Glaciological field work and remote sensing in connection with hydropower investigations, West Greenland

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As a part of the GGU programme for mapping the hydroelectric potential of West Greenland, mass balance and temperature data have been collected. Additionally, remote sensing has been applied to the delineation of drainage basins on the Inland Ice.

Field work

The field work was carried out on the Inland Ice adjoining a drainage basin at Pâkitsoq , proposed for a local hydropower project (fig. 34). The field programme was started in August 1982, when stakes for measuring the mass balance were drilled into the ice. Brief reports of the work have been given in Thomsen (1983b, 1984b), and a more detailed description can be found in Thomsen (1983a, 1984a).

Mass balance measurements 1983/1984. The stakes were visited by helicopter on 15th May

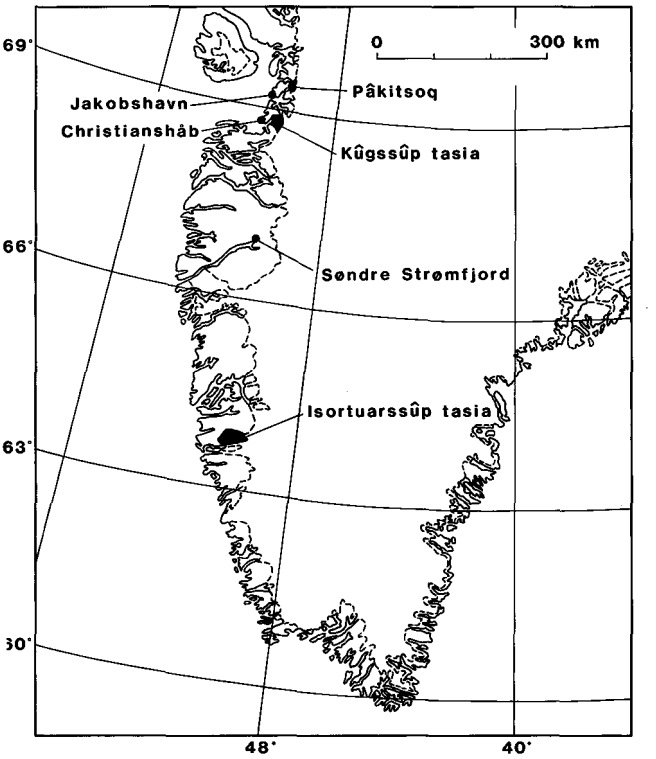

Fig. 34. Locality of the drainage basin at Pâkitsoq, the site of a proposed local hydropower scheme.

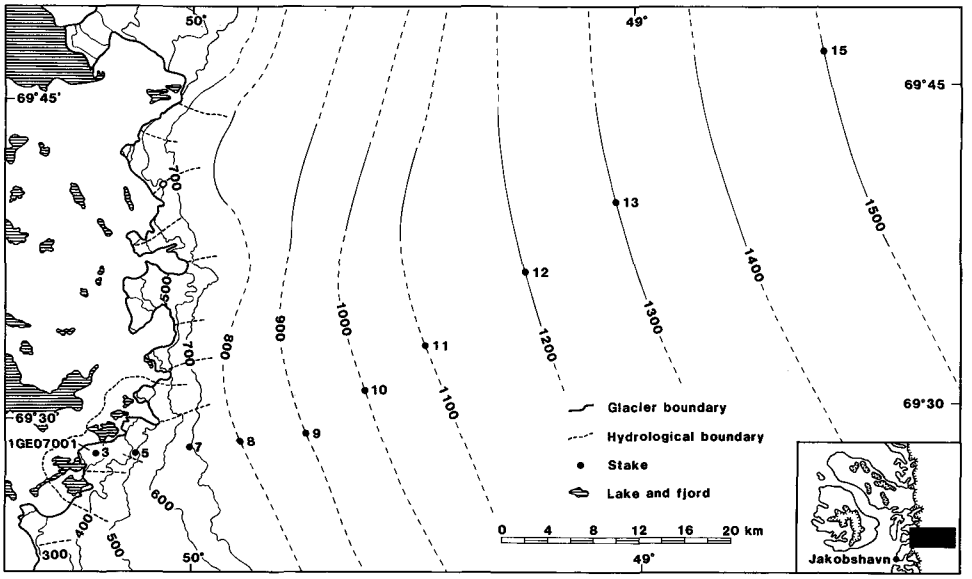

Fig. 35. Drainage basin at Pâkitsoq showing locations of stakes drilled into the ice.

and on 24th August 1984 to measure the mass changes during the winter and summer periods (fig. 35). Three stakes (stakes 9, 13 and 15) could not be found in May, and four stakes (stakes 9, 12, 13 and 15) could not be found in August.

