NUMBER 61

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ICE

INTERNATIONAL GLACIOLOGICAL SOCIETY

CONFERENCES

1-3 APRIL 1980, Cambridge, U.K. — Conference on the Use of icebergs: scientific and practical feasibility.

Organized by: International Glaciological Society

Hosted by: Scott Polar Research Institute

Sponsored by: Iceberg Transport International, Limited
King Faisal Foundation and Abdul Aziz University

25-30 AUGUST 1980, Geilo, Norway — Symposium on Processes of glacier erosion and sedimentation.

Organized by: International Glaciological Society
in co-operation with: Norsk Polarinstitutt and University of Oslo

31 AUGUST — 4 SEPTEMBER 1981, Columbus, Ohio, U.S.A.
— Third International Symposium on Antarctic Glaciology.

Sponsored by: Scientific Committee on Antarctic Research
International Commission of Snow and Ice
International Glaciological Society

Hosted by: National Academy of Sciences in co-operation with
The Ohio State University

Proceedings of these conferences will be published by the Society in the *Annals of Glaciology.*

Circulars about the conferences may be obtained from the Secretary General, International Glaciological Society, Lensfield Road, Cambridge CB2 1ER, England.

ICE

NEWS BULLETIN OF THE

INTERNATIONAL GLACIOLOGICAL SOCIETY

NUMBER 61 3rd ISSUE 1979

CONTENTS

1980 DUES. Reminders have been sent to all members, with a plea for donations. Already many members have responded most generously, especially our Junior Members, and we are very grateful for these gestures of support. Would you please send your dues as soon as possible in 1980, so that our cash flow can be maintained easily. Thank you.

NEW LOOK. Watch for changes in ICE! Type, lay-out, features, personnel — will be re-arranged, re-organized, re-vitalized. ("Not before time", did I hear someone say?) After 61 issues, your Editor craves a change herself . . . . . Your suggestions for regular and occasional features will be welcome.

COVER PICTURE. Evening sun on the Antarctic Peninsula plateau with very light ground drift, December 1976. At this static glaciological campsite (70° 53'S, 64° 57'W), studies were made of the electrical properties and the heavy metal content of the surface snow. Photograph by Michael Landy, British Antarctic Survey, Madingley Road, Cambridge CB3 0ET.

RECENT WORK

DENMARK

GLACIOLOGICAL ACTIVITIES OF THE GEOLOGICAL SURVEY OF GREENLAND

In recent years there has been much speculation about the exploitation of the meltwater resources of the Greenland Inland Ice for generation of hydroelectric power. However, despite the efforts of a number of expeditions and individual investigators, comprehensive information about glacier ablation and streamflow in Greenland are still far short of what is needed for rational planning and water resource management. The Geological Survey of Greenland (GGU) has accordingly assumed responsibility for systematic study of hydrological conditions in Greenland with especial emphasis on glacial waters. The present work is concentrated on West Greenland between latitude 60° and 71°N and includes inventories of hydrological basins and of glaciers, compilation of information about glacier fluctuations and, at present, studies of mass balance and local climate on two outlets from the Inland Ice. The long-term goal of the project will be to develop a regional model which can be used for planning as well as being a contribution towards a better understanding of the climatic role of large ice masses. In view of the increasing work load, the original two-man Glacier Section comprising A. Weidick (section chief) and O. B. Olesen has been expanded in 1979 by the addition of R. J. Braithwaite (modelling and climatology), P. Clement (glacier hydrology) and H. Uth (technician).

The basin inventory of West Greenland

The inventory (Hydrologiske Bassiner i Vestgrønland) was completed and published at the end of 1978 by Weidick and Olesen. It comprises an identification and coding system together with basic physiographic parameters and estimates of water balance elements, in the form of tables and maps, for a total of 870 basins in West Greenland lying between the coast and the supposed equilibrium line on the Inland Ice. There is, in addition, a proposal for a preliminary division of the Inland Ice into sectors. Four basic types of basin are distinguished: ice-free, local glacier, Inland Ice quiet sectors and Inland Ice calving sectors. The study permits a rough assessment of the total water balance of West Greenland (484 000 km^2) whereby 157 km^3 of water are retained as accumulation on the Inland Ice out of a total annual precipitation of 217 km^3 whilst the net ablation of the Inland Ice contributes about 60 km^3 to annual run-off and 97 km^3 are lost due to calving. However, not all of the water from ablation of the Inland Ice is exploitable as much of it originates from exudation areas whilst local glaciers and glacier-free basins supply significant extra amounts of water.

The glacier inventory of West Greenland

As a supplement to the basin inventory, an inventory of glaciers and Inland Ice lobes is now being made by Weidick. Delineation has been extended to an altitude of 1800 m on the Inland Ice and areal measurements are being made for 100 m altitude bands. A glacier coding system has been agreed with the Temporary Technical Secretariat for World Glacier Inventory (TTS) but considerable departures from international instructions for carrying out the inventory work are necessitated by the special conditions of Greenland. Some of the work is being contracted to N. T. Knudsen of Aarhus University.

Ablation modelling

The assessment of water balance elements which has been made is based on some rather crude assumptions about specific ablation and precipitation. Efforts to refine the calculation using positive temperature sums extrapolated from coastal weather stations are being made by Braithwaite. Parameters in the current model are actually based upon results from other areas but the model will be fitted to Greenland conditions as more field data from the area become available.

Fieldwork

Mass balance and local climate studies were started on the Nordbogletscher in Johan Dahl Land (Lat. 61°20'N, Long. 45°28'W, basin number JHB,G,5.0) in 1977 by Olesen whilst a new station was set up in August 1979 beside the Qamanârssûp sermia in the Godthåb district (64°29'N, 49°33'W, GHB,H,21.0). Both glaciers are outlets from the Inland Ice with ill-defined accumulation areas and the present work is mainly confined to the ablation areas with maintenance of stake networks and measurement of climatological elements with both manual and automatic stations. Stakes will be established in the accumulation areas in future whilst discharge measurements are planned to start at both glaciers from the 1980 field season.

Future plans

Negotiations are underway with various geophysical groups for a joint airborne remote sensing programme in West Greenland which will include radioecho sounding to map subsurface topography. This would allow refinement of the present sectorial divisions and improvement in the estimates of calf ice production

from the Inland Ice as well as giving the first information about subsurface drainage. Addition of a further glacier to the measurement network as well as measurement of energy balance at selected locations are future possibilities if the means become available.

R. J. Braithwaite

ICELAND

During the summer of 1979 glacial geomorphological-sedimentological research was continued at the northern margin of Myrdalsjökull (Sléttjökull and Merkurjökull) as well as at the margin of Höfdabrekkujökull, a southeastern extension of Myrdalsjökull. A brief report on the introductory research carried out by an expedition in 1977 appeared in ICE No. 55, p. 5, 1977; some of the preliminary results have been published in various publications, among others the papers "Structures and textures in till indicating subglacial deposition", BOREAS Vol. 8, pp. 323-340, 1979, and "The proglacial area of Myrdalsjökull with particular reference to Sléttjökull and Höfdabrekkujökull. General report on the Danish Geomorphological Expedition to Iceland, 1977". FOLIA GEOGRAPHICA DANICA Tom. XV, No. 1, 64 pp. (in press).

The 1979 Expedition was organized by the Geomorphological Department of the Geographical Institute of the University of Copenhagen. The members were: the three assistants, Eskild Lund, Lisbeth Pedersen, and Henrik Højmark Thomsen, one scientific collaborator, Ole Humlum, and the leader of the expedition, Johannes Krüger. Thanks are due for financial assistance from the Danish Natural Science Research Council, and for most valuable assistance during the preparatory stage of the expedition kindly rendered by Helgi Björnsson, Reykjavík.

The expedition left Reykjavík on 7 July and after having visited Sólheimajökull it moved on to Höfdabrekkujökull where a base camp was established at Rjupnafell. From July 7-17, the group worked at the glacier front and the northeastern glacier forefield especially studying processes of englacial transportation and supraglacial deposition. On 17 July the group moved to the northern margin of Myrdalsjökull and stayed there until 7 August. This period was devoted to investigations of ground moraine topography as well as structures and textures in till caused by subglacial transportation, deposition, and post-depositional deformation processes. During the stay at the northern margin of Myrdalsjökull three camps were established: one in the Mælifell area and one in the Bláfjöll area situated in the eastern and western part of the Sléttjökull forefield, respectively. The third camp was set up at Mófellshausar close to the impressive medial moraine extending from the nunatak Enta which separates Sléttjökull from Merkurjökull. After having returned to the research field at Höfdabrekkujökull and stayed there for another 7 days, the expedition arrived at Reykjavík on 14 August. Throughout the stay in Iceland the expedition was favoured with fine weather.

