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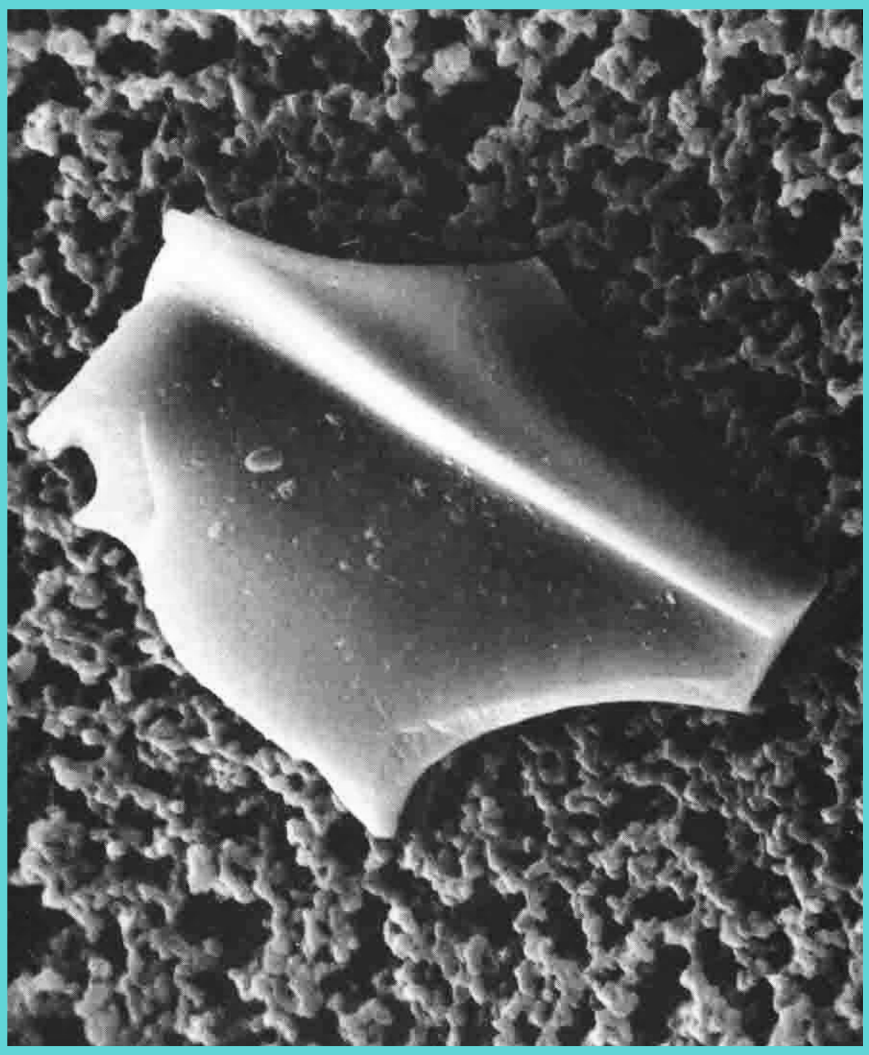
ICE



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ICE

NEWS BULLETIN OF THE

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NUMBERS 62 & 63 1st & 2nd ISSUES 1980

CONTENTS

CHANGES? A few with this issue, more to come later in the year. As a change from people-profiles, and despite one suggestion that we should highlight the "eccentrics" in the Society (the Editor was under the impression that this characteristic was one essential requirement of membership), there will appear profiles on organizations related to the Society's work. The biggest change will be in Editorship: after 63 issues of ICE, plus several of its predecessor, "Reports to Members", your Editor feels that both she and ICE need a change. Furthermore the management of the Society's new publication, "Annals of Glaciology", keeps her very busy.
This double issue clears her files of an accumulation of items for ICE. The new Editor, with the approval of the Society's Council, will be Simon Ommanney of Canada, and he will handle the 3rd issue 1980. He has been our Correspondent for Canada for several years, and has always been very helpful, kind and efficient. The HQ office will miss his efforts, but ICE will gain. Your present Editor looks forward to dealing with ICE in future as leisure-time reading. Please continue sending news to HQ office for the time being. We will let you know about the new arrangements in the next issue of ICE.

COVER PICTURE. Scanning electron micrograph of a volcanic fragment from a depth of 28.6 meters in the French 9000-m Dome C, Antarctica core. The calculated age of this depth is ∿ 7200 Y.B.P. The magnification is 3000 diameters. The long axis is 33 μm and the substrate is 0.45 μm Millipore filter paper. The primary constituents are Si, Al, Fe, K, Na, Ca and Si/Al ratio is 4.6. Photograph taken by Ellen Mosley-Thompson and Lonnie G. Thompson, Institute of Polar Studies, The Ohio State University, 125 South Oval Mall, Columbus, OH 43210, U.S.A.

We are sorry to report the death of Fritz Müller, whose work on glaciers in many parts of the world is well known to all glaciologists. He died on the Rhone Glacier on 26 July 1980. An obituary will be published in the *Journal of Glaciology*.

CANADA

GLACIER STUDIES—GENERAL

**For abbreviations used see Ice, No.59, 1979, p.15*

GLACIER INVENTORY OF CANADA
(C.S.L. Ommanney & M.M. Strome, GD NHRI/EC*)
The Glacier National Park study is continuing. A further 24 basins with 1191 glaciers were added to the Yukon inventory (S.G. Collins). All Glacier Atlas of Canada maps are now available in French.

NORTH WATER REGION
(F. Müller & K. Schroff, GEOG/ETH-McG)
Mass balance measurements were made on the "Laika" Glacier and Ice Cap (Coburg Is.) and on Leffert and an unnamed glacier on Ellesmere Island.

AGASSIZ ICEFIELD, ELLESMERE ISLAND
(W.S.B. Paterson, R.M. Koerner & D.A. Fisher, PCSP/EMR)
A 138 m borehole was drilled to bedrock at the crest of the Agassiz Icefield. Dirt layers found in the lowest few metres suggest that the basal ice was at the melting point at some stage in the past. This is surprising because the present basal temperature is -22°C and there were no dirt layers in the 1977 core about 1.5 km down slope. There are also major differences in oxygen isotope profiles in the two cores. Laboratory analysis of the 1977 core is continuing with emphasis on microparticle concentration, trace elements, and the detection of volcanic eruptions by measurement of electrical conductivity. Without an accurate map, a complete mass balance of the Icefield was not possible. However, measurements show that melting on the irregular surface of a western glacier is an order of magnitude higher than on the smooth surface of a glacier that drains the NE side of the Icefield.

AXEL HEIBERG ISLAND
(F. Müller, GEOG/ETH-McG)
Separate winter and summer balance measurements were made on White and Baby glaciers. Data from earlier years, back to 1959/60, have been compiled and analyzed for publication. On White Glacier, an improved drill successfully reached bedrock in the accumulation area. Two holes were drilled there, one at the equilibrium line, and two more in the tongue close to the glacier edge, all reached bottom between 80 and 350 m. There are now a total of 22 thermistor sites along the longitudinal profile.

MEIGHEN ISLAND
(W.S.B. Paterson, R.M. Koerner & D.A. Fisher, PCSP/EMR)
Routine mass balance measurements were carried out on the Meighen Ice Cap.

DEVON ISLAND
(W.S.B. Paterson, R.M. Koerner & D.A. Fisher, PCSP/EMR)
The mass balance of the NW side of the Devon Island Ice Cap was -99 kg/m^2 for 1976-77 and +27 kg/m^2 for 1977-78.
(P. Marsh & M.-K. Woo, GEOG/McM)
A runoff model for high arctic basins is being developed. It incorporates data from glacierized and nival basins studied near Eidsbotn Fiord.

QUEEN ELIZABETH ISLANDS
(B. Alt (under contract), PCSP/EMR)
Investigations of the synoptic meteorology of years with extreme conditions during the period of record (the last 20 years) are continuing. Analysis of the 'warm' summers, those in which the mass balance of the ice caps is strongly negative, showed that contraction of the 500 mb polar vortex, or a shift of it towards the Soviet side of the Arctic Ocean, results in universally warm conditions in the Queen Elizabeth Islands. Differences within the region can be explained by the position and shape of the vortex. The cold summers are now being studied; the situation seems to be more complex than in the warm summers.

BYLOT ISLAND
(R.N.W. Dilabio & W.W. Shilts, GSC/EMR)
Laboratory analyses of till and debris samples from glaciers and moraines in SW Bylot Is. indicate that (1) the different grain size fractions of debris have different provenances; (2) englacial debris includes debris derived from the glacier bed: (3) the finest debris from the hinterland is diluted in a regular way in the down-ice direction; and (4) the

lithology of glacial debris can be used to characterize drainage basins of individual glaciers and their tributaries.

BAFFIN ISLAND – PENNY ICE CAP

(G. Holdsworth, GD NHRI/EC)
A reconnaissance ice core site survey was carried out on the Penny Ice Cap (67°15'N, 64°55'W; Elev. 2000 m). A 20 m core was retrieved which covers the last 30 years. About 42% of the core is ice, with a marked decrease in ice content since 1954 (maximum). The core was dated using $\delta^{18}O$ and tritium plots. The average isotopic temperature is -18°C, whereas the measured borehole temperature between 10 and 20 m is close to -14°C. Ice depth at the site (near the divide) is 550-600 m. Additional radio-echo sounding was done by P. Gudmandsen. Reference poles, in a strain array, were inserted and a cache left for future medium-depth core drilling planned for 1981-82. An electro-mechanical drill, based on a Rufli-Rand design, has been constructed and tested in Ottawa. (For other Baffin Island studies see USA report for the Universities of Minnesota and Wisconsin.)

GLACIER STUDIES—YUKON

ICE-DAMMED LAKES

(G.K.C. Clarke, GPHYS/UBC)
A time-lapse film was made of the 9-11 July 1979 drainage of Hazard Lake. After the outburst flood, a levelling survey of the empty basin was carried out and a detailed bathymetric map prepared. Down-hole seismometers have been emplaced in the Steele Glacier ice dam so that seismicity accompanying future jökulhlaups can be recorded. A study of the paleohydrology of Recent Lake Alsek is being continued.
(G.J. Young & M. Perchanok, GD NHRI/EC)
A reconstruction of the glacial lake chronology for the Donjek Glacier terminus area is well underway.

GLACIER AND ROCK GLACIER HYDROLOGY

(P.G. Johnson, GEOG/OTT)
Hydrological regimes encountered in the Yukon fluctuated very widely with large hydrograph responses to small climatic variations and precipitation events. Routing of flow was difficult due to complex subsurface conditions, dilution and the absence of resurgences, especially with rock glaciers. Water chemistry studies offer promise of a better definition of routing and water sources with some distinct trace element patterns emerging.

MCARTHUR RANGE

(O.L. Hughes, GSC/EMR, Calgary)
A debris-covered glacier with ice exposed in a large collapse pit was examined.

GLACIER STUDIES—CORDILLERA

ISKUT RIVER, B.C.

(O. Mokievsky-Zubok, GD NHRI/EC)
Three glaciers (106 km²), representing an ice coverage of 67% and 23% in two watersheds draining into the Iskut River, have been chosen for a study of the impact of glacier variation and runoff on a proposed reservoir. "Andrei", "Yuri" and "Alexander" glaciers had negative balances of -0.64, -0.57 and -0.50 mH_2O, respectively.

FLOOD GLACIER JÖKULHLAUP, B.C.

(O. Mokievsky-Zubok, GD NHRI/EC)
Lakes dammed by the Flood and "Natavas" glaciers flash-flooded the tributaries of the Iskut and Stikine rivers. The lakes and sites were investigated before and after the discharges and some measurements were taken.

BRIDGE RIVER, B.C.

(O. Mokievsky-Zubok & S. Fogarasi, GD NHRI/EC)
Studies continued in order to determine the effect of glaciers on basin runoff and to evaluate the seasonal and operational forecast models for a downstream reservoir (with J.R. Gordon, BC Hydro). A Data Collection Platform (DCP) was used for continuous monitoring of hydrological and meteorological variables. Bridge, "Sykora" and "Zavisha" glaciers had balances of -1.1, -1.1 and -0.69 mH_2O, respectively.

MASS BALANCES, COAST MOUNTAINS, B.C.

(O. Mokievsky-Zubok, GD NHRI/EC)
Measurements of winter and summer balances, meteorological variables and melt-water flow continued on Sentinel and Place glaciers. Mass balance only was determined for Helm Glacier. Specific net balances were -1.72, -1.98 and -2.71, respectively.

SENTINEL GLACIER, B.C.

(S. Fogarasi and O. Mokievsky-Zubok, GD NHRI/EC)
Daily total direct and diffuse radiation was calculated on a 250 m grid and the sum compared with measured global radiation values. Initial surface albedo was estimated, its daily variation calculated by Petzold's method, and inferences made with respect to the magnitude of attenuation coefficients. Net radiation values were calculated, plotted, and their impact on hydrologic processes examined.

UPPER CLENDENNING CREEK, LAKE AND GLACIERS, B.C.

(RICKER)
Studies of the glaciers draining into Clendenning Creek show many to be advancing, while one other large valley glacier is now slowly retreating at the expense of an enlarged terminal lake. "Surf Glacier", at the head

of the valley, is overriding "Wave Glacier". Cairns have been placed on the latter to monitor changes and tree ring and lichen measurements made on a recessional sequence of five moraines. The region is covered more or less by 10 sets of aerial photography dated from 1940 to 1979. The advance and retreat of the glaciers will be determined using 1947/48 as the datum. The results will appear in the 1980 Canadian Alpine Journal.

SNOWCAP LAKE AND GLACIER, B.C.

(RICKER and W.A. Tupper, BCIT)
A simplified geomorphic and glacier history of the area has been developed and published in the Canadian Alpine Journal. The glaciers of interest are now being plotted from the various years of aerial photography and changes in areal extent will be calculated over the coming year.

WEDGEMOUNT LAKE AND GLACIER, B.C.

(RICKER and W.A. Tupper, BCIT)
Extreme ablation, following a dry and warm summer, exposed many old firn lines, stripped the glacier of the 1979 snowpack up to the 2200 m level and gave rise to a much siltier lake with higher levels. 1979 saw the establishment of two velocity profiles, the extension of the survey net, rephotography and mapping of the snout, moraines and trimlines. A 1:10,000 scale map of the entire glacier basin will be available in 1980. The N side of the snout retreated 10 m while the S side advanced 5 m. Observations on a newly developing ice front lake were taken in the next valley north of Wedgemount where a paternoster sequence of lakes have appeared since the climax advance around the turn of the century.

CATHEDRAL GLACIER, B.C.

(L.E. Jackson, Jr., GSC/EMR, Calgary)
Debris flows generated by the jökulhlaup from Cathedral Glacier were investigated.

MOUNT ASSINIBOINE ROCK GLACIER, B.C.

(B.M. Yarnal, GEOG/FRASER)
Analysis of the nature and distribution of sediments and plant cover of a complex rock glacier-like feature suggests that the present configuration is the result of an early Holocene event and three separate periods of Neoglacial activity. The two oldest stages of development are rock glacier in character, while the remains of the two more recent events are glacial.

SIMULATION OF ALPINE RUNOFF

(J.M. Power & G.J. Young, GD NHRI/EC)
Extensive modelling of runoff from the Peyto Glacier catchment used an adaptation of the UBC hydrologic forecasting model for glacierized watersheds. This model is also being used on the glacierized Goldstream River basin (Columbia River). The program to monitor the hydrology and climatology of non- and glacierized catchments in Yoho National Park continues.

PEYTO GLACIER, ALBERTA

(G.J. Young, GD NHRI/EC)
The basic monitoring of mass balance (-0.81 mH_2O), meteorology and hydrology continued. A detailed water chemistry and sedimentation study was undertaken (D.N. Collins, GEOG/Manchester): snowpack density investigations continued (J. Edworthy) and an investigation of glacier winds was undertaken (C.E. Banfield and A. Stenning).
(D.S. Munro, GEOG/UofTE)
A model of the net shortwave radiation distribution in a glacierized basin has been devised. It estimates global radiation from sunshine records, and distributes the values according to slope and aspect. Values of surface reflectance are applied to the incoming radiaton to estimate net shortwave radiation. Provision is made for snowline migration.

