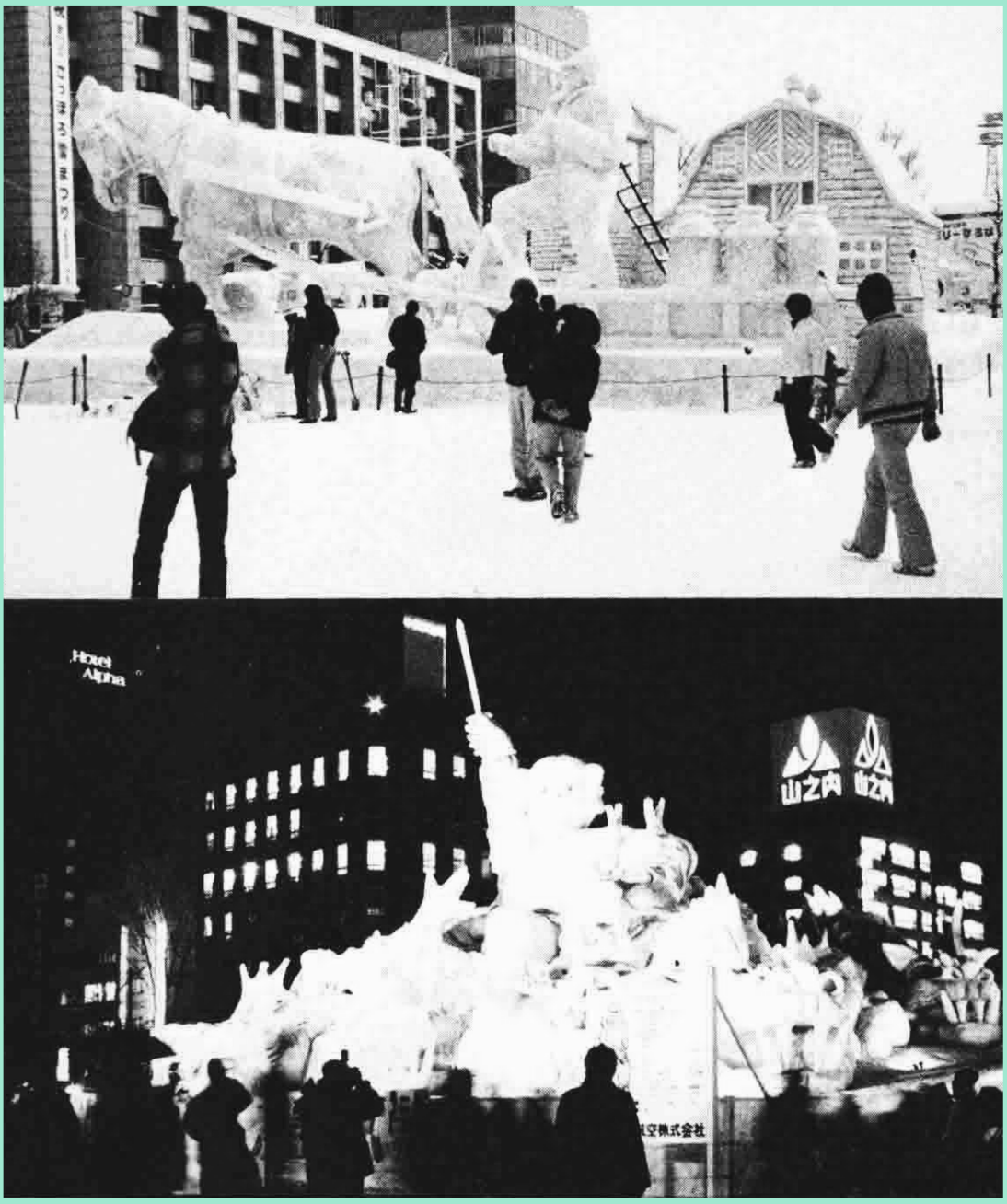
NUMBER 74 1st ISSUE 1984

ICE



INTERNATIONAL GLACIOLOGICAL SOCIETY

REYKJAVIK,
ICELAND

1985
26-29 AUGUST

Symposium on
GLACIER MAPPING
AND SURVEYING

CAMBRIDGE,
ENGLAND

1986
6-12 SEPTEMBER

Second Symposium on
REMOTE SENSING
IN GLACIOLOGY

The Second Circular for the Reykjavík meeting and the First Circular for Cambridge have been mailed to members. Extracts will be published in the next issue of ICE.