In the northeastern part of **Höfdabrekkujökull** the following investigations were made:

1. In crevasses and meltwater channels deeply cut in the glacier margin, the inglacial stratigraphy was studied in detail. The investigations were mainly concentrated on the banding, concentration, and texture of debris, as well as the inglacial macro-clast fabric.

2. A 600 m long traverse was made across a hummocky glacier forefield (this area is glacier-covered on the 1960 air photographs) and a zone of disintegrating glacier ice; along this profile the thickness of flow till was studied. On the top of mounds and ridges where the deposits flow off the ice core they are rarely more than 0.1-0.5 m thick, but in hollows they often make up thicknesses of more than 1-2 m.

3. Within a selected area (60 x 70 m) of the hummocky dead-ice landscape the surface topography was mapped (contour interval 0.5 m) and the size-sorting caused by surficial creep, sliding, or falls of boulders described. Furthermore, samples for granulometric analyses were collected from the flow till and a number of macro-clast fabric analyses performed. The fabric diagrams mainly show a dispersed pattern probably caused by short-distance changes of flow direction concurrently with the inversion of the relief and the deposition of the complex flow till.

4. Therefore, three isolated lobate till flows were dissected and the pattern of orientations of rod- and blade-shaped clasts was studied to show the basic fabric in a single flow.

5. The detailed stratigraphy of thick flow till beds overlying debris-rich stagnant glacier ice was investigated in the many natural sections. Flow-till sequences interrupted by pockets of stone and boulder agglomerations indicate an alternation of till flows and boulder accumulations in former topographic hollows in the disintegrating dead-ice landscape.

6. A recent meltwater fan was mapped topographically in two situations showing the changing pattern of small streams which results in the cone formation.

In the **Mælifell area** the investigations were mainly concentrated as follows:

1. Detailed geomorphological mapping (2 x 2 km) in the scale 1:10 000 was carried out south and southwest of Mælifell in continuation of the geomorphological mapping in 1977.

2. A net of control points was set up in the glacier forefield for establishment of stereographic models on the basis of air photographs taken in the autumn of 1978 and 1979.

3. In 1977, a 2.5 km long traverse was made across the glacier margin and the ground moraine in the glacier forefield. Based on field

studies and air photo interpretations the average frontal retreat was shown to be 6.9 m year^{-1} between 1906 and 1937 rising to 33.8 m year^{-1} in the period 1937-1945. During the following period 1945-1960 it fell to 23.3 m year^{-1} and between 1960 and 1977 it was 18.8 m. The latest observations demonstrate an unusually low rate of retreat along the above profile of only 8.8 m year^{-1} for the period 1977-1979.

4. At several locations the glacier sole was described concerning the debris concentration and the character of the debris content. In the till bed a large number of ploughing blocks and boulders with stoss-and-lee side forms were observed and their orientation measured. These features may result from subglacial deposition by lodgement processes. Furthermore, the shape, orientation, and size of clasts left on the ground moraine surface during the glacier front retreat were studied. The observations clearly demonstrate that during the transportation of debris in the glacier-bed interface certain critical clast fractions are selected.

5. Within a selected area (150 x 280 m) of the extensive ground moraine the surface topography was mapped (contour interval 0.25 m) as well as the occurrence of annual moraines, fluted moraines, and boulders more than 30 cm in length. The stratigraphy of the selected area was studied in excavations. Furthermore, a number of till macro-fabric analyses was performed and orientated samples for meso- and micro-fabric analyses were collected. Most of the macro-fabric analyses show a very strong longitudinal A-axis orientation.

6. In natural sections in a drumlinized part of the ground moraine glacio-dynamic fold structures and overthrusts were investigated. Certain erosional structures were shown to be filled and deformed meltwater channels.

7. In the drumlinized ground moraine a selected drumlin complex was studied in detail concerning surface topography, stratigraphy, sedimentary structures, pattern of clast fabric, and in situ strength (vane test).

In the **Bláfjöll area** detailed geomorphological mapping (3 x 5 km) of the glacier forefield in the scale 1:10 000 was carried out (unfinished) and a net of control points was set up for establishment of stereographic models.

In the **Mófellshausar area** geomorphological mapping of large scale landforms of fluvioglacial origin was carried out and the changing systems of glacier drainage in context with the history of deglaciation investigated. Furthermore, the sedimentary structures in fossil meltwater fans and in an actively disintegrating kettle sandur were described and samples for granulometric analyses collected.

It is intended to continue the investigations in Iceland.

Johannes Krüger

UNITED KINGDOM

UNIVERSITY OF CAMBRIDGE, DEPARTMENT OF PHYSICS

(D. J. Goodman)

A theory has been developed which goes some way towards explaining how dislocations move through the ice lattice. The constitutive equation, which results from the model, is used to construct deformation mechanism maps to show how the different creep mechanisms in polycrystalline ice are dominant for different temperatures and stresses. They show, for a given grain size, how diffusional creep will dominate over proton rearrangement controlled glide at low stresses.

Indentation and four point bend tests have been carried out between −4° and −38°C, to determine the critical stress intensity factor, K_{Ic}, for polycrystalline ice. Ice behaves as purely brittle solid for loading times faster than 10 s.

A new technique for continuous measurement of surface strain changes on glaciers and sea ice has been developed. This is based on an instrument developed to measure earth tides by the Department of Geodesy and Geophysics in Cambridge, which uses an INVAR wire as a length standard. Another new instrument, which uses an INVAR bar instead of a wire, has also been designed and built. Successful trials were carried out on fast ice in Bylot Sound, NW Greenland, and on the surface of the Roslin Glacier, E Greenland (in collaboration with the Scott Polar Research Institute, Cambridge). Subsequently the instrument has been used to monitor surface strain changes on the Barnes Ice Cap, Baffin Island and on the Erebus Glacier Tongue, McMurdo Sound, Antarctica (in collaboration with G. Holdsworth, Environment Canada), and to study the response of sea ice floes to the action of swell off the east Greenland coast (in collaboration with P. Wadhams of the Scott Polar Research Institute).

The field experiments have been directed towards the measurement of the critical strain at failure of a natural ice mass. The Erebus Ice Tongue has grown to the same length where it was observed to calve 30 and 60 years ago. The results will be used to predict where and when the next calving will occur. The ice floes studied off the east Greenland coast were being broken up as the swell penetrated into the pack ice. In fact one floe calved, while the instruments were in place to give a direct measurement of the strain at failure.

In the French Alps measurements have been made (using the INVAR wire instrument) of the elastic strain changes in the rock under the Glacier D'Argentière, where the ice is 80 m thick and is sliding forward at about 1 m per day. These records have shown long periods of quiescence, with occasional elastic strain excursions lasting about twenty minutes with a characteristic sharp rise time followed by a slow decay. The events can be explained if the glacier freezes to its bed in localised patches.

UNIVERSITY OF CAMBRIDGE, DEPARTMENT OF GEOLOGY

(M. J. Hambrey)

The Pre-Pleistocene Tillite Project operates from Cambridge as Project No. 38 of the International Geological Correlation Programme which is jointly sponsored by IUGS and UNESCO. The principal aim is to gather critical data on alleged glacigenic rocks throughout the world by inviting specialists to contribute summary papers following an exhaustive list of instructions.

A reliable data base is needed in order to analyse glacial events throughout geological history and to enable global correlations to be made. This world-wide survey is intended to provide a basis for studies of the following:

a) Sedimentology of glacial environments and establishment of criteria for their recognition.

b) Palaeoclimatic patterns and palaeogeographical reconstructions.

c) The processes that relate to the origin of ice ages and thus provide a key to understanding climatic change.

d) Time correlation, especially of those Precambrian rocks in which normal stratigraphic indicators are lacking.

Some 190 summary papers are planned for a volume to be published by the Cambridge University Press in mid-1980. The volume will also include a preliminary analysis of the data, including the extent of Pre-Pleistocene ice ages through space and time. It is being edited, collated and indexed by M. J. Hambrey and W. B. Harland, assisted by N. M. Chumakov of Moscow (who is dealing with Soviet contributions) and K. N. Herod. The editors are responsible to an International Working Group which includes the following members: N. M. Chumakov (USSR), J. C. Crowell (USA), W. B. Harland (UK, Leader), A. M. Spencer (UK), R. Trompette (France), E. Welin (Sweden) and G. M. Young (Canada). A further 25 persons form an Advisory Group.