GLACIER SURVEYS, ALBERTA

(I.A. Reid & J.O.G. Charbonneau, WSC EC, Ottawa)
The Saskatchewan and Athabasca glaciers were resurveyed by terrestrial photogrammetry. Maps and reports from these and previous surveys are in preparation.

GLACIAL GEOLOGY

Annual reports on Quaternary geology are published by GSC/EMR in "Current Research". Specific studies of interest are those by W. Blake, Jr. (with H. Hyvärinen, Univ. of Helsinki) dealing with climatic change and glacier fluctuations in the Cape Herschel area, Ellesmere Is., by R.W. Klassen and S.R. Morison in the Laberge (105E) and Carmacks (115I) areas, by O.L. Hughes in the Mayo area identifying glacier sites in the Gustavus and McArthur Ranges and high surfaces in the latter and near Keno Hill that appear to be unglaciated, by J. Clague and V. Rampton developing the history of Lake Alsek and the Neoglacial moraine complex of Lowell Glacier (the preceding all in the Yukon), by L.E. Jackson, Jr. on an ice-free corridor between the Rocky Mountain and Laurentide ice sheets in Alberta, and by D.R. Grant on the Atlantic Provinces identifying areas of ice accumulation and dispersal. In separate reports M.M. Fenton and others (ALTA RES) have been studying various locations in Alberta, particularly the Sand River (73L), Edmonton (83H), Wabamum (83G), Vermilion and Medicine Hat-Lethbridge areas. R.W. May, J. Shaw and N.W. Rutter (GEOL/UofA) have been involved in a number of till and stratigraphic studies in Alberta, the Yukon and parts of B.C. Dating by P.G. Johnson (GEOG/OTT) appears to confirm the post-Wisconsin fluctuations in the St. Elias Mountains, Y.T., hypothesized by Denton and

Karlen. In Manitoba, regional studies are included in the "Report of Field Activities" of the Mineral Resources Division (S. Ringrose) and J.T. Teller (ES/Manitoba) has studied the late-Wisconsin and Holocene sedimentary history of the Lake Manitoba basin through analysis of 3 long and 48 short cores from Lake Manitoba. Glacial deposits, deglaciation and post-glacial events are being studied in Quebec by J.-M.M. Dubois (GEOG/SHER) and in the Atlantic Provinces by D.J.W. Piper and others (GEOL/DAL).

SNOW STUDIES

REGIONAL DISTRIBUTION BY REMOTE SENSING

(J.B. Maxwell, CCC)
A study documenting mean and extreme semi-monthly northern hemispheric snow boundaries based on 1966-1979 satellite records and some surface data was completed in 1979.
(B.E. Goodison, CCC)
A cooperative inter-agency project (AES, CCRS and Inland Waters Directorate) is assessing airborne SAR (X and L band) imagery for determining snow cover conditions. Only one overflight (during melting conditions) was completed.

RESOLUTE BAY, N.W.T.

(P. Marsh, M.-K. Woo & R. Heron, GEOG/McM)
Detailed snow surveys have been carried out near Resolute Bay for the last 4 years. Basin snow storage is generally twice that indicated by nearby weather station snowfall or snow survey data. Snowmelt processes have been studied and models developed to evaluate changes in basin snow storage during the melt period.

SNOW AND THE FOREST COVER, ALBERTA

(D.L. Golding, FORRES/UBC)
Research continued on the relationship of snow accumulation and melt to forest opening size at the James River site and on the effect of forest harvesting treatment in the Marmot Creek basin. The objective is to prolong snowmelt recession flow and delay the time of peak runoff.

QUEBEC

(G. Paulin, Ministère des Richesses naturelles, Québec)
The density, homogeneity, reliability and cost effectiveness of Quebec's snow gauge network has been analyzed with a view to moving to a more modern methodology using fewer sampling points but greater measurement frequency. A nuclear snow profiling gauge is being modified for connection to a GOES data platform.

ELIZABETH LAKE BASIN, LABRADOR, NFLD.

(W.P. Adams, TRENT & D.R. Barr, GEOG/McG)
A detailed survey of various properties of near-peak snowcover was made in order to relate snow conditions to cover type.
(W.P. Adams & N. Roulet, GEOG/TRENT)
The spatial patterns of snow and various types of ice have been studied in the lake basin. Light transmission studies through ice and snow will be undertaken in the future.

SAINT JOHN RIVER BASIN, N.B.

(W. Hogg, CCC)
Following the launch of TIROS-N the computer programs for snow cover mapping using visible and infrared imagery are being modified.

SNOW INSTRUMENTATION

(B.E. Goodison, CCC)
A field testing program of the accuracy and utility of new types of snow samplers and cutters was continued in cooperation with other U.S. and Canadian agencies. Further modifications are still required.

Results from a special observation program in the Arctic and Prairie regions indicate that the Nipher gauge catch may be 20% too low due to non-measurement of trace amounts. Changes in method of observation are being considered.
(W.P. Adams, TRENT)
The performance of four pairs of Tretyakov and Canadian Nipher gauges in different locations is being assessed.
(B.E. Goodison & V. Turner, CCC)
Initial measurements from Nipher-type shields on Fischer and Porter and Universal recording precipitation gauges have been very encouraging. The prototype network has been expanded into other regions for the 1979-80 season.

TRANSMISSION OF SOLAR RADIATION THROUGH SNOW

(A.D.J. O'Neill & P.W. Galbraith, MWO/AES)
A modified Giddings and LaChapelle diffusion model has been used to estimate the magnitude of solar radiation absorbed by selected natural surfaces beneath a shallow snowcover. Both the snowpack condition and the underlying surface are important in determining the magnitude of solar radiation flux to, and the absorption by, the ground beneath shallow snow. Small fibre-optic sensors have been shown to have significant potential for measuring solar radiation fluxes in snow with minimal disturbance to the natural radiation field within the pack.

AVALANCHE AND SNOW PROPERTY STUDIES

(R. Perla, GD NHRI/EC, Canmore, Alberta)
Numerical models for computing avalanche speed and runout distance have been developed with the help of T. Cheng (WSC) and D. McClung (DBR/NRC, Vancouver). Snow properties were studied in Banff National Park and at

Whistler Mt. (with C. Stethem, Garibaldi Lifts Ltd.). New methods for quick preparation of plane sections using various organic liquids and stains have been developed to help describe the interconnected snow texture and metamorphism. Snow samples from the Park have been laboratory tested in compression at various rates concentrating on fracture propagation and healing.

AVALANCHE ENGINEERING

(P.A. Schaerer, DBR/NRC, Vancouver)
Impact pressure and seismic signals of 8 avalanches at Rogers Pass in the winter 1978-79 were recorded. Analysis of 1972-78 observations led to the conclusion that large dry snow avalanches have a wave-like motion and three stratified layers. The initial impact pressure on an object proved to be greater than was previously assumed. B.B. Fitzharris concluded from a study of major avalanches at Rogers Pass that winters with large avalanches do not occur at regular intervals and that variable weather is responsible for them. H. Norem studied decision making methods for avalanche control by using the highway through Fraser Canyon as an example.

AVALANCHE HAZARD EVALUATION

(A.A. Salway, DBR/NRC, Vancouver)
The development of numerical forecasting models for observations at Rogers Pass was continued by introducing snowpack characteristics and selected sets of weather observations. The predictions of the models were as good as those of a field analyst but their accuracy was limited by the accuracy in time of the data base.

FLOATING ICE—LAKE & RIVER

FREEZE UP, BREAKUP AND ICE JAMS

(D.A. Sherstone, GD NHRI/EC)
The program on the upper Mackenzie and lower Liard rivers involved remote sensing of the breakup phenomena and ground study of pre-breakup ice conditions and ice jam dynamics. Aerial photography was carried out with a PCSP aircraft. Ice jam prone sites were located in the spring and studies of channel geometry at them completed in August.
(P.F. Doyle, ALTA RES)
About 15 ice jams at selected river sites in Alberta have been documented to date and the data are being analyzed within the framework of existing theoretical models. Qualitative descriptions of freeze up and breakup processes at selected river sites are also being obtained.
(R. Gerard, ALTA RES)
Information on past breakup water levels at several sites in Alberta has been collected and a method of analysis developed to determine estimates of the probability distributions of annual peak breakup water levels at these sites. A method of analyzing historical data has been developed. Its application to data collected at one site has shown that the flood frequency curve is dominated by ice breakup water levels and not by summer floods.

CORNWALLIS ISLAND, N.W.T.

(R. Heron, M.-K. Woo, GEOG/McM
Factors controlling lake ice melt are being studied and a model predicting lake ice conditions is being developed.

ICE RESISTANCE OF BEAUHARNOIS CANAL

(G. Tsang, NWRI/CCIW)
A study, based on 8 years of data, showed that the resistance of the Canal is highest when ice first appears in the channel and is in the form of slush. The quantitative effects of the amount of ice, the area of the ice cover, and the variousmeteorological parameters were studied.

ST. LAWRENCE RIVER, ONTARIO

(D.F. Witherspoon, IWD/EC, Cornwall)
The hydraulic resistance of an ice-covered river is being investigated using a standard backwater model and the various theories relating river bed roughness to ice roughness, in order to monitor ice roughness on a daily basis.

ICE ACTION ON STRUCTURES

(C.R. Neill, NWC)
The ice force clauses of the Canadian highway bridge design code have been revised. Some difficulties still remain. No guidance is given on how to calculate forces on substantially inclined piers by bending theory. Provision for transverse forces does not cover the case of severely oblique impact by large ice sheets on the sides of piers.
(A.W. Lipsett & R. Gerard, ALTA RES)
Measurements over 12 seasons have indicated maximum instantaneous apparent pressures of up to 2.4 MPa on a vertical cylindrical pier and up to 1.2 MPa on a pier inclined 23° from the vertical. It has become evident that use of an apparent pressure for an inclined pier is not appropriate; an alternative method of analysis has been formulated to account for ice failure modes other than crushing. Recently, an analysis of the dynamic response of piers to typical ice loading histories was initiated. To determine the dynamic pier response characteristics that are necessary for this type of analysis, a field program of pier vibration tests was initiated.
(B. Michel, IML CIVIL/LAVAL)
A laboratory tank 5 m square has been built with a rig having a 2 m stroke piston to push various types of indentors into a floating ice sheet. The first series of tests will deal with buckling of ice sheets by vertical face indentors.

ICE THICKNESS

(A.W. Lipsett, ALTA RES)
Ice thickness measurements are being carried out at selected sites in order to determine the effect on them of different processes in a river – such as clear ice, snow ice, aufeis and frazil ice formation. Results to date show that floes much thicker than "usual" may occur at spring breakup due to the latter two processes. The possibility of such formations occurring upstream of a bridge or other hydraulic structure must be assessed during design.
(D.W. Lawson, HYDR/REE)
The program to measure the thickness of ice in Prairie dugouts, its monthly and annual variability, and the effect of temperature, exposure, snow cover, orientation and water depth continued for a final year.

LOAD BEARING CAPACITY

(A.W. Lipsett, ALTA RES & S. Beltaos, NWRI/CCIW)
A search for a failure criterion independent of time and loading history revealed that the concept of a critical strain energy per unit volume of the material was successful in describing the results of prototype tests by both the Division and other investigators. To predict the response of a floating ice sheet to an arbitrary loading history a semi-empirical method has been formulated from which the deflection-time curve for any loading history can be determined. A simple method for measuring deflection-time variations due to moving loads has been developed.

INTERNAL STRESSES IN LAKE ICE

(B. Michel, IML CIVIL/LAVAL)
The measurement of internal stresses caused by wind and thermal expansion has started on Lake St. Joseph, near Quebec City. Micro-pressure transducers are being developed to measure the internal stresses.

FRAZIL ICE

(A.W. Lipsett, ALTA RES)
Field investigations are in progress to determine the mechanics of formation of a frazil ice hanging dam on the Smoky River, Alberta, its effects on spring breakup and the possible action of hanging dams against hydraulic structures.
(T.O'D. Hanley, CAMP & S.R. Rao, University of Regina)
Following the discovery of acoustic emissions accompanying frazil formation, experiments are in progress to develop an instrument for detecting frazil formation by its emissions, and to identify the mechanisms which give rise to them.
(B. Michel, IML CIVIL/LAVAL)
Long term studies on the temperature of nucleation of frazil particles are being continued. Studies are now concentrating on the thermal boundary layer at the surface of natural flowing water.
(G. Tsang, NWRI/CCIW & G. Hunt, Ontario Hydro)
An instrument is being developed for measuring the point concentration of frazil ice and the velocity of frazil slush. The principles have been confirmed and a prototype constructed and tested.

OIL RECOVERY IN RIVER ICE

(G. Tsang, E.C. Chen & R. Carson, NWRI/CCIW)
Oil may be recovered by cutting an angled slot in the ice cover to trap and guide spilled oil to the recovery point. This was shown by field tests on the North Saskatchewan River, in March 1978, when more than 99% of the oil was recovered. Other techniques, such as imbedded barriers or slot-barrier combinations, have also been studied.
(G. Tsang, NWRI/CCIW & N. Vanderkooy, EPS/EC)
An oil boom has been developed for use on ice infested rivers that initially deflects the ice floes and permits the oil slick to flow through to the ice-free area behind, then further deflects the oil to shore for recovery. The boom needs only to be anchored at one point and fins are used to adjust the boom's angle with the current. More design parameters are being obtained from laboratory tests.

ICE AND MICRO-CLIMATE

(B. Michel, IML CIVIL/LAVAL)
Using a met station and a network of ice stations the growth and decay of ice and its micro-climatic influences are being studied on Lake St. Joseph, Quebec.

BIOLOGICAL INFLUENCE OF SNOW AND ICE COVERS, ONTARIO

(W.P. Adams & D.C. Lasenby, Biology/TRENT)
Results from some studies on Coon, Jack's and St. George lakes are now available. The oxygen depletion work remains as the basic theme but there has been a shift of emphasis from phosphorus loading to the role of snow and ice on the lake light regime. The latter studies will focus on Dummer Lake.

ICE CUTTING WITH WATER JETS

(D.B. Coveney, MECH/NRC)
To assist in breaking thick ice an experimental study has been carried out on the capability of high pressure water jets to cut continuous slots in sheets of floating ice. Slots into and through natural fresh water ice up to 70 cm thick have been made at pressures up to 70 MPa. Small scale laboratory tests have also been carried out on both fresh water and simulated sea ice.

AUFEIS, N.W.T.

(J. Anderson & A. Gell, GD NHRI/EC)
Work continued on an aufeis site on Hans Creek, near Parsons Lake, on investigating the structure and growth mechanisms of this annually recurring feature. Monitoring of overflow ice

accumulations within highway culverts south of Inuvik also continued. Culvert icings were of moderate thickness when compared with those of the two previous years.

FLOATING ICE—SEA

GENERAL

(H. Hengeveld, Ice Branch/AES)
Data acquisition and ice forecasting services in support of marine activities in ice-covered waters continued at normal annual levels with highlights involving the acquisition of a minicomputer for forecasting application, participation in special projects such as SURSAT and the Winter Ice Experiment in the Beaufort Sea (WIEBS). During the Fall an experiment to test the Gulf of St. Lawrence freeze-up models using air-droppable thermographs instead of ship cruises was made. Climatological activities continued to concentrate on analysis of laser profiler data for ice topographical statistics, the publication of ice atlases and consultation to the marine industry.

CANADIAN ARTIC ARCHIPELAGO, N.W.T.

(D. Lindsay (under contract), PCSP/EMR)
The program of aircraft observation of sea ice conditions, begun in 1961, was terminated at the end of the 1978 season. Atlases for 1961-68 and 1969-74 have been published and a third volume covering the remaining years is in preparation.

NORTH WATER WINTER SEA ICE, N.W.T.

(F. Müller & K. Steffen, GEOG/ETH-McG)
Seven flights to measure sea ice temperature with a PRT-5 precision radiation thermometer were made from October 1978 to February 1979 along a 2100 km flight path. For visual information on sea ice types and distribution an area of 10^5 m² was illuminated with a SX-16 Spectrolamp search light and filmed with a 16 mm camera. With this information sea ice conditions and heat flux of the North Water during the arctic winter will be evaluated.

SOUTHERN DAVIS STRAIT PACK ICE INCURSION

(P.N. Trofimenkoff, ESSO)
Forecasts of long range pack ice incursion are based on a comparison of current land station temperature data with historical data, and on pack ice conditions during the summer melting season (and during incursion in Baffin Bay) with historical ice patterns obtained from ICECEN ice charts. Long range forecasts for incursion in November and December at specific sites can be made in September with sufficient accuracy to be useful for planning offshore operations.

