Hazard Assessment:
Volcanic Eruptions and Jökulhlaups from the Western part of Myrdalsjökull and from Eyjafjallajökull

ABSTRACT

In December 2002 the Civil Protection Committee of the district Rangárvallasýsla in Southern Iceland contacted National Civil Defense of Iceland to request that a hazard assessment be done for volcanic eruptions in the Katla volcano beneath the Glacier Mýrdalsjökull and threats that such eruptions would pose to the Civil Protection district of Rangárvallasýsla. Recent geologic evidence has recently been discovered which point to major jökulhlaups (glacier outburst floods) along the channel of the river Markarfljót which runs through a densely populated farming area. In fact most of the farms are situated on a large ancient outwash plain. Earlier it was believed that the outwash plain was formed at the end of the last stage of glaciation during the Quaternary epoch.

The Civil Protection district Rangárvallasýsla is very much marked by volcanic activity. The southern part of the Eastern Icelandic Volcanic Zone runs through the area. Volcanoes are prominent in the landscape, amongst these are Hekla (1491 m), the glacier capped stratovolcano Eyjafjallajökull (1640 m) and the Katla volcano underneath Mýrdalsjökull. The Katla volcano is about 30 km in diameter and in the center of the volcano there is a caldera which is about 100 km^2 in area and the rims of the caldera reach 1400 m.a.s.l. in places. The Katla volcano lies underneath the glacier Mýrdalsjökull. The thickness of the glacier in the caldera ranges between 400-700 meters (fig. 1).

A steering committee was formed at the beginning of 2003 to oversee and direct the work on the hazard assessment. The first task of the committee was to look for existing findings of research on volcanism and jökulhlaups in the area. The next step was to identify topics that needed further research to compliment existing knowledge of the threat posed by the volcanoes in the area.

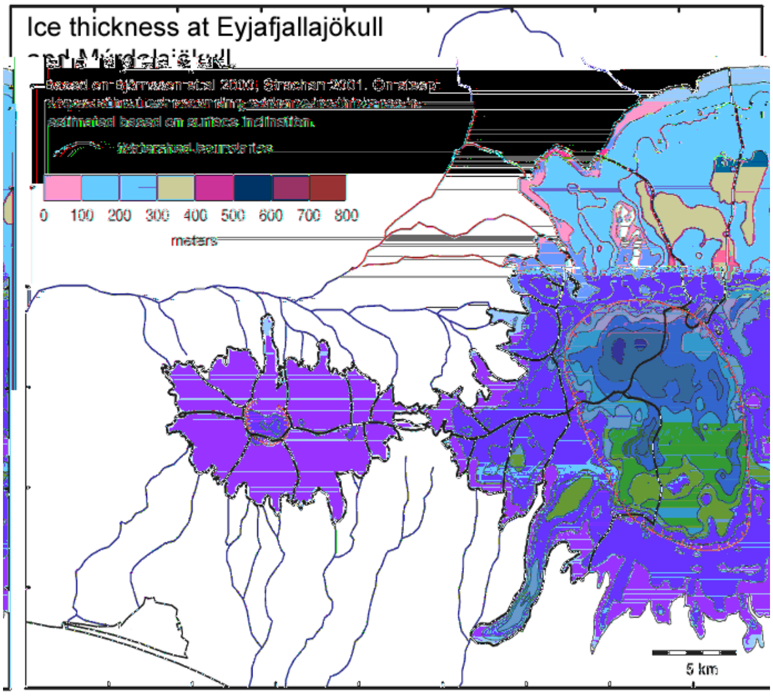

Figure 1 Ice thickness at Eyjafjallajökull and Mýrdalsjökull.

It soon became evident to the steering committee that the focus of the research would be volcanic eruptions in the western part of the Katla volcano and in the stratovolcano Eyjafjallajökull. Neither the recurrence rate of eruptions in other volcanoes in the area nor their proximity to inhabited areas posed as imminent a threat as the two above named volcanoes. The eruptive history of these volcanoes was examined. Eyjafjallajökull has erupted four times in the past 1400 years (fig. 2). These eruptions took place in ca. 500 A.D., ca. 920 A.D., in 1612 and finally 1821-1823.