In addition to work for the volume occasional bulletins are issued listing recent work, correspondence, discussions on terminology and publications on tillites. (Since the start of the Project in May 1977 six bulletins have been issued, and a further two are planned before completion of the Project in mid-1980.) Interested persons may wish to be placed on the circulation list. The address to write to is Dr M. J. Hambrey, Pre-Pleistocene Tillite Project, Department of Geology, Sedgwick Museum, Downing Street, Cambridge, CB2 3EQ, U.K.

UNIVERSITY OF MANCHESTER INSTITUTE OF SCIENCE AND TECHNOLOGY, DEPARTMENT OF PHYSICS

(A. J. Illingworth and W. Gaskell, J. Caranti, P. Krehbiel)

Laboratory work on charge transfer during collisions between ice crystals and simulated hailstones is in progress in an attempt to explain thunderstorm electrification. Field work involving aircraft penetrations and radar surveillance of thunderstorms is planned for this summer in order to measure charge on solid and liquid precipitation elements.

A possible mechanism for ice splinter production associated with riming (J. Latham and T. W. Choularton)

It is now well known that the concentrations of ice crystals in some supercooled cumulus clouds far exceeds the concentration of ice forming nuclei active at the coldest temperatures found at the cloud top. Hallett and Mossop have demonstrated that numerous ice splinters are produced by the riming process at temperatures around −5°C and Chisnell and Latham from Manchester University have shown that the observed ice crystal enhancement can be produced by this process in a realistic time.

Work performed at UMIST by Choularton, Griggs, Humood and Latham during the past year has thrown some light on the mechanism of production of those secondary particles during riming. Experiments suggest that splintering occurs when a relatively large cloud droplet is accreted on to an already frozen smaller drop so that the heat flow from the freezing larger drop is mostly symmetrical to the surrounding air. This results in the formation of an ice shell around the freezing drop and subsequent freezing produces a buildup in internal pressure. At certain freezing rates (associated with temperatures around −5°C) the high internal pressure results in knobs or protuberances in the ice shell. At first these are open, extruding water, but later in the freezing process they close off and evidence exists to suggest that at this stage a sudden rise in the internal pressure within the drop causes the protuberance to fragment in a small number of examples. The observed sensitivities of this process to temperature, etc. agrees well with the observed sensitivities of splinter production to the same parameters.

1) **Zero-gravity study of water drop freezing** (C. P. R. Saunders)

NASA is providing the Spacelab to be carried into orbit in the 1980's aboard Space Shuttle. A series of cloud physics experiments is to be performed in the Atmospheric Cloud Physics

Laboratory (ACPL) within Spacelab. One of these experiments is to make use of the long observation time available in order to study the freezing behaviour of unsupported supercooled water drops. The lack of supports, the time scale of the experiment and the lack of convection provide a novel environment for the study of aspects of freezing hitherto limited in earth-bound laboratories. Following freezing in a temperature controlled static-diffusion chamber, a known supersaturation will be applied and the resulting crystal growth structure will be studied.

2) **Electrical charging during ice multiplication** (C. P. R. Saunders with E. R. Jayaratne)
During a sabbatical visit to UMIST in 1978 by J. Hallett an ice multiplication experiment was set up which duplicates that of Hallett and Mossop with the added facility that electric charge transfer to the riming surface can be monitored during riming. The multiplication process itself plays an important role in some forms of clouds, such as Florida cumuli, where a bi-modal spectrum of supercooled water droplets, the larger end being over 25 μm diameter, together with temperatures in the -3 to -8°C range provide the necessary conditions for multiplication to occur. The objective of the present research, which continues now that Dr Hallett has returned to Reno, is to determine whether significant electric charge transfer occurs during multiplication. Results so far indicate that the charge transfer is significant and that the sign of the charging is a function of the degree of saturation in the cloud.

3) **Ice nucleation** (C. P. R. Saunders with K. Hussain)
A continuous flow diffusion chamber has been constructed in which ice nuclei of two distinct types can be detected by permitting them to be activated and to grow as they pass in a supersaturated environment between two parallel ice-coated plates. Static diffusion chambers, with paper filters through which an aerosol sample has been drawn, have often been used to activate deposition (sublimation) nuclei and one of these chambers has been constructed. The objective is to compare the numbers of nuclei activated in the two devices, the limitations of each device being rather different. With conditions of ice supersaturation in either chamber, the deposition nuclei will be activated; by increasing the supersaturation in the continuous flow chamber to above water saturation, condensation-freezing nuclei will be activated. It is thought likely that these latter nuclei are active in some clouds and that conventional ice nuclei detectors are not sensitive to this type of nucleus, thus leading to the discrepancy between ice nuclei and ice crystals counted. The work is in an early stage but encouraging results have been obtained.

INSTITUTE OF HYDROLOGY

Deterministic, distributed snow melt model (Elizabeth M. Morris)
This research is funded by the EEC in co-operation with the Danish Hydraulics Institute and the French consulting engineers Sogreah. The research provides a series of snowmelt models for use in the Système Hydrologique Européen (S.H.E.) a deterministic, distributed hydrological model designed for commercial use in the 1980s.

Field work is being carried out in the Cairngorms and on Peyto Glacier to provide data against which to test the predictions of the models. In addition, data obtained in Finland by the Finnish Hydrological Office, and data obtained in South Georgia by BAS are also being used. During the past 12 months the computer programmes have been written and the process of modelling "real" data has now begun.

Design of instrument for measurement of snow water content (T. Dean)
A simple, portable field instrument for measurement of snow water content through capacitance measurements is being developed.

Design of automatic weather stations for use in cold climates (I. C. Strangeways)
The Institute of Hydrology developed an automatic weather station in the 1960s and about 70 are now in use both in the UK and overseas. During the past 3 winters experiments have been carried out in the Scottish Highlands to modify the station so that it is capable of operation under conditions of rime ice and high winds, for use in the mountainous and cold regions of the world. Work has been concentrated on developing techniques which do not use heat or power, since stations must operate unattended in remote areas. While first attempts were directed at simple modifications to the standard Institute station recent developments have led away from this approach and towards a station with many new and novel features. Development is not yet completed, although it is well advanced, but the outcome will probably be a system with characteristics that make it suitable for a wide variety of hostile (and normal) environments beyond those of icing.

UNIVERSITY OF READING, DEPARTMENT OF GEOGRAPHY
Okstindan, Norland, Northern Norway
(Compiled by John M. Reynolds)
Research has been carried out in Okstindan under the auspices of the Department of Geography, University of Reading, since 1968. Details of the history and early project results can be found in ICE, No. 40, 1972. The Okstindan Research Project publishes a 'Preliminary Report' series which attempts to chronicle the year to year work of the Project. Reports are available for the years 1968, 1969, 1972-76 inclusive.

This report describes the work carried out since 1973. Broadly speaking, four basic themes have featured in the research: glaciology, glacial geomorphology and stratigraphy, pedology, and periglacial effects. From the inception of work in Okstindan, the emphasis has been on the inter-relationship between these themes.

A. **Neoglacial morphology and stratigraphy**

In 1973 N. J. Griffey completed the mapping, surveying and sectioning of the Neoglacial deposits, also establishing the sizes of lichen Rhizocarpon geographicum sp. on the end moraine sequences. A map of the Neoglacial glacier recession zone based on readily distinguishable morphological and vegetational characteristics was completed. All the areas mapped in 1972 were checked. The outer limit of the Neoglacial zone was not reached by all the glaciers at the same time, but may represent glacier marginal positions dating from around 1910 A.D. back to several thousand years ago. It has also been found that between 2500 and 3000 years ago, the glaciers achieved dimensions similar to those of the "Little Ice Age", and that there is growing support for the criterion that a comparable situation existed some 700 to 900 years ago.

A geomorphological study of the end moraine sequences at four localities was completed. A variety of internal structures was found. At Austre Okstindbreen evidence has been found which suggests that slices of sediment frozen into the base of the glacier melt out of the ice at the end moraine site. Griffey employed lichenometric dating techniques to the analysis of the moraine sequences, concentrating on Rhizocarpon geographicum sp. In addition, radiocarbon dating of samples of peat bands found within some end moraines has been undertaken.

B. **Structural glaciology of Charles Rabots Bre**

Charles Rabots Bre is a small, steep and narrow glacier situated on the eastern side of the Okstindan massif. It consists of a roughly circular upper basin from which ice flows over a steep slope below which it is joined by another smaller stream from the south side.

In 1973, M. J. Hambrey completed work on the structure of the glacier and continued his analysis of flow rates. Despite the overall steepness of the glacier it is relatively slow moving, circa 9 m a^{-1} maximum. Trigonometric surveying of stakes from rock-based stations around the glacier has revealed that active ice occurs in the upper basin only, i.e. in the accumulation zone. The greater part of the glacier is essentially stagnant. It is suggested that, in part, it is frozen to its bed.