GOLDEN JUBILEE

The Society's fiftieth anniversary will be celebrated in 1986 during the symposium in Cambridge and afterwards with a special tour of Switzerland. It was on the Jungfraujoch in 1936 that the Founder of the Society, Gerald Seligman, and colleagues studied the metamorphosis of snow into glacier ice.

ISSN 0019-1043

ICE

NEWS BULLETIN OF THE

INTERNATIONAL GLACIOLOGICAL SOCIETY

NUMBER 74 1st ISSUE 1984

CONTENTS

COVER PICTURE: Ice sculptures at the Sapporo Snow Festival. Top: Pioneer Farmer of Hokkaido (A. Higashi, 1982). Bottom: Prince Susano surrounded by his beloved animals, a hero from a Japanese mythological story (Munical Office of Sapporo, 1984).

CANADA

GLACIER STUDIES

Glacier work in Canada in 1983 varied from the routine measurement of mass balance in the Cordillera, northern Newfoundland, and the Arctic Islands, through continuing the inventory of Canadian glaciers, monitoring of glacier fluctuations and surges, ice thickness mapping by airborne radar to use of Landsat imagery as a glaciological tool and the contribution and mode of glacier melt to stream flow. Climate change is appearing as an even more important ingredient of some glacier studies and adds further justification to the monitoring of Canadian ice bodies. Modelling of glaciers is an expanding field and last year encompassed flow and temperature models as well as reconstruction of the Laurentide Ice Sheet. Progress was made in relating synoptic climatology to glacier mass balance and history.

GLACIER STUDIES — GENERAL

(For abbreviations used see ICE, No.59, 1979, p.15)

GLACIER INVENTORY OF CANADA
(C.S.L. Ommanney, J.W. Clarkson and A. Champoux, SID/NHRI)
Six of the eight index maps covering 5373 glaciers in the Iskut and Stikine river basins have been drafted. Compilation work continues in the other two map areas where 2286 glaciers have been identified to date. Interpretation of ice features in Glacier National Park is virtually complete. Other work continues on the inventory of glaciers contributing to the headwaters of the Yukon River. It is anticipated that the basic compilation of all Yukon glaciers will be finished shortly. Procedures for digitizing inventory data and reducing it to the standard format have been developed. Studies are now underway, with P. Howarth (GEOG/Waterloo), on the use of Landsat digital data for some inventory and related work.

ISOTOPE GLACIOLOGY
(M.G. Maxwell, P. Whaite and R.D. Russell, GEOPHYS/UBC)
Maxwell is studying the application of isotopic methods to the problem of identifying regelation ice in glaciers. Oxygen isotope analyses are being performed on the automated system at UBC and hydrogen analyses are being done at the University of Alberta.

