Journal of Glaciology, Vol. 31, No. 109, 1985

SHORT NOTES

A JÖKULHLAUP NEAR SØNDRE STRØMFJORD, WEST GREENLAND, AND SOME EFFECTS ON THE ICE-SHEET MARGIN

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ABSTRACT. On 19 and 20 August 1984, an ice-marginal lake drained through a subglacial tunnel beneath the ede of the Greenland ice sheet, discharging about 22.3 x 10^6 m^3 of water in less than 19 h. The event, which may occur annually, modified ice-margin dynamics at the lake site and along a 3 km stretch of ice margin 11 km down-stream.

RÉSUMÉ. *Un Jökulhlaup près de Søndre Strømfjord, Groenland Occidental, et quelques conséquences en bordure de l'Indlandsis.* Les 19 et 20 Août 1984 un lac marginal s'est vidangé par un tunnel sous glaciaire sous la bordure de l'Indlandsis. Environ 22,3 x 10^6 m^3 d'eau se sont écoulés en moins de 18 h. Le phénomène, qui peut-être annuel, modifie la dynamique au voisinage du lac et sur 2 km de la bordure de l'Indlandsis, 11 km à l'aval.

ZUSAMMENFASSUNG. *Der Gletscherlauf bei Søndre-Strømfjord, West-Grönland, und einige Auswirkungen auf den Rand des Inlandeises.* Am 19. und 20. August 1984 entleerte sich ein Eisrandsee durch einen subglazialen Tunnel unter dem Rand des grönländischen Inlandeises, wobei in weniger als 18 Stunden etwa 22,3 x 10^6 m^3 Wasser ausliefen. Das Ereignis, das jährlich eintreten dürfte, veränderte die Dynamik des Eisrandes an der Stelle des Sees und längs eines 2 km breiten Streifens des Eisrandes 11 km stromabwärts.

This note records a jökulhlaup caused by the sudden drainage of an ice-dammed lake in West Greenland on 19/20 August 1984, and describes its main effects on the ice-sheet margin. The lake lies 32 km inland from the head of Søndre Strømfjord (Fig. 1). The flood skirted the ice margin for a distance of 11 km as it flowed along the course of a melt-water stream and through three lakes on its way to Søndre Strømfjord (Fig. 2). Sudden emptying is a well-known feature of ice-dammed lakes in many glacierized parts of the world. In Greenland, the most glacierized part of the Northern Hemisphere, surprisingly little information is available and the few known instances have been mentioned by Clement (1984). In view of this background, it seems worth describing the event observed by the writers in 1984.

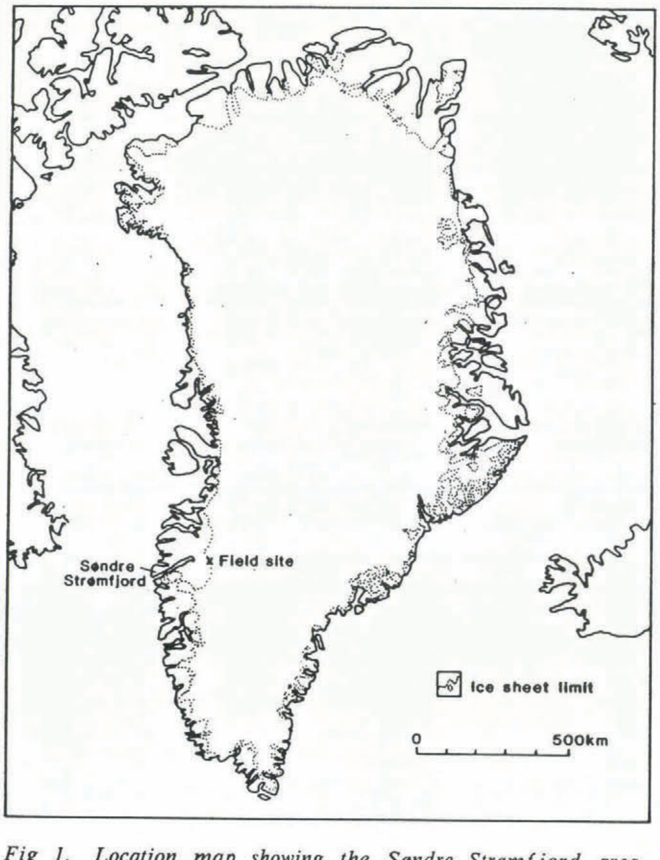

Fig 1. Location map showing the Søndre Strømfjord area, West Greenland.