EAST COAST ICE DATA BANK

(L.G. Spedding, ESSO)
For the East Coast offshore area (45°N to 65°N) an AES Ice Branch data bank for 1963 to 1972 has been updated to include 1973 to 1978. Computer retrieval and analysis programs have been installed to permit generation of statistics as required.

REGIONAL REMOTE SENSING STUDIES

(G. Morrissey, CCC)
The Aerospace Meteorology Division is developing the capability for precision mapping and radiance analysis of TIROS-N/NOAA satellite high resolution data as a prerequisite for research into methods of computer assisted production of sea-ice analyses. Although primarily designed for ice applications the system's capability for both multi-spectral and temporal analysis will also be used to extract snow cover and sea and lake surface temperature.
(F. Müller & H. Ito, GEOG/ETH-McG)
Satellite image analysis of sea ice distribution and movement in the North Water area is being carried out.
(B. Dey, GEOG/SASK)
Areal variations of pack ice and open water in the Beaufort Sea for August 1976 and 1977 were correlated with monthly weather maps using NOAA images. Offshore SE winds, higher than normal temperatures and higher accumulated summer melting degree day values resulted in maximum retreat of the pack ice edge and expansion of open water in 1977. Onshore NW winds and lower than normal temperatures resulted in a very small area of open water in 1976. NOAA and LANDSAT images have been used to study the breakup and freeze up of Mackenzie Bay, N.W.T., from 1971 to 1977. Though the breakup proceeds from the south as well as the north, the southern melt rate is faster because of the influx of warm water from the Mackenzie River. Freeze up proceeds from south to north – from the fresh to the saline water areas of the Bay.

MODELLING

(V. Neralla, CCC)
The ice drift and compactness models developed earlier have been further modified by incorporating more realistic physics in the internal ice stress formulation. These models were run in an operational mode at ICECEN for areas in the Gulf of St. Lawrence and the Beaufort Sea. A regional model for predicting sea ice motion on a coarse scale is being developed in connection with WIEBS. The site specific model is being developed by industry (Dome, Canmar – Intera).

ICE RUBBLE FIELD STUDIES

(S.B. Shinde, ESSO)
Ice conditions around an artificial island in 20 m deep water in the Beaufort Sea were monitored during the winter of 1979. Ground and

aerial observations were made to determine the characteristics of the ice rubble field and to monitor ice movements. Visual observations, a transit survey, augered holes and standpipe installations provided the data. A side scan sonar survey was made after breakup in July to determine any scouring of island fill below sea level. Experimental studies are being done to predict forces generated during scour as a function of sea bottom soil parameters.

ICE ENGINEERING

(R. Frederking, DBR/NRC)
A mathematical model has been developed to describe dynamic ice forces on an inclined plane structure. Theoretical predictions compared well with model test data. The ice behaviour around the dock at Strathcona Sound, N.W.T., continued to be studied. A qualitative model of ice behaviour has been formulated. A laboratory test program was carried out on downdrag loads developed by floating ice covers on wooden piles. The influence of pile diameter, ice thickness and loading rate was investigated.

MECHANICAL PROPERTIES

(J.-R. Murat, CINEP/UofM)
A technique using strain gauges glued on the surface of sea ice specimens has been developed to measure Young's modulus and Poisson's ratio at different temperature and strain rate levels. Creep tests are being performed on sea ice beams subjected to constant flexural loads to study load level, temperature and salinity effects. The main goal is to develop a creep law describing both primary and secondary creep that can be used for long-term bearing capacity problems.
(R. Tinawbi, CINEP/UofM)
Cold room study and theoretical simulation by the finite element method of the short- and long-term deflections and bearing capacity of sea ice plates has been continued and extended to cover the wider range of temperatures and loading conditions.
(J.F. Lane, MECH/NRC)
A review of the various strengths of sea ice (cantilever beam, simple beam, tensile, compressive, single shear, ring tensile, brazil tensile, double shear) has been completed and strength-brine volume relations for average sea ice determined. Correlation factors between the first six strengths were established. The above data have been used to develop a technique for estimating the cantilever beam strength of first-year level sea ice given its top ice temperature and thickness.

ICE TEST BASIN EXPERIMENTS

(K.N. Wood, ESSO)
Ice loading on a $\frac{1}{10}$ scale model of a shallow angle (30°) cone was investigated during the winter of 1978/79. A variety of ice conditions were simulated including consolidated multi-year ridges, unconsolidated and consolidated rubble fields. High salt concentrations were used to reduce ice strength and elasticity in accordance with scaling requirements. In-situ tests were carried out to determine the mechanical properties of the saline ice.

GROWTH PROCESSES IN SALINE ICE

(M. Nakawo, DBR/NRC)
A method has been developed to relate the growth of sea ice to weather and snow cover conditions. It has been successfully applied to data from Eclipse Sound near Pond Inlet. A dependence has been shown between the predicted growth rate and the measured salinity. The vertical salinity profile and the texture of first year sea ice, towards the end of the season, depicted a record of previous climatological conditions. Dependence of grain structure on the direction of water current has also been observed. Heat budget observations during the construction of an ice platform in the High Arctic have been made and analyzed. Desalination process in built-up ice was also examined during the construction of the platform.

ICE ISLANDS AS DRILLING PLATFORMS

(E.S. Vittoratos, ESSO)
Three wells were drilled from grounded ice platforms constructed in the Mackenzie River at Norman Wells. A field and analytical program was conducted to develop information on – ice flooding efficiency during construction, thermal interaction of the rig with the ice island, frost penetration from the ice island into the river sediments and island disposal techniques.

SEA ICE RADARS

(K. Iizuka, ENG/UofTT)
A novel 'step frequency' radar has been developed for measuring sea ice thickness and detecting buried objects. The frequency is 200-800 MHz for better penetration in lossy sea ice with a prediction that the sea ice bottom can be detected at depths up to 2 m. The radar can be either helicopter or ground vehicle borne. Because of the off-set capability of the radar the resolution stays practically the same regardless of flying height. Two conical log periodic antennas are used, 1.3 m long with a base diameter of 0.36 m and weighing less than 4.5 kg each.
(J.Y. Wong, Electrical Engineering/NRC)
A radar is being developed to operate at lower frequencies in the hope of greater depth penetration in sea ice. The radar transmits a narrow pulse of energy at a pulse recurrence frequency (PRF) of 1.28 MHz. The time delay of the received signal relative to the transmitted signal is a function of two factors, the helicopter altitude and the ice thickness. The phase changes in three harmonics of the transmitted signal, centred at 10.24 MHz, are mea-

sured. This allows simultaneous determination of ice thickness and aircraft altitude. A bread-board model of the radar should be ready for proof-of-concept trials in the spring of 1980.

EFFECT OF ICE IN THE TIDAL ZONE

(H.E. Sadler & H. Serson, DREP)
Ice in the tidal zone of arctic beaches has been studied with a view to obtaining useful criteria for the selection of locations where damage to cables and equipment will be minimal. Preliminary results indicate that most damage is caused by the incorporation of cables, etc., into the ice by bottom accretion, resulting in tension breaks when the ice moves.

RADAR TRACKING OF ICEBERGS, LANCASTER SOUND

(NORDCO and SEAKEM, Sidney, B.C.)
Using radars on Cape Fanshawe (Bylot Island) and Cape Sherard (Devon Island), overlooking Lancaster Sound, icebergs were tracked during the open water season. Satellite tracking transponders were installed on a number of bergs and a series of bergs were tracked by aircraft.

ICEBERG SCOURING

(V. Barrie, C-CORE)
A joint participation program with the Atlantic Geoscience Centre was continued. Repetition of side-scan sonar and seismic surveys of scoured areas of the Labrador Shelf was achieved, and is being analyzed to define the annual scouring rate. Studies were made of *in situ* grounding icebergs, to obtain data for modelling the scouring process.

SEA ICE MECHANICS

(A. Allan, J. Jones, T. Laidley & C. Roche, C-CORE)
Emphasis continues on ice engineering including load bearing capacity tests on sea and freshwater ice, a laboratory study of crystal fabric in artificially thickened ice platforms, and an investigation of techniques for the determination of ridge structure. A study of the problems in and possible solutions for creating an instrumented test platform to stimulate an offshore structure has been made. Ice and iceberg behaviour are being monitored at Gull Island, Strait of Belle Isle and Groswater Bay by the use of shorebased marine radar with time lapse cinematography.

OIL IN ICE

(E. Reimer, C-CORE)
An intensive ad hoc study on the fate of bunker-C oil in pack ice was undertaken during March and April 1979. Subsequently, a number of research programs have been undertaken to further understand and predict oil-ice interactions for the purpose of countermeasures development. These activities include participation in an experimental oil spill in the Beaufort Sea and work in the east coast pack ice to determine the levels of mixing energy available for oil dispersion.

ICE PHYSICS—LABORATORY STUDIES

MECHANICAL PROPERTIES

(B. Michel, IML CIVIL/LAVAL)
The program of uniaxial testing of freshwater ice samples in the brittle and ductile range has been completed. Two studies have been made on biaxial behaviour of an ice plate tested with a square edge indentor. A general mathematical model has been developed to represent the rheological behaviour of freshwater ice.
(D. Sego & N. Morgenstern, CIVIL/UofA)
The mechanical behaviour of ice under low applied stresses has been studied to establish a flow law of ice for use in the design of foundations. Constant stress (uniaxial), constant strain rate (triaxial), simple shear, and punching experiments under constant displacement rates have been conducted between -0.5°C and -4.0°C. Laboratory creep data shows that a simple power law, with an exponent approximately equal to 3.0 describes the data which shows an important influence of the ratio of crystal size to sample size that has to be accounted for in order to establish the appropriate influence of stress on the flow law. An inflection point in the strain versus time curve occurs at about 1.0% strain; the strain rate increased beyond this point. The experiments established a minimum strain rate, but a well defined steady state region is not illustrated.
(S.J. Jones, GD NHRI/EC)
Triaxial testing of frozen sand (with V.R. Parameswaren, DBR/NRC) was continued and results submitted to the Journal of Glaciology. These were obtained at -10°C and a strain rate of $7.7 \times 10^{-5} s^{-1}$. Yield and failure stresses increased with increasing hydrostatic pressure up to about 40 MPa, beyond which they dropped. Creep tests of pure ice under triaxial conditions, compression plus hydrostatic pressure, were continued. Constant strain-rate triaxial tests on pure polycrystalline ice were concluded. Results were obtained at -10°C in the strain-rate range 10^{-7} to $10^{-1} s^{-1}$ and will be submitted for publication soon.
(B. Ladanyi, CINEP/UofM)
Three Ph.D level investigations have been started. First, an attempt to accelerate the creep testing of frozen soils by using the time-temperature parameter concept. Secondly, to test a method for the indirect measurement of intergranular stresses in frozen sand. Thirdly, to study the mechani-

cal properties of undercooled frozen soils and rocks (-165°C) in connecting with the underground transport and storage of LNG. Borehole dilatometer relaxation tests on fresh water ice have also been continued. The tests are able to furnish basic creep parameters for ice under plane strain conditions.
(V. Neth, FENCO, Calgary)
Following purchase of a cold room experiments are being conducted to relate mechanical and other ice properties, obtained in the field, to laboratory test data. Emphasis is on naturally grown, first and multi-year, ice and flooded ice. Variables such as salinity, sample temperature, strain and stress rates, strength, elastic modulus, etc., are being investigated and are complemented by thin section analysis to determine internal ice structure. Oil in ice experiments are also underway.
(N.K. Sinha,DBR/NRC)
Further studies have been made on the rate sensitivity of compressive strength of S2 ice on cross-head displacement rates (nominal strain rates) at -10°C. A numerical method of predicting the strain history from stress history, and hence the stress-strain relationship, has been developed on the basis of a generalized creep equation incorporating the grain size effect. A limited number of strength tests of S2 ice have been carried out on closed-loop test systems at the HSVA Laboratory in Hamburg, West Germany, and at EXXON Production Research in Houston, U.S.A. The results further confirmed the importance of test system characteristics on observed ice behaviour.

IMPACT HARDNESS TESTS ON ICE

(D.B. Coveney & G.W. Timco, MECH/NRC)
In search of a simple test to characterize ice strength for water jet cutting experiments, an available tester was modified to drop a spherical ended projectile from a fixed height onto the ice surface, thereby causing an indentation, the depth of which could be measured easily. The average compressive stress over the impact area, as calculated by an energy balance, could not be related to the water jet penetration. It was concluded that much higher energy levels would be necessary to achieve the desired result.

PHYSICAL PROPERTIES OF DOPED ICE

(G.W. Timco, MECH/NRC)
Studies have continued into the mechanical and morphological properties of ice grown from aqueous solutions containing up to 2% of various chemical impurities including chlorides, acetates, alcohols and sulfates. The results indicate that within a homologous series the greatest strength reduction usually occurs for the lowest member. An empirical relationship has been found which estimates the concentration of electrolytic dopant required to effectively reduce the strength of ice.

OPTICAL PROPERTIES

(G.P. Johari & H.A.M. Chew, GD NHRI/EC)
A substantial amount of data on the effect of pressure and temperature on the OH and OD stretching, and translational vibrational modes, in ice have been obtained. Results have been presented at the 62nd Canadian Chemical Conference (p.148-9, 1979).

DIELECTRIC PROPERTIES

(E. Whalley, CHEM/NRC & G.P. Johari, GD NHRI/EC)
The low-frequency dielectric constant is inversely proportional to the temperature above 133°K, and so within the precision there is no evidence of an ordering transition. An Arrhenius plot of the relaxation time is S-shaped. The three regions, in order of decreasing temperature, seem to be caused by: (1) the motion of intrinsic defects; (2) the motion of impurity-generated defects where the impurity is fully dissociated; and (3) the motion of impurity-generated defects where the impurity is slightly dissociated.
(G.P. Johari, GD NHRI/EC)
The results of a study on the excess entropy of disordered solids are now in press (Philosophical Magazine).

HIGH PRESSURE ICES

(J.E. Bertie & B. Francis, CHEM/UofA)
Study of the Raman spectra of ices II and IX at atmospheric pressure and 25-110°K is continuing. A paper on the OD and OH stretching vibrations is in press (J. Chem. Phys.). The Raman spectra of the Translational and Rotational vibration are being completed and their analysis pursued.
(G.P. Johari, GD NHRI/EC)
Results of the completed study on the dipolar correlation factor and dipole moment of a water molecule in ice III have been published in the Philosophical Magazine (39[3], 219-228).
(E. Whalley, CHEM/NRC & H. Engelhardt, CIT, California)
The infrared spectrum of ice IV has been measured in the range 4000-400 cm^{-1}. It shows that the water molecules are orientationally disordered.
(E. Whalley, CHEM/NRC & G.P. Johari, GD NHRI/EC)
The values of the orientational correlation parameter along the crystal axes of ice VI have been calculated, and allow the dipole moment of a water molecule in ice VI to be determined.
(G.P. Johari, GD NHRI/EC)
Evidence for a very slow transformation in ice VI at low temperatures has been gathered and reported on in the Journal of Chemical Physics (70[5], 2094-99).

DEVELOPMENT OF A MODEL ICE

(G.W. Timco, MECH/NRC)
An improved model ice for refrigerated towing basins has been developed from tests of the mechanical properties of large ice sheets grown from chemically impure melts. It has been found that ice grown from wet-seeded solutions containing 1.3% carbamide (urea) results in an ice sheet which accurately simulates sea ice on a reduced scale.

PERMAFROST & GROUND ICE

TEMPERATURE DATA

(A.S. Judge, A.E. Taylor & M. Burgess, EPB/EMR)
The acquisition of deep permafrost temperature data has continued and a sixth volume of data been published on about 100 deep wells. Analysis of the data is well underway including published results of a theoretical modelling of the return to equilibrium of large diameter wells and an analysis of past climates in the Ungava region using down-hole temperatures and thermal properties. A similar method of well preservation and data acquisition is underway in the Rockies to develop a deep thermal data base to complement alpine permafrost investigations.