GLACIER STUDIES — ARCTIC

ARCTIC ICE SHELF STUDIES OFF THE NORTH COAST OF ELLESMERE ISLAND
(M.O. Jeffries, GEOG/Calgary; H.V. Serson)
Ice cores were obtained from nine locations on Ward Hunt and Milne ice shelves and in Ayles Fiord. A 32 m core from Ward Hunt Ice Shelf penetrated old sea ice at about 10 m depth. From 10 m to 32 m mean salinity = 6°/$_{oo}$, mean $S^{18}O$ = +0.1‰. A wire strainmeter installed on Ward Hunt Ice Shelf recorded vibrations of 35-40 second and 20 minute periods probably related to ocean swell at the ice front and internal waves beneath the ice shelf respectively. These vibrations might influence ice island calving. Mass balance measurement on Ward Hunt Ice Shelf revealed a continuing net loss of surface ice. Moraines of local provenance on Milne Ice Shelf attest to the flow of ice tongues across Milne Fiord. The ice tongues together with movement (perhaps surging) of Milne Glacier have restricted the mature development of an undulating surface topography on the inner ice shelf unit. Isotopic and crystallographic studies suggest the latter unit is composed of a form of lake ice. Ice conditions along 180 km of coastline between Cape Albert Edward and Hansen Point were noted: about 40 km^2 of ice had calved from the east end of Ward Hunt Ice Shelf since spring 1982. Stratified lakes A and B, and Disraeli Fiord were investigated again. Stratified water conditions were discovered at the south end of Milne Fiord.

POLAR CONTINENTAL SHELF PROJECT, EMR
(R.M. Koerner, D. Fisher, B. Alt, M. Parnandi, J. Bourgeois and K. Langley)
Laboratory investigations:
A three-dimensional model of the 18,000 B.P. Laurentide Ice Sheet was computed in collaboration with N. Reeh of the University of Copenhagen; the work has been submitted for publication. A model of vapour transport and its relationship to oxygen isotope ratios in ice cores was developed. Work on the northern Ellesmere Island pre-Holocene ice is almost completed. The study of regional variations in pollen rain in the High Arctic continues and the analysis of pollen concentration in the northern Ellesmere core has been completed. Using a synoptic approach certain sections of the ice-core time series were studied to assess the effect of variations in the ratio of warm to cold season snow accumulation on oxygen isotope values.

Field Work:
The mass balance of four Arctic ice caps was remeasured. On Agassiz Ice Cap, in northern Ellesmere Island, bulk snow samples for pollen analysis were collected, borehole tilt and diameter remeasured and samples for graphite particle analysis by the University of California were taken.

GLACIER FLOW MODELLING
(E.D. Waddington, GEOPHYS/UBC)
A project involving flow and temperature modelling of the Agassiz Ice Cap, Arctic Canada, using finite-difference and finite-element methods has now been completed. The Polar Continental Shelf Project has several drill holes near the divide of this ice cap and cores are being analyzed with the aim of extracting a climate record. The modelling is to assist this effort.

WHITE GLACIER, AXEL HEIBERG ISLAND, N.W.T.
(W.P. Adams, J.R. Glew and D.C. Pierson, GEOG/Trent)
Measurements were made and stakes were redrilled in the ablation area to study the mass balance of this glacier.

GLACIER STUDIES — YUKON TERRITORY

TRAPRIDGE GLACIER, YUKON TERRITORY
(G.K.C. Clarke and J. Schmok, GEOPHYS/UBC; S.G. Collins, Dartmouth)
Trapridge Glacier last surged around 1945 and its next surge is expected to occur within several years. A large wave-like bulge has formed in the middle region of the glacier and is propagating downglacier at 25 ma^{-1}. The bulge is at the boundary between warm-based (upstream) and cold-based (downstream) ice. At sites downstream from the bulge, basal temperature varies with time, suggesting the influence of water flowing beneath the frozen substrate. In 1983, 12 new holes were drilled down to the glacier bed, in order to monitor basal temperature changes. Schmok is attempting to trace the subglacial water flow from the warm-based region by releasing dye in drill holes connected to the subglacial system. Glacier flow measurements were taken at 1-min intervals over a period of 36 hours using a computer-controlled survey system designed at UBC.

MOUNT LOGAN/DONJEK GLACIER ICE CORE STUDIES
(G. Holdsworth, SID/NHRI/EC)
In core related work, an area at the head of the Donjek Glacier (Yukon) was radar sounded and reflections obtained from a 1500 B.P. White River volcanic eruption at 450m depth. Mount Logan core work proceeds with assembly of data pertinent to the 1908 Tunguska meteorite event and spectral analysis of a 100 year oxygen isotope time series.