The Katla Volcano has been far more active than Eyjafjallajökull in recent centuries. There is historical evidence of about 25 eruptions in the past 1200 years. On the average Katla erupts twice each century. The size and intensity of the eruptions varies. The largest known eruptions in historic times (after 900 A.D.) occurred in 934 A.D., 1262 A.D., 1500 A.D., 1625 A.D., 1755 A.D. and 11918. The last of these is of course by far the best documented eruption. Several written eyewitness accounts exist as well as a number of photographs of the debris (mostly ice) carried by the glacial surge. Historically glacial surges from Katla have run to the east over Mýrdalssandur. This is a mostly uninhabited area so these jökulhlaups have not posed a major threat to human lives.

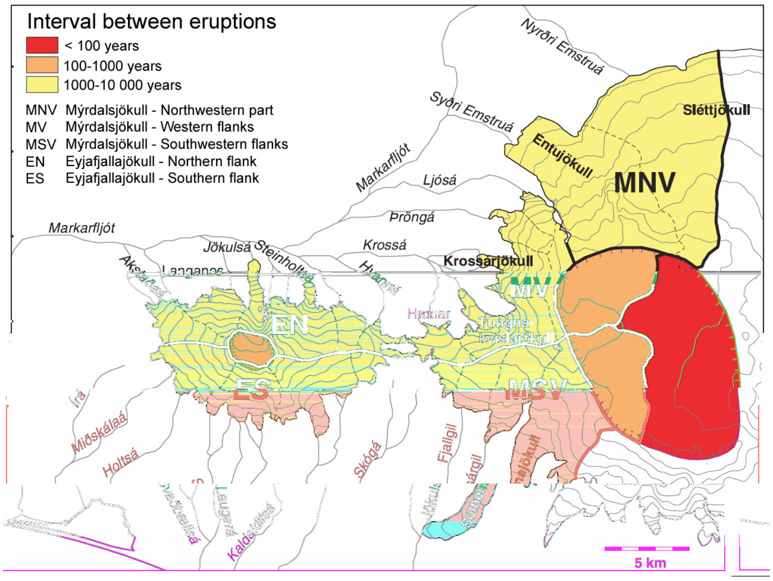

Figure 2 Recurrence time of eruptions in the Katla volcano and Eyjafjallajökull volcano.

Recent research of geomorphologic evidence along the Markarfljót river has added to the known eruptive history of the Katla volcano and the knowledge about jökulhlaups along the Markarfljót river. Part of the research done specifically for the hazard assessment was to measure the cross sections of the Markarfljót upstream canyon and valley where evidence of high water levels due to jökulhlaups was found. These cross sections were in turn used to calculate peak discharge values and to estimate the total runoff during these catastrophic events (fig. 3). The estimated peak discharge of the largest of these prehistoric jökulhlaups was found to be about 250.000 $m^{3/s}$. The findings from this research was then used as input into a simulation of a jökulhlaup down Markarfljót and onto the outwash plain which has around 1600 inhabitants.

