Notes

Varves in a Proglacial Lake, Sermilik, South East Greenland.

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Three cores collected from a proglacial lake with an Axelsson corer are x-rayed. The stratification is interpreted as varves. The cores cover periods of sedimentation with a duration from 5 - 23 years. The average thickness of the varves vary from 1.9 - 20.0 mm indicating a tenfold variation in the sedimentation rate.

Keywords: *Varves, Proglacial Lake, Greenland.*

This study is a part of an interdisciplinary study of the landscape forming processes in an arctic area. Monitoring of the sediment fluxes is necessary for determining the impact of the different processes. In order to evaluate the glacioflucial erosion and transport, measurements of sediment transport have been carried out at the main outlet from the Mitdluagkat Glacier (Hasholt 1976, 1992 and 1994). However, because of costs and lack of manpower measurements have only covered different periods of the melting seasons, not whole seasons. Even if it has not been possible to compute the transport for single years, it is assumed that the combined results from different years give a fair approximation of the magnitude of average yearly output from the glacier.

The accumulation of sediment in lakes is an archive of the sediment transport in their drainage basins. In areas with a strong seasonality it is easier to identify changes in the accumulation. Particularly in arctic areas where the formation of varves is a well-known phenomena, and varves are often used to quantify changes in the transport, e.g. Axelsson and Händel (1972), Deslorges (1994) and Østrem and Olsen (1987).

The north-western flank of the Mitdluagkat Glacier drains toward the sea through a string of lakes (fig. 1). During the summer of 1994 part of the research programme was concentrated on investigations of the lake nearest to the ice-margin, called Icefall Lake because the glacier is calving into the lake.

This preliminary presentation deals with the description of three cores taken at different locations in the lake. The results of the whole investigation including bathymetry, a Cs 137 inventory and measurements of the sediment concentration, will be published later.