ROCK GLACIERS
(P.G. Johnson, GEOG/Ottawa)
Most of the rock glaciers studied in the southwest Yukon are produced by rapid flow, high magnitude events. The deformation measured as contemporary flow is due to past formation adjustments or residual flow characteristics. Granular flows, slides or slab failure are considered the most important mechanisms and they were particularly effective in the immediate past glaciation period when many valley wall debris masses were unstable.

GLACIER STUDIES — CORDILLERA

EAST ARM GLACIER, ALSEK RANGES, ST. ELIAS MOUNTAINS, B.C.
(St.Joe Canada Inc.and Karl Ricker, advisor)
Interest in the East Arm Glacier, which has surged in the past, was stimulated by finds of massive sulphide boulders on its end moraines in the mid-1950s. Attempts to locate the mother lode have been thwarted by the extensive ice cover in the hinterland. Gravity survey showed ice thickness of 300 m. From 1983 onwards St. Joe has continued the field surveys which included the establishment of an ice surface velocity profile so that basal velocities can be approximated, thereby aiding any contemplated through-ice drilling program in future.

ISKUT RIVER GLACIERS, COAST MOUNTAINS, B.C.
(O. Mokievsky-Zubok, SID/NHRI/EC)
For the three glaciers under continuing investigation in the Iskut River basin the mass balance results and vertical height loss of ice at their termini were as follows: Andrei Glacier -0.79 mH_2O and 4.8 m, Alexander Glacier -1.39 mH_2O and 3.1 m, and Yuri Glacier -1.10 mH_2O and 2.3 m. Andrei Glacier retreated 40 m in 1982/83.

GLACIER-DAMMED LAKES, B.C.
(O. Mokevsky-Zubok, SID/NHRI/EC)
Observations on flood hazards from Natavas and Flood lakes, in the Iskut and Stikine rivers watershed, showed no impounded water in Natavas Lake during the summer though Flood Lake was filled to capacity (approx. $200 \times 10^6 m^3$) and discharged two-thirds in August.

PSFG REPORTS - COAST MOUNTAINS
(Karl Ricker, private consultant et al.)
Glacier snout fluctuation data was filed on 17 glaciers in the Coast Mountains. Glaciers in general for the 1970s have been advancing in the Snowcap and Clendenning areas (Maritime belt), retreating at varying rates in the Tchaikazan transition zone, holding their own in an ice-cored moraine snout complex on a leeward site in the high but dry Tatlow Massif, but ablating rapidly in the lower elevated Lillooet Range leeward side.

With the exception of the Tatlow area, there has been tremendous ice front retreat everywhere else during the period 1920 to 1960, though Terrific Glacier (Clendenning-Toba) was the apparent pre-cursor signal of a reversal to this trend which began prior to 1947. Friendly Glacier in the Tchaikazan and Lillooet Range glacier area have prevailed with a near doubling of their historic rates of withdrawal. Ice in the latter is all but gone, with only remnants clinging to its upper headwall.

"NEW MOON" GLACIER, BUCKLEY RANGES, HAZELTON MOUNTAINS, B.C.
(Karl Ricker, private consultant and St. Joe Canada Inc.)
Dendrochronology, with the help of L. Jozsa of Forintek Corp., established the age (1875 +22) of the inner prominent set of climax moraines while glacier positions for 1946 to 1978 were picked off several series of aerial photos. The outer moraine is an 18th century feature. Initial rapid glacier retreat from the inner climax moraine has gradually decelerated from a once single lobe into two prominent ice tongues and lesser lobes now stalled in position at the base of steep slope gradient. About 1300-1500 m of ice retreat has occurred since the turn of the century.

TIEDEMANN AND BENCH GLACIERS, B.C.
(O. Mokievsky-Zubok, SID/NHRI/EC)
Studies to determine mass balance and to assess glacier melt contribution to the Homathko River, for a hydro feasibility investigations, continued. Tiedemann Glacier had a substantial vertical ice loss on the snout of 9.7 m, while that on Bench Glacier was 4.9 m. Both glaciers had negative mass balances of -0.59 and -0.54 mH_2O respectively.

