whole eruptive, episodes interspersed over a time interval of several hundred years have alternated with even longer periods of volcanic quiescence. The last eruptive episode of the Peninsula ended some 750 years ago. This was preceded by about 300 years of volcanic unrest which was again preceded by about 800 years of repose. As yet there is too little known about older reposes and active periods to trace this sequence further back in time.

The lava flows of fissure origin at Reykjanes range from 5-10 km^2 in size, the volcanic fissures being a few km long. On land the production of pyroclastic material has been small, being limited to small scoria and spatter cones. The lavas have been rather fluid. Both pahoehoe and aa types occur. The latter type is more common. The eruptions may have lasted a few

days at most.

There are eleven ash layers of phreatic origin known which have been erupted offshore Reykjanes. Most of them have a limited distribution and are found only at Reykjanes or the western part of the Peninsula. Three of those are several tens of cm thick at Reykjanes, but the others are less significant. The oldest of these ash layers is about 6000 years old. In the first half of the 13th century (1211-1240) both lava and ash eruptions occurred at Reykjanes. The 1211 eruption produced the thickest ash layer on Reykjanes but the distribution is restricted to the tip of the Peninsula due to easterly winds. Still it is 40-50 cm in the central part of the Reykjanes rift zone but only 2-4 cm at the two Sandvíks to the north and south. The most widely dispersed ash was erupted in 1226. It was blown to the NE and is found over the whole Reykjanes Peninsula and even beyond. At Reykjanes the thickness of this layer is 15-25 cm (corresponding to 20-35 cm fresh fallen). The dispersal of those two ash layers is shown in Fig. 2.

From what is known about the volcanic history of Reykjanes, it is likely that the next eruption will occur on the western swarm rather than on the eastern one. Both lava flow and ash fall can be expected as the eruptive fissure is likely to extend from the land into the sea.

The tectonics of Reykjanes are dominated by the rift zone, with its subsidence and extensional features, such as faults and open ground fissures. The marginal faults on the SE lie on the northern slopes of the Skálafell and Háleyjabunga shields. On the NW they cut the south slopes of Sandfellshæð shield northeast of Stóra Sandvík. The faults and fissures grow incrementally with time. As a result the largest throws and gashes are observed in the oldest lavas, i.e. the shields. They are inconspicuous in the younger post - 3000 years lavas and lack altogether in the youngest Stampar flow. Clearly faults and fissures must exist below the younger flows, however. These might open in future volcanotectonic episodes. It should be remarked that Jónsson's map is not exhaustive regarding the faults and ground fissures, although the main faults stand out clearly. Therefore a more detailed mapping of these features is needed of the proposed building sites.

Ground levelling on Reykjanes has shown that a latent subsidence of maximally a few mm/y in the geothermal field is occurring in the rift zone (H. Eysteinsson 1993). The fault pattern of the Reykjanes Peninsula as a whole suggests oblique spreading, i.e. both strike-slip movement and extension. Small ground movements have been observed in the geothermal field following earthquake swarms. Major fault movements, however, are expected to be a corollary of volcanic or tectonic episodes, when transtensional strain accumulated during repose periods is released.

Considering the above we propose below a few potential building sites and discuss briefly their advantages and disadvantages (Fig. 1). The listing is not necessarily one of priority.

1. A suitable building site is on the SW part of Skálafell. This site is on a pahoehoe type shield lava of over 8000 years old. The site is to the SE of the marginal fault of the rift zone and ground fissures are not prominent. The fault forms a wall of over 10 m height which protects the site from lava flowing from the north. The site is in the SW continuation of the eastern volcanic swarm. Potential thickness of ash erupted near shore on the western swarm could reach just over half a metre if the main dispersal was to the SE. The site is close to the geothermal field which may indeed extend below it at depth, but the limits are unclear there. The site is like all the others at about 20 m above sea level.

