The jökulhlaup on Skeiðarársandur in November 1996: Event, discharge and sediment

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In the beginning of October 1996 a volcanic eruption within Vatnajökull ice cap melted approximately 3 km^3 of glacier ice. The melt water got trapped in a subglacial reservoir in the Grímsvötn caldera with water table at about 1500 m a.s.l. At about 9:30 pm on 4 November 1996 the ice barrier of the reservoir failed. At 7:20 am on 5 November a jökulhlaup broke explosively out 50 km down-glacier at eastern corner of the terminus of Skeiðarárjökull outlet glacier. This indicates a speed of about 5 km/h along the glacier bed. During the day the flood broke out successively farther to the west along the terminus which is at about 100 m a.s.l. At 15:40 pm flood liquid issued from almost the entire 20 km length of the terminus. The flood wave traveled 20-25 km to the coast at the speed of 8-10 km/h.

The two main channels of the jökulhlaup, Gígjukvísl and Skeiðará, had estimated peak discharge of 33,000 m^3/s and 23,000 m^3/s respectively. Fifteen hours after the break out at the terminus the combined peak discharge reached more than 50.000 m^3/s, the second largest river of the earth at that moment. The total area covered by the flood outside the glacier was about 750 km^2. The coastline advanced up to 800 m in front of the mouth of river Gígjukvísl. The area of the new land was measured to be about 7 km^2.

The Hydrological Service (HS) created a model to predict the progress of the small jökulhlaup in April 1996. The discharge of the flood was assumed to increase and decrease exponentially with time in accordance with the experience from earlier floods. The volume in the Grímsvötn caldera, the rate of growth and decrease of the jökulhlaup determine the progress of the flood. The Science Institute of the University of Iceland (SIUI) gave an estimate of the volume in the Grímsvötn caldera at the beginning of the jökulhlaup. The growth rate of the flood was calculated using the first three discharge measurements in Skeiðará, and the rate of decrease of the flood was estimated from experience from earlier floods. The prediction of the model made by HS agreed very well with discharge measurements made during the jökulhlaup, as well as predicting the discharge peak and its time of occurrence.

After the volcanic eruption started in Vatnajökull in the beginning of October 1996, HS decided to use the model described above to predict the progress of the expected great jökulhlaup. The HS made a new model based on how the volume of stored water in the Grímsvötn caldera changes with time accounting for both inflow and outflow of the Grímsvötn caldera. The plan was to use discharge measurements made at the beginning of the jökulhlaup and information from SIUI on the volume and inflow to the Grímsvötn caldera to calculate the growth rate of the expected jökulhlaup. To estimate the rate of decrease of the jökulhlaup, documentation of older large jökulhlaups from this century were used.

The model was used to predict possible scenarios of the progress of the expected jökulhlaup based on the hydrographs of four earlier jökulhlaups from the twentieth century. As soon as new information came from SIUI on the volume in the Grímsvötn cald-

era the new model was used to create scenarios of the expected jökulhlaup.

The catastrophic beginning of the jökulhlaup on Skeiðarársandur in November 1996 prohibited traditional measurements of the discharge during the event. During the jökulhlaup the discharge of the three major rivers on Skeiðarársandur was estimated during the first day of the flood, while it was still increasing, and on the second day when the flood was decreasing. The discharge was estimated independently by scientists from the HS and the Icelandic Public Roads Administration (IPRA). These independent estimations corresponded well with each other. The hydrographs of the three rivers were determined from these estimates, assuming that the discharge increases and decreases exponentially with time and by using additional information about the time of the peak discharge. The peak in Skeiðará was observed just before midnight and the peak in Núpsvötn was between 7 and 8 pm on November 5th. The jökulhlaup started with a huge flood wave in each of these rivers making it easy to schedule the beginning of the flood. According to HS, earlier jökulhlaups in Skeiðará show that assuming an exponential growth and decrease in the discharge, is a reasonable assumption, but the peak usually flattens out a little. This was taken into account by cutting 10% off the peak discharge, from each estimated hydrograph.

In the evening of the first day, the estimates were used as input to the new model. According to the model calculation, the peak discharge of the jökulhlaup was predicted to be about 45,000 m^3/s between 10 pm and 11 pm that evening. In the easternmost branch of the river Skeiðará the discharge kept increasing until 10:30 pm even though the growth was very slow from 7:30 pm. At the next visit at 00:30 am it was observed that the jökulhlaup was decreasing in agreement with the model forecast made by HS earlier that evening.

The total hydrograph of the jökulhlaup was estimated by adding the three individual hydrographs together. The curve of the total hydrograph is a little bit edged because of the mathematical methods used. The peak discharge of the flood according to this hydrograph is 52,000 m^3/s and the total flow volume that appeared on Skeiðarársandur is approximately 3.4 km^3 which correlates well with the volume estimated by the SIUI.

Conditions to take sediment samples from the flood were extremely difficult because of the size and the spreading of the jökulhlaup. Samples could only be taken from the surface at the riverbanks. Since sediment concentration increases with depth it can be assumed that measured concentration in the samples is about 1/5 to 1/2 of the real sediment concentration in the flood.

The sediment carried by the flood in the river Skeiðará alone is calculated to be about 60 million tons. The total sediment in the jökulhlaup from the Grímsvötn caldera is calculated to be about 180 million tons. In estimating the total sediment transport, only samples from Skeiðará were used, because of lack of samples from the other rivers.

These numbers which are greatly underestimated are much higher than numbers on sediment transport in jökulhlaups originating from the Grímsvötn caldera over the last 25 years. Those floods were much smaller and therefore sediment measurements were more accurate.