BRIDGE RIVER GLACIERS, B.C.
(O. Mokievsky-Zubok, SID/NHRI/EC)
Bridge, Sykora and Zavisha glaciers all had positive mass balances of +0.21, +0.64 and +0.37 mH_2O respectively. A Data Collection Platform (DCP) provided meteorological data and river flow level.

MASS BALANCES, S.W. COAST MOUNTAINS, B.C.
(O. Mokievsky-Zubok, SID/NHRI/EC)
Measurements of winter and summer balances and meltwater flow continued on Sentinel and Place glaciers. Mass balance only was measured on Helm Glacier. Sentinel Glacier again showed a positive balance of +1.18 mH_2O while Place and Helm had negative balances of -0.44 mH_2O and -0.21 mH_2O respectively.

WEDGEMOUNT LAKE AND GLACIER, NORTHERN GARIBALDI PARK, COAST MOUNTAINS, B.C.
(Karl Ricker, private consultant; W. Tupper and students, Survey Department/BCIT)
Surface ice velocities of the glacier across the snout and at the equilibrium line were monitored by phototheodolite stations. This line was lower than normal due to a very wet and cloudy summer, despite a less than average snowfall in the previous winter. However, excessive melting at the junction of the east to the main arm of the glacier has led to almost total separation of the two. The east arm has a lower accumulation zone which faces south and west. The snout continues to calve into the lake from a much lower and narrower frontal ice cliff, though it appears that the southside is slightly advanced from the previous year, while the north continues to recede on an ever enlarging outwash deltaic fan.

GLACIER STUDIES — ROCKY MOUNTAINS

CATHEDRAL GLACIER, YOHO NATIONAL PARK, B.C.
(G. Holdsworth, SID/NHRI/EC)
A reconnaissance of Cathedral Glacier was made to follow up previous jökulhlaups that disrupted CP rail transport.

ROCKY MOUNTAINS, ALBERTA AND B.C.
(J. Power, Surface Water Division/NHRI/EC)
Collection of mass balance and suspended sediment data at Peyto Glacier and of streamflow data at Peyto and three sites in the adjacent Kicking Horse River basin, continued under contract to P.G. Johnson (GEOG/Ottawa). Heavy rains in early July caused extreme high flows and mudslides which destroyed the stream gauge and sediment sampler on Peyto Creek. G. Holdsworth (SID/NHRI) employed a portable monopulse radar system to measure the thickness of the glacier tongue at various locations. Work continues on incorporating glacier melt runoff into conceptual hydrologic forecasting models such as the UBC model.

PEYTO GLACIER SEDIMENTS
(P.G. Johnson, GEOG/Ottawa)
The extreme variability of glacier discharge suspended sediment regimes continues to be studied at Peyto Glacier. Sediment pulses are apparent in both short time frame (minutes) and longer time frame (daily). Results from 1983 were destroyed by continuation of flood and landslide events at the glacier terminus as a result of very heavy precipitation events between July 11 and 14 after a prolonged period of wet weather in early July.

FLUVIOGLACIAL SEDIMENT IN PEYTO CREEK
(G. Binda, GEOG/Ottawa)
Temporal variations in suspended sediment concentration and hydrochemistry in glacier-fed Peyto Creek, Alberta, were studied to determine the seasonal and diurnal fluctuations.

Meltwater of Peyto Glacier had a low solute concentration. Divalent cations (Ca^{++}, Mg^{++}) were more abundant than the mono-

valent ones (Na^+, K^+) with calcium (Ca^{++}) being the most abundant and potassium (K^+) the least.

Suspended-sediment concentrations fluctuated erratically, peaks occurred both before and after peak discharge.

Hourly analysis of the suspended-sediment samples showed that calcium (Ca^{++}) was the most abundant cation present on the sediment surfaces, almost ten times that of the others (Na^+, K^+, Mg^{++}).