C. **Analysis of periglacial processes and phenomena in an area of sporadic-discontinuous permafrost**

R. S. Giles carried out his last season's work in 1973. He made detailed studies on snow conditions throughout the summer period as well as investigating the moisture content of frozen ground, and excavating ice veins. Apart from continuing his mapping of patterned ground he attempted to measure frost heave and compare the results of an automatic frost heave recorder and heave targets. The data were in reasonable agreement. Two temperature recorder sites were established to determine the thermal behaviour of the ground comprising a polygon. Each recorder measured the temperature from nine thermistors placed at a variety of depths in both the centre and furrow of the polygon.

D. **Braided channel processes**

Gravel sediment transport needs to be better understood in order that gravel terraces in Britain may be interpreted more realistically. With this in mind, a study was initiated to compare the fluvial geomorphology of the Kennett Valley in Berkshire, England, with that of a modern day glaciated region. G. H. Cheetham undertook the study of braiding mechanisms applied to a valley train reach of the combined Charles Rabots Bre and Corneliussensbre meltwater streams. His first season (1974) was taken up with a series of nine cross-sections along a braided reach for the purpose of examining the spatial distribution of various hydraulic parameters within a braided network. Also he examined the effects of stage changes from a consideration of hydraulic exponents. The work was extended the following summer to encompass the effect of morphological development. Fieldwork was principally concerned with hydraulic factors leading to and associated with embryonic braided channels.

In 1976, Cheetham extended the work by studying the shear stresses within the streams over a range of stages in order to determine the variation of volume sediment transport with stream energetics.

E. **Pedogenesis and ground movement in an arctic region**

In 1974 S. Ellis began a programme of research on the pedology and soil genesis of north-east Okstindan. An east-west transect was made so as to encompass the altitude range of all the major soil types in the area, from 600 m above sea-level in the east up to 1500 m in the west.

In his first season, Ellis classified the major soil types. He considered the pedalogical development, from lithosols and regosols through Arctic Brown soils to Podzols, to be a sub-arctic pedogenetic sequence which has developed during post-glacial times. Subsequent laboratory analysis has shown that pedalogical processes in the sub-arctic operate very slowly and that soil development decreases with increasing altitude.

Ellis extended his study in 1975 to include soil profile development in relation to ground movements associated with the formation of patterned ground, a previously little studied

subject. Examination of soil profile macromorphology indicates that disturbance to the soils takes place by two principal types of ground movement. These are movements en masse, characteristic of unstable sites, and movement confined to the re-orientation of individual stones, typically in stable sites. Arctic Brown soils are not as developed as Podzols. This is primarily due to differences in vegetation and micro-climate whose influences on pedogenesis overshadow those of ground movement.

Ellis has proposed that Brown Soils (previously referred to as 'Arctic Brown Soils') may be genetically related to Podzols in terms of iron translocation. Under favourable micro-climatic and vegetational conditions, Brown Soils possibly represent the immediate pedogenic precursor of Podzols in the Okstindan area.

F. **Identification and measurement of the factor contributing to nivation**

In his last season (1973) K. J. Hall measured the temperatures in and around a large snow patch with a view to investigating nivation processes in the snow patch environs. Year-round data were obtained by using two 'Grant model D' automatic recorders. Also he measured the displacement of stake lines, tubes and pillar sets to obtain an idea of ground movement. Even with all this information the results are somewhat inconclusive. However, it is clear that there can be appreciable movement of material away from a snow patch site. When the temperature above the snow is sub-zero, sub-snow movement of material can still occur. The snow acts as a protective cover from the external sub-zero temperatures. During the summer the ground thaws to at least 1 m depth and so mass movement is again possible. The temperature data suggest that frost creep is an additional mechanism of movement.

G. **Minor research based at the Okstindsjöen Research Station**

In addition to the post-graduate research programmes described above the Project enabled some undergraduates to undertake degree projects. Most students were from the University Geography Department but others were from Botany, Biochemistry, and Geology Departments at Reading University. A wide range of topics has been studied and some have featured in the Project's Preliminary Report Series. Subjects have included micrometeorology, fluvial hydrology, plant colonization, glacial hydrology, bedrock geology, and the glacial application of georesistivity amongst others.

H. **Research away from the Okstindan area**

In more recent years, the research interests of Project members have become more geographically diverse. M. Alexander (Durham University) and P. Worsley (Director, ORP) have concentrated upon Engabreen near Svartisen, paying particular attention to the pedology of the neoglacial zone with respect to glacier fluctuations and environmental implications. Also, some undergraduate work has been done at Engabreen. Two post-graduate research projects were started in 1976 and are currently being written up.

I. **Neoglacial stratigraphy in the Arctic Circle area of Scandinavia**

The objective of D. M. Bertie's project was to increase the understanding of Neoglaciation in the Arctic Circle area of Scandinavia between 65°30' and 66°45'N. Environmental changes during this period are monitored by glacier advance and retreat, the chronology of which can be reconstructed from a study of Neoglacial zones.

In 1976, Bertie worked principally in three areas—Austerdalsisen, Høgtuvbreen and Norra Storfjället, mapping the Neoglacial deposits and landforms. Chronological control was obtained to some extent by the use of lichenometry (Rhizocarpon geographicum sp.). Some difficulties were encountered whilst constructing a lichen growth curve. Data from dated grave-stones were used until it was discovered that devoted relatives of the deceased used to scrub the grave-stones clean for years after the burial. Because of the uncertainties in the chronology additional dating control was sought by obtaining Carbon-14 dates on buried organic horizons in end moraine sequences.

Bertie also attempted to determine the palaeoclimate. To do this he used two main methods. A study of the present day relationship between glacier mass balance and climate was made, from which the palaeoclimate could be inferred by analogy during periods of glacier advance. Secondly, dendrochronology was used, in particular the relationship between tree-ring width sequences and climate, to deduce palaeoclimate during glacier advance and retreat stages.

The 1977 field work was an extension of the above methods. Two different areas were studied — Beiardalen and Krutfjellet — and other glaciers at Høgtuvbreen and Norra Storfjället were examined.

There seems to have been a systematic difference in timing of the maximum advance between the glaciers in Sweden, influenced by continental climate (oldest advance) and the Norwegian glaciers in an area of maritime climate (youngest advance). The physical system is more complicated and the overall picture of this region of Scandinavia in Neoglacial times awaits the final analysis of all the field evidence.

J. **Late Weischelian/Early Flandrian ice retreat from Ranafjord**

In 1976 S. Levell started her research programme centred on Mo i Rana, a principal port on Ranafjord, northern Norway. The objective of her work was to interpret the Late Quaternary depositional record found below the Marine Limit (which is indicative of the time of deglaciation and inundation by the sea).

Principal methods used in this work were the measurement of shoreline displacement, stratigraphy and palaeoecological analysis of marine macro- and microfauna.

Recent agricultural policy in the area has meant a great deal of man made influence on the marine terraces. This has been both a help and a hindrance to the work. A help, because excavations often gave access to deep cross-sections through sediments which otherwise would have been inaccessible; a hindrance because earthworks have complicated the interpretation of the levelling and mapping of the terraces.

A large number of recessional moraines are glacio-marine deltas and are proving to be of considerable sedimentalogical interest. Mrs Levell intends to construct facies models of delta moraine genesis. Although these deltas are fairly common in Norway, the depositional mechanisms involved are poorly understood.

The Marine Limit decreases in elevation northwards suggesting that the ice persisted longest in the areas surrounding Langvatnet. In the valleys on the south side of Ranafjord the Marine Limit is related only to differential uplift. The rate of ice retreat was very rapid following the deglaciation of the main part of Ranafjord whereas around Langvatnet the rate of retreat was much slower.

By combining all the field evidence a detailed picture is emerging of conditions in these formerly ice-filled valleys and of the effect of climatic amelioration and ice withdrawal on fauna and sedimentation.

K. **Future work**

1979 is the first year since the inception of the Project that there has been no Expedition to Norway by the Department of Geography of Reading University. This is primarily because all the current post-graduates have completed their field work. The Institutt for Geologi, University of Oslo, is using the Okstindsjöen Research Station this year as a base for its students who are carrying out some geological work in the area. This reflects the fact that much is still to be learnt from the Okstindan environment. Other fields which are still open to extensive long term programmes, in addition to bedrock geology, are botany, microclimatology and zoology. Given a suitable financial climate there is no reason why the next decade should not be as profitable as the first.