The variations in discharge associated with the Søndre Strømfjord flood were measured at a site 11 km down-stream from the lake and are shown in Figure 3. At 22.30 h on 19 August, discharge of the melt stream was 30 s^{-1}, a value probably normal for the time of year. By 05.00 h the next day the stream was rising rapidly and peak discharge of 1226 m^3 s^{-1} was achieved at 13.00 h. At this stage the river level had risen 2.63 m and surface velocities in mid-stream were 6.2 m s^{-1}. Discharge fell rapidly in the afternoon and was 310 m^3 s^{-1} at 16.30 h, and only 62 m^3 s^{-1} at 21.30 h. The discharge curve would have been more peaked had the measurements been made at the outlet of the ice-dammed lake, because the three intervening lakes along the route taken by the flood waters acted as temporary storage reservoirs damping down the flood. Such an effect was demonstrated by the observation that the levels of the lower and middle lakes were found, on the basis of driftwood and ice fragments, to have risen 2.58 and 3.11 m, respectively (Fig. 2).

Immediately prior to emptying, the lake had a surface area of 0.71 km^2 and was dammed by a 1.5 km stretch of ice sheet with an overall surface slope of 4° (Fig. 4). The water line on the ice showed that the lake level had risen to within 8 m of the ice surface at the ice margin. During emptying the lake level fell 39.8 m and lost 22.3 x 10^6 m^3 of water. This estimate of previous lake volume agrees closely with the discharge measurements made on the river. The lake drained through a subglacial tunnel, the entrance of which was visible on the ice cliff of the drained lake as an iceberg-choked cave 15 m across (Fig. 5). Ice blocks, presumably derived from the tunnel, were strewn on an outwash fan near the tunnel exit as well as on lake shores and sandur plains for about 11 km down-stream (Fig. 2).

The drained lake floor was notched by a series of 16 shorelines incised less than 1 m into areas of unconsolidated sediments. A particularly well-developed lake shoreline