GLACIAL HYDROLOGY
(D.C. Ford and C.C. Smart, GEOG/McM)
A series of hydrological and other studies of Castleguard Cave and underlying karst spring systems have been completed. The Cave extends beneath parts of the Columbia Icefield, Alberta/B.C., and the springs are draining portions of the Icefield, the Saskatchewan Glacier and smaller glaciers via sink points at the ice base.

"BOUNDARY" GLACIER (BANFF/JASPER PARKS), ALBERTA
(J.S. Gardner and N.K. Jones, GEOG/Waterloo)
Surface movements from 6.4 m near the glacier terminus to 35.9 m in an icefall area were measured on a small valley glacier, tentatively named "Boundary" Glacier, during July and August 1983. Vertical height losses ranged from 2.5 to 3.0 m in the lower ablation zone. Measurements of meltwater stream discharge indicated diurnal peak flow occurred between 1300 and 1700 hours,the low flow between 2400 and 0800 hours; seasonal flow peaked during the second week of August. Peak discharges ranged from 0.303 $m^3 s^{-1}$ in early July to 0.758 $m^3 s^{-1}$ in mid-August.

GLACIER STUDIES — LABRADOR

TORNGAT MOUNTAINS GLACIERS, LABRADOR
(R.G. Rogerson, GEOG & EARTH SCI/MUN)
Mass balance, ice movement snout measurements were continued in July and August 1983 on four cirque glaciers south of Nachvak Fiord. Low snowfall the previous winter resulted in early exposure of the ice surface and large amounts of ice melt despite a cool, rainy summer. Mass balance was strongly negative but one glacier continued slight readvance (<1 m since August 1982). Semi-permanent snow patches over much of the Torngats were obliterated or severely reduced compared with the two previous summers.

GLACIAL GEOLOGY

PLEISTOCENE GLACIAL SEDIMENTS
(C.P. Gravenor, R.L.B.P. Monteiro, A.C. Rocha-Campos, V. von Brunn, A. Dreimanis, GEOL/University of Windsor)
Studies undertaken so far include: ice thrust features and a possible intertillite pavement in the Proterozoic Macaubus Group, Jequitai area, Minas Gerais, Brazil, patterns of Late Paleozoic glacial sedimentation on the southeast side of the Parana Basin in Brazil, and the nature and classification of waterlain glaciogenic sediments. At present the magnetic and pebble fabrics of glaciolacustrine and glaciomarine diamictons are being studied in order to determine the origin of ancient diamictites.

SLIMS RIVER SEDIMENTS, YUKON TERRITORY
(P.G. Johnson, GEOG/Ottawa)
The suspended sediment regime of the Slims River in the southwest Yukon was monitored at the Alaska Highway bridge. The river is fed from the Kaskawulsh Glacier and although the variability of suspended sediment load is damped downstream the characteristics of the regime are still glacier controlled. Analysis is proceeding.

TALBOT CREEK/ALASKITE CREEK, YUKON TERRITORY
(P.G. Johnson, GEOG/Ottawa)
A post glaciation environmental record for the Ruby Range, southwest Yukon is being constructed from lake basin sections in Talbot Creek and Alaskite Creek. A succession of highly organic strata, clays and coarse Alaskite sand occurs below the White River ash horizon (1240 years B.P.). It is hypothesised that a 10,000 year Holocene record exists in these sediments.

"CALTHA LAKE" MORAINES, STERN RIVER DIVIDE, LILLOOET RANGES, B.C.
(Karl Ricker, private consultant, Vancouver)
Study was commenced on these moraines because of the virtual lack of ice in the basin beyond them. By lichenometry a two-fold prominently oxidized striped pair of moraines were dated at 1898 $\pm$ 7 A.D. and 1914 $\pm$ 9 A.D. Downvalley, oxidized sandy gravel hummocks of glacio-fluvial origin are tentatively dated to 1745 $\pm$ 31 A.D. A morainal forefield beyond them displays excellent crag and tail, ridge and groove, and stoss and lee topography that is intersected by meltwater channels located at the sill of the cirque. A scarcely oxidized but gullied moraine to one side and and ancient poorly developed tree trimline located below the threshold in the valley suggests that a much more extensive and yet older Late Neoglacial advance was present. The limited attempts to date it by lichenometry failed to provide the corroborative data. Further work using dendrochronology is planned on this feature.