The winter snow cover on the ice was very patchy, and was confined mainly to drifts in gullies and crevasses up to stake 7, while it was continuous at higher elevations. The transient balance for the winter period was measured in snow pits and by depth soundings at the stakes. As there were no signs that heavy melting occurred during the winter, the observed distribution of winter snow is probably due to wind drifting. The transient and annual balances are shown in fig. 36.

Temperature registration. Runoff modelling for the basin at Pâkitsoq has been carried out by Braithwaite & Thomsen (1984) and Thomsen & Jørgensen (1984), based on climate data from the coastal station at Jakobshavn. Analysis of temperature data by Braithwaite (1983), from the Godthåbsfjord area about 500 km south of Pâkitsoq, shows an inland heating effect and a glacier cooling effect, when moving inland from the coast and up onto the ice. Figures for these effects found by Braithwaite (1983) have been used in the runoff modelling at Pâkitsoq.

To get a better data base for the location, an automatic station recording air temperature was set up in May 1984 on the Inland Ice at Pâkitsoq at an elevation of 500 m a.s.l. This was carried out as a collaboration between GGU and the Greenland Technical Organization (GTO). The records from the station for the period May 1984 to September 1984 have not yet been analysed, but it appears that the station did function throughout the whole period (Thorkild Thomsen, GTO, personal communication).

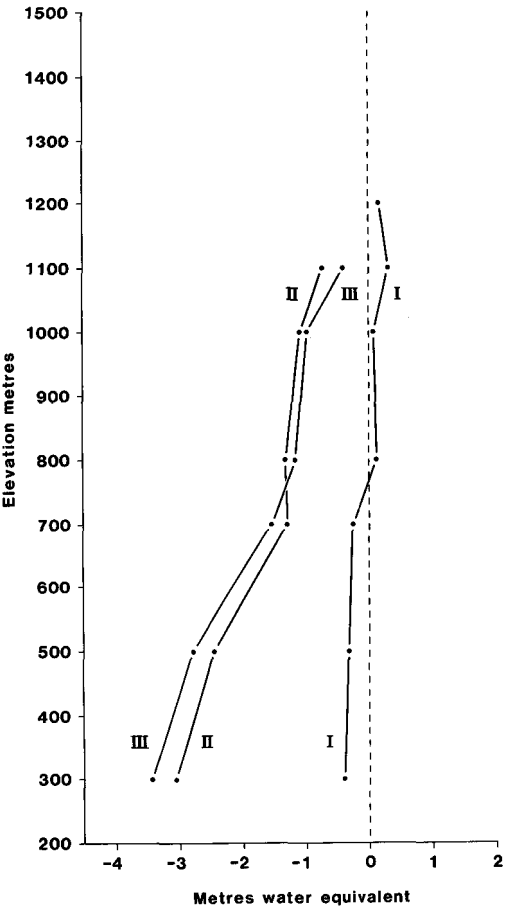

Fig. 36. Mass balance in relation to elevation on the Inland Ice at Pâkitsoq. I) Transient balance (11th August 1983 – 15th May 1984) II) Transient balance (15th May 1984 – 24th August 1984) III) Annual balance (11th August 1983 – 24th August 1984).

Delineation of drainage areas by remote sensing

Far the largest part of the runoff from several drainage basins proposed for hydroelectric installations in West Greenland is made up of meltwater from the Inland Ice. There are special problems in delineating individual drainage basins on the Inland Ice, especially at higher altitudes where the topographic information is limited. Furthermore, the surface drainage basins inferred from maps may not reflect the actual hydrological basins because of the influence of the subglacial topography on routing of the englacial and subglacial drainage patterns. Information about the subglacial tography is therefore of great importance.

Studies of existing topographic maps and Landsat data have been used for preliminary delineation of drainage areas on the ice. Radio-echo soundings have also been tried to get a more exact map of the subglacial topography.