REGIONAL STUDIES

(A.S. Judge, A.E. Taylor & M. Burgess, EPB/EMR)
Studies of the shallow permafrost regime have continued to Alert (with R.J.E. Brown, DBR/NRC and DREO), at the drained lake site in the Mackenzie Delta (with UBC and GSC), in the shallow water of the offshore Beaufort Sea (with GSC) and in connection with evaluation of the gas pipeline proposal in the Yukon.
(R.J.E. Brown, DBR/NRC)
Regular ground temperature observations have been made in the western Cordillera, the Gaspé and Newfoundland to obtain information on alpine permafrost. In situ thermal conductivity and long-term temperature observations at various sites are being continued.

BANKS ISLAND, N.W.T.

(H.M. French, GEOG/OTT)
Investigations included a study of slopewash processes, permafrost stratigraphy and thaw lake evolution, collapsed pingos and of other similar features resulting from the melt-out of buried glacier ice.

TUKTOYAKTUK AREA, N.W.T.

(A. Gell, GD NHRI/EC)
Field and laboratory studies of permafrost in this area are continuing.

DEMPSTER HIGHWAY AREA, Y.T.

(G.H. Johnston, DBR/NRC)
Observations at a test site at Mile 237, containing foamed-in-place polyurethane insulation, were continued. A progress report on the performance of a bridge over the Eagle River was presented to the Permafrost Engineering Workshop at the Canadian Geotechnical Conference.
(H.M. French, GEOG/OTT)
Permafrost conditions and terrain disturbances in the north interior Yukon, particularly the Eagle Plains area, have been investigated in support of the ALUR program.

MACKENZIE HIGHWAY AREA, N.W.T.

(G.H. Johnston, DBR/NRC)
Field observations at a test site near Inuvik, insulated with polystyrene boards, were terminated in September 1978. A report on the six year project is in preparation.

DAWSON HIGHWAY AREA, Y.T.

(R.W. Klassen & S.R. Morison, GSC/EMR)
Several shallow borings were completed in permanently frozen organic terrain in the northeast corner of the Carmacks area.
(O.L. Hughes, GSC/EMR, Calgary)
Extensive thermokarst glacio-lacustrine deposits with high ground-ice content were delineated along the Stewart River, and its tributaries Watson and Nogold creeks, and along the Kalzas and Moose rivers, tributaries of the McMillan River. Permanently frozen sediments were cored at several localities for moisture determinations.

MANITOBA AND DISTRICT OF KEEWATIN

(R.J.E. Brown, DBR/NRC)
Regular ground temperature observations in northern Manitoba and the District of Keewatin are being made to study the boundary between continuous and discontinuous permafrost.
(G.H. Johnston, DBR/NRC)
At Thompson (Manitoba) observations were continued to evaluate "n-factors" at a gravel surface test site. Planning for instrumenting a pavement-covered test site in September 1979 was completed.
(W.R. Rouse, GEOG.McM)
Measurement of net radiation, soil heat flux, soil temperatures, soil moisture, evaporation, snow depths and densities were continued at Churchill (Manitoba) from before snow melt to full freeze-back. Terrain units include tundra, open forest, lowland tundra of various wetnesses and shallow lakes.

SCHEFFERVILLE AREA, P.Q.

(M.K. Seguin, GEOL/LAVAL)
Discontinuous permafrost zones were delineated using electrical resistivity sounding, very low frequency magnetic and refraction seismic techniques. Generally, the former and latter were the most useful.

LEAF BAY REGION, S.W. UNGAVA BAY, P.Q.

(J.T. Gray, GEOG/UofM & CINEP)

The development of the active layer, in response to the heat and moisture flux in a variety of sediment and vegetation cover types, has been studied at regular intervals, as well as the spatial continuity, thickness and thermal regime of the permafrost bodies. In collaboration with Annan and Davis (GSC) a comparison was made between geophysical and temperature probe traverses as means of measuring active layer depths in a variety of terrain types. In 1978, two deep hole temperature installations were monitored and four new ones madeat Lac Jourdan, 70 km to the south.

JAMES BAY – GREAT WHALE REGION, P.Q.

(J.T. Gray & B. Singh, GEOG/UofM & CINEP)

Detailed studies were begun in July 1979 at Lac Hélène, near the LG-2 site, to study frost and thaw penetration in different types of unconsolidated sediments, and to relate it to the radiative exchange between the atmosphere and ground surface, and to the moisture and textural characteristics of the sediments themselves (with J. Poitevin). Meteorological instruments and recording equipment were installed 5 m above the surface at one site, and temperature cables and access tubes for soil moisture studies were set at depths of up to 6 m in different terrain types around the main site.

GREAT WHALE RIVER BASIN, P.Q.

(J.T. Gray, GEOG/UofM & CINEP)

The Geological and Geotechnical Division of Hydro-Québec drilled a series of deep holes at selected sites in the Great Whale River basin in 1977 and thermocouple strings were installed. Interpretation of the initial data reveals that, although it is very discontinuous, permafrost may exceed depths of 100 m where terrain conditions and local climates permit. Ground temperatures will be read in the future with high precision potentiometers.

CHIC-CHOC MOUNTAINS, GASPESIE, P.Q.

(J.T. Gray, GEOG/UofM & CINEP)

Geothermal studies begun in 1977 have revealed the presence of permafrost at a cable site near the summit of Mont Jacques Cartier, at 1270 m. Temperature profile data to 30 m indicates an active layer slightly thicker than 5.75 m, overlying permafrost. Extrapolation of the profile, based on heat flow and thermal conductivity data, indicates that the permafrost body is 45-60 m thick. The proximity of the permafrost table to the surface, the low mean annual air temperature (-3° to -5°C) and the thin winter snow cover on the plateau surface indicate that the feature is contemporary. The mean annual ground surface temperature at the cable site is estimated at -1° to -1.5°C.

FROST HEAVE

(O.J. Sevec, DBR/NRC)

Ground temperature and movement observations were continued on a steel post and three steel piles at Thompson, Manitoba. A frost heave parametric study including suction potentials induced by soil freezing is underway. The influence of various parameters will be compared to published experimental results by other authors. An experimental cell for studying the heat flow around a model chilled gas pipeline has been constructed and several tests performed. First results on the control of the frost heave of a pipeline by heating cables have been reported.

(E. Penner, DBR/NRC)

Work was continued on the position of the ice lens with respect to the 0° isotherm in order to establish the temperature of the actively growing face from its position in the thermal gradient field. It appears that phase changes are predictable from the Clapeyron equation, and the structure of the ice phase is related to the heave rate.

(J.M. Konard & N.R. Morgenstern, CIVIL/UofA)

An engineering theory of frost heave has been developed that accounts for the physical behaviour of soils as they freeze. Laboratory experiments have been conducted which confirm the theory and establish the values of the important parameters required.

(B.Ladanyi, CINEP/UofM)

A cold room study of ice segregation in glacial till from the James Bay area, and the resulting changes in its physical properties, continued with a view to improving the prediction of frost heave behaviour in glacial till used for dam and embankment construction in the north.

(T.O'D. Hanley, CAMP & S.R. Rao, University of Regina)

Voltages generated across an advancing freezing front in soils (in the direction of the advance) are being studied to determine the effects of soil type, ionic content, and other factors. The controlling mechanism seems to be separation of ions due to different coefficients of distribution of different ions. The effects on water migration and ion concentration are being monitored.

CREEP IN FROZEN SOIL

(K.W. Savigny & N.R. Morgenstern, CIVIL/UofA)

Creep behaviour of frozen material from a slope of the Great Bear River was studied in the laboratory and field. It is strongly related to the orientation of the ice lens with respect to the loading direction. Finite element analysis of the field results confirms that the majority of the time dependent deformation is occurring within a zone of very ice-rich soil located within the slope.

PHYSICO MECHANICAL PROCESSES IN FROZEN SOILS

(V.R. Parameswaren, DBR/NRC)
Adfreeze strength of various kinds of piles – wood, concrete and steel – to different frozen material (Ottawa sand, sandy silt and ice) have been measured. Creep of piles in frozen soils under constant loads has also been studied. Deformation behaviour and strength of frozen saturated sand under various conditions of temperature, strain rate and hydrostatic confining pressure were studied. It was found that at -2°C the deformation behaviour was remarkably different from that at lower temperatures. The strength and modulus were also much lower than those predicted by extrapolation from lower temperatures. Studies were conducted on the electrical freezing potentials generated during freezing of ice and frozen sand to hollow copper and steel piles. The force of adhesion was found to be a function of charge concentration based on electronic band theory of solids.

PILE BEHAVIOUR IN FROZEN SOILS

(J. Weaver, CIVIL/UofA)
A laboratory study of a pile-frozen interface established that the deformation-time behaviour was similar to that of ice. Low confining pressures on the interface have little influence. The design of piles in ice-rich frozen soil should be established by using the appropriate flow law of ice for the particular temperature of interest.

DEFORMATION AND STRENGTH OF FROZEN SOILS

(T.H.W. Baker, DBR/NRC)
Unconfined compression tests showed strength of undersaturated frozen soil to be proportional to the degree of saturation. Little strength is achieved by freezing soils with less than 10% saturation with water. Normalized curves for prediction of maximum active layer thickness were produced for five areas in the North. Frozen saline sands (salinity of 0.55% at -6°C) showed a strength reduction of 60-90% compared to similar conditions at zero salinity. Time-domain reflectometry techniques have been used to measure moisture content and freezing front progression in laboratory specimens (with J.L. Davis, GSC/EMR).

GENERAL

(R.J.E. Brown, DBR/NRC)
Work continues on a new permafrost map of Canada to be published jointly with GSC/EMR. Technical literature with information on permafrost distribution and environmental relationships in Canada and elsewhere is being surveyed.
(G.H. Johnston, DBR/NRC)
The final draft of a book entitled "Permafrost Engineering – Design and Construction" was completed and negotations for publication begun.
(A.S. Judge, A.E. Taylor & M. Burgess, EPB/EMR)
Under the Energy Research and Development fund, contract investigations into the behaviour of soil moisture in cold regions as it affects industrial development have continued. Funded projects have been reported on above.

GROUND THERMAL REGIME

(L.E. Goodrich, DBR/NRC)
A study carried out on three-time-level methods of parabolic differential equations was subsequently applied to a numerical model for simultaneous heat and mass transport in soils. Laboratory evaluation of the NRC soil thermal conductivity probes is nearly complete. Field thermal conductivity measurements have been reinstated at the Thompson Field Station and continued at Ottawa.

EQUIPMENT DEVELOPMENT

(A.S. Judge, A.E. Taylor & M. Burgess, EPB/EMR)
A 16-channel multisensor scanner with a resolution of 1 part in 10^4, and the capacity to record on $\frac{1}{4}$ inch magnetic tape for 2 years at 2 hour intervals, has been developed, and testing of prototypes is underway. Standard field bridges are being upgraded with LED null detectors rather than meter movements.

GAS HYDRATES

(A.S. Judge, A.E. Taylor & M. Burgess, EPB/EMR)
A watching brief has been maintained on gas hydrates and several small contracts let to determine their physical properties. An overview report on gas hydrates on the Labrador Shelf is in press.
(E. Whalley, CHEM/NRC)
The speed of longitudinal sound in clathrate hydrates relative to the speed in ice I has been calculated. It should help to assess whether seismic methods could distinguish between ice and clathrate hydrate in permafrost.

ATMOSPHERIC ICE & CLIMATE

NORTH WATER RADIATION AND ENERGY BALANCE

(F. Müller & A. Ohmura, GEOG/ETH-McG)
The monthly radiation budget and energy balance was reevaluated. The annual energy balance is characterized by different summer and winter regimes. In the latter large supplies of heat are provided by the subsurface water – 450 cal/cm²/d in January or a winter average of 350 cal/cm²/d.

ARCTIC ARCHIPELAGO MESO-CLIMATE AND ENERGY BALANCE

(A. Ohmura, GEOG/ETH-McG)
Analysis of data from 1969, 1970 and 1972 shows that the fundamental difference in the surface energy balance among the tundra, ocean and glaciers in summer is the magnitude of the latent heat of fusion. The energy consumption through this component of the ocean and

glacier surface is four to six times larger than on tundra and this difference forms the basis of the regional climatic differences in the Arctic in summer.

ENERGY EXCHANGE, RESOLUTE BAY, N.W.T.

(F. Müller & K. Steffen, GEOG/ETH-McG)
An energy exchange study on the sea ice near Resolute Bay was carried out from 78/11/15 to 79/02/16 to infer the oceanic heat flux from energy fluxes and to calibrate the remote sensing flights.

ICE CRYSTALS, INUVIK, N.W.T.

(S. Shewchuk, SASK RES)
Ice crystal morphology and aerosol particle concentration were studied at Inuvik, N.W.T. Particular attention was paid to the structure of crystals at air temperatures below -25°C. The influence of various crystal shapes and the effect of ice crystal droplet mixtures on the atmospheric electrical field have also been studied.

BAFFIN BAY CLIMATE

(A. Ohmura, K. Schroff & K. Steffen, GEOG/ETH-McG)
Synoptic observations, radiation balance, shore ice and ice thickness data have been collected from Coburg Island, Carey Islands and Cape Herschel and together with other data will form the basis for a climatological atlas of Baffin Bay.

(J.B. Maxwell, CCC)
The Arctic Meteorology Section has completed an analysis of the offshore climate of NW Baffin Bay concentrating on the marine area adjacent to Devon and northern Baffin islands. Short climatic analyses for Craig and Dundas harbours have also been completed. A detailed climatology of the Canadian Arctic Islands and adjacent waters, completed in 1978, is expected to be published before mid-1980.

ICE ACCRETION ON CYLINDERS AND HELICOPTER ROTOR BLADES

(J.R. Stallabrass, MECH/NRC)
Further icing wind tunnel tests have been made on the icing of a cylinder in support of the numerical model of the ice accretion process, the development of which was reported last year. These tests have investigated the temperature of the icing surface, as well as the effect of using snow nozzles to produce the ice particles in the simulation of mixed icing conditions. The undesirability of this method of simulation was evident, since the small ice particles produced by the snow nozzle prematurely nucleated the supercooled droplets of the icing cloud.

Reports collected by Simon Ommanney

ICELAND

In June 1978 and 1979, the Iceland Glaciological Society sent expeditions to Grímsvötn to measure the height of the lake level in order to predict when the next jökulhlaup on Skeidarársandur is likely to occur. The next jökulhlaup may be due in 1980.

In June 1978 a group from the Science Institute, University of Iceland (Helgi Björnsson) carried out radio echo sounding on Vatnajökull, surveying in detail the Grímsvötn caldera and the Bardarbunga area.

In August 1978 echo soundings were carried out successfully on the valley glacier Gljúfurárjökull in Northern Iceland with an improved version of the echo sounder described in Ice 55, 1977, and in March-April 1979 the group surveyed with the same equipment three glaciers in Tarfala, Northern Sweden in collaboration with colleagues from the Department of Geography, University of Stockholm. The glaciers were Storglaciären, Isfallsglaciären and Rabotsglaciären.

The soundings on Vatnajökull were continued in June 1979, mainly in the area north of Grímsvötn and in the Kverkfjöll area in northern Vatnajökull. Ice thickness up to 900 m was recorded.

Records of jökulhlaups and glacier variations have been kept by S. Rist. Longitudinal glacier variations were measured at about 30 localities. Most of the glacier margins are still retreating but some of the most active glaciers, such as Sólheimajökull and Virkisjökull, have started advancing.

In 1977 the Society put up two huts on Vatnajökull, one in the nunatak area Esjufjöll, ca. 700 m above sea-level, and one in Western Kverkfjöll in nearly 1700 m height. A third hut was put up in 1979 on Godahnúkar in easternmost Vatnajökull, ca. 1400 m above sea-level. The huts are all of the same size, with berths for 12 persons (6 double beds). Altogether there are now six huts located in the Vatnajökull area, a great benefit for research work on the glacier.

In 1979 a hut of the same type and size was also put up on a nunatak, Fjallkirkja, in Eastern Langjökull, 1200 m above sea-level.

The number of members of Iceland Glaciological Society is now ca. 550.

Sigurdur Thorarinsson
Helgi Björnsson

BRITISH ANTARCTIC SURVEY

In order to examine the problem of the stability and possible disintegration of the West Antarctic ice sheet a field programme was started last year to study the dynamic behaviour of an outlet glacier, the Rutford Ice Stream, where it joins Ronne Ice Shelf and starts floating on the sea. The grounding line region is expected to be the most sensitive area responding to external climatic changes or to internally induced surging phenomena. By monitoring the position of the grounding line any advance or retreat could be interpreted as an early warning that sea level changes may be imminent.