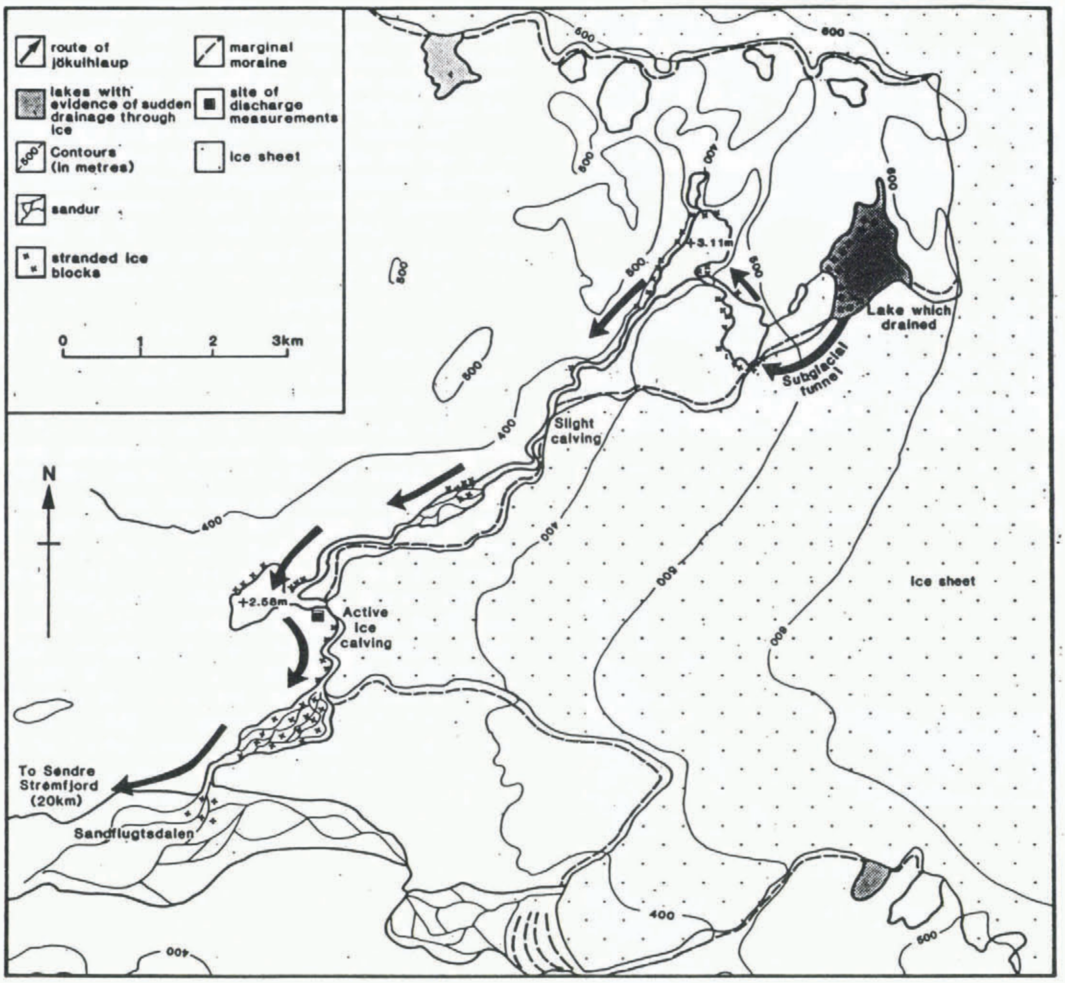

Fig. 2. The route of the jökulhlaup, showing the location of the lake which drained, the subglacial tunnel, sites of ice calving, and stranded ice blocks along the flood-water route. Two other suddenly draining lakes revealed by air-photograph interpretation are also shown.

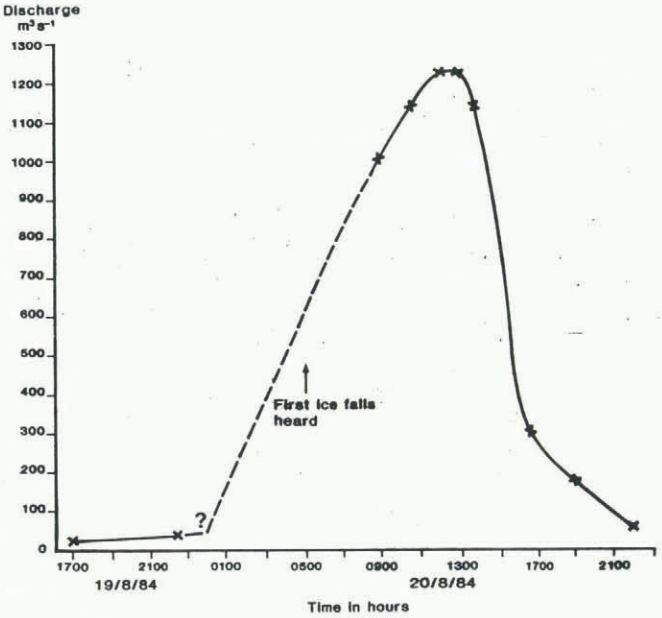

Fig. 3. Variations in discharge recorded 11 km down-stream of the emptying lake (see Figure 2 for location). The solid line and crosses reflect measurements while the dotted line is inferred on qualitative grounds.

