Veðurstofa Íslands
Report

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PRENLAB workshop on the Húsavík earthquake, July 30, 1998

A brief description of the main outcome of the workshop and proposed action to be taken

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1 INTRODUCTION

The main objective of the July 30, 1998 workshop in Húsavík was to compare results of the ongoing multidisciplinary research attempting to improve prediction of earthquake motion that may cause damage within the Húsavík area. Such research is a basis for actions to be taken for mitigating risks from earthquakes for people and facilities.

Participants in the workshop were scientists within the PRENLAB project who are carrying out field work, geophysical measurements, evaluation of the observations and modelling in the Húsavík area. Some scientists which have carried out significant research in the area for the same purpose, although outside the PRENLAB group also participated.

Participants:

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2 SUMMARY OF THE OUTCOME OF THE SCIENTIFIC DISCUSSION IN THE WORKSHOP

The Húsavík-Flatey fault is a 70 km long ESE-WNW transform fault zone, between the NVZ (North volcanic zone) near Þeistareykir and the Eyjafjörður rift graben which stretches towards north from the mouth of Eyjafjörður (Figure 1). It is an eastern segment of a 120 km long active right lateral transform fault system with WNW strike that reaches the mouth of Skagafjörður. This fault system takes up a major part of the average plate divergency of 1.8 cm per year in the ajacent NVZ of Iceland and the Kolbeinsey ridge.

How large a part of the plate divergency the Húsavík-Flatey fault has taken up during its 7 million years of existence varies with time. The interplay between the general plate divergency across Iceland and the Iceland plume activity causes great variations in the stress conditions which influences strongly at any given time where rifting and strike-slip movements take place within the Tjörnes fracture zone.

As the Húsvík-Flatey fault passes through the town, earthquakes on the fault may cause significant damage in Húsavík and in its neighborhood. Because of the characteristics of earthquake occurrence the fault may be divided into an eastern segment, the Húsavík segment and the west-