Map and satellite studies. Geometrically-corrected and contrast-stretched Landsat images have been used to detect ice and meltwater drainage patterns on the Inland Ice. In addition mapping of the subglacial topography has been carried out by studying shadow patterns on

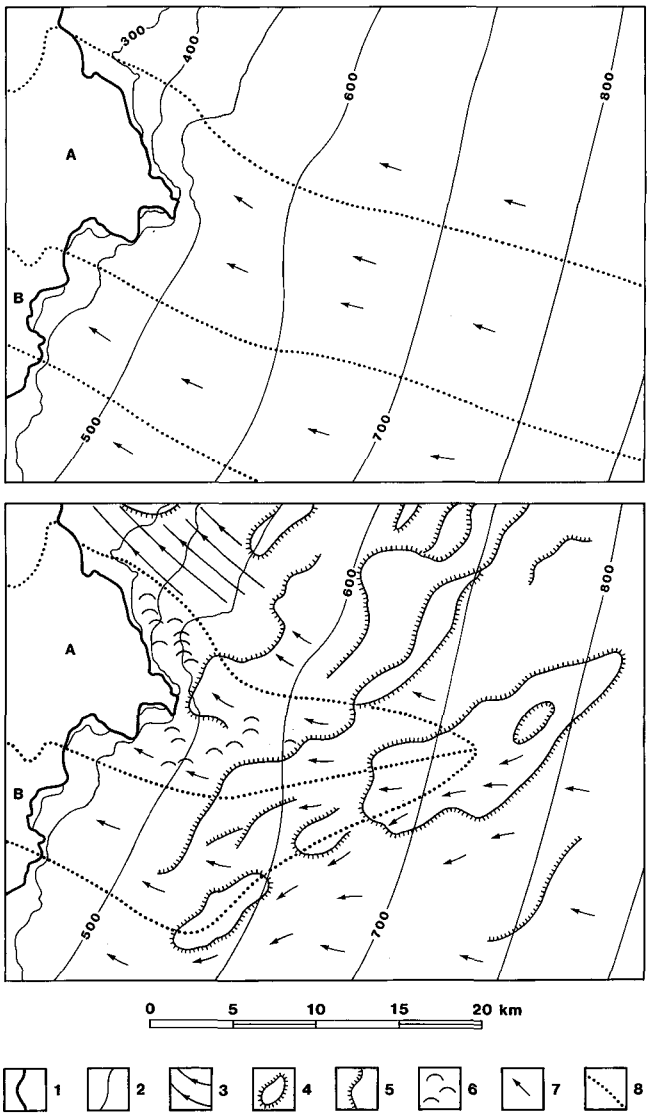

Fig. 37. Sketch map showing the marginal part of the Inland Ice draining to the ice-free basins A and B. *Upper* map shows drainage basin delineation based on surface topography. *Lower* map shows drainage basin delineation taking into account the subglacial topography. (1) Ice margin, (2) contour line, (3) flow lines, (4) marked positive relief, (5) marked change i slope, (6) undulating terrain, (7) direction of meltwater drainage, (8) hydrological boundary.

Landsat images taken under low sun-angles (Thomsen, 1983d). The information has been compiled to form surface feature maps of the ice (Thomsen, 1983c, 1984b).

On basis of surface feature maps and existing topographic information, the delineation of drainage areas has been estimated. The delineation is based on how the mapped subglacial terrain is assumed to affect the drainage pattern. An example of drainage area delineation is given in fig. 37.

Estimates of drainage basin areas on the ice at the localities Pâkitsoq, Kûgssûp tasia and Isortuarssûp tasia show that smaller areas than estimated earlier can be expected. It must be

stressed that the delineations are preliminary and that more exact subglacial topographic information is required for a better estimate of the drainage basins on the ice.

Radio echo sounding. In response to the demand for better subglacial topographic information, a radio-echo sounding programme was set up by GGU in cooperation with the Electromagnetics Institute of the Technical University of Denmark. Recordings of about 2200 km of bed-profiles from the marginal zone of the Inland Ice near Pâkitsoq and Kûgssûp tasia (fig. 34) were planned. The programme was carried out at the beginning of May 1984 using a 300 MHz ice-radar mounted in a Twin-Otter aircraft. The mission was stopped after 800 km of flown profiles, because no bottom echoes were recorded. Inspection of the equipment showed technical problems in connection with the radar that could not be repaired on the spot. A closer inspection of the radar equipment is being made to see whether the technical failure can explain the missing results.

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