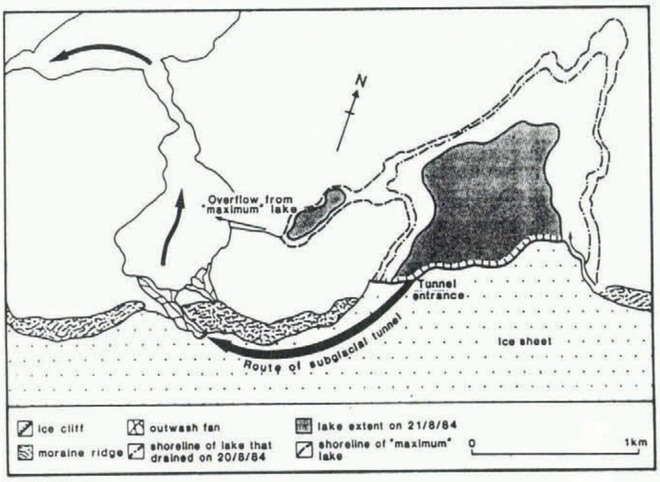

Fig 4. Details of lake extent before and after the event, the approximate line of subglacial drainage, the "maximum" lake shoreline, and the associated outflow route over a col to the west.

https://doi.org/10.3189/S0022143000006729 Published online by Cambridge University Press

Fig. 5. The ice dam and tunnel entrance photographed on 21 August 1984. The ice cliff rises about 50 m above the water level. (Photograph by J. Sugden.)

Fig. 6. The collapsing ice margin at the site of the drained lake photographed on 21 August 1984. The ice surface rises 55 m above water level. Former notches and lake shorelines, debris-bearing ice, and melt-water tunnels are all visible. (Photograph by J. Sugden.)

occurs 7 m above the 1984 lake level and represents the maximum level achieved by the ice-dammed lake. Its height is limited by the altitude of an overflow channel crossing a bedrock col north-west of the lake (Fig. 4). Vegetation development on the shoreline shows that it has not been used for some years.

There is some evidence that the lake might empty most summers. At the time of the last air-photograph survey, 17 August 1968, the presence of stranded icebergs suggest that it had just drained. In 1984 a "tidemark" of twigs and grass was present around lakes on the flood route 20-30 cm above the level of the recent flood event. The driftwood was so fresh that it could have been no more than a year old and probably represents a flood in 1983.

The flood affected the ice-sheet margin in two places – at the site of the drained lake and down-stream from the discharge measuring station, where the river undercuts the ice margin for nearly 2 km. Following lake emptying, the ice cliff at the former site stood 55 m above the lowered lake level (Fig. 6). The loss of lateral support caused large ice falls which were occurring almost continuously 24 h after the lake emptied. This activity reflects the glacier response to changing stress gradients; presumably a 1 km wide section of the ice front advances selectively and rapidly in response to the sudden loss of lateral support provided by the former lake.

The second site of accelerated ice-edge flow was just down-stream from the discharge measuring station, the main locality where the stream made contact with the ice. During the flood the river undercut the ice cliff and triggered ice falls all along its 2 km length. After each fall, the river swept the ice fragments down-stream and on to a sandur plain 1.5 km in length and 0.75 km wide. The whole sandur surface was completely submerged at the height of the flood and became covered in ice blocks, those at the head measuring 3-4 m in diameter and block size progressively decreasing down-sandur. It was noticeable that the ice cliff remained very active for some days after the flood, periodically discharging ice debris sufficient to block the river temporarily. The overall effect of the flood was suddenly to enhance ablation along a 2 km stretch of ice margin, thereby locally increasing velocities and stress gradients.

This jökulhlaup shows that the sudden emptying of a modest-sized lake can have significant effects on a considerable length of ice margin. When such lakes drain regularly on an annual basis, the cumulative effect on ice-margin dynamics and ice-margin processes (e.g. moraine formation) will be significant. Bearing in mind that there are three such lakes in a straight-line distance of only 13 km of ice-sheet margin in this part of West Greenland (Fig. 2), it is possible that such effects are more important than commonly supposed.

ACKNOWLEDGEMENTS

We thank the University of Aberdeen for financial support, and J. Sugden for help in the field.

REFERENCE

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MS. received 2 January 1985 and in revised form 16 May 1985

https://doi.org/10.3189/S0022143000006729 Published online by Cambridge University Press