"BOUNDARY" GLACIER AREA (BANFF/JASPER PARKS), ALBERTA
(J.S. Gardner and N.K. Jones, GEOG/Waterloo)
Analyses of glacial debris sources,transport paths and depositional mechanisms, as well as the consequent glacial till and landforms, were made in a small valley glacier

basin. Preliminary investigations indicate rockfall and snow avalanches to be the primary sources of debris. Supraglacial transport of this debris seems to be dominant although englacial and subglacial transport also occurs. Deposition occurs by supraglacial melt-out and let-down, and subglacial melt-out mechanisms. Lodgement is an unimportant process in this situation. Both supraglacial and basal tills are evident in recently deposited sections.

PALEOGLACIOLOGY
(J.M. Dubois, M. Parent, A. Laroque, G. Laroque, Q.H.J. Gwyn, A. Poulin, P. Boissonnault, C. Dubé, A. Morrissette, J.C. Dionne, A. Painchaud, R. Cadieux, D. Gratton, P. Bigras, J. Gagné and A.Royer, GEOG/Sherbrooke)
Glacial histories of several regions such as Asbestos-Valcourt, Lake Memphrémagog, Weedon and Patrie,have been studied. The regions of Sherbrooke and Saint-François heights, and Coaticook-Malvina are also under study. An investigation of the largest moraine in Québec, between Baie-Comeau and Goose Bay on the Côte-Nord of the Saint Lawrence, has been completed. The Quaternary history of the Côte-Nord has been completed and maps at a scale of 1:25,000 and 1:100,000 made.

On Anticosti Island, the western regions, Jupiter River basin, the central south and Potato River have been studied. In southern Ontario, the regions studied were: the Oak Ridge moraine, the postglacial Champlain Sea in the Hawkesbury region, Glacial Lake Algonquin and the Newmarket till.

In the eastern Antarctic, the paleoclimatic history of the last 30,000 years has been studied by examining the physical and optical properties of microparticles from an ice core.

LACUSTRINE AND MARINE FEATURES
(D. Coté, Q.H.J. Gwyn, G. Lessard and J.M. Dubois, GEOG/Sherbrooke; B. Lauriol, GEOG/Ottawa)
Behaviour of karst lakes of variable levels and the periglacial features along their coasts have been studied on Anticosti Island. In the Sept-Iles region of the Côte-Nord, the glacial features and behaviour of coastlines have been studied.

QUATERNARY GEOLOGY, NEWFOUNDLAND
(M. Batterson, P.H. Davenport, J.W. McConnell, B.G.Sparkes and D.G. Vanderveer, Dept. Mines and Energy, Govt of Newfoundland and Labrador)
Geochemical orientation studies and Quaternary mapping around the Strange Lake deposit in northern Labrador were undertaken. The deposit was discovered by the Iron Ore Company of Canada following a geochemical anomaly in the regional lake sediments and water survey.

Surficial and glacial mapping of the east half of the Great Gull Pond was conducted.

Glacial dispersion in the Great Gull Pond area may have been affected by two glacial flows, an early northeastward flow and a later northward flow. The lodgement till which overlies sand and gravel in the Gullbridge mine area may be related to this later flow or to a more localized advance of ice in the Great Gull Pond area. The forthcoming analysis of the pebble fraction of tills, as well as the particle size and geochemical analyses, should provide more information on the glacial history and characteristics of the tills of the area.

Detailed follow-up studies of geochemistry surveys in the area northeast of Gander, Newfoundland, were carried out, to provide insight into the regional Quaternary sequences. Analysis of the samples collected from the area for grain size distribution, geochemistry and lithologies is ongoing.