BRITISH SCHOOLS EXPLORING SOCIETY EXPEDITION TO LYNGEN, NORWAY

(W. B. Whalley and J. E. Gordon)

A party from the British Schools Exploring Society did a glaciological and geomorphological reconnaissance of two ice caps in the Lyngen Peninsula (60°30′N; 19°40′E) in August 1979. Bredalsfjell (1538m) has relics of a cap which is now in two parts (approx. 0.2 & 0.1 km^2); Balgesvarri (1622m) has a much larger (0.6 km^2) cap with an estimated thickness of 60m. Both ice margins are retreating, most markedly on Bredalsfjell, and sorted polygons are appearing from under the ice, which in places on Balgesvarri, is frozen to the bouldery base.

Detailed contour maps were made of both summit areas and ice caps. Snowpits were dug at both sites and deep-drilled ablation stakes and thermistors were left for a future visit intended in four years' time.

The position of the snout of Sydbreen was surveyed to compare with a map made in 1975. During the last four summers the recession (estimated from moraine ridge spacings) was 13 m (to the end of August 1979); 16 m (1978); 12 m (1977) and 14 m (1976).

Several other glaciers in the Lyngen Peninsula were visited and distances were measured from fixed points on their forefields to the snouts of Strupbreen and Koppangsbreen.

UNIVERSITY OF BRISTOL, DEPARTMENT OF PHYSICS

(M. E. R. Walford)

A three-man team from Bristol University spent seven weeks during May and June 1979 in the Canadian high Arctic. Their objective was to explore ways of using a 60 MHz phase-sensitive pulsed radio-echo sounder to provide detailed information about the local topography of the reflecting bedrock surface beneath polar ice masses.

Radio-echo soundings were carried out mainly near the Polar Continental Shelf Project drill-sites on Mer de Glace Agassiz and on a glacier known unofficially as "Drambuie" Glacier, which lies some ten miles east of these drillsites.

It was interesting just to note that, in the vicinity of the drillsites, the surface underlying the ice cap appeared to be unusually smooth, providing an almost specular reflection of 60 MHz radar waves.

In this situation it was found very easy to define and measure a single ray direction for radio echoes. Hence one may calculate the local bedslope and, by moving the echo sounder about on the surface of the snow, one can monitor the changing range of the bed with accuracy of a small fraction of a wavelength. Over deeper ice and particularly at the "Drambuie" Glacier echoes are more complicated. Under these conditions it is necessary to record quite large amounts of data which can be partially processed in the field but which require a major computing facility for their complete analysis. A micro-processor-controlled data-acquisition system built for this purpose was in fact not used in the field due to damage in transit and subsequent technical difficulties. Instead a reserve photographic system was used to record field data

from several sampled regions of increasing echo complexity. These data will be analysed in due course using techniques already established for the analysis of model data from laboratory echo sounding experiments.

It is a pleasure to acknowledge the cooperation and support of the Polar Continental Shelf Project, Department of Mines Energy and Resources of Canada in respect of this fieldwork.

UNIVERSITY OF CAMBRIDGE, SCOTT POLAR RESEARCH INSTITUTE, SEA ICE STUDIES

(P. Wadhams)

Two field operations were carried out during 1978 to study the response of ice floes in the moving pack to forces due to wave action. The aim was to measure the attenuation rates of waves in ice, the heave and bending responses of floes and the failure strength of floes in bending. Wire strainmeters were used to record the surface strain, accelerometers to record the heave and waverider buoys to measure the local wave field. Overlying aircraft provided laser profiles of wave decay within the ice field and overlapping photography from which the development of floe sizes from the ice edge could be measured.

The first experiment was carried out in February-March 1978 in co-operation with C-CORE at Memorial University of Newfoundland. The SPRI party comprised P. Wadhams and S. Moore and the work was carried out in the Labrador Sea pack ice from a research trawler and a Canadian Coastguard icebreaker. Over-flights were provided by an ice patrol aircraft equipped with a laser profilometer and aerial cameras, with A. M. Cowan on board. Successful measurements were made on the late winter first-year ice.

The second experiment took place in September 1978 in the east Greenland pack ice, using Mesters Vig as a base. The party comprised Wadhams, Moore and Cowan from SPRI and D. J. Goodman from the Cavendish Laboratory, who had originally developed the wire strainmeter for use on sea ice. The experiment was carried out in co-operation with the Electromagnetics Institute, Technical University of Denmark, which was represented by Søren Overgaard and Ole Christiansen. A Bell 204B helicopter was employed to land the party on floes (mainly multi-year) on the pack which extended 20-40 km out to sea from the mouth of Davy Sund. Considerable long-period swell was encountered, which provided valuable data although also rendering operations difficult at times — one floe broke up directly under the strainmeters, giving a direct measurement of failure strain but necessitating a rescue operation for the equipment. A Twin Otter ice patrol aircraft of the Danish Meteorological Institute provided photographic coverage. Nine days of successful helicopter operations were carried out, with 35 sites visited. Two co-operative experiments were also performed with the US Naval Postgraduate School, Monterey, California, whereby a US Navy P3 aircraft laid sonobuoys outside the ice edge while the helicopter party deployed similar buoys through the ice at different distances from the ice edge. The aim was to measure the underwave noise generated near the ice edge due to wave-ice interaction.

V. A. Squire continued his studies of the propagation of gravity waves in fast ice, modelled as a viscoelastic material. Miss P. J. Langhorne and S. Moore constructed a tank apparatus in a cold room to study the effect of an ocean current on the crystal fabric orientation of fast ice. A. M. Cowan developed techniques of analysing sea ice imagery, using a newly acquired Optomax image analysing computer.

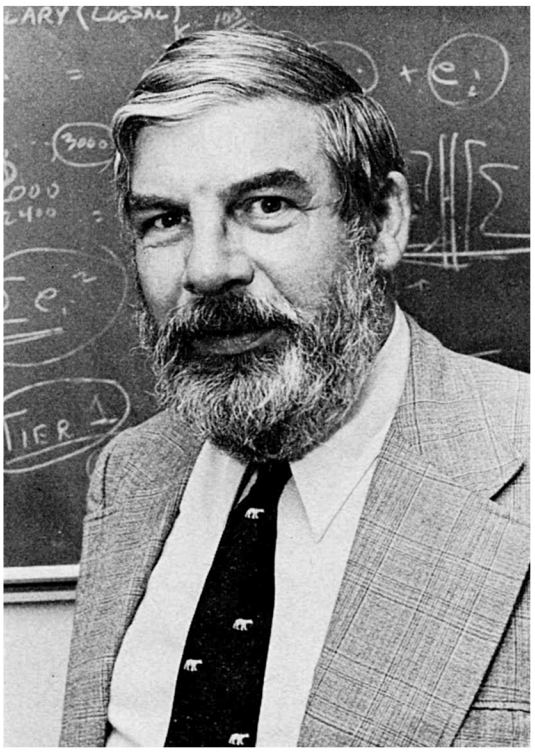
Analyses of submarine sonar profiles of the bottom surface of sea ice, and of concurrent airborne laser profiles of the top surface, obtained during the 1976 cruise of HMS *Sovereign* to the North Pole, have now been completed by P. Wadhams and R. J. Horne in co-operation with R. T. Lowry (formerly of Canada Centre for Remote Sensing). In addition, at the request of the Office of Naval Research, Horne and Wadhams carried out a similar analysis of sonar profiles obtained by the US submarine *Gunnard* under the site of the joint US-Canadian Arctic Ice Dynamics Joint Experiment in the Beaufort Sea.

UNIVERSITY OF ABERDEEN, DEPARTMENT OF GEOGRAPHY

(C. M. Clapperton, D. E. Sugden)

C. M. Clapperton and D. E. Sugden spent the 1978/79 austral summer in the Antarctic Peninsula studying the Quaternary geomorphology of the area. Two months were spent in the neighbourhood of George VI Sound. In addition brief visits were made to sites adjoining Marguerite Bay and sites further north along the Antarctic Peninsula and the South Shetland Islands. The objectives of the programme were to (1) map and analyse Quaternary landforms and deposits, (2) establish the former extent, nature and chronology of the maximum and other Quaternary glacier advances, (3) compare the results with Quaternary events in the sub Antarctic Islands, and (4) assess the importance of cold-based and/or warm-based ice in influencing glacial processes and fluctuations.

Submitted by J. G. Paren, U.K. Correspondent.



COLIN BULL

Colin Bull was born in Birmingham, England, and his early days were spent in Herefordshire.

People with a keen ear for accents can detect that, even though there is now slightly stronger evidence of his later life in the United States. Colin is widely travelled, having held professional appointments in the United Kingdom, New Zealand and U.S.A. and done geophysical field work in Greenland, Spitsbergen, Alaska and the Antarctic.