The Rutford Ice Stream was chosen for this study by C.S.M. Doake because of its great thickness (more than 1700 m), its unbroken surface which facilitates travel (most outlet glaciers have badly crevassed surfaces) and because of its proximity to the Ellsworth Mountains where fixed rock points can be used for accurate surveys of ice velocity and strain. The surface velocity along a 40 km stake network in the flow direction was found to be very uniform at around 1 m/day. The basal velocity was measured by S.N. Stephenson using a radar technique that compared the displacement of echo diffraction patterns. In the middle of the scheme just downstream from the grounding line the basal velocity of the glacier was found to be the same as the velocity at the surface: there was no relative displacement between top and bottom of the glacier. This rather surprising result had been predicted by a theoretical model which computed velocity and thickness profiles downstream from a grounding line, using as an adjustable parameter the proportion of movement at the grounding line due to basal sliding and internal deformation. One explanation could be that the position of the grounding line was on a local pinning point and that the ice stream was floating again further upstream. Preliminary results from tiltmeters suggest that tidal flexing does occur close to the glacier boundaries upstream but it is difficult at the moment to reconcile surface levelling and ice thickness data with the requirement that the glacier is floating in hydrostatic equilibrium at these places. S.N. Stephenson used an array of seismometers in an attempt to locate sources of seismic activity and to distinguish between noise generated by the sliding of the glacier over its base and the possible formation of bottom crevasses where the ice starts floating. Surface cracking is audible as the tide rises and falls but it should be possible to distinguish these events from bottom noises. Because any migration of the grounding line depends on the bedrock topography, explosion seismology is to be used to measure water depths beneath the ice shelves.

Landsat satellite imagery has been used by R.D. Crabtree and C.S.M. Doake to describe the flow regime of the Ronne and Filchner ice shelves. Lineations corresponding to flowlines can be followed in some cases for several hundred kilometres from outlet glaciers to the ice front. Relative sizes of catchment areas can be inferred, agreeing with estimates made from balloon altimetry. Areas of local grounding, which are important for providing stability to the ice shelf, can be recognized by the greater spatial variation in tonal range compared with the more usual uniformity. Lines of crevasses, both shear and transverse, can be identified and related to their appropriate flow regimes in the ice shelf. The position of the grounding line can often be delineated by following the boundary between smooth areas and areas with surface relief; ridge type features commonly outline promontaries or ice rises.

There have been several new developments in ice-sounding radar equipment. A signal processing unit, based on a microprocessor, has been built by G.J. Musil for an impulse radar to be used for sounding temperate glaciers. This unit will allow the radar equipment to operate in a number of different ways and will give immediate values for ice thickness, echo strength and bedrock roughness. H.E. Thompson has designed a compact film recording system incorporating a fibre optic cathode ray tube in which the image is recorded directly onto film without the need for a lens system. The film recorder has been designed to meet the requirement for a low power, lightweight and compact unit suitable for use in light aircraft. A digital recording system based on a microprocessor-controlled cartridge data logger is being developed for recording ice thickness, echo strength, and aircraft navigation data. A new aerial system has been designed for Twin Otter aircraft to allow the 60 MHz ice radar to operate as a polarimeter and to give instantaneous readings of polarisation parameters relating to the ice sheet.

BAS glaciologists took part in a major international drilling project to obtain the first ice core to a depth of one hundred metres from a site in the Antarctic Peninsula. Drilling at Siple Station (75°56'S, 84°15'W) was carried out by a team with participants from the University of Nebraska and Instituto Antártico Argentino, with J.G. Paren of BAS.

Continuous cores were recovered to a depth of 97 m; they are expected to yield a climatic record extending back about 250 years. An ice drill designed by J. Loynes which uses hot water as the drilling fluid has been used for two seasons in the Antarctic. The drill was developed for providing access holes into which instruments can be lowered. Using a 30 mm nozzle on the drilling head, a 194 m deep hole was drilled in 3¼ hours. One hole successfully penetrated George VI Ice Shelf to allow oceanographic observations to be made beneath the ice shelf far from the open sea.

Geo-electrical studies carried out by J.M. Reynolds on George VI Ice Shelf have led to two exciting discoveries. Experiments carried out over a number of years to deduce the resistivity of dense ice in cold polar regions have shown it to be about one thousand times smaller than the resistivity of ice in the ablation regions of temperate glaciers. The reasons for this large factor are not understood; however arguments have centred on the fact that in general, polar ice is formed by the sintering of dry snow whereas in temperate glaciers, changes of phase are involved in the transformation of snow to ice through meltwater percolation and refreezing. New experiments were undertaken in an area where summer melting occurs but is not sufficient to raise the ice temperature at depth to 0°C. The observed resistivity was consistent with other measurements in polar dry snow environments and within 20% of values obtained on the far colder Ross Ice Shelf. We now know therefore that polar ice has a very narrow range of resistivity irrespective of the controlling densification mechanism. Processes that are unique to temperate glaciers must be responsible for the increase in their ice resistivity. Analyses of resistivity profiles obtained using a Schlumberger array have confirmed the thickness of the ice shelf obtained by radio echo sounding but have not shown the contribution that was expected from sea water beneath. At present the only plausible explanations are that the ice shelf is afloat on fresh water or that it is aground on sediments impregnated with fresh water. Fresh water up to half the draft of the ice shelf has been found in rifts at the edge of the sound where melt water drains into the sea in summer; but salt water lay beneath the fresh water. Non-tidal currents in George VI Sound are small, so it is possible that water circulation is nearly closed off by grounding of the ice shelf; this would allow the accumulation beneath the ice shelf of significant quantities of melt water 250 km from the ice front.

The objective of current oceanographic studies is to deduce the melting rate at the base of ice shelves by application of hydrodynamic and thermodynamic arguments to measurements of current flow, salinity, and temperature. Conventional oceanographic profiling has been carried out by J. Loynes and J.R. Potter at five stations through rifts in the ice shelf near the northern ice front, and an Aanderaa current meter has been moored for operation over the winter. In addition, an electromagnetic current meter and a conductivity/temperature profiler specifically designed for use in narrow access holes have been tested against conventional reversing bottle and current meter observations. The temperature-salinity relationship (conventionally plotted on a T-S diagram with respect to depth) shows one or two linear segments. In summer the T-S relationship above the base of the shelf is essentially the linear freezing point depression with the freshest water at the surface and cooling to a salinity of around 33.5% at the base of the ice shelf. Beneath this, both temperature and salinity increase linearly with a gradient of around 2.7 degrees for 1‰ change in salinity. This is close to the value of L/C_pS (where L is the latent heat of fusion, C_p the specific heat of seawater, and S the salinity) predicted by a simple thermodynamic model of ice shelf melting.

The last decade has seen increasing interest in the trace chemical constituents of the atmosphere, ranging from nitrate as a possible indicator of sunspot activity to plutonium fallout from nuclear bomb tests. Polar snow preserves an excellent record of historical variations in these impurities for up to tens of thousands of years. Antarctica is particularly well suited for such studies owing to its remoteness from man-made sources. BAS is investigating the heavy metals Cd, Cu, Hg, Pb and Zn. While industrial emissions increase annually, these elements have been found by others to be highly enriched in the atmosphere with respect to terrestrial dusts. Some controversy exists as to whether this enrichment is due to increasing industrial pollution or alternatively whether it can be accounted for by natural processes such as volcanism and low temperature volatalisation.

Two complementary techniques have been developed to analyse the minute concentrations found in Antarctic snow. An improvement in Anodic Stripping Voltammetry equipment has led M.P. Landy to the measurement of average concentrations in peninsula plateau snow lower than any ever recorded elsewhere, even at more remote inland Antarctic sites with lower snow accumulation. Seasonal variations were detected, and they correlate roughly with microparticle concentrations. Preliminary results have shown little correlation with possible local sources such as the sea or exposed rock. The second technique developed by M.P. Landy and E.W. Wolff involved the spontaneous preconcentration of metals from snow melt onto tungsten wire; these samples will be analysed in the UK by Atomic Absorption Spectrophotometry. By sampling from the walls of a deep crevasse it should be

possible to compare present-day concentrations with those up to fifty years ago. Parallel atmospheric sampling has been undertaken by D.A. Peel with the aim of establishing the relationship between metal or dust concentrations in snow and concentrations in air. The air concentrations will be related with prevailing meteorological conditions.

Laboratory studies by J.W. Mumford have compared the microparticle and marine-ion variations in snow with the well-proven oxygen isotope method of stratigraphic dating. The results are being correlated with known meteorological and sea-ice records over the last fifteen years. Sodium and magnesium proved to be the best marine ion indicators, with apparently annual peaks which, although giving similar periods to both the other methods, did not always coincide in time.

All glaciers respond to climatic changes but the speed and sensitivity of response vary inversely with the size of glacier considered. A 5-year study of climatically induced changes on Hodges Glacier, a small cirque glacier on South Georgia, is therefore complementary to studies of larger glaciers in Antarctica. Hodges Glacier was first mapped in 1955 and a comparison by R.J. Timmis with recent surveys has now quantified the long-term budget and areal changes of a sub-Antarctic glacier for the first time. Between 1955 and 1977 the glacier lost 27% of its area and thinned by 20 m of water equivalent near its snout. This wastage continues and a fall of 0.3°C in mean annual temperature would be needed to halt the recession of the present glacier margins. The climate of South Georgia is representative of the Southern Ocean and lies significantly within the influence of Antarctica. Thus the evidence from Hodges Glacier is indicative of recent climatic amelioration over a large sector of the Southern Hemisphere and contrasts with the well-documented cooling of the Northern Hemisphere since the 1940s.

C. Swithinbank

BRISTOL UNIVERSITY

A Bristol University expedition (M.E.R. Walford, M. Harper and R. Berry) to the Agassiz Icefield was successful in developing some new field techniques for phase-sensitive radio-echo sounding. It seems that this can be used for recognizing and analyzing some reflection situations and distinguishing between grossly different geomorphological regimes.

M.E.R. Walford

U.S.A.

THE PALISADE GLACIER RESEARCH PROJECT: A PROGRESS REPORT

The North Palisade Glacier, the largest glacier in the Sierra Nevada, California, lies at elevations between 3700 m and 4000 m in a north-facing cirque in the shadow of several 4270 m peaks. At a latitude of 37° 06'N the glacier is one of the most southerly active glaciers in North America. The glacier is within a U.S. Forest Service wilderness area where no mechanized equipment nor permanent works of man are allowed and scientific research can be undertaken only under permit from the Forest Service. Access is by hiking 14 km from the nearest road. Consequently all equipment and supplies must be carried to the glacier by a combination of backpacking and pack animals.

A modest on-going research program is in progress that should yield quantitative information about the glacier which also may be representative of other cirque glaciers in the Sierra Nevada. Thirty 13 cm x 20 cm metal plates have been placed on the glacier that are to be resurveyed annually in order to determine the rate of flow and map the distribution of velocity of the glacier. All surveying is done with a one-minute theodolite and a battery-powered Hewlett-Packard 3800 Electronic Distance Meter. Positions of the plates are determined by surveying from a 244 m baseline and are plotted using three dimensional rectangular coordinates. Preliminary work shows that the central part of the eastern lobe of the glacier at an elevation of 3800 m is moving at about 6 m a^{-1}.

Considerable thinning of the glacier has occurred since at least 1940. Comparison of photographs taken in 1940 with surveyed measurements made in 1976 indicate that the surface of the glacier at an elevation of about 3800 m has lowered approximately 21 m.

Additional work is planned by annual visits at the end of each ablation season.

D.D. Trent

COLUMBIA GLACIER, ALASKA

The U.S. Geological Survey has been carrying out a research program on Columbia Glacier in Alaska since 1974. Columbia Glacier discharges icebergs into Valdez Arm of Prince William Sound and thus into the shipping lane for tankers carrying oil from the terminus of the trans-Alaska pipeline. The research program has led to the conclusion that irreversible, drastic retreat of Columbia Glacier, and thus

increased iceberg discharge, is imminent. This prediction is given in a report, Predicted timing of the disintegration of the lower reach of Columbia Glacier, Alaska, by M.F. Meier and others (U.S. Geological Survey Open-File Report 80-582, available from Open-File Services Section, Branch of Distribution, U.S. Geological Survey, P.O. Box 25425, Federal Center, Denver, CO 80225). This report states that the rate of retreat of Columbia Glacier will accelerate during the next two or three years, and that the annual discharge of icebergs will increase to a peak of about 8-11 km^3/y (6-8 times the 1978 value) in the period 1982 to 1985. It is expected that the glacier will have retreated about 8 km by 1986, and that retreat will continue for several decades. This result is based on observations by Austin Post and others of all 52 calving glaciers in Alaska, and on an intensive data-gathering program by L.R. Mayo, D.C. Trabant, W.G. Sikonia, and others at Columbia Glacier. Quantitative measurements by C.S. Brown and M.F. Meier of calving variables on 12 glaciers yields a very simple calving law, in which calving speed is simply proportional to water depth at the terminus. This law was used in a new calving model developed by L.A. Rasmussen, based on mass continuity and an assumed, but glaciologically reasonable, future retracted profile. A dynamic model developed by R.A. Bindschadler was used to confirm the calving model. The calving model results also match the present thinning and retreat of the glacier.

BARNES ICE CAP, BAFFIN ISLAND, N.W.T.

R. LeB. Hooke, Department of Geology and Geophysics

A hole was drilled to 316 m at the top of the South Dome and cores were extracted at depth intervals of about 25 m. With increasing depth C-axis fabrics in the core change from weakly oriented near the surface to distinct two maximum fabrics indicative of pure shear, and thence to small circle fabrics reflecting uniaxial compression. Previous holes were resurveyed for deformation and temperature. In hole TO2O hole-parallel strain rates are approximately independent of depth over the top 100 m, or roughly one-third of the glacier thickness, and the temperature profile has been affected by a surface cooling event of about 2.5°C some 40 years ago. This is attributed to a climatic warming resulting in the formation of superimposed ice which restricts the penetration of percolating meltwater, thus decreasing the importance of this heat source in the near surface ice.

A laboratory test of various theories of sliding of temperate glaciers is being initiated. A block of ice about 20 x 45 cm, under a normal force of 30,000 lbs, will be forced over an irregular bed by a shear force of 3000 lbs.

R.W. Baker, Department of Plant and Earth Sciences

Creep tests in simple shear were continued on samples of natural ice collected from the surface and within the wedge of deformed-superimposed ice at the margin of the Barnes Ice Cap. 24 specimens have been tested, in the field and laboratory, to study the combined effects of crystal size and fabric on creep rate. Results show that for samples with similar fabrics, creep rate increases in proportion to the 2.3 power of the grain size, d, for d=1.7 to 7.3 mm ($\dot{\gamma} \propto d^{2.3}$). For samples with similar grain sizes, creep rate increases in proportion to the 1.5 power of the fabric intensity, fi, (as determined by the number of points in 1% of the area of an equal-area stereographic projection) for fi=8 to 40% ($\dot{\gamma} \propto fi^{1.5}$). The latter results are being analyzed using Kamb's method of statistically evaluating fabric diagrams.

About 180 kg of glacier ice, taken from the field in 1979, are being tested in a university cold laboratory. Priority is being given to testing samples with multiple-maxima fabrics in simple shear and samples with isotropic fabrics in multiaxial stress - simple shear with simultaneous uniaxial compression. The multiaxial tests should provide information on the relationship of the third invariant of the deviatoric-stress tensor to creep rate.

PERMANENT SERVICE ON THE FLUCTUATION OF GLACIERS

Since the nineteenth century, scientists working in astronomy and geophysics have realized that the central collection and reduction of certain kinds of data, on an international basis, is necessary. In 1919, with the founding of the *International Astronomical Union* (IAU) and of the *International Union of Geodesy and Geophysics* (IUGG), the maintenance of permanent services for this work became one of the important responsibilities of the Unions. During the following years other services were set up, including one maintained by the *Union Radio Scientifique Internationale* (URSI), and the financial burden on the three Scientific Unions became so heavy as to prevent them discharging their other responsibilities.