2. Another potential building site is north of Sandvík east of Háleyjabunga. It is also east of the rift zone, partly on a lava which is probably the oldest on Reykjanes and partly on a somewhat younger flow. The surface is both of pahoehoe and aa type with

inconspicuous ground fissures others than the marginal rift faults. A low fault wall to the NW protects to some degree against lava flowing from the northwest. Potential thickness of ash erupted near shore on the western swarm could reach 10-15 cm if the dispersal was towards the site. The distance to the geothermal field is 2-3 km.

3. The third potential building site which should be considered is on an aa type lava, about 1800 years old, just to the north of the geothermal field (and the salt plant). The site lies between the two volcanic swarms at similar risk in case of eruption on either one. Faults or fissures are not visible at the surface but must exist below. There is little possibility of locating them accurately. Potential thickness of ash erupted near shore on the western swarm could reach up to 50 cm if the dispersal was towards the site. Nearness to the geothermal field is an advantage.
4. A fourth potential building site is on the same ~ 1800 years old aa-type lava just east of the eastern volcanic swarm. It is at less risk than site 3 as lavas from the western swarm which is more likely to erupt next would probably not reach it. Hidden faults may exist below the surface flow as at site 3. Potential thickness of ash erupted near shore on the western swarm could reach 15 cm if the wind was blowing from the west. The distance to the geothermal field is 2 km.
5. The fifth building site to be proposed is on the ~ 12,000 years old Sandfellshæð shield lava north of Stóra Sandvík. It is north of the northwestern marginal rift fault on ground little disturbed by ground fissures. The site can be regarded safe as regards lava flows. Potential thickness of ash erupted near shore on the western swarm could reach about 10 cm in southwesterly winds. The main disadvantage is the distance from the geothermal field which is about 5 km.

References:

Eysteinsson, Hjálmar 1993. Ground leveling and gravity measurements on the Reykjanes peninsula 1992 (a report in Icelandic, with an English summary). OS-93029/JHD-08, 53 pp.

Jónsson, Jón 1978. Geological map of the Reykjanes peninsula (1:25000) and a report (in Icelandic). OS-JHD-7831. 303 pp.

Sigurgeirsson, Magnús Á. 1992. Pyroclastic formations on Reykjanes (in Icelandic). Master Thesis, University of Iceland. 114 pp.

Sigurgeirsson, Magnús Á. 1995. The Younger-Stampar eruption on Reykjanes (in Icelandic, with an English summary). Náttúrufræðingurinn 64, 211-230.

Figure captions

Fig 1. Geological map of Reykjanes (Jónsson 1978). The two volcanic swarms are shown and the ages of lava flows (H 1, D 1 et c.) are indicated. The potential building sites suggested in the report are marked by numbers 1-5.

Fig 2. Dispersal of ash from two near shore phreatic eruptions on the western volcanic swarm. One layer was blown towards the land, the other towards the sea.

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Reykjanes high-temperature area.
Potential building sites.

22° 45' 22° 40' 22° 35'

63° 50'

Kalmannstjörn
Bergholl
Hafnaberg
Langholl
Stóra – Sandvik
Tjaldstaðagjá
Sýrfell
Sýrfellsgrog
Sandfell
Sandfellshæð
Haugur
Haugsvörðugjá
Eldvörp
Klofningahraun
Berghraun
road
Sandvik
Bæjarfell
Skálafell
Háleyjabunga
Valahnúkur
Reykjanestá
Staðarberg

D1 D2 D3 D4 D5 D6
H1 H2 H3 H4 H5 H6 H7 H8 H9 H10 H11 H12 H13 H14 H15 H16 H17
1 2 3 4 5
~1800 BP
~750 BP
>10000 BP
>8000 BP
>3000 BP
>2000 BP
3000 BP
10000 BP

Volcanic swarms
Surface geothermal features
Outer limits of geothermal field
Potential building sites
H 3 Number of individual lava flow
>2000 BP Age of lava flow (before present)