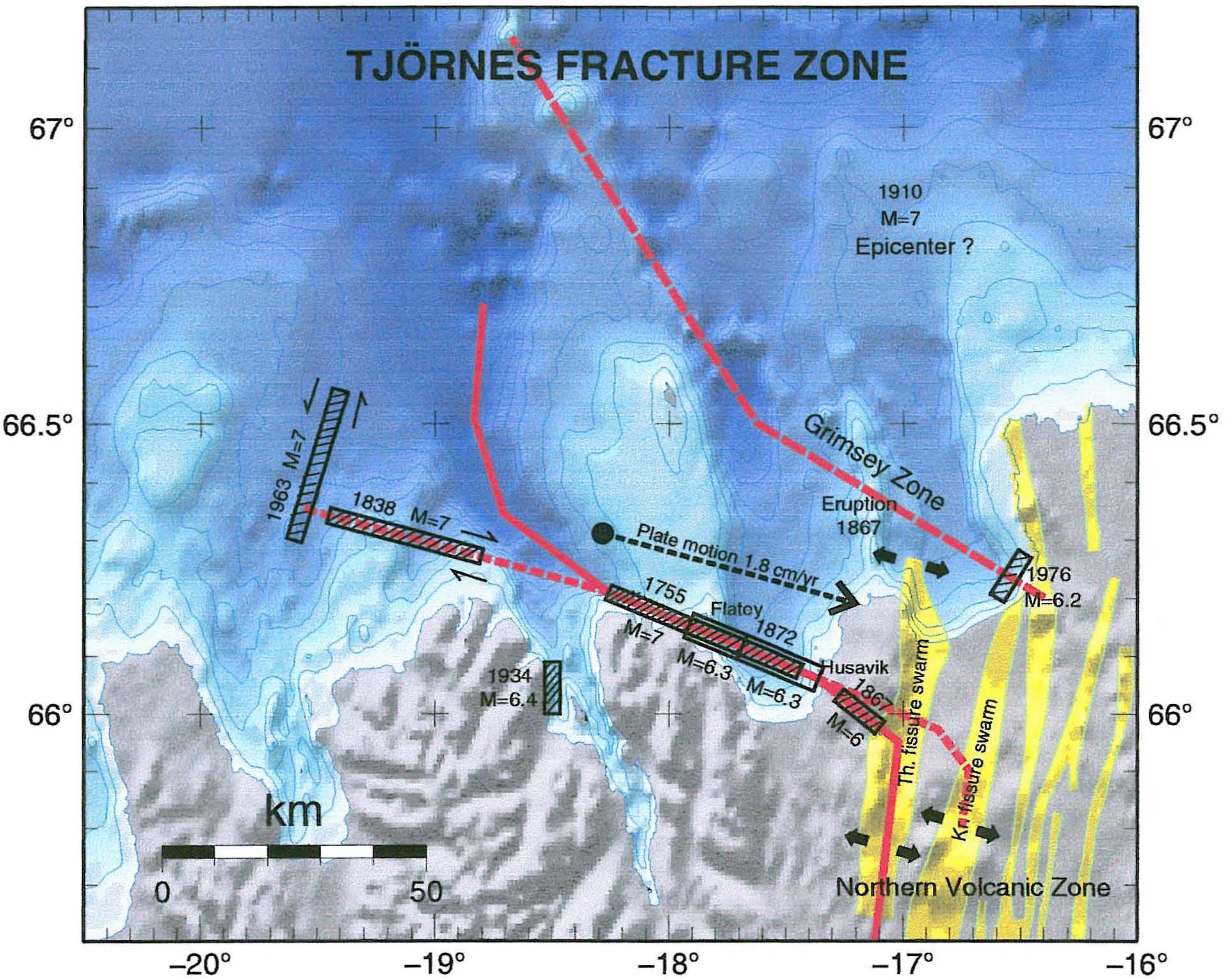

Figure 1. *Overview of the Húsavík-Flatey fault and the Tjörnes fracture zone. The hatched boxes are the estimated rupture planes of individual historic earthquakes.*

ern segment, the Flatey segment. The energy center for a magnitude 7 destructive earthquake of 1755 was probably in the Flatey segment, but the destructive earthquakes of 1872 of a somewhat smaller magnitude had their energy center in the Húsavík segment. Where exactly the division is between these two cannot be stated so far but it is likely that it is 5-10 km east of Flatey.

Studies of geological signatures and paleostresses suggest that right-lateral plate motion across the Húsavík-Flatey fault is greatly variable with time. There may even have been times when left-lateral motion took place on the fault. Historical seismicity points toward quite a high velocity during the last 300 years, i.e. that most of the average plate motion, of the order of 1.8 cm/year, would during this time be taken up by the fault. It has been suggested that only a fraction of the total plate motion in the Tjörnes fracture zone is taken up by the Húsavík-Flatey fault, but to a large extent taken up by parallel fault zones to the east and to the west of the main fault. In such a case one could speculate if the large earthquake activity since 1700 was exceptionally high for the fault, and did release strain that was built up for a much longer period. However, there is no significant supporting evidence for such an interpretation. On basis of the present knowledge we cannot draw definite conclusions about what is the present day average velocity of the fault. Being unable to do that we have to assume that most of the average large scale plate motion of 1.8 cm/year is released in motion across the fault in earthquakes similar to the 1755 and the 1872 earthquakes.

The resemblance of the rifting episode in the Krafla fissure swarm which started 1725 to the episode that started in the same area in 1975 suggests that we might expect a similar pattern in earthquake activity now, i.e within a few decades, as followed the 1725 episode. The earthquake of 1755 may have been triggered by a strain wave migrating a few kilometers per year stemming from the 1725 rifting. The pattern of earthquake activity at and near the northwest end of the fault during recent years suggests that the northwest end of the fault is stressed. Absence of seismic activity near the eastern end of the fault since 1976 as well as repeated GPS measurements during recent years suggest that the eastern part is locked. The above evidence indicates that the next large earthquake on the fault would its have energy center in the western segment of the fault, i.e. in the Flatey segment. Strain energy may have been building up since 1755 in a significant part of the Flatey segment. Although the main source of energy would be in the Flatey segment it can be expected that faulting will proceed into the Húsavík segment of the fault, even causing surface fissures in Húsavík, as in 1755.