In 1948 he graduated from Birmingham University with a First Class Honours B.Sc. degree in Physics. A thesis on the luminescence of diamond gained him a M.Sc. degree in Physics in 1950. For his Ph.D. thesis in 1951, he studied the nature of electron trapping states in solid inorganic phosphers, under G. F. J. Garlick. 1951-55 saw him in Cambridge, as a Post doctoral Fellow in the Department of Geodesy and Geophysics, with B. C. Browne, M. N. Hill, and S. K. Runcorn as Preceptors. In 1951 he visited Spitsbergen, as geophysicist on the Birmingham University Expedition, and in 1952-54 he was geophysicist and 1953-54 Chief Scientist of the British North Greenland Expedition. His election to this post was by popular acclaim.

It was on this expedition that he got to know several people from other countries connected with snow and ice work. An American glaciologist is wont to recall how, at his first meeting with Colin, he was reminded of a musk-ox; now, with hindsight, he realises that Colin may have, in fact, started the hippie movement.

The first major move came in 1956, when he took up an appointment in New Zealand, as Senior Lecturer in Physics at the Victoria University of Wellington. He married Gillian in that year, and the family home was located in Wellington for the next 5 years. During this period, a son and a daughter were born. The period in New Zealand covered the International Geophysical Year, and he was heavily involved in the University's expeditions to the Antarctic. His work there was mainly concerned with gravity and paleomagnetism, and with the Quaternary glaciations in Southern Victoria Land.

In 1961 he moved to the Ohio State University in Columbus, Ohio, U.S.A., first of all as a visiting Assistant Professor of Geology and a Research Associate at the Institute of Polar Studies. He became an Associate Professor in 1962 and retained this status until 1965, when he became Director of the Institute and Professor of Geology. His second son was born in 1962, and the family became well established in Columbus. He led a University expedition to Sukkertoppen Ice Cap in Greenland in 1962, and one to Yukon Territory in 1964. His Antarctic experience was widened in 1962-63, when he was the Principal Investigator on the U.S. Antarctic Research Program, Byrd Station Traverse.

Institute of Polar Studies expeditions to the surging Sherman Glacier took up much of his time in the period 1965-69, and he was also involved in a U.S. Army radio-echo sounding expedition to Greenland in 1966, and in U.S. Antarctic Research Program projects at Plateau Station and Wright Valley 1966-67.

In 1969 he was appointed Chairman of the Department of Geology and a Research Associate of the Institute of Polar Studies, and in 1972 became Dean of the College of Mathematics and Physical Sciences and Professor of Geology and Mineralogy. His involvement in Antarctic work continued in 1971-72, as Supervisor of the USARP Deception Island Project. Increasingly his attention was taken up by the administrative load that his positions carried, but his service to science increased through election and appointment to numerous committees and councils, both national and international. He shows there the same commitment and expertise that is revealed in his academic work.

Colin has always shown excellent management qualities and his warm-heartedness and sense of humour have won him many friends in all parts of the world. These friends enjoy their visits to his attractive home, which is full of momentoes of his travels and samples of artistic weaving by his wife, and which has a happy family atmosphere.

INTERNATIONAL GLACIOLOGICAL SOCIETY

THIRD INTERNATIONAL SYMPOSIUM ON ANTARCTIC GLACIOLOGY

The Ohio State University, Columbus, Ohio, USA

31 August — 4 September 1981

FIRST CIRCULAR November 1979

A Symposium on Antarctic Glaciology will be held 31 August-4 September 1981 at the Ohio State University under the sponsorship of the Scientific Committee on Antarctic Research (SCAR) of the International Council of Scientific Unions, the International Commission of Snow and Ice (ICSI), and the International Glaciological Society (IGS). On behalf of the sponsors, the National Academy of Sciences in cooperation with the Ohio State University extends a cordial invitation to attend this symposium.

TOPICS

Papers dealing with any aspect of Antarctic glaciology will be welcome. Provisional themes for the meeting are (1) climatic and glacial changes in Antarctica on time scales from 10 to 10 million years, (2) mass and energy balances of the ice sheet and of sea ice, and (3) physical and chemical properties of Antarctic snow and ice.

PAPERS

Details about the submission of abstracts and final papers will be given in the Second Circular, to be published in September 1980. Dates for submission will be firm and must be adhered to. English will be the official language at this conference.

PUBLICATION

By special arrangement with the International Glaciological Society, the proceedings of the symposium will be published as a volume of the *Annals of Glaciology*. Papers will be refereed according to the usual standards of the Society before being accepted for publication.

TRAVEL FUNDS

It is hoped that some travel funds may be available for a few invited speakers, but almost all participants will have to secure their own travel support.

SOCIETY AND WORKING GROUP MEETINGS

Formal meetings of the SCAR Working Group on Glaciology and the Scientific Council of the International Antarctic Glaciolcgical Project, and business meetings of the International Glaciological Society and ICSI will probably be held during or after the symposium.

REGISTRATION FEES

Fees have not been finalized but will probably not exceed $50 per person ($25 for students).

FURTHER INFORMATION

You are invited to attend the symposium and to return the following preliminary registration form as soon as possible. Those who return the form will be assured of receiving subsequent circulars.

STEERING COMMITTEE

C. B. B. Bull, Chairman, U.S. member SCAR WG on Glaciology
D. H. Elliot, Director, Institute of Polar Studies, OSU
L. W. Gold, President, International Glaciological Society
E. F. Roots, President, International Commission on Snow and Ice
A. L. Washburn, Chairman, Polar Research Board, NRC
J. H. Zumberge, Chairman, Committee on International Polar Relations, NRC
T. F. Malone, Foreign Secretary, NAS

LOCAL ORGANIZING COMMITTEE

C. B. B. Bull (Chairman)
P. J. Anderson
C. R. Bentley (U. Wisconsin, Madison)
D. H. Elliot
H. Richardson (IGS)
L. G. Thompson
I. M. Whillans

PAPERS COMMITTEE

C. W. M. Swithinbank (Chairman)
W. F. Budd
C. B. B. Bull
J. W. Glen
H. Kohnen
V. M. Kotlyakov
C. Lorius
O. Orheim
H. J. Zwally

MAIL TO: Institute of Polar Studies, The Ohio State University, Columbus, Ohio 43210, U.S.A. Preliminary informal registration — Please return by March 1, 1980.

My attendance at the symposium is:.....definite.....probable.....possible.

I expect to be accompanied by:.....

I plan to offer a paper entitled:.....

.....

This paper will be appropriate to theme number.....
falls outside the proposed themes.....

To help in planning, my preference for accommodations is

.....Regular hotel ($30 and up per day, single, private bath, without meals)

.....University dormitory (about $6 per day each for four to a room to $15 per day for a single; all have private baths and telephone, and are airconditioned; meals are available at a cost of about $2 a day for breakfast to $10 a day for three meals)

NAME .....
(please print)

ADDRESS .....

.....

JOURNAL OF GLACIOLOGY

The following papers have been accepted for publication in forthcoming issues of the *Journal of Glaciology:*

L. G. Thompson:
Glaciological investigations of the tropical Quelccaya ice cap.

B. B. Narod & G. K. C. Clarke:
Airborne UHF radio echo-sounding of three Yukon glaciers.

A. T. C. Chang, B. J. Choudbury & P. Gloersen:
Microwave brightness of polar firn as measured by Nimbus 5 and 6 ESMR.

C. E. Thorn & K. Hall:
Nivation: an Arctic-Alpine comparison and reappraisal.

A. Denoth:
The pendular funicular liquid transition in snow.

R. L. Brown:
Pressure waves in snow.

J. Perez, C. Mai, J. Tatibouet & R. Vassoille:
Dynamic behaviour of dislocations in HF-doped ice Ih.

P. Duval & H. Le Gac:
Does the permanent creep-rate of polycrystalline ice increase with crystal size?

W. B. Whalley & C. C. Langway:
A scanning-electron-microscope examination of subglacial quartz grains from Camp Century core, Greenland — a preliminary study.

R. H. Thomas, D. R. MacAyeal, C. R. Bentley & J. L. Clapp:
The creep of ice, geothermal heat flow and Roosevelt Island.

W. Tangborn:
Two models for estimating climate-glacier relationships in the North Cascades, Washington.

G. V. B. Cochran:
Instruments and methods: Field techniques for experimental stress analysis in Arctic sea ice.

S. J. Johnsen, W. Dansgaard, N. Gundestrup, S. B. Hansen, J. O. Nielsen & N. Reeh:
Instruments and methods: A fast light-weight core drill.