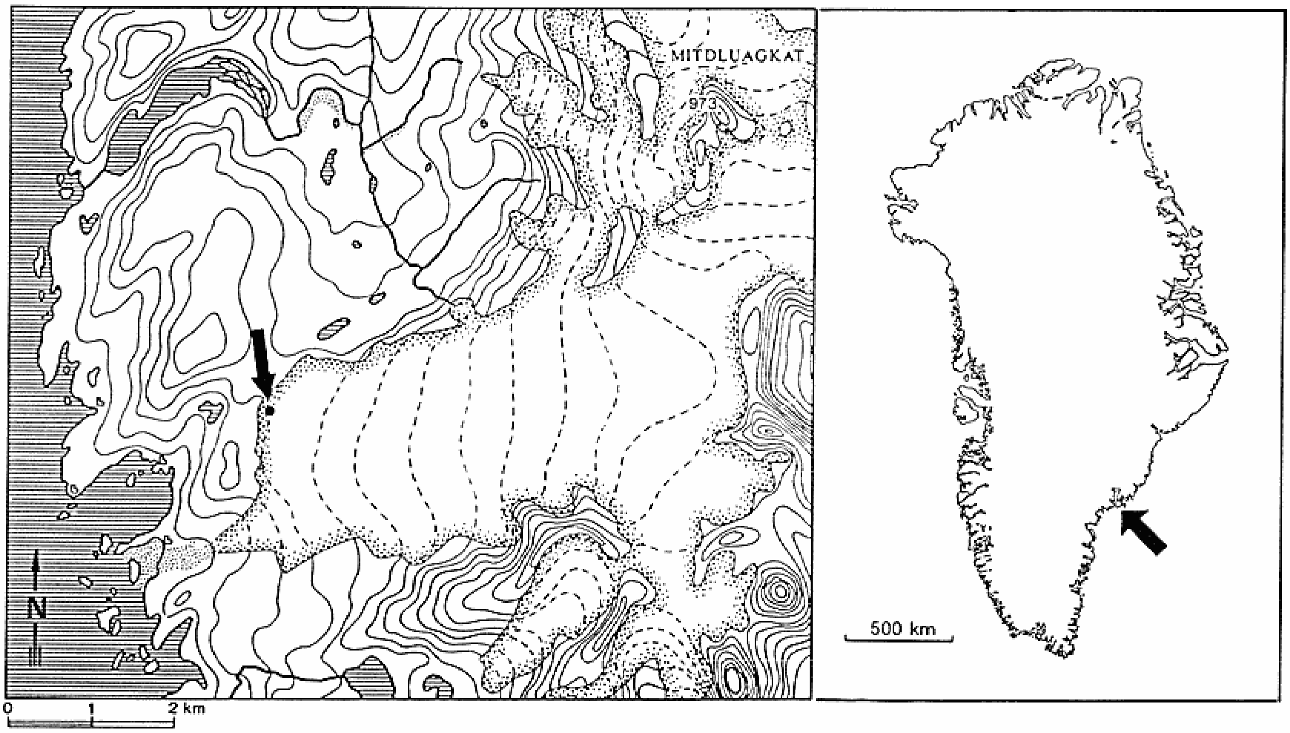
Study Area

The Icefall Lake is situated at the north-western flank of the Mitdluagkat Glacier (fig. 1.). It was probably gradually formed when the glacier front retreated from its Little Ice Age maximum advance, which was reached around 1895 (Humlum, pers.com.). The lake cannot be found on the map from the Geodaetic Institute 65 Ø1 E from 1932-33, which might indicate that it was formed later than 1933. On aerial photos from 1972 the lake is clearly visible. Today the ice margin has melted further back toward east and south of the 1972 position. Due to the active calving it is not possible to determine the exact location of the front, but the approximate position in 1994 is 100-200 m from the 1972 position. The surface of the lake is ca. 147 m. a.s.l. Two basins, separated by a threshold at 10 m depth, following the direction of fissure valleys, can be identified. The northern basin has a maximum depth of 28 m, while the southern has a maximum depth of at least 35 m near the calving front. The western part of this basin is shallow with depths less than 10 m.

Methods

A light weight raft was used for coring and eccosounding. It was kept in position by ropes spanned across the lake and an anchor. The position was recorded by use of a Kern theodolite with an electrooptic distance meter. Corings were carried out with a modified Nesje corer (Nesje 1992). An Axelsson corer (Axelsson and Håkanson 1972) was used to provide cores that could be X-rayed. It proved very difficult to collect samples from the lake because the loose sediment slipped out in spite of the use of core catchers. The recovery rate was sometimes as low as one core out of fifteen attempts. This presentation only deals with the three cores that were collected with the Axelsson corer. Excess water was siphoned away from the cores before transportation to Ammassalik Hospital, where X-radiography of the unextruded cores was carried out.

The best settings were: KV 75 and MAS 12. On X-ray photos areas with higher densities will appear lighter than



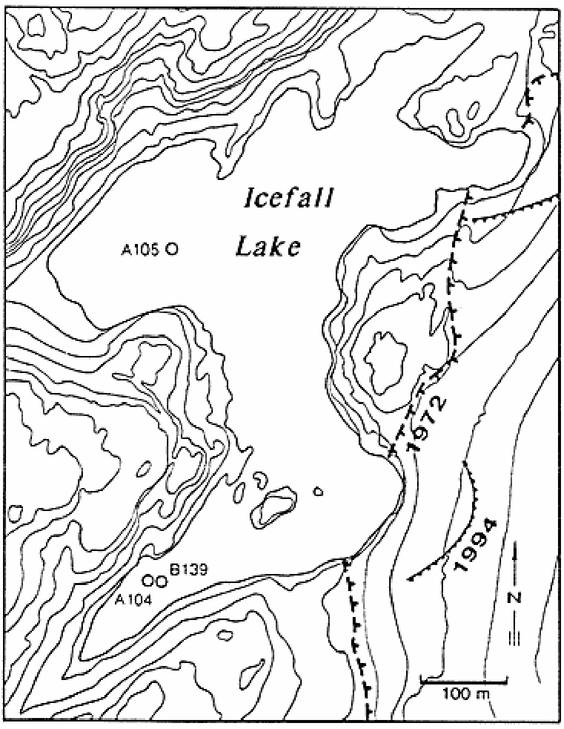


Figure 1: Situation at the research area. The arrow and the dot indicate the position of Icefall Lake on the map based on the map 65 Ø 1 E from the Geodetic Institute, surveyed 1932-33, contour intervals are 50 m. Reproduced with permission (A. 578/72). The position of the cores is shown on the map from 1972, the position of the ice margin in 1972 and 1994 is indicated. Contour intervals are 5 m.