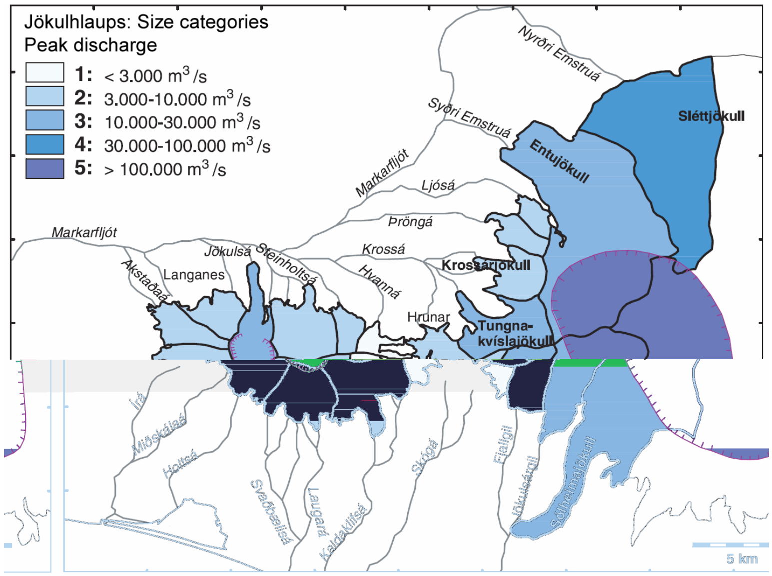

Figure 3 Jökulhlaups: Size categories based on calculated possible peak discharge

The results of the simulations show that the entire outwash plain of the Markarfljót river would be inundated in a glacial surge lasting six hours in all, which reaches a peak discharge of 300.000 $m^{3/s}$ in two hours and where that peak discharge is maintained for another two hours before the surge tapers off in another two hours (fig. 4). This gives a total amount of 4320 million m^3 of water. The valley to the north of Eyjafjallajökull would be totally inundated and the water would reach a depth of 15 meters. Further upstream the water would reach a depth of 45 meters whereas the water would reach a depth of at least 1-2 meters in the inhabited outwash plain. The simulations also showed that the outwash plain would be inundated for over 24 hours.