P. H. Gammon, H. Kiefte & M. J. Clouter:
Elastic constants of ice by Brillouin spectroscopy.

M. Ya. Verbitsky & D. V. Chalikov:
A thermohydrodynamic model of an ice sheet.

C. Obled & W. Good:
Recent developments in avalanche forecasting by discriminant analysis techniques.

K. Hutter:
Time-dependent surface elevation of an ice slope.

J. Desrues, F. Darve, E. Flavigny, J. P. Navarre & A. Taillefer:
An incremental formulation of constitutive equations for deposited snow.

J. Niewodniczanski, J. Grabczak, L. Baranski and J. Rzepka:
The altitude effect on the isotopic composition of snow in high mountains.

R. L. Brown:
An analysis of non-steady plastic shockwaves in snow.

E. R. LaChapelle & T. E. Lang:
A comparison of observed and calculated avalanche velocities.

L. W. Morland & I. R. Johnson:
Steady motion of ice sheets.

R. L. Hooke & P. J. Hudleston:
Ice fabrics in a vertical flow plane, Barnes Ice Cap, Canada.

T. E. Lang & R. L. Brown:
Snow avalanche impact on structures.

M. Sverrisson, A. Johannesson & H. Björnsson:
Instruments and methods: Radio-echo equipment for depth sounding of temperate glaciers.

C. U. Hammer:
Acidity of polar ice cores in relation to absolute dating, past volcanism, and radio-echoes.

P. Wadhams & R. J. Horne:
An analysis of ice profiles obtained by submarine sonar in the Beaufort Sea.

M. M. Herron & C. C. Langway:
Firn densification: an empirical approach.

S. Hastenrath & J. K. Patnaik:
Radiation measurements at Lewis Glacier, Mount Kenya.

P. Duval:
Creep and fabrics of polycrystalline ice under shear and compression.

V. R. Parameswaran & S. J. Jones:
Triaxial testing of frozen sand.

B. Dey:
Applications of satellite thermal infrared images for monitoring North Water during periods of polar darkness.

M. Nakawo & G. Wakahama:
Preliminary experiments on the formation of elongated air bubbles in glacier ice by stress.

SHORT NOTES

U. K. Bassi, S. Chopra & A. P. Tewari:
A note on the morphology of Baspa Glacier, District Kinnaur, Himal Pradesh, India.

W. C. Mahaney:
Late Quaternary rock glaciers, Mount Kenya, East Africa.

D. R. MacAyeal & R. H. Thomas:
Ice-shelf grounding: ice and bedrock temperature changes.

T. T. Zwick:
A comparison between modern and composite Pleistocene snow-lines, Absarola and Beartooth Mountains, Montana, Wyoming, USA.

J. Weertman:
Bottom crevasses.

A. C. Fowler:
The existence of multiple steady states in the flow of large ice masses.

RECENT MEETING (of another organization)

INTERNATIONAL WORKSHOP ON THE REMOTE ESTIMATION OF SEA ICE THICKNESS

An International Workshop on the Remote Estimation of Sea Ice Thickness was held in St. John's, Newfoundland, on 25 and 26 September 1979. The sixty participants included both researchers and operational users from North America, Europe, and the Soviet Union. Nineteen invited papers were presented in three sessions: overview of problem; recent sea ice studies; and ice sounding technology. The final session was devoted to a panel discussion, culminating in recommendations for research priorities in this field.

A significant amount of time at the Workshop was spent discussing the electrical properties of sea ice, since most of the remote measurement techniques involved radar sounding. Sea ice is a very complex natural material and discussion focused on the high variability of its electrical properties. There is a strong need for standardization of electrical property measurements so that the results from different workers can be compared. The frequency range of interest — approximately 100 MHz — is a very difficult range in which to work, particularly for making *in situ* measurements.

New data on the horizontal electrical anisotropy of sea ice and a new theoretical model were presented. The anisotropy phenomenon appears to be closely related to the structure of the lower part of first-year sea ice. This topic is one of considerable research interest at the moment. In general, it was felt that we have very poor basic understanding of the electrical properties of sea ice, and that the existence of any "quick fix" to remedy this is unlikely.

Discussion concerning the processing of sounding results indicated that significant advances could probably be achieved by

appropriate signal processing. This might be pre-processing, post-processing (matched filtering), or use of new "super-resolution" algorithms. Interpretive procedures need to be oriented toward real-time operational output.

There were papers on the use of a laser profilometer and a satellite altimeter to determine statistical ice properties over long tracks. The suggestion was made that inertial systems might be developed to extend these types of measurement for synoptic estimates of ice freeboard and hence thickness.

The majority of sounding results presented were based on a broad-band impulse radar system that has been used for several years. Concern was expressed over the fact that measurements are made in the near field of the antenna without properly allowing for this, and the importance of diffraction effects was noted. Several new systems are under development, including: synthetic pulse radar, a phase measurement system, and a "distributed-source" antenna. In the U.S.S.R. modulated pulse radar and synthetic pulse radar have been used for some years. A new two-frequency phase-pulse system is under development in that country. The importance of testing new systems in the real environment was stressed.

Finally the needs of the various users was underlined. It appears that each user has particular needs, and it is possible that these will not all be met by a single instrument. For example, the need of some operators is for good definition of multi-year ice thickness; for others, the design parameters for offshore structures. Some people need operational strategic planning devices; whereas others are more interested in tactical support. The location and time of year of operation are also significant. It seems clear, however, that ice thickness devices should be much more than merely research tools. To this end, the Workshop was able to bring together both researchers and those people who will ultimately have to make use of this technology and the data that are collected.

The Proceedings, including the written papers and a detailed summary of the Discussion Session, will be printed by C-CORE early in 1980.

James R. Rossiter
Centre for Cold Ocean Resources Engineering
Memorial University
St. John's, Newfoundland
A1B 3X5, Canada

FUTURE MEETINGS (of other organizations)

SYMPOSIUM ON ICE

Quebec, Canada, 27-31 July 1981

First Announcement
The Symposium is sponsored by the International Association for Hydraulic Research, co-sponsored by the International Association of Hydrological Sciences, World Meteorological Organization, and International Glaciological Society, and organized by Gouvernement de la Province de Québec and Université Laval, Québec.

Time schedule:

Abstract submission	1 February 1980
Preliminary acceptance	1 August 1980
Full paper submission	1 February 1981
Final acceptance of papers	1 April 1981
Pre-Registration deadline	1 April 1980

The second announcement for this symposium will be made in February 1980.

History
The Ice Symposium of the International Association for Hydraulic Research have been organized since 1970. This is the sixth of these symposiums, the others having been held at the following places: Reykjavik, Iceland (1970), Leningrad, U.S.S.R. (1972), Budapest, Hungary (1974), Hanover, U.S.A. (1975), Lulea, Sweden (1978).

Earlier symposiums have had approximately 150-200 delegates and have been a forum for discussions and exchanges of research results in the field of ice engineering.

Programme
The programme includes the following topics which cover quite completely the field of ice engineering: thermal regime of rivers, ice hydraulics, ice mechanics, ice and structures, modelling ice phenomena.

Special seminars will be organized every day dealing with the various technical tasks of the Committee on Ice Problems of IAHR.

Visits and tours
Information concerning tours will be published in the next brochure.

During the Symposium many technical and touristic visits will be organized at Laval University, in the Quebec Harbour, and in the Quebec city area. There will be a reception and a banquet during the Symposium.

Registration fee
The registration fee for participants is estimated at $150 for pre-registration before 1 April 1981, and $200 after that date. The fee will include pre-prints and proceedings.

Location
The Symposium will be held in the famous "Château Frontenac" of the city of Quebec, right in the center of the oldest Canadian city. A block of rooms has been reserved at lower cost for participants, but other rooms will be available in tourist class hotels as well as in the dormitories of Laval University. Transportation will be provided to hotels and the University.

Preliminary registration
Please write for a form to:

International Symposium on ice, Québec 1981
Prof. Bernard Michel
Dept. of Civil Engineering
Université Laval, Ste-Foy,
Québec, Canada G1K 7P4;

SYMPOSIUM ON THE MECHANICAL BEHAVIOUR OF STRUCTURED MEDIA

Carleton University, Ottawa, Canada

18-21 May 1981

Scope

The underlying theme of this symposium, namely the mechanical behaviour of structured media, forms a link which attempts to unify the various areas of research activity devoted to the examination of mechanical properties or engineering applications of materials such as soils, rock, ice, wood, metals, concrete and other composites. The subjects to be covered include fibre reinforced media, wood and fibrous media, creep and fracture processes in concrete, porous elastic media, fluid saturated media, mechanical behaviour of ice and frozen soils, microstructural phenomena in fluids.

The symposium is intended as a forum for the exchange of knowledge, experience and newly conceived ideas by bringing together leading scientists and engineers from these selected areas of research activity.