areas with lower densities. In the early ablation season a large amount of coarse material will be deposited, whereas later, during fall and winter, a minor amount of fine material will sedimentate. A sequence beginning with a light layer followed by a dark is interpreted as a varve. The light layers are interpreted as layers from the early ablation period (summer), the dark as winter layers. The thickness of the different layers is measured with an accuracy of +/- 0.1 mm. A tentative age of the single layers is found by counting the varves from the top layer and down. A precondition for using this method is that the varves represent annual cycles and not events within a year.

Results

The X-ray photos of the three cores are shown in figs. 2 - 4. Core A105 (fig.2) is collected in the northern basin at a depth of 23 m (fig.1). The sediment was light-brown, and separate layers could be distinguished in the field with some difficulty. The core is slightly disturbed in the top and bottom. Fifteen varves could be identified on the x-ray photo. The lowermost undisturbed layer is from the summer of 1979. The average thickness of a varve is 7.5 mm, ranging from 1.9 - 31.0 mm. The average thickness of summer-layers is 6.1 mm, ranging from 0.9 - 30.0 mm. The corresponding values for winter-layers are 1.4 mm, and 0.5 - 2.8 mm. Small clasts were found in the summer layers in 1983-1985 and 1994.

The core A104 (fig.3) is from the southern basin (fig.1). The depth at the sampling point was 8 m and the sediment was light-brown, which made it difficult to distinguish the layering in the field. On the X-ray photo 5 varves can be