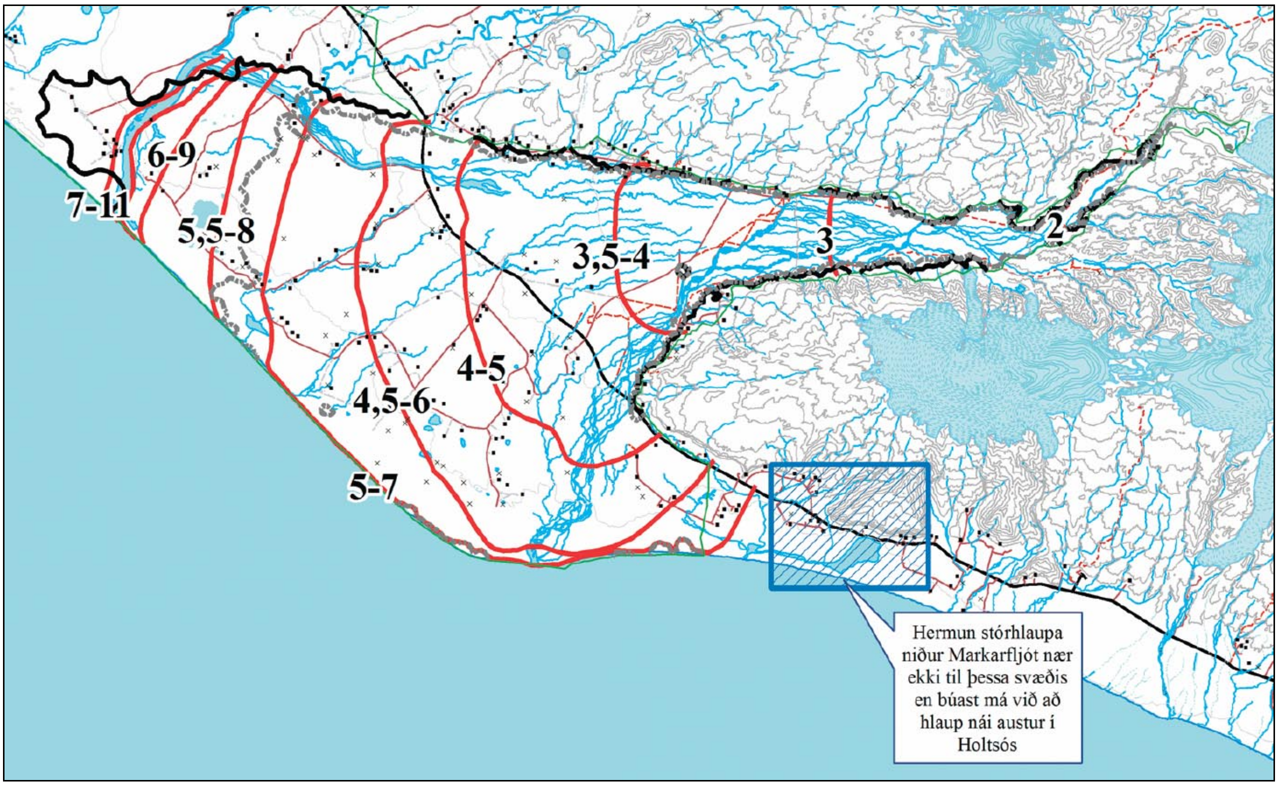

Figure 4 Advance of a jökulhlaup with a peak discharge of 300.000 $m^{3/s}$. The numbers indicate the number of hours from the start of an eruption in the Katla volcano until the front of the jökulhlaup is at the corresponding red line. The lower number at each line is the estimated worst-case scenario based on flood simulations.

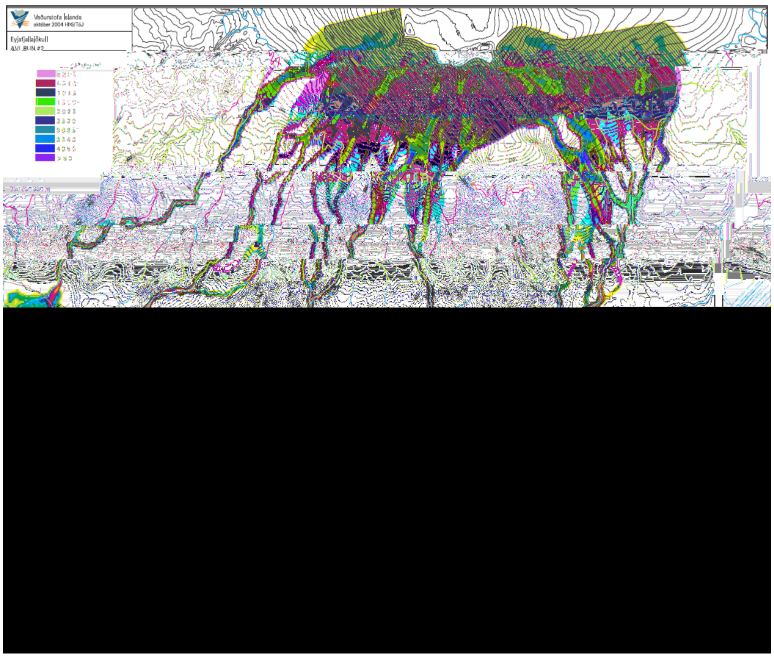

Figure 5 Simulation of flash floods on steep slopes generated by the melting of glacial ice in a volcanic eruption. Yellow indicates a maximum water depth of 0.5 meters, orange on the other end of the spectrum indicates water depths exceeding 5 meters.

In addition to the simulation of glacial surges along Markarfljót a study was undertaken of the behavior of floods down the slopes of Eyjafjallajökull following an eruption which would in turn melt a substantial amount of ice (fig. 5). For these purposes a simulation was run using a model which has been thoroughly tested for use in avalanche hazard assessments. Water released suddenly at the top of a very steep slope behaves very much in the same manner as snow moving down such a slope. The crucial information gained from these simulations is on the one hand the extent and depth of the water but also and more importantly the amount of time it takes for the water to travel down the slopes. The travel time for the water is between 15 and 30 minutes. This means that in order to evacuate the affected areas Civil Protection will have to rely on earthquake monitoring to give indications or warnings of imminent volcanic eruptions.

Reference: Magnús Tumi Guðmundsson and Ágúst Gunnar Gylfason, editors, 2005, Hættumat vegna eldgosa og hlaupa frá vestanverðum Mýrdalsjökli og Eyjafjallajökli. 210 pages, Ríkislögreglustjórinn. Reykjavík, 2005