0 1 2 km

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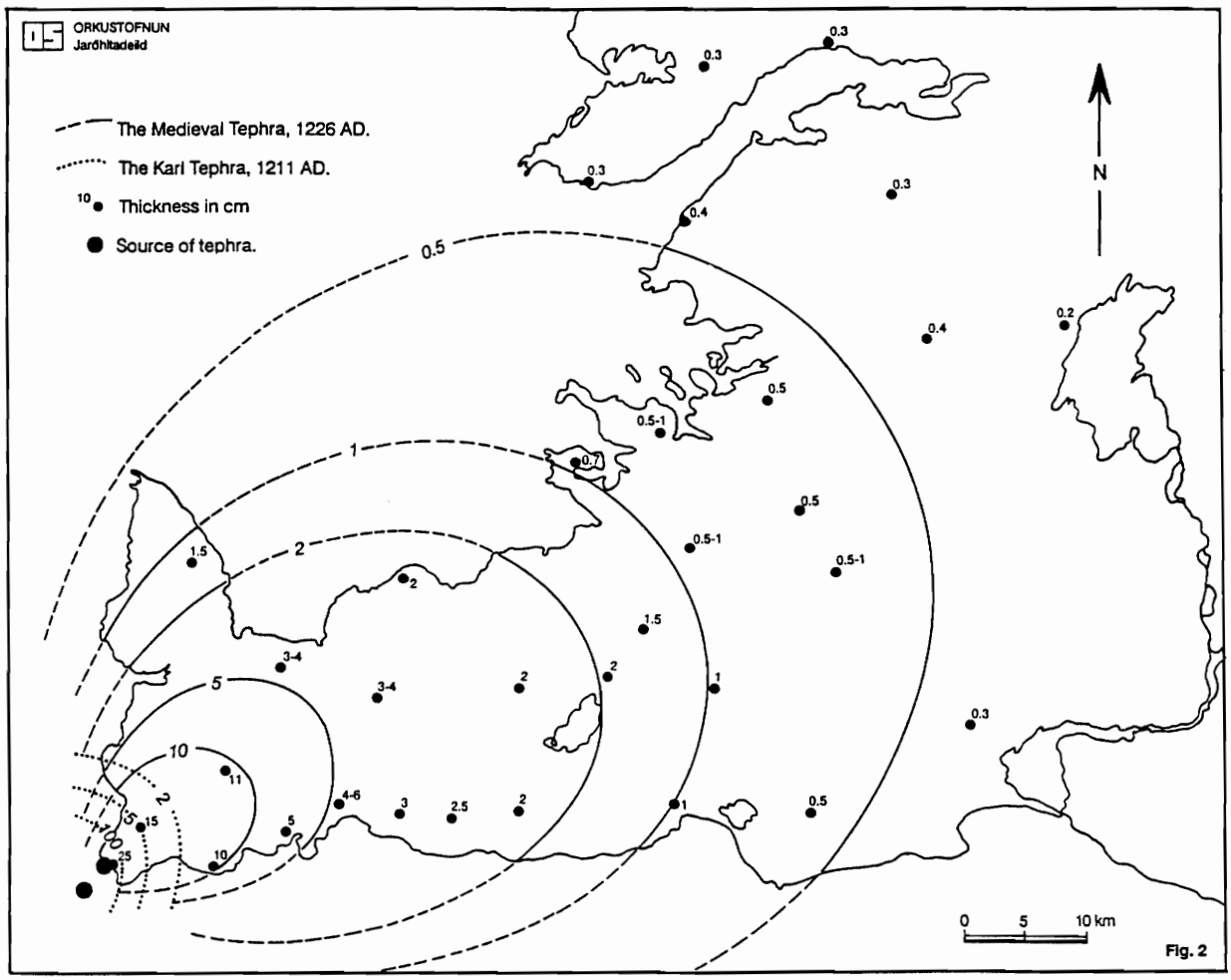
Fig. 1

22° 45' 22° 40' 22° 35'

F 17017 Reykjanes T164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Jarðhitadeild
The Medieval Tephra, 1226 AD.
The Karl Tephra, 1211 AD.
10 Thickness in cm
Source of tephra.
N
0 5 10 km

Fig. 2