Addresses will be given by distinguished researchers who have made outstanding contributions to the understanding of the mechanical behaviour of structured media.

Abstracts

Those who wish to submit papers to this symposium are requested to send extended abstracts of no more than 1000 words to Professor A. P. S. Selvadurai before 30 June 1980. Accepted papers will be included in the Proceedings of the Symposium to be published in hardcover edition and distributed through Elsevier Scientific Publishing Company, Amsterdam.

Three copies of the abstract should be sent to: Professor A. P. S. Selvadurai, Department of Civil Engineering, Carleton University, Ottawa, Ontario, Canada, K1S 5B6, from whom further information may be obtained.

GLACIOLOGICAL DIARY

1980

1–3 April
Conference on Use of Icebergs, Cambridge, U.K. Organized by International Glaciological Society, hosted by Scott Polar Research Institute, sponsored by Iceberg Transport International. (Mrs H. Richardson, International Glaciological Society, Lensfield Road, Cambridge CB2 1ER, England.)

7–17 April
International Geological Congress (International Union of Geological Sciences), Paris. (Sec. Gen. International Geological Congress, Maison de la Géologie, 77-79 rue Claude Bernard, 75005 Paris, France.

17 April
British Branch meeting, International Glaciological Society, Birmingham. (Dr M. Walford, Department of Physics, Tyndall Avenue, Bristol BS8 1TL, U.K.)

24–30 August
Symposium on Processes of glacial erosion and sedimentation. Geilo, Norway, International Glaciological Society. (Mrs H. Richardson, Secretary General, Cambridge CB2 1ER, England.)

3–5 November
Avalanche Workshop 1980. Vancouver, British Columbia, Canada. (G. L. Freer, 3404 W. 4th Avenue, Vancouver, B.C., V6R 1P5, Canada.)

1981

18–21 May
Symposium on the Mechanical behaviour of structured media. Carleton University, Ottawa, Canada. (A.P.S. Selvadurai, Department of Civil Engineering, Carleton University, Ottawa, Ontario, Canada). (See p. 18 of this issue of ICE.)

27–31 July
International Association of Hydraulic Research—Ice Symposium, Quebec City. (B. Michel, Département Génie Civil, Université Laval Ste-Foy, Quebec G1K 7P4, Canada.)

27–31 July
Port and Ocean Engineering under Arctic Conditions (POAC-81), Quebec. (B. Michel, Département Génie Civil, Université Laval, Ste-Foy, Quebec G1K 7P4, Canada.)

31 August–4 September
Third International Symposium on Antarctic Glaciology. Columbus, Ohio, USA. Scientific Committee on Antarctic Research of ICSU. Co-sponsored by International Commission of Snow and Ice and International Glaciological Society. (Dr C. B. B. Bull, Office of the Dean, College of Mathematics & Physical Sciences, Ohio State University, 164 West 17th Avenue, Columbus, Ohio 43210, U.S.A.)

1982

19–30 July
International Association of Hydrological Sciences Assembly. Exeter, U.K.

early August
Symposium on Physics and chemistry of ice. Rolla, Missouri, U.S.A.

23–27 August
Second Symposium on Applied Glaciology, Hanover, New Hampshire, U.S.A. Organized by International Glaciological Society, hosted by Cold Regions Research and Engineering Laboratory. (Mrs H. Richardson, International Glaciological Society, Lensfield Road, Cambridge CB2 1ER, England.)

1983

July
Fourth Permafrost Conference. Fairbanks, Alaska, U.S.A. (T. L. Péwé, Dept. of Geology, Arizona State University, Tempe, AZ 85281, U.S.A.)

(dates to be announced)
International Union of Geodesy and Geophysics General Assembly. Hamburg, Germany.

REVIEW

P. J. Williams. **Pipelines and permafrost. Physical geography and development in the circumpolar north.** London and New York, Longman, 1979. 98 p. £3.95.

Professor Williams has given us a very helpful and needed little book, written for the non-specialist. He describes the main features of frozen ground — solifluction, patterned ground, pingoes, thermokarst, and others — and relates them to the major northern engineering project of the moment, the building of large pipelines. Indeed, one may infer that it was Williams' own involvement, as a Canadian university scientist, in the Mackenzie Valley Pipeline Inquiry of 1974-77 that provided the stimulus for writing the book; and it is much more interesting to have a textbook (which is what this really is) hung on the peg of involvement in very topical events.

Many interesting points emerge. The design of the functioning Trans-Alaska hot oil pipeline is discussed, and the conclusion reached that the delays in authorisation of the project turned out to be "essential to the successful construction"; if the original design had been approved, disaster might have followed — or perhaps more likely, extremely expensive re-design. Then there is the very interesting and still unsolved problem of coping with frost heave in the context of a chilled gas pipeline. Leading consultant engineers at first considered that an earth mound ("berm") of a maximum height of 3 m would hold the pipe down; but as a result of Williams' questioning it is now accepted that a height of 20 m might be required — thus clearly ruling out that method. These sorts of argument raise strong emotions, especially when billions of dollars are involved, but it must be said that Williams is very fair in keeping the balance between industry and conservation. The book, as the author says, is not only about pipelines and permafrost, but about the erratic development of our knowledge: an excellent way to bring a textbook to life.

This is an ideal book for students. It has good plates and diagrams, and is clearly expressed in everyday language, yet with full references to the technical literature. Altogether, it is a model of its all-too-rare kind. Williams ends with a plea that the intellectual excitement of investigating these unsolved problems of technology should be seen to be just as great as that aroused in studying the social issues involved. So his book may have the desirable result of attracting recruits into the subject.

Terence Armstrong

NEWS

Dr E. Fred Roots, Science Advisor in the Canadian Department of the Environment, has been elected President of the International Commission on Snow and Ice.

Dr Mark F. Meier, U.S. Geological Survey, Tacoma, Washington, U.S.A., has been elected President of the International Association of Hydrological Sciences, the first time that a glaciologist has held this position.

COURSE

The Department of Geography, Carleton University, is considering sponsoring another course in glacier hydrology to be run by Dr Gunnar Østrem. Any individuals interested in taking such a course are asked to contact, as soon as possible, the Director of Graduate Studies, Department of Geography, Carleton University, Colonel By Drive, Ottawa, Ontario K1S 5B6, Canada.

PUBLICATIONS

The Proceedings of the Workshop on the bearing capacity of ice covers, held in Winnipeg in October 1978, have now been published. They comprise the text of 17 technical papers, discussions on such papers, and summaries of panel discussions. Three main subject areas covered are: (1) performance measurements of ice covers under dynamic and static loading; (2) laboratory and theoretical investigations of long-term bearing capacity; and (3) operational experience in constructing, maintaining and operating roads and airstrips on ice.

Further information may be obtained from Mrs Joyanne Curran, Secretary, Snow and Ice Subcommittee, National Research Council, Ottawa, Ontario K1A OR6, Canada.

Dr Marcel de Quervain writes that the **Proceedings of the Symposium on Skiing and Safety III, Avalanches,** organized by the Forum Davos have been published. The meeting took place in mid-September 1979 and the volume was ready for dispatch on 21 November 1979. "The man who produced this astonishing result was Dr med. P. Matter, chief surgeon of the Davos Hospital and his staff."

NEW MEMBERS

Comer, Patricia L., University of Manchester, School of Geography, Manchester M13 9PL, England, U.K.

Dardis, George F., Ulster Polytechnic, School of Environmental Science, Shore Road, Newtownabbey, Co. Antrim, Northern Ireland.

Hansen, H. S., Boholtevej 3 II tv, 4600 Køge, Denmark.

Jeffries, M. O., 100 Carrington Lane, Sale, Cheshire M33 5NG, England, U.K.

Sato, S. S., College of Nursing and Medical Technology, Hirosaki University, Hon-cho 66-1, Hirosaki-shi, Aomori-ken 036, Japan.

Wells, Herbert C., 2004 E. Bonita, Las Vegas, NV 89105, U.S.A.

INTERNATIONAL GLACIOLOGICAL SOCIETY

Lensfield Road, Cambridge CB2 1ER, England

DETAILS OF MEMBERSHIP

Membership is open to all individuals who have scientific, practical or general interest in any aspect of snow and ice study. Payment covers purchase of the Journal of Glaciology and Ice. Forms for enrolment can be obtained from the Secretary General. No proposer or seconder is required.

ANNUAL PAYMENTS 1980

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Junior members	Sterling:	£ 6.00
Institutions, Libraries	Sterling:	£35.00 for Volume 25 (Nos. 91, 92, 93) £35.00 for Volume 26 (Number 94)

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ICE

Editor: Hilda Richardson

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