In 1954, Mr G.R. Laclavère, then Secretary-General of the IUGG, proposed that the services maintained by the three Unions should be federated with the object of obtaining independent financial support for them from various sources. After many discussions, the *International Council of Scientific Unions* (ICSU) accepted this proposal and in June 1956 established the *Federation of Astronomical and Geophysical Services* (FAGS); its governing body, the Council of FAGS, held its first meeting in October of the same year.

The Services in FAGS are directly concerned with the time-varying characteristics of the Earth-Sun environment. In these areas of study, small but significant trends and periodic changes become evident only after the careful statistical examination of long sequences of observations. Their detection and correlation help scientists to understand the processes that control or influence such important phenomena as the weather and climate, radio communications, earthquakes and changes in sea level. The improvement of our capabilities for observation and computation makes it vital that these sequences of observations of environmental indicators be continued and that the data be made available in convenient forms for current and future use.

The work of the Services is, by its very nature, less exciting than individual scientific research, but it is none the less an essential preliminary to an understanding of many complicated astronomical and geophysical phenomena. It requires qualities of foresight and enthusiasm to maintain world-wide observational networks and to collate and publish the results, in a useful form, for the benefit of present or future research workers. Each Service works under the scientific direction of a *Directing Board* which is appointed by one or more of the scientific unions, International Astronomical Union (IAU), International Union of Geodesy and Geophysics (IUGG), Union Radio-Scientifique Internationale (URSI). The Board determines the type of data to be collected, the methods of reduction and analysis to be used, and the format of publication for the results. The Federation is guided for administrative and financial purposes by a *Council* composed of representatives of the three Unions and of ICSU. Grants, totalling about $50,000 per year, are made to FAGS by UNESCO, ICSU and, to a lesser extent, by other international organizations. The Council allocates these funds to the Services in accordance with the general policy of the Unions. Most of the costs of the individual Services and all of the costs of data acquisition are borne by the host institutions and the observing stations. The international funds are used primarily to meet the special expenses involved in reducing and publishing the data to meet the requirements of the international scientific community; they also serve to demonstrate the value placed on the work by this community.

FAGS is a federation of International Services and the statutes of FAGS require its members:

- to collect, as a continuous activity, observations, information and data relating to astronomy, geodesy and geophysics,
- to analyse and synthetize them,
- to draw conclusions from them,
- to distribute data on request,
- to publish the results obtained.

The Services may also carry out other related tasks, such as the co-ordination of observing programmes in order to ensure that there is global coverage of selected events.

Each Service is placed under the authority of a Directing Board, which includes the Director of the Service. The composition of each Board is decided by the interested Union or Unions which also appoint a Director.

FAGS COUNCIL (1980)

President: Dr H Enslin (IAU)

Members: Ing.Gén. G.R. Laclavère (ICSU), Dr S. Ruttenberg (IUGG), Dr V Bumba (IAU), Dr J.C. Ribes (URSI), Professor J.Van Bladel (URSI).

Observer: Mrs R. Rudström (UNESCO)
Secretary: Dr C Boucher
Past Secretary: Dr J.A. Wilkins

The following member organizations belong to FAGS in 1980:
International Polar Motion Service (IPMS), Bureau International de l'Heure (BIH), Quarterly Bulletin of Solar Activity (QBSA), International Service for Geomagnetic Indices (ISGI), Permanent Service for Mean Sea Level (PSMSL), Bureau Gravimétrique International (BGI), International Centre for Earth Tides (ICET), International Ursigram and World Days Service)IUWDS), and International Service on the Fluctuations of Glaciers (ISFG).

The publications of FAGS

The results of the work of the Services are made available in several ways, but most are made available for general use (now and in the future) in printed form in special series of publications.

In addition to providing vital information for major programmes of ICSU (International Geophysical Year, International Magnetospheric Study, International Geodynamics Project, World Climate Programme, etc.) the Services of FAGS make important contributions to UNESCO and WMO scientific programmes, and it is to be hoped that this co-operation will be continued.

It is almost impossible to guage the wide utilization of the FAGS publications, for not only are they used by research workers in many widely differing disciplines but they also form an invaluable collection of data for future research. Thus the international scientific community, through FAGS, is discharging its responsibility of disseminating geophysical and astronomical data on a world-wide basis and of ensuring that the heritage is safeguarded in many laboratories and libraries throughout the world.

FAGS and the Developing Countries

It is important to point out that the Services are ready to make available to developing countries any information that can be of direct use to them. Such information can sometimes concern the actual territories of these countries; in other cases it is the result of observations made in countries that possess the necessary highly developed scientific instruments.

PERMANENT SERVICE ON THE FLUCTUATIONS OF GLACIERS

History

Based on a recommendation taken in 1960 at the IUGG General Assembly in Helsinki and approved in 1963 by the IUGG General Assembly in Berkeley, the Permanent Service on the Fluctuations of Glaciers (PSFG) was formally established in 1967 as one of the services of FAGS.

Continuing a long-standing tradition of observations of glacier variations, the Service was established in Switzerland where as early as 1773 César Bordier of Geneva suggested regular observations of glaciers and where in 1869 the Swiss Glacier Commission had started a programme of standard measurements. Reports on variations of glaciers in the Swiss Alps have been published without interruption since 1881. The *International Commission on Glaciers*, founded in 1894 and its successor, the *International Commission on Snow and Ice* (ICSI), published regularly reports on the variations of glaciers from an ever widening number of glacierized areas of the world from 1895 until 1959.

A pilot-study for the PSFG carried out by Ing. P. Kasser, Zürich, resulted in the publication of *Fluctuations of Glaciers* 1959-65, which serves as Volume I of the new PSFG publication series now appearing at regular intervals of 5 years under the auspices of FAGS with support from UNESCO and of the International Association of Hydrological Sciences (IAHS).

Objectives

The objectives of the PSFG activities are : to reproduce a global set of data on the fluctuations of glaciers which would
- *afford a general view of the changes,*
- *encourage more extensive standardized measurements,*
- *invite further processing of the data, and therewith*
- *serve as a basis for research*

The participation of UNESCO in this endeavour was from the beginning very important. Based on Resolutions I-13 to I-15 of the first session of the UNESCO Co-ordinating Council of the International Hydrological Decade, UNESCO published jointly with IAHS and ICSI a series of *Technical Papers in Hydrology* aimed at a study of snow and ice as natural resources and of the mechanism of glacier variations and their relationship to climatic variations. Some of these *Guides* are still in force, others have been slightly changed and adjusted to new experience. Relevant for the PSFG are:

a) *Perennial Ice and Snow Masses.* A Guide for Compilation and Assemblage of Data for a World Glacier Inventory. Technical Papers in Hydrology No 1, UNESCO 1970, which is partly superseded by F. Müller, T. Caflish and G. Müller, 1977: *Instructions for Compilation and Assemblage of Data for a World Glacier Inventory* issued by the Temporary Technical Secretariat for World Glacier Inventory of ICSI at the Department of Geography, Swiss Federal Institute of Technology (ETH), Zürich.

b) *Variations of Existing Glaciers.* A Guide to International Practices for their Measurement. Technical Papers in Hydrology No 3, UNESCO, 1969, which is in part super-

seded and made more specific by *Instructions for Submission of Data for Fluctuations of Glaciers* 1970-75 issued by the PSFG on 1 February 1977.

c) *Combined Heat, Ice and Water Balances at Selected Glacier Basins*, Part I : *A Guide for Compilation and Assemblage of Data for Glacier Mass Balance Measurements*. Part II : *Specifications, Standards and Data Exchange*. Technical Papers in Hydrology No 5, UNESCO 1970 and 1973, which remains unchanged.

Organisation

Responsibility for the general operation of PSFG is delegated to the *Directing Board of the PSFG* which consists of:

- the President, Vice-Presidents and the Secretary of ICSI,
- the Chairman of the ICSI Working Groups *World Inventory of Perennial Ice and Snow Masses* and *Combined Heat, Ice and Water Balances*, and
- the Director of PSFG.

Publications

a) *Fluctuations of Glaciers* 1965-1970, Volume II of PSFG published in 1973, assembles on an extended basis data from several hundred glaciers in 15 countries with addenda from earlier years.

b) *Fluctuations of Glaciers* 1970-1975, Volume III of PSFG. The main activity of the PSFG during 1977 was the preparation of Volume III of *Fluctuations of Glaciers*, again containing addenda from earlier years. The volume went to press in March 1978 and is published jointly by UNESCO and IAHS and with the help of subventions from FAGS/ICSU and considerable institutional support from the Geography Department of the Swiss Federal Institute of Technology in Zürich. The publication contains raw but standardized data relating to various aspects of glacier fluctuations together with the necessary explanatory text. In addition, a selection of twelve glacier maps of different types are included in the back-flap of the publication to illustrate the present state of the art of glacier mapping. Data for glaciers in 20 different countries as well as from Antarctica are included with tabulations of basic parameters for a total of 929 glaciers. Out of this total, data relating to frontal variations are given for 763 glaciers, mass balance data for 86 glaciers and data relating to changes in area, volume and thickness for 26 glaciers. The geographical bias of the data is obvious with most comprehensive data from arctic and western North America, Scandinavia, the Alps and the U.S.S.R. and still relatively little data from South America, Africa, Asia, Australasia and Antarctica.

For the first time, emphasis has been placed upon computerization of the data so that a high standard of uniformity of data processing, checking and presentation was achieved. As a means of ensuring uniform input data with respect to type of data and units, standard data request forms were designed by the PSFG for soliciting of data.

National Correspondents and Collaborators

An updated list of the PSFG National Correspondents and Collaborators is given in Volume III of *Fluctuations of Glaciers*. Since publication, useful contacts have been established with the Academy of Sciences in Peking and with working glaciologists in several other Asian countries as well as in South America so that the PSFG is confident that the next volume of *Fluctuations of Glaciers* will show a much more balanced geographical coverage of glaciers under study.

Co-operation with TTS

The PSFG is at present located in the same institute (Department of Geography, Swiss Federal Institute of Technology in Zürich, Switzerland) as the UNEP/UNESCO/IAHS *Temporary Technical Secretariat* (TTS) for the *World Glacier Inventory* and the two organisations are working in close collaboration. From the scientific point of view, the objectives of the TTS and the PSFG are closely related : the TTS is to describe the present datum-state of glaciation as a worldwide phenomenon, whilst the PSFG has the task of describing deviations from this state on the annual and secular time-scales.

Outlook for the Future

The main task for the PSFG will be preparations for the publication of Volume IV of *Fluctuations of Glaciers* 1975-1980 to be published in 1981.

Further information about PSFG may be obtained from the Geographisches Institut, Eidgenossische Technische Hochschule, Sonneggstrasse 5, 8006 Zürich, Switzerland. (With great regret, we announce that Professor F. Müller, who was Director of the Service, died on 26 July 1980 while working on the Rhone Glacier.)

(Abstracted from the paper submitted to the General Committee of ICSU, Brussels, 1979, by permission of G. Laclavère.

INTERNATIONAL GLACIOLOGICAL SOCIETY

ANNUAL GENERAL MEETING 1980

This will take place at 1800h on Thursday 28 August in the Geilo Hotel, Geilo, Norway, during the week of the Symposium on Processes of glacier erosion and sedimentation. (The meeting may have to be re-scheduled to Wednesday 27th, for which an excursion is at the moment planned, should weather conditions prevent the excursion taking place on that day.)

UNITED KINGDOM MEMBERS

The Society is a registered charity in the U.K. and therefore U.K. members working professionally in snow and ice research may claim tax relief on the annual membership dues. Please be sure to quote both of the following names of the Society when applying for relief:

British Glaciological Society
International Glaciological Society

Inland Revenue Number: X80190A

BRANCH NEWS

OTTAWA GLACIOLOGICAL GROUP

The second year of activity began with the following meetings:

17 January	R.J.E. Brown (Division of Building Research, NRC) - Investigations of alpine permafrost in Canada.
28 February	R. Wade (Canadian Coast Guard) - Ice breaking with air cushion technology.
27 March	Peter Johnson (Ottawa University) - Rock glacier research in S.W. Yukon Territory.
29 April	Vic Prest (Geological Survey of Canada) - Glacial concepts and the lost ice sheet complex.
22 May	E. Whalley (Division of Chemistry, NRC) - The other kinds of ice.

WESTERN ALPINE BRANCH

The 1979 meeting in Saas Almagell was notable for the fact that one group climbed to the summit of Allalin (4027 m), led by Louis Wuilloud, President. Visits to other glaciers took place the following day, while the third day was devoted to the presentation of papers. Social and business meetings occupied participants at other times, and included much appreciated hospitality from local authorities. It was decided that the 1980 meeting would be held 4-6 September in the region of Luchon in the Pyrénées. It was hoped that an excursion to Iceland could be arranged for July 1981. In association with the 1980 meeting in the Pyrénées, the Société Hydrotechnique de France will hold its annual meeting 7-11 September, in the same place.

JOURNAL OF GLACIOLOGY

The following papers have been accepted for publication in the Journal:

M.J. Hambrey, A.G. Milnes and H. Siegenthaler:
Dynamics and structures of Griesgletscher (Switzerland).

R. Vivian:
The nature of the ice rock interface: the results of investigation on 20,000 m^2 of the rock-bed of temperate glaciers.

SYMPOSIUM ON SNOW IN MOTION (Vol.26 No. 94)

K. Lied and S. Bakkehøi:
Empirical calculations of snow-avalanche run-out distance based on topographic parameters.

F. Valla:
Education of mountain skiers in the matter of avalanches.

K. Williams:
Credibility in avalanche warnings.

A. Judson, C.F. Leaf and G.E. Brink:
A process-oriented model for simulating avalanche danger.

M. Martinelli, T.E. Lang and A.I. Mears:
Calculations of avalanche friction coefficients from field data.

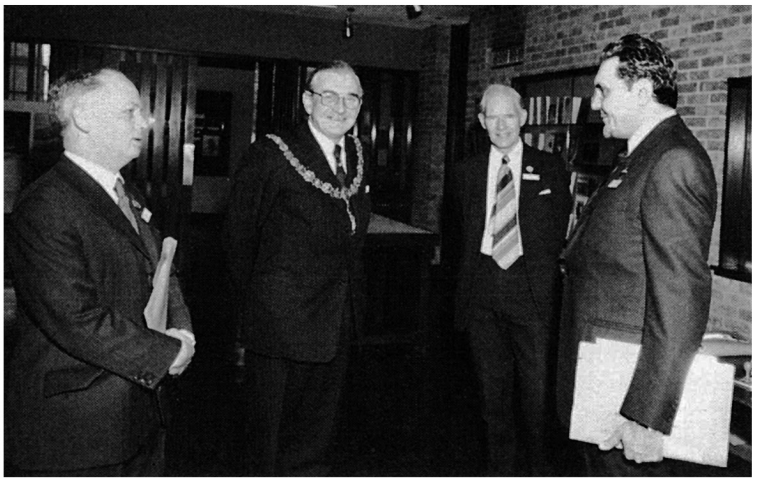
R.D. Tabler:
Geometry and density of drifts found by snow fences.

