Inferences from a 19 m firn core, Nordbogletscher, South Greenland

Roger J. Braithwaite, Poul Clement and Henrik Clausen

During the 1981 field season on the Nordbogletscher, South Greenland, a firn core of almost 19 m was recovered (R. J. B. & P. C.) and isotopic analyses of the resulting samples were made at the geophysical Institute, University of Copenhagen (H. C.). The collection of such a core represents a modest first venture by the GGU into a new field. However, some findings have emerged which are interesting both in connection with the Johan Dahl Land project (Clement, 1981) and the long-term programme of modelling glacier hydrology (Braithwaite, 1981).

Fieldwork

The core was taken at an elevation of about 2060 m in the period 6–9 June 1981. The drill site was in the middle of a flat and, apparently, homogeneous plateau with an area of a few square kilometres which is located a little to the west of the crest of the Inland Ice. The site was reached by driving snow scooters up the Nordbogletscher from the base camp. A round-trip of 118 km was logged by odometer. Some problems with crevasses were encountered.

The core was collected using a 3-inch SIPRE corer turned by hand. The core segments of lengths 0.1–0.3 m were weighed on a spring balance for density determination. The thicknesses of ice layers were measured but to save time detailed analyses of grain size and shape were not made. Core pieces were individually sealed into plastic bags and exposed to the sun to melt. Finally, meltwater samples of about 50 ml were poured off into plastic bottles for transport to Copenhagen.

Because of the looseness of the material, substantial losses of core totalling nearly 1 m occurred in the top 6 m, but below that there was little further loss. There was no difficulty in recognising the 1980 summer horizon, both in the core and in a nearby snowpit, as it was marked by a hard layer of coarse-grained firn.

Results

Some results are illustrated in fig. 34 which shows profiles of firn density, $^{18}O/^{16}O$ isotopic ratio (delta), and total β-activity (beta) as a function of depth below the snow surface. It should be noted that the original samples were of irregular lengths and the results shown are interpolations to a regular sampling interval of 0.2 m.

The average density of the whole core, of length 18.98 m, is 570 kg m^{-3} while the density peaks in fig. 34 are associated with ice layers which are traces of strong melting/refreezing. These, combined with the fact that the measured temperature at 10–12 m is below –3°C, indicate that the site belongs to the percolation zone (Müller, 1962). This means that this part of the glacier has no runoff and essentially no ablation except for the minor amount due to evaporation. However, from the irregularities in the delta curve, e.g. local minima within

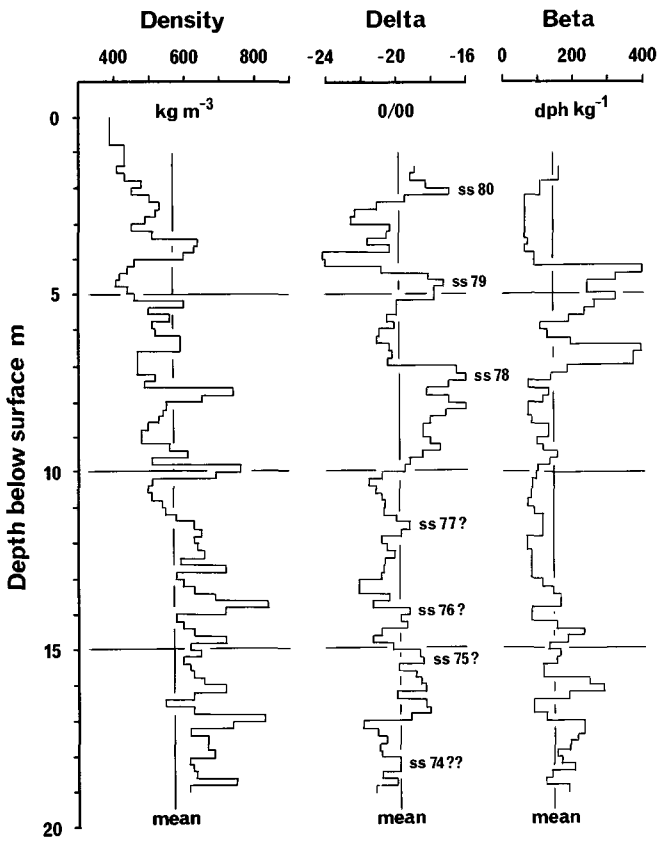

Fig. 34. Profiles of firn density, $^{18}O/^{16}O$ isotopic ratio (delta) and total β-activity (beta) as a function of depth below surface, Nordbogletscher, approximately 2060 m above sea level.

isotopically 'warm' summer layers, it seems that meltwater can transgress annual layers even at this relatively high elevation.

The mean beta value is close to that found at DYE-3 (unpublished data, Geophysical Isotope Laboratory) for snow in the surface layers. However, from the beta curve there is no sign of the well-known 1963 horizon whose traces can extend up to 1966, i.e. the core contains less than 14 years of accumulation. The delta curve is irregular and shows rapid attenuation with depth but there are hints of at least seven years of record, and more if annual layers have been merged by melting. These figures suggest then an average net balance in the range of about 700–1400 kg m^{-2} a^{-1}. On the other hand, there appear to be three distinct annual layers in the delta record from 1.8 to 11 m which would give a net balance of about 1600 kg m^{-2} a^{-1}. Despite the lack of quantitative precision in these estimates, they indicate a higher accumulation than was expected, e.g. annual precipitation in Narssarssuaq is only about 600 kg m^{-2} a^{-1}. If correct, this relatively high accumulation might reflect the predominance of an east-coast precipitation regime at the site in question.

From a regression of the measured sample densities against the thicknesses of ice layers, the density of pure 'firn' is estimated to be about 510 kg m^{-3}. Material of this density could

be transformed to the observed average density by an amount of melting/refreezing equivalent to about 10 per cent of the annual accumulation. From the estimated net balance this gives a range of 70–140 kg m^{-2} a^{-1} for the average melting/refreezing. This is somewhat less than the value calculated by the current runoff model (Braithwaite, 1981).

Conclusions

Annual accumulation in the uppermost parts of the Nordbogletscher appears to be higher than expected. Melting does occur at this elevation but the meltwater is retained within the firn and the area has no runoff.

References

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H. C.,
Geofysisk Isotop Laboratorium,
Haraldsgade 6,
DK-2200 Copenhagen N.