There are several reasons for believing that a useful warning can be issued before a large earthquake on the Húsavík-Flatey fault. The two large earthquake sequences of 1755 and 1872 had both rather strong earthquake activity preceding the major earthquakes. Signatures of fluid activity in the fault are found from ongoing geological and seismological studies. It is probable that expansion caused by local fluid intrusions would, by decreasing normal stresses across the fault, precede large earthquakes. Effects caused by high pore-fluid pressure can be monitored by observing sources of microearthquakes and changes in shear-wave polarizations. Neither the historical, geological nor the seismological observations mentioned here would directly secure earthquake warnings. However, the better the dynamics of the fault are known the more likely it will be that useful warnings can be issued.

Seismological measurements indicate that the eastern end of the Húsavík fault has been locked since the start of the Krafla episode in 1975. Repeated GPS measurements surrounding the western part of the fault indicate that there is no transform motion across the fault. However, there is measurable right-lateral shearing across the area to north and south of the fault, showing that energy for strike-slip motion is building up in the fault. The same measurements indicate a slight expansion between the fault sides. Seismological measurements indicate strike-slip motion and expansion near the western end of the Húsavík-Flatey fault, fading out towards east. This straining of the fault area is related to the rifting episode that has been taking place since 1994 in the north-south striking Eyjafjörður graben, north of Eyjafjörður.

It is possible that precise monitoring of seismicity and real-time GPS monitoring across the fault may create basis for useful short-term warnings for earthquakes, i.e. warnings on the time scale of hours to days. But such monitoring will also increase our basis to understand better the dynamic properties of the fault and thus also create a better basis for long term prediction, i.e. to understand what we might expect from the fault in a longer future.

3 PROPOSED ACTIONS

In light of the above conclusions the following actions are proposed:

1: Modelling. To model the fault motion of the probable next large Húsavík earthquake, and the expected fault slip and moment release along the fault. It is to be carried out on basis of the present understanding of the nature of the fault and especially on basis of the effects of the 1755 and 1872 earthquakes. This is an ongoing multidisciplinary undertaking of the PRENLAB-2 project.

2: Geological mapping. The surface movements due to a large earthquake depend not only on the movement and energy release in the crust. It strongly depends on the surface conditions, the sediment layer and the proximity to faults and fissures in the sedimentary layer and in the bedrock.

A detailed geological mapping is necessary in the Húsavík area including studies of faults and fissures in the bedrock. This can be done on exposed cross sections, by observations in building lots, complemented by trench digging. An effective way of studying the sedimentary layer and active fissures below the layer is by a borehole study, i.e. boreholes of a few tens of meters that could give various information, such as heat gradient which can reveal faults in the bedrock. With modern borehole logging equipment it would be possible in these boreholes to study the conditions in the surface layers. There are several seismic methods which can be useful to study how surface materials react to incoming seismic waves. These methods, which are differently cost effective and secure, cannot, however, replace a detailed geological map which is needed.

A special attention was brought to the possibility of landslide into lake Botnsvatn from the steep hillside to the north of the lake. Botnsvatn has approximately 20 million cubic litres of water, and a landslide causing the lake to overflow could produce severe flooding in Húsavík. The lake and the hillside are a part of the Húsavík fault, and landslides are probable during strong earthquake motion. It was also pointed out that there exist methods, like shallow S-wave splitting technology, to estimate if a landslide is impending. Botnsvatn and lake Höskuldsvatn, further up the valley from Húsavík, are basin pull-apart lakes, or sag-ponds, typical of strike-slip fault movements.

3: Increased real-time monitoring of the fault. Watching continuously faults and fault movements and how stresses are built up in and near the fault would increase significantly the possibility of a short-term warning for a large earthquake. The monitoring necessary for this would also aid the possibilities to assess in the long term what can be expected from the fault. For this purpose it is most significant to intensify observations and evaluations of small earthquakes from the fault area, and to introduce continuous monitoring of deformation in the area by GPS measurements.

It is proposed that 3 seismological stations will be set up in the area, linked to the SIL real time evaluation center in Reykjavík. These seismic stations would also be equipped with precise GPS instruments for continuous monitoring of deformation. These stations would be on Flatey island, in Flateyjardalur, near the coast, and at a selected site on Tjörnes north of Húsavík. The SIL seismic station which is in operation at Granastaðir, 15 km to the south of the fault should also be equipped with instruments for continuous GPS monitoring.