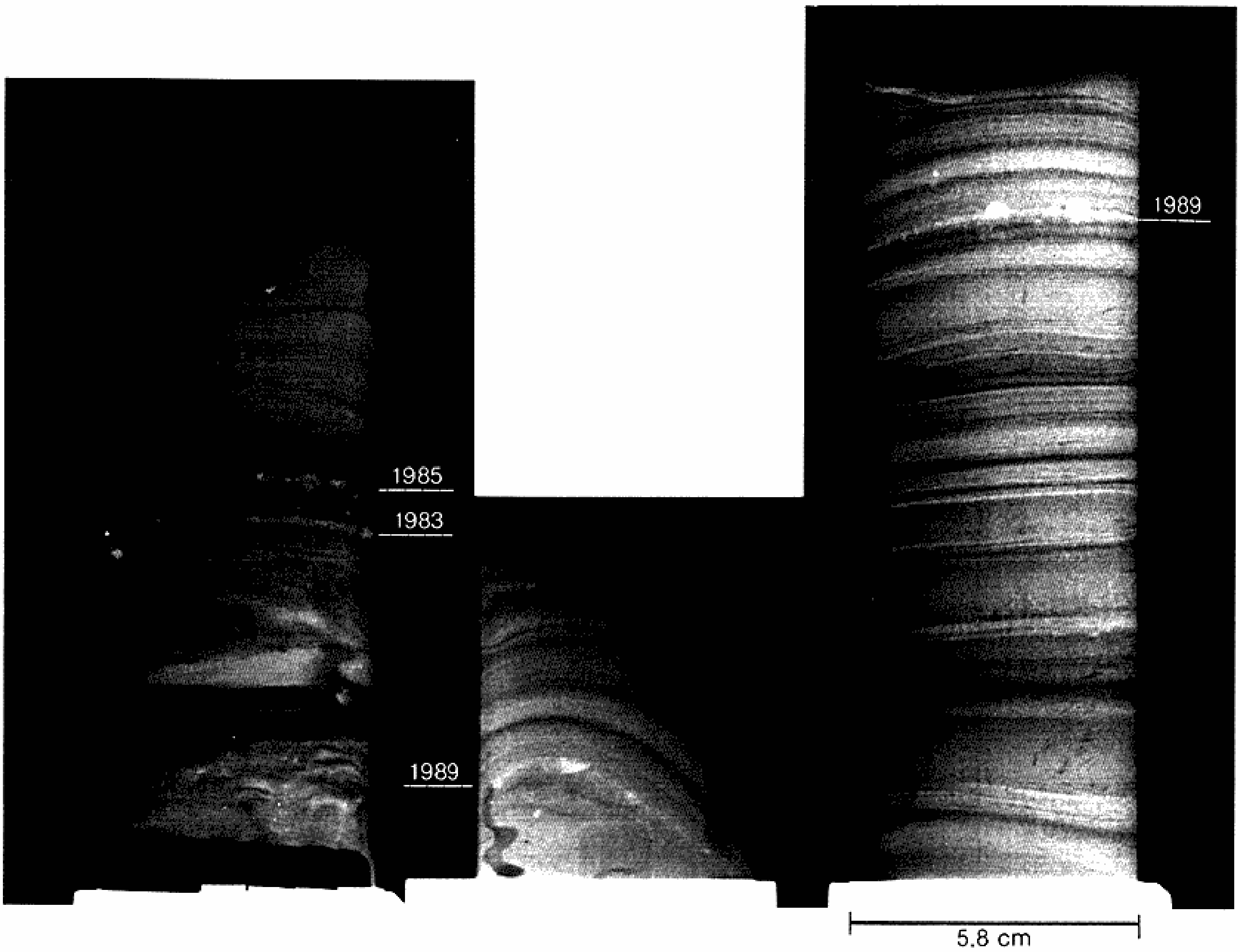


Figure 2: Core A105, width 5.8 cm, top of the core is upwards. ***Figure 3:*** *Core A104, width 5.8, top of the core is upwards.* ***Figure 4:*** *B139, width 5.8 cm, top of the core is upwards.*