J.D. Bergen:
A slip velocity hypothesis applied to hydraulically smooth wind flow over a snow cover.
R.D. Tabler:
Self similarity of wind profiles in blowing snow allows outdoor modelling.
R.A. Sommerfeld:
Statistical models of snow strength.
H. Gubler:
Simultaneous measurements of stability indices and characteristic parameters describing the snow cover and the weather in fracture zones of avalanches.
O. Buser and H. Frutiger:
Observed maximum run-out distance of snow avalanches and the determination of friction coefficients μ and ξ .
H. Frutiger:
History and actual state of legalization of avalanche zoning in Switzerland.
P. Föhn:
Snow transport over mountain crests.
H. Björnsson:
Avalanche activity in Iceland, climatic conditions and terrain features.
Shi Yafeng and Wang Wenying:
Researches on snow cover in China and the avalanche phenomena of the Batina Glacier in Pakistan.
R.G.W. Ward:
Avalanche hazard in the Cairngorm Mountains.
B.B. Fitzharris and P.A. Schaerer:
Frequency of major avalanche winters.
P.A. Schaerer and A.A. Salway:
Seismic and impact pressure monitoring of flowing avalanches.
G.L. Freer and P.A. Schaerer:
Snow-avalanche hazard zoning in British Columbia.
E.R. LaChapelle:
The fundamental process in conventional avalanche forecasting.
E.R. LaChapelle and S.A. Ferguson:
Snow-pack structure: stability analyzed by pattern-recognition techniques.
E. Hestnes and K. Lied:
Natural hazard maps for land-use planning in Norway.
J. Montagne:
The University course in snow dynamics - a stepping stone to career interests in avalanche hazards.
A.I. Mears:
A fragment-flow model of day-snow avalanches.
A.I. Mears:
Municipal avalanching zoning: contrasting policies of four western United States communities.
Qiu Jiaqi and Hu Ruji:
The avalanches of December 1966 in western Tien-shan, China.
J.B. Johnson:
A model of snow-slab failure under conditions of dynamics loading.
Z. Watanabe:
Tensile strain and fracture of snow.
R.L. Armstrong:
An analysis of compressive strain in adjacent temperature-gradient and equi-temperature layers in a natural snow cover.
D. Marbouty:
An experimental study of temperature gradient metamorphism.
L. de Crécy:
Avalanche zoning in France - regulation and technical bases.
J.D. Iversen:
Drifting snow similitude-transport rate and roughness modelling.
Wang Zhonglong and Chen Yuan:
Research on prevention of snow-drifts by blower fences.
M. Takeuchi:
Vertical profile and horizontal increase of drift snow transport.
S.W. Hackett and D. Fesler:
Informal cooperative state-federal avalanche warning system and public education program for south-central Alaska, U.S.A.
H. Shimizu, T. Huzoika, E. Akitaya and H. Narita:
A study of high-speed powder avalanches in the Kurobe canyon, Japan.
N. Maeno, K. Nishimura and Y. Kaneda:
Viscosity and heat transfer in fluidized snow.
H. Narita:
Mechanical behaviour and structure of snow under uniaxial tensile stress.
E. Akitaya:
Observations of ground avalanches with a video tape recorder (VTR).
T.E. Lang and J.D. Dent:
Scale modelling of snow-avalanche impact on structures.
R. Perla, T.T. Cheng and D.M. McClung:
A two-parameter model of snow-avalanche motion.
C. Stetham and R. Perla:
Snow slab studies at Whistler Mountain, British Columbia, Canada.
W. St. Lawrence:
The acoustic emission response of snow.
R.L. Brown:
Propagation of stress waves in alpine snow.
S.C. Colbeck:
Thermodynamics of snow metamorphism due to variations in curvature.
J.D. Ives and M. Plam:
Avalanche hazard mapping and zoning problems in the Rocky-Mountains, with examples from Colorado, U.S.A.
D.A. Ellerbruch and H.S. Boyne:
Snow stratigraphy and water equivalence measured with an active microwave system.

Short note -
H.J. Körner:
The energy-line method in the mechanics of avalanches.

CONFERENCE ON THE USE OF ICEBERGS

Cambridge, U.K.
1–3 April 1980



The Mayor of Cambridge attended the Opening Session — Councillor Mackay is seen here with H.R.H. Prince Mohammed al Faisal al Saud, Dr Charles Swithinbank, and, on left, Dr Gordon Robin, Director of the Scott Polar Research Institute.

Centre left — Dr Lorne Gold, President of the International Glaciological Society, welcomed participants.

Centre right — His Royal Highness gave the Opening Address.

Participants from 12 countries attended three days of sessions in the lecture theatre of the Scott Polar Research Institute.

The keynote speech was given by Dr Wilford Weeks.

"Tell me that one again", said the Secretary General.

Registration Time —
Pat and Beverley looked after the participants.

ANNALS OF GLACIOLOGY

As announced at the 1979 Annual General Meeting (13 August), and reported in the minutes of that meeting published in ICE no. 60, 2nd issue 1979, proceedings of conferences with which the Society is associated will in future be published in our new series, Annals of Glaciology. All papers in these volumes will be reviewed and edited before being re-typed and printed by photo-lithography. The scientific editing is undertaken by those people who serve on the Conference Papers Committees, chosen for their expertise in the particular subjects and spread widely across the world. The technical editing is undertaken by our House Editor, Mrs Ailsa Macqueen, who helped for several years with some of the Journal of Glaciology reference lists.

The two conferences held in 1980 will form the first two volumes of the Annals:

Volume 1 - Proceedings of the Conference on the Use of Icebergs: practical and scientific feasibility. (1-3 April 1980, Cambridge, U.K.)
We hope to publish this volume in November. It will contain about twenty-three papers presented at the Conference, and will be available to members of the Society who place an order, at a special price, thanks to a grant from the King Faisal Foundation and other sponsors. The normal price will be £15.

Volume 2 - Proceedings of the Symposium on Processes of Glacier Erosion and Sedimentation. (25-30 August, 1980, Geilo, Norway.)
We hope to publish this volume in the period April – June 1981, depending on the degree of co-operation we receive from authors and referees. It will contain over forty papers presented at the Symposium and will be available to members who place an order, at a special price, thanks to a grant from Nordic sources. The normal price will be £20.

Anyone who wishes to order Annals of Glaciology Volume 1 and/or Volume 2 should write to the Society as soon as possible but in any case not later than 1 October for Volume 1 and 1 March for Volume 2. (Members have been sent a special order form.)

RECENT MEETING (of another organization)

WORKING SESSION ON ISOTOPE-GEOCHEMICAL STUDIES OF GLACIERS

The working session of the representatives of the Institute of Geography, the USSR Academy of Sciences, Arctic and Antarctic Institute and the Institute of Geology of the Estonian Academy of Sciences, took place in Tallin on 15-16 January 1980. It was devoted to isotope-geochemical studies of glaciers. Results of ice core investigations in the laboratories of the Institute of Geology of the Estonian Academy of Sciences, and the Institute of Geography, the USSR Academy of Sciences, were discussed at the Session, which also scheduled some co-ordinated plans for future investigations.

The Head of the Isotope Laboratory of the Institute of Geology, Estonian Academy of Sciences, dwelled upon the problem of ice core stratification. He pointed out that paleogeographic concepts should not be considered the basis for plotting the time scale of ice cores; quite the opposite approach is necessary. Ice age scales, plotted on the basis of dynamic ice models, are not absolute either. With this in view, it is very important to develop isotope methods of ice dating and supplement them with studies of the dust and chemical composition of the ice core. Attempts were made to analyse the ice core from the Lomonosov Plateau, Spitsbergen, for Cl and SO_4. Good agreement between the Cl contents and the relations of O^{16}/O^{18} isotopes was revealed. Evidently, the changes in Cl contents are connected to time changes of the ice-cover of the seas surrounding Spitsbergen, while the peaks of sulphate-ion in the ice column are caused by volcanic eruptions.

R.A. Vaikmaye, from the same laboratory, spoke about the studies of ice undertaken by the laboratory since 1974. Special attention is paid to accuracy of selection and transportation of samples. A set of experiments indicated that samples are best transported to the laboratory in the form of an ice core. Other, though less pure, ways may be the transportation of frozen waters from the melted core or liquid water in sealed ampoules. Correlation between isotope composition of solid precipitation and temperature of its occurrence was studied in samples delivered from Spitsbergen, Severnaya Zemlya, the Polar Urals and Estonia. The samples are investigated with the help of improved mass-spectrometer 12-01 with the metal overlap system and a computer. It is possible to analyse 20-50 ice samples daily, and it is hoped to complete the isotope - oxygen analysis of 1500-2000 samples annually.

The Head of the Department of Glaciology of the Institute of Geography, USSR Academy of Sciences, V.M. Kotlyakov, dwelt upon the general objectives of the International Antarctic Glaciological Project and activities of this Project for the last 10 years. At present the isotope and geochemical glaciology is one of the most promising branches of the science of ice. It may help us to solve many problems of the former and present regime of glaciers, closely connected to the studies under the climatic programme. Isotope analysis of ice is now developed in laboratories of many countries, primarily in Europe, in Denmark, Switzerland and France. The World Data Center A for Glaciology in Boulder, Colorado, USA proposes to create a data bank of ice cores, which is of great scientific importance.

The Head of the Department of Geography of Polar countries, of the Arctic and Antarctic Institute, V.N. Petrov, spoke about the plans of the Soviet Antarctic Expedition for 1981-1985, which include the development of deep drilling techniques and the drilling of deep boreholes at Vostok Station, in some other areas of the ice sheet and on the ice shelves, as well as paleogeographic interpretation of glacier profiles in the Arctic and in Antarctica.

F.G. Gordienko, from the Department of Glaciology of the Institute of Geography, the USSR Academy of Sciences, reported on the studies of isotope glaciology, undertaken in Moscow for the last 5 years. 12,000 ice samples have been analysed, half of them being of Antarctic origin, the rest from the glaciers of the Caucasus, Pamirs, Polar Urals and Spitsbergen. In view of the deep (down to the bed) drilling at Vostok Station, it is necessary to complete many preliminary studies; a) studies of precipitation, falling in the vicinities of Vostok Station during 2-3 years, including the level of their condensation; b) location of some not very deep boreholes in the area of the supposed deep borehole; c) drilling of two or three 100-metre deep boreholes along the flow line, crossing Vostok Station.

A specialist from the Department of Geography of Polar Countries, of the Arctic and Antarctic Institute, N.I. Barkov, spoke about the necessity to enlarge the core depository in Leningrad, for which new prospects open now, due to the near completion of the new building of the Arctic and Antarctic Institute. It is also important to construct good core depositories at Vostok Station and in the vicinity of Mirniy.

The Working Session adopted the following recommendations:

1. In view of the great importance of isotope-geochemical studies, to pay special attention to these studies, and undertake them in good agreement and in complexes; to develop actively studies of ice geochemistry and to improve the methods of laboratory investigations.
2. To draw special attention to the development of methods for broadening the nomenclature of the most informative chemical elements, studied with the goal of more accurate stratification of glacier sequences.
3. In view of the preparations for the drilling of a deep borehole at Vostok Station in Antarctica, to charge the Institute of Geography, the USSR Academy of Sciences, and Institute of Geology of the Estonian Academy of Sciences, with the compilation of the complex programme of isotope - geochemical studies of the ice core from this borehole and related studies in the vicinities of Vostok station and along the profile of the flow line, beginning in this region.
4. When planning isotope - geochemical analyses, to consider the plans of the Soviet Antarctic Expedition, which schedules the drilling of a several hundred metre-deep borehole at Pionerskaya Station in 1980-1981. These plans also presuppose a borehole at Komsomolskaya Station about 1000 m deep and the beginning of the drilling of the 1-1.5 km borehole at Vostok Station.
5. To ask the Institute of Geology, Estonian Academy of Sciences, to investigate in 1980-1981 the core from the 556 metre deep borehole from Severnaya Zemlya and from several boreholes, of some hundred metres in depth, drilled in Spitsbergen. To ask the Institute of Geography, the USSR Academy of Sciences, to investigate the rest of the core from the Vostok-1 borehole and the core from the vicinities of Mirniy Station, at the 73rd km from the coast.
6. To think it expedient to deliver the main results of isotope-geochemical studies of the ice core, undertaken in the Institute of Geography, the USSR Academy of Sciences, and in the Institute of Geology, Estonian Academy of Sciences, to the World Data Center A for Glaciology, and ask this Center to provide us with the corresponding primary data of foreign studies.
7. With the objective of improving investigation methods and experience exchange, to practise the work of specialists in ice analysis during several days in the laboratories of the Institute of Geography, the USSR Academy of Sciences, and in the Institute of Geology, Estonian Academy of Sciences.
8. To hold such working sessions annually in Leningrad, Moscow and Tallin devoted to information - exchange, discussion of obtained results and co-ordination of the plans of future studies.

V.M. Kotlyakov

GLACIOLOGICAL DIARY

1980

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

2-6 March
Fourth Canadian Permafrost Conference, Calgary, Alberta. (Associate Committee on Geotechnical Research, National Research Council of Canada. Mrs M.L. Baignée, Conference Services Office, Building M-58, National Research Council of Canada, Ontario, Canada K1A OR6.)

11-13 May
Conference on "Antarctica: weather and climate", Melbourne, Australia. (N.A. Streten, Department of Meteorology, School of Earth Sciences, University of Melbourne, Parkville, 3052 Australia.)

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).

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, U.S.A. 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.)

4-6 September
IGS Western Alpine Branch meeting, Luchon, Pyreneés, France. (F. Valla, c/o Nivologie CT-GREF, B.P. 114, 38402 St Martin d'Hères, France.)

9-11 September
IGS British Branch meeting, Norwich, U.K. (G.D. Smith, School of Mathematics and Physics, University of East Anglia, Norwich NR4 7IJ, U.K.)

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.

A.L. Washburn, *Geobryology. A survey of periglacial processes and environments.* London, Edward Arnold Ltd, 1979. 406p.

When "Periglacial Processes and Environments" was published in 1973 a revised edition was already in the planning stages. After a six year gestation period this revision has now appeared and "Geocryology" will prove a worthy replacement for its well known predecessor. During the last decade considerable attention has been focussed on periglacial environments as a result of resource exploitation, particularly in North America, and the increased availability of scientific data on these areas (e.g. the International Permafrost Conferences at Yakutsk, 1973 and Edmonton, 1978). Dr Washburn has successfully gleaned the associated flood of literature and assimilated it into the framework he used in "Periglacial Processes and Environments" to provide a new and authoritative summary of many aspects of periglacial science.

The two books appear identical in size but this similarity disguises the magnitude of the changes between them. "Geocryology" is, in fact, 86 pages longer (thinner paper is used) but the most obvious difference is the change of format. The extravagant layout of the first edition and its awkward bookshelf shape (type face parallel to the longer side of the page) have been abandoned for a more conventional arrangement which significantly increases the area of text per text page. With this new format only a 50% increase in page allocation is needed to accommodate a 140% growth in the number of references listed. Both editions are superbly illustrated with diagrams, photographs and tables occupying about half of the body of the text in each case. Almost all the illustrations from the first edition are retained with a greater variation in reproduction size and thus more effective use of space. The proportion of total space allocated to photographs is significantly decreased (fewer full page illustrations are used) but almost 20% of the photographs are new. About half the diagrams in"Geocryology"are also new, have been revised or redraughted, and the space allocated to tables has more than doubled. The text has also been greatly augmented: almost every section contains additional material and many have been completely rewritten. The only exception is Chapter 13 which is halved in length due to the revised format but is otherwise unchanged. The new text sections are skilfully interpolated and are often impossible to isolate without recourse to the original. Therefore, despite the similar size of the two editions it appears that about 40-50% of the content of "Geocryology" is new material, most of it postdating 1970. To double information content in this manner whilst retaining a clear and attractive presentation of the material is a remarkable feat and both the author and publishers are to be congratulated on their achievement.

Periglacial science has always been characterised by a rich, multi-lingual vocabulary which has sired many terminological discussions. The lack of a well established name for the subdiscipline is a good example. By the book title and the introduction Dr Washburn suggests that the term geocryology (used in the restricted sense of the study of frozen ground excluding glaciers) might be an acceptable alternative to "periglacial studies" or "periglaciology". Although it provides an elegant and provoking title, it seems unlikely that the term geocryology will become popular in English language studies. Despite its ambiguities the adjective periglacial is too convenient and well established: it is used consistently throughout the book whereas geocryology rarely appears after page 2.

The organization, chapter and sub-section headings of "Geocryology" follow those of the first edition with only minor changes. Chapters 4 (frost action processes) and 5 (some periglacial forms) are subdivisions of the old chapter 4 and slopewash is now the subject of a separate chapter (3 pages) which largely consists of a discussion of grèzes litées. The first two chapters provide some basic definitions and a brief, introductory review of periglacial science, the characteristics of periglacial environments and the environmental factors which control the operation of periglacial processes. The greatest strength and most significant contribution of the book lie in the four long chapters (3-6) concerned with ground ice, significant periglacial processes and related landforms.

Chapter 3 deals with frozen ground and is largely a discussion of the distribution, development, physical and thermal characteristics of permafrost. The vast increase in available data is reflected in new maps of permafrost distribution (Canada, Alaska, U.S.S.R. and China) and the presentation of considerable material on permafrost depth, offshore and alpine permafrost. Frost action processes are reviewed in Chapter 4 and the controls and operation of freezing processes, frost wedging, heaving, sorting and cracking (including ice wedge formation) are all discussed in detail. An exhaustive account of the origin, development and characteristics

of patterned ground dominates chapter 5 (some periglacial forms) but pingos, involutions, stone pavements and palsas are also reviewed. Chapter 6 discusses mass wasting processes, associated landforms and deposits with the major emphasis on frost creep and gelifluction.

