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Determination of ice thickness by magnetic methods at Nordbogletscher, South Greenland

Leif Thorning

The topographic relief hidden under glaciers and the Inland Ice plays an important role in the study of ice dynamics, and several methods have been applied to map the subglacial surface of the Inland Ice in areas of interest for hydropower investigations. Radar-echo soundings or electromagnetic reflection methods (EMR) have often given good results, but have largely failed over the western rim of the ice cap, where inhomogenities in the form of melted and refrozen layers, water bodies, and cracks in the ice scatter the radar wave to such an extent that no useful echo is returned. In the summer of 1984 the author was in South Greenland for other purposes (Thorning & Boserup, this report), and it was decided to attempt to determine the ice thickness by magnetic profiling on the ice surface. Magnetic field measurements are not affected by the physical properties and structure of the ice, and thus it should theoretically be possible to obtain results near the rim of the ice cap, where the EMR method has failed. Whether results could be obtained would depend on limiting factors such as the magnetic properties of the underlying rocks, instrument capabilities, sensitivity of correction and modelling methods, and the general ambiguity of potential field methods.

The field work reported here was a pilot study of the application of magnetic methods to

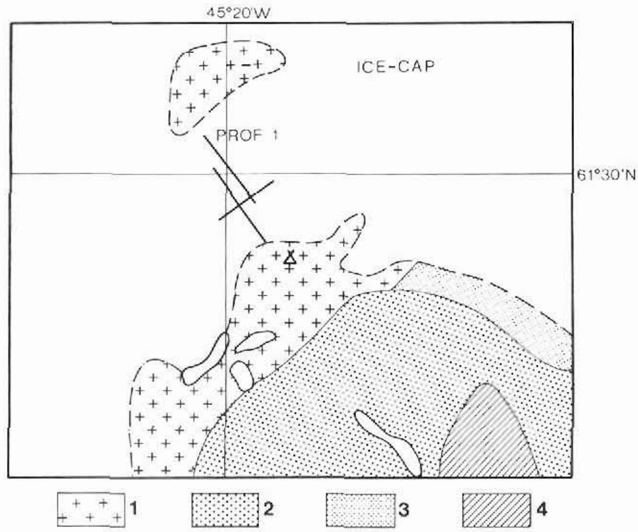

Fig. 43. Index map with simple geology and approximate position of magnetic profiles. Base magnetometer site indicated. 1: Granite, 2: Diorite, 3: Basic intrusives, 4: Monzonite.

the determination of ice thickness for the Glaciology Section of GGU and was carried out in order to test the method on realistic data. A locality near Nordbogletscher (fig. 43) was chosen. The field work was carried out by E. Hansen and the author between 1st and 5th September from a tent camp just off the ice cap.

Preliminary results

The instrumentation used for the magnetic profiling and subsequent treatment of data in the field have been described by Thorning & Boserup (this report). Three profiles were measured with 10 m between points over a total distance of 5.9 km (fig. 43). Magnetic susceptibilities were measured near the camp site.

The results obtained are very encouraging, and seem to confirm that magnetic methods can be used successfully for determination of ice thicknesses.

In fig. 44, one of the profiles is shown before and after diurnal correction. This clearly demonstrates, (1) the importance of a careful diurnal correction, and (2) that the correction routines do remove diurnal effects effectively and quite accurately, when the distance between the base magnetometer site and the field area is small (in this case 1–2 km). A qualitative evaluation of the corrected profile leaves little doubt that the shape of the underlying bedrock is reflected in the very smooth magnetic anomaly. The small peak at the south end of the profile correlates perfectly with a ridge of marginal moraine inbedded in the ice. Magnetic susceptibility measurements showed a well defined distribution from which a statistically well defined average value can be obtained.

Future work

Modelling work has not been concluded but is expected to yield good results. The geophysical modelling work will also include simulated variations of magnetic and geometric

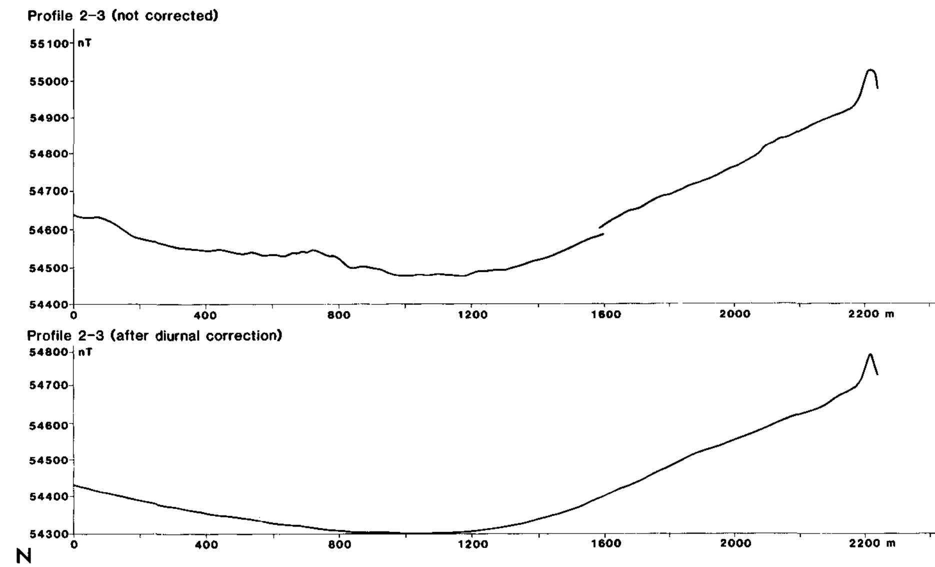

Fig. 44. Magnetic profile before and after diurnal correction.

properties in order to evaluate how such variations affect the feasibility of the method. Other interpretational methods described in Thorning (1982) will also be applied. It has already been demonstrated in the course of the field work that it is possible to make magnetic profiling on the ice, even where this is broken up, uneven, and dominated by crevasses. It thus appears that this approach to the problem may be useful and there are several ways to extend the method to give even better results.

(1) The magnetic measurements can be carried out from an aircraft. This demands an accurate local navigation system and a nearby base magnetometer (see above).

(2) The magnetic measurements can be supplemented by coincident gravity measurements providing two sets of potential field data constraining each other, and thus giving better modelling conditions.

(3) Seismic reflection methods or EMR on the ice surface can be used to provide calibration points for the ice thickness of the model.

A combination of these techniques will probably be used in the Jakobshavn area to quantify the indications of relative topography obtained from the study of low sun-angle satellite images (Thomsen, 1983).

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