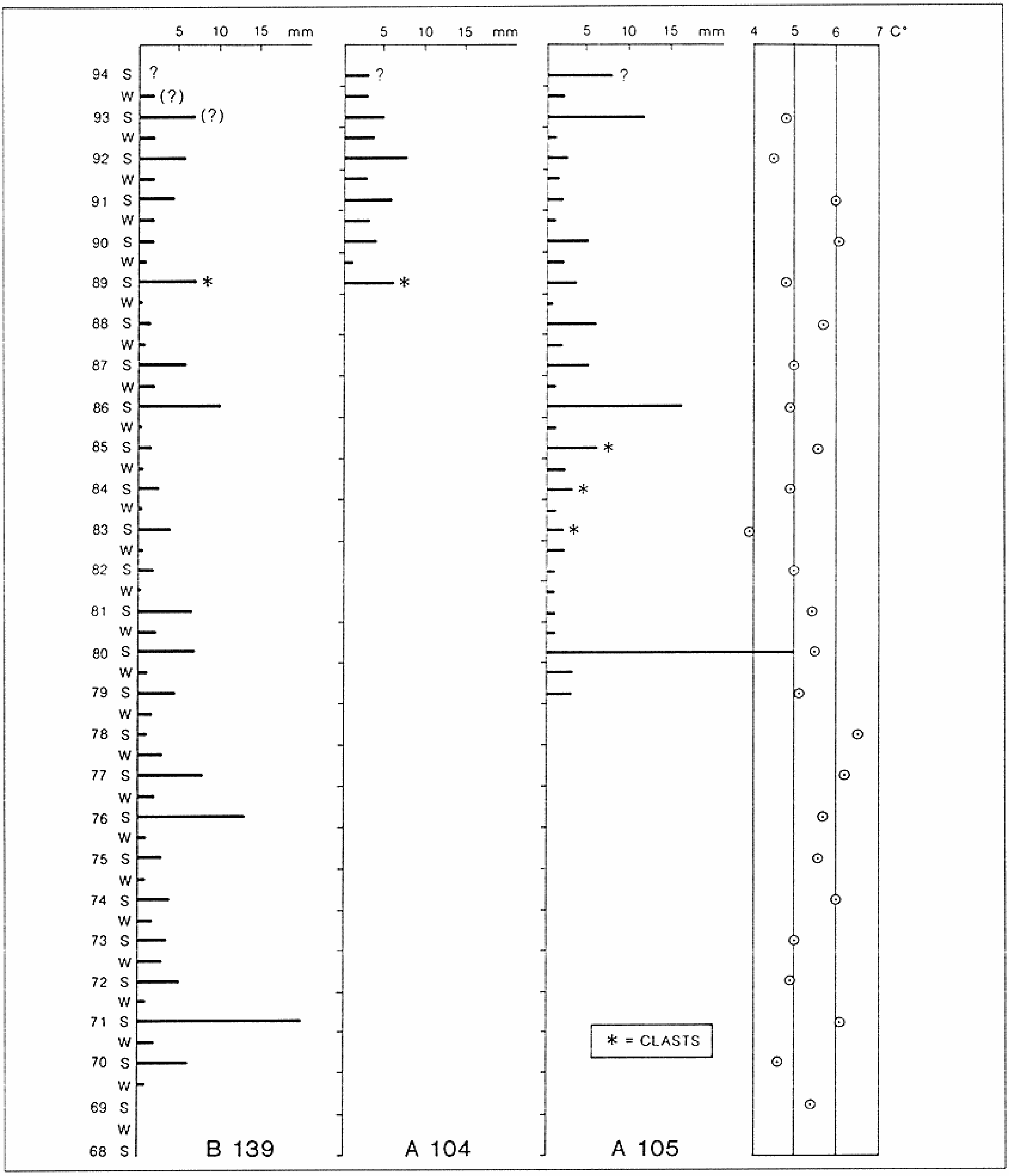


Figure 5: *Thickness of "summer" and "winter" layers in mm. Temperature average of months: June, July and August, degrees Celcius (DMI). The asterisks indicate occurence of small clast.*

identified, starting with the summer of 1989. The average varve thickness was 8.0 mm (6.5 - 11.2 mm). For summer layers the average was 5.4 mm (3.7 - 7.4 mm), for winter layers the corresponding figures were 2.6 mm (0.9 - 3.7 mm). Clasts were found in the 1989 summer layer.

The core B139 (fig.4) was taken 15 m from A104 at a depth of 8 m (fig.1). The sediment was also light-brown and some layers could be distinguished in the field. The X-ray photo shows a sequence of nearly undisturbed layers starting the winter of 1969. The number of varves is 23. Because the surface is disturbed by the siphoning of water the 1993-94 layer is not complete. The average varve thickness is 6.6 mm (2.4 - 21.0 mm). For summer-layers the average thickness is 5.4 mm (0.9 - 20.0 mm. For winter-layers the corresponding figures are 1.3 mm (0.5 - 2.9 mm). Clasts are also found in the 1989 summer-layer.

Discussion and Implications

Modern varves are here described for the first time from this part of Greenland. The average yearly sedimentation (thickness of varves) is 7.5 mm in A105, 8.0 mm in A104 and 6.6 mm in B139. A diagram showing the thickness of "summer" and "winter" layers together with summer temperature is constructed in order to compare the three cores and, if possible, to relate them to the temperature (fig.5). Because the two last cores are only 15 m apart, the upper four layers in A104 and B139 resemble each other, both in the average thickness (7.7 mm and 6.4 mm respectively) and in the occurrence of clasts and other patterns. Looking at core A105 it is difficult to find similarities with B139 and A104. The clasts are found in different layers indicating that local variations are important. However, in both cores the 1980 and 1986 layers are quite thick indicating that years with a major sediment input will cause increased sedimentation all over the lake. The occurrence of clasts in different layers in the cores can be explained by the drifting of the icefloes resulting from the calving.

An average yearly sedimentation of 7.4 mm distributed over 75% of the lake bottom will correspond to approximately 800 m3 of sediment, 75% of the area is chosen because the sediment will not deposit on the steeper parts of the bottom. The variation in the thickness of the varves shows a variation in the yearly sedimentation by a factor 10. A comparison between the varve series and the summer average temperature does not show a straightforward relationship. This indicates that other processes than the ablation need to be taken into account.

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