These four chapters contain a series of masterly reviews. They are comprehensive, detailed, almost up to the minute reports with published references extending to 1979 and the frequent citation of as yet unpublished material. The fruits of the author's considerable field experience are generously blended with his encyclopaedic knowledge of the literature and ongoing research. To many English language readers the careful review and commentary on the Soviet and other European literature will be particularly valuable. Each section contains a concise discussion of terminology and the definitions used by the author; multiple and often conflicting observations are clearly and carefully reported and invariably keyed to the reference sources (author, date and page). Typographic errors are rare and perhaps the only stylistic irritant is the overlong cross referencing system to other sections of the text (could not page or chapter numbers have been used?). The organization of Chapter 6 might have benefited from a clearer separation and discussion of the differences between steep rockwall (alpine) and other slope systems. Although the discussion of the major slope foot landforms is excellent and the sections on talus, rock glaciers, protalus and avalanche boulder tongues have been considerably augmented, the review and classification of rapid mass movements in periglacial environments could be improved.

Chapters 7-12 deal with nivation, slope wash, fluvial activity, lacustrine and marine action, wind and thermokarst phenomena. All have been expanded but their combined length is less than any of the preceeding four chapters. The chapters on fluvial activity and nivation are surprisingly short and concentrate on the discussion of relic phenomena rather than studies of contemporary processes. The difference in emphasis and amount of detailed discussion between chapters 3-6 and 7-12 reflect the author's interest but also emphasise a systematic bias in the literature and previous work on geomorphic processes in periglacial areas. A significant distinction can be made between those geomorphic processes (and resulting features) which are limited to and therefore considered characteristic of periglacial environments and those geomorphic processes which play a significant part in landscape development in contemporary periglacial environments. This book and most of the literature focus on periglacial processes in the former sense with the aim of understanding their nature and also providing a capability for the interpretation of distinctive fossil forms. Emphasis on these unique phenomena has diverted attention away from processes such as fluvial activity, slopewash, chemical weathering, debris flows and rockfalls, which are not restricted to the periglacial realm but may play a very significant part in the development of contemporary and presumably former periglacial landscapes. A fuller understanding of contemporary periglacial environments can only be attained by consideration of the whole suite of geomorphic processes operating in that landscape. Therefore it would perhaps have been useful to add an extra dimension to the brief environmental overview (Chapter 13) by including summary data from studies which have attempted to measure the relative significance of different geomorphic processes in contemporary periglacial environments (e.g. Rapp 1960, Caine 1975) supplemented by available sediment yield data for periglacial river basins.

The final chapter, environmental reconstructions, has been greatly expanded and deals primarily with the estimation of paleoclimatic data from fossil periglacial phenomena using contemporary analogues. The discussion is organized on a regional basis. Most of the information comes from Continental Europe, North America, Britain and the U.S.S.R. but data from the Southern Hemisphere and Japan are also presented. The nature of the assumptions which can be made from relic features are carefully evaluated. The discussion is well illustrated with regional maps showing the distribution of fossil periglacial phenomena, particularly those which indicate the former extent of permafrost e.g. pingos, frost cracks (ice wedges) and involutions. Estimates of the temperature increase since the last glacial maximum are summarised in table and map form.

"Geocryology" is an excellent book and an outstanding contribution to the literature. It presents an almost encyclopaedic summary of the present state of periglacial research. Though one can argue that some topics deserved more attention than they received (e.g. permafrost hydrology) in every case the appropriate published material to provide such detail is cited in the relevant section of text. The reference list alone (over 2100 entries) is an indispensable resource to be quarried with pleasure. This is undoubtedly the most comprehensive, best illustrated and documented advanced text/reference source in the periglacial literature and every serious student of periglacial or quaternary science will want a copy for their bookshelf. Sadly, however, I fear that the fourfold increase in price between the two editions will direct too many to the well thumbed library copy or a xerox machine.

References cited:

Cain, T.N. (1975): The influence of snow and increased snowfall on contemporary geomorphic processes in alpine areas, in H.W. Steinoff and J.D. Ives, eds., San Juan Ecology Project, Interim Progress Report, March 1975, Colorado State University Report CSU-DWS 7052-3, pp 59-80.

Rapp, A. (1960): Recent development of mountain slopes in Kärkevagge and surroundings, northern Scandinavia. Geografiska Annaler 42, pp 73-200.

B.J. Luckman

G.L. Herries Davies and Nicholas Stephens. *Ireland*. Methuen, 1978. 250p £7.90 (cloth), (paperback later).

This is the third in a series of regional geomorphology texts intended as a guide for all students to the evolution of the landforms in the British Isles. The book is written by Professors Davies and Stephens with contributions by Francis Synge; all three have been deeply involved in unravelling the complex geomorphic history of Ireland. The book deals with the geologic background, geomorphic regions (identified mainly on structural grounds), Tertiary history, the evolution of the drainage pattern, the events of the glacial age and the evolution of the coastline.

The text is often attractively written. For example, when discussing the southern half of the Mullet Peninsula the authors write that a visitor will remember "... kilometre after kilometre of sodden blanket-bog, studded with the boles of ancient trees, and spreading across the landscape like some malignant fungus" (p. 54). When commenting on the difficulties encountered by earlier workers in identifying former plantation surfaces, it is suggestive to see the misprint "plantation surfaces" (p. 93)! There are numerous geomorphic and Pleistocene maps and diagrams accompanying the text, covering both the whole of Ireland and smaller regions. Unfortunately there is not one photograph.

The book is very detailed in its account. There is a great deal of regional subdivision and, as recommended in the Preface, it is necessary to make regular reference to the twenty-five sheets of the Half-Inch maps of Ireland in order to follow the text effectively. In part this may reflect the authors' aim, but in part it may reflect the scale of Ireland's geomorphological variation. The authors note that, unlike Scotland and Wales, Ireland cannot be divided into broad physiographic units; rather "nature has produced a terrain which is full of finicky detail..." (p. 17), and this is reflected in the text.

The chapter on Pleistocene events is of particular interest to readers of Ice. Although there is still much uncertainty, there are many highlights, as for example: the complexity of the inter-relationships between local and regional ice masses; the variation in ice flow directions accompanying glacier build-up and decay during the course of a single glaciation; the conclusion that ice did not build up in the peripheral mountains of Ireland and then radiate outwards to cover the central lowlands; the absence of deposits of known last-interglacial age; the puzzling lack of peat in or below tills of the last Devensian glaciation; the conclusion that, if beads of eskers reflect annual events, then the ice sheet edge retreated at rates of 76-130 m per year during deglaciation; the presence of two tills of apparently different ages in the drumlins of Ulster; the way drumlin density varies both parallel to and transverse to former ice sheet flow directions; the existence of 14 km-long eskers which await detailed sedimentary and palaeo-hydrological analysis.

Overall the book is to be warmly welcomed because it brings together a vast mass of up to date information on the geomorphic history of Ireland. It will appeal especially to those travelling in Ireland, to students in Ireland and to earth science students visiting Ireland on field trips.

David Sugden

PERSONALIA

The President of the Society wrote to two distinguished members who have recently retired. Dr de Quervain has served for many years on the Council, including three years, 1975-78, as President. Dr Kuroiwa has also served on the Council.

DR M. De QUERVAIN

Director
Swiss Federal Institute for Snow and Avalanche Research
7260 Weissfluhjoch, Davos
Switzerland.

Dear Marcel,

We are fast approaching a major milestone in your career. It is appropriate at this time to look back at some of your accomplishments. During the past thirty-five years you have actively participated in the rapid growth of glaciology. You have made a very significant contribution as a scientist, as the Director of the Swiss Federal Institute for Snow and Avalanche Research and through your involvement in national and international glaciological affairs. Your work has had a major influence, in particular, on the development of knowledge we now have concerning avalanches and avalanche defence systems.

The International Glaciological Society is particularly grateful for the attention you have given to its affairs. You have actively participated in its symposia, served several years on its Council and committees and guided it as President from 1975-1978. On behalf of the Society I want to thank you for the support you have so generously given over the years. We know that you will maintain an active interest in glaciology after your retirement from your administrative responsibilities and look forward to further benefit from your counsel and experience in the years ahead.

We wish you and Rita all the best in the career that you will be starting at the end of May.

DR DAISUKE KUROIWA

Section of Snow and Ice
Department of Civil Engineering
Hokkaido Institute of Technology
Teine-Maeda 419-2, Nishi-Ku Sapporo 061-24
Japan

Dear Daisuke,

On behalf of the Division of Building Research and the International Glaciological Society, I wish to extend to you our very best wishes on the occasion of your retirement. We value highly our friendship with the Institute of Low Temperature Science and greatly appreciated your interest in both the work of the Division of Building Research and the affairs of the Society during your tenure as Director. I wish to say personally, how much I have enjoyed the opportunities to talk with you at meetings, particularly the time we first met during the twenty-fifth anniversary celebrations of the Institute.

We were pleased to see that you will continue to be involved with snow and ice work. I am certain that you will find this activity both challenging and enjoyable. We look forward to further contact with you, both with respect to your new position at the Hokkaido Institute of Technology and your involvement with the International Commission on Snow and Ice.

DR CLAUDE JACCARD has succeeded Dr de Quervain as Director of the Swiss Federal Institute for Snow and Avalanche Research, Davos, Switzerland.

DR SEITI KINOSITA has succeeded Dr Kuroiwa as Director of the Institute of Low Temperature Science, Sapporo, Japan.

DR G.P. JOHARI, Research Scientist in the Canadian Department of the Environment has been selected for the Noranda Lecture Award for the year 1980. The Award, which carries an amount of $1000, is given to a scientist under forty years of age who has made a distinguished contribution in the field of Physical Chemistry while working in Canada. The title of his lecture, given at the Chemical Institute of Canada Meeting on 10 June 1980, was "The Electromagnetic Spectrum of Ice".

PUBLICATIONS

DYNAMICS OF SNOW AND ICE MASSES, Edited by Samuel C. Colbeck (U.S. Army Cold Regions Research and Engineering Laboratory, Hanover, New Hampshire, U.S.A.) and published by Academic Press, Inc. (111 Fifth Avenue, New York, NY 10003, USA). April 1980, 512 pp., $55.00/ISBN 0-12-179450-4.

Dynamics of Snow and Ice Masses describes the growth, motion, and decay of snow and ice masses. The book is divided into seven chapters, each of which treats one major type of body. These include ice sheets and ice shelves, mountain glaciers, sea ice, icebergs, lake and river ice, snow cover, and avalanches.

THE TENTH INTERNATIONAL RADIOCARBON CONFERENCE was held 19-26 August 1979 in Bern, Switzerland and Heidelberg, Germany. The meeting was hosted by the Physikalisches Institut, Universität Bern, under the direction of Hans Oeschger, and the Institut für Umweltphysik, Universität Heidelberg, under the direction of K.O. Munnich.

Some of the major topics of the conference were natural and man-made ^{14}C variations, radiocarbon dating of the Quaternary, dendrochronologic, oceanographic, and soil and groundwater dating, and accelerator techniques in radiocarbon dating. A workshop was also held on the ^{14}C calibration curve.

The proceedings of the conference are being published by *Radiocarbon*, edited by Minze Stuiver, University of Washington, and are scheduled for Summer 1980 publication. Two issues, Volume 22, Numbers 2 and 3, 1980 contain the proceedings and will be sold together for $35.00. Please address inquiries or orders to: Renee Kra, Managing Editor, *Radiocarbon*, Box 2161, Yale Station, New Haven, CT 06520, U.S.A.

N.R.C. WORKING GROUP ON HYDRAULICS OF ICE COVERED RIVERS is affiliated to the National Research Council of Canada through its Associate Committee on Hydrology, and the Associate Committee on Geotechnical Research.

Its initial role concerns the Resistance and Conveyance Capacity of Ice Covered Rivers, as relating to the planning, design, and operation of river control systems in the winter. It has as its primary objectives:

- Assessment of available predictive methodologies and preparation of State-of-the-art reports concerning these.
- Examining the adequacy of field measurement techniques, instrumentation, and data collection programs.
- Identification of major research needs and their priorities.
- Consolidation of available information on this subject and disseminations through presentations at workshops, symposia, etc.
- Encouraging coordination of study effort in related problems in Canada.
- Maintaining active liaison with other international groups of hydraulicians with similar interests.

The Working Group has already prepared some reports which deal with Classification of Ice Covers and Related Resistance, Resistance of Consolidated Smooth and Rough Ice Covers, Resistance of Fragmented Ice Covers (including Ice Jams), Resistance Effects of Frazil and Anchor Ice. These have been published in the Proceedings, Canadian Hydrology Symposium: 79, Vancouver, May 1979. Available from: National Research Council of Canada, Ottawa, Ontario, Canada K1A OR6. (Price $22.50 Can.)

The Working Group has currently completed arrangements for holding a Workshop on Hydraulic Resistance of River Ice, at the National Water Research Institute, Canada Center for Inland Waters, September 23 and 24, 1980, Burlington, Ontario. Attendance is already fully subscribed, but some extra copies of the Proceedings will be available at a reasonable cost. Persons interested in securing copies of the Workshop Proceedings should contact: Dr G. Tsang or Dr S.Beltaos, % National Water Research Institute, Canada Center for Inland Waters, P.O. Box 5050, Burlington, Ontario, Canada L7R 4A6.

Those interested in further information or future activities of the N.R.C. Working Group on Hydraulics of Ice Covered Rivers should contact: Dr K.S. Davar, Chairman, N.R.C. Working Group, Hydraulics of Ice Covered Rivers, % Dept. of Civil Engineering, University of New Brunswick, P.O. Box 4400, Fredericton, New Brunswick, CANADA E3B 5A3.

We have received the following notice from Wang Kou-chung, President of Shanghai Scientific & Technical Publishers, 450 Rui-Jin Er Road, Shanghai, People's Republic of China

"Our new colour scientific album, *Glaciers in China*, compiled by the Institute of Glaciology and Cryopedology, Academia Sinica, represents in full the face and movements of China's glaciers, which make up 40% of the total area of the glaciers in Asia, and represents also the face of famous peaks in the world and of the glaciers on them. It is a result of Chinese scientific workers' surveys since 1957 of the glaciers in the west of China.

The present edition of *Glaciers in China* is rather limited. However, as we think that the International Glaciological Society may be interested in the album, we are ready to accept and execute mail-orders which your Society and its members in various countries may place with us, so as to facilitate academic exchanges. Please refer to the following regulations concerning mail-orders for *Glaciers in China*.

1. The price of Glaciers in China is US $56.00 per copy, inclusive of the fee for registered surface mail. If the album is required to be sent by air, the relevant expenses incurred are to be borne by the subscriber.

2. In the case of orders for 10 copies upwards, a quantity discount will be allowed as follows:

Number of copies ordered	Discount allowed	Price per copy after deduction of discount
10 - 19 copies	10%	US $50.40
20 - 29 "	15%	47.60
30 - 49 "	20%	44.80
50 - 99 "	25%	42.00
100 - and upwards	30%	39.20

3. In case of subscription, the covering draft(s) with indication of "Payment for..... copies Glaciers in China" should be mailed to:

Mail-order Department
Shanghai Scientific and Technical Publishers
450 Rui-Jin Er Road
Shanghai 200020
People's Republic of China

INTERNATIONAL ASSOCIATION OF HYDROLOGICAL SCIENCES (IAHS)

Several members of the Society were elected to positions in the Association during the 1979 Quadrennial Meeting for the period 1980-83.

IAHS President: M.F. Meier

International Commission on Snow and Ice –
President: E.F. Roots

Vice Presidents: C. Lorius, D. Kuroiwa, C.W.M. Swithinbank
Secretary: M. Mellor

International Commission on Water Resources Systems –
President: G. Golubey
Vice President: H. Lang

NEW MEMBERS

Barrie, J.V., C-Core, Memorial University of Newfoundland, St. John's, Newfoundland, Canada A1B 3X5.
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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

Private members	Sterling: £15.00
Junior members	Sterling: £ 6.00
Institutions, Libraries	Sterling: £35.00 for Volume 25 (Nos. 91, 92, 93) £35.00 for Volume 26 (Number 94)

Note—Payments from countries other than Britain should be calculated at the exchange rate in force at the time of payment. If you pay by bank draft, rather than by personal cheque, please ensure that sufficient money is included to cover the bank charges. Thank you.

ICE

Editor: Hilda Richardson

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