Results of glacial observations suggested a dominant earlier flow towards the east with a later overprint revealing a radial flow pattern that could be related to the remnant ice cap in the area.

SALERMUIT RANGE, TORNGAT MOUNTAINS, LABRADOR
(R.J. Rogerson and D.J.A. Evans, GEOG/MUN)
Mapping of moraines and other glacial features south of Nachvak Fiord has resulted in the recognition of at least four glacial stades since the area was carved out by some extensive earlier (certainly pre-Wisconsin) glaciation. Soil development tentatively dates moraines and indicates only local glaciers affected the area in Wisconsin time. The shores of Nachvak Fiord are currently submerging.

REMOTE SENSING

REMOTE SENSING OF GLACIERS
(P.J. Howarth, GEOG/McM)
LANDSAT digital data was used for glacier inventory. The areas studied were the Steacie Ice Cap, on Axel Heiberg Island, the Kaskawulsh and Tweedsmuir glaciers, in the St. Elias Mountains, and the Athabasca and Saskatchewan glaciers, of the Columbia Icefield. Using data for the Tweedsmuir Glacier, G.Holdsworth (SID/NHRI/EC) in Calgary is analyzing changes in moraine patterns between 1973 and 1978 to determine displacement and hence velocities and strain rates. Applying the analysis methodology developed for the Tweedsmuir Glacier, it is hoped to study changes in the Lowell Glacier which is currently surging.

RADIO ECHO SOUNDING GLACIERS - NORTHERN ELLESMERE ISLAND
(B.T. Prager, B.B. Narod and G.K.C. Clarke, GPHYS/UBC)
In June 1981 the UBC 840 MHz radar was mounted in a Canadian Forces Twin Otter and 2000 line-km of ice soundings taken over the

Ayles, Milne, M'Clintock and Ward Hunt ice shelves and the Milne and Disraeli glaciers. Prager has recently completed an M.Sc. thesis on the computer processing of these digital radar data.

ALL-WEATHER RECONNAISSANCE AND ICE MANAGEMENT STUDIES

(L. Gray, C. Livingstone, B. Hawkins, K. Singh and L. Arsenault, CRRS/CCRS)

Research and development of airborne, microwave sensors has continued in CCRS to improve all-weather ice reconnaissance.

Analysis has continued on the 1982 CCRS sea-ice data collected in the Beaufort Sea during both cold (April) and melting conditions (June and July). Microwave signatures of cold, winter/spring conditions from the Ku-band scatterometer,K-band radiometer, and SAR imagery show similar trends to results from earlier missions and from other experimenters. Interestingly, however, it has been shown that grey ice covered with 'frost flowers' provides not only a bright target for X- and Ku-band radars but also that the relative and absolute brightness, exhibited by different regions of apparently homogeneous grey ice, does vary with azimuth look angle (at the same radar incidence angle). This result implies some 'order' in the small scale roughness related to frost flowers, possibly connected to the surface wind direction at the time of ice growth.

Cooperative work is being carried out with R.G. Onstott, University of Kansas, on the analysis of the overlapping surface and airborne ice-backscatter data collected under melting conditions near Mould Bay, Prince Patrick Island. Results confirm the importance of the snow layer melt process and surface conditions.

Several ice classes have been selected for detailed study from the Labrador Sea data acquisition in March 1982. These include very rough first-year pack ice, with small floes (10-30 m), and younger interstitial ice, smooth snow-packed lake ice, and young ice from Groswater Bay. Varying degrees of pack concentration and pack divergence can be seen and identified in the pack ice from the SAR imagery. As well, the mission provided a rich source of iceberg signatures in close pack-ice, which has been used in simulation work. A comparative study of Labrador Sea and Beaufort Sea ice is in progress.

During 1983,the CCRS Convair 580 aircraft, equipped with the CCRS-ERIM X/L/C synthetic aperture radar, flew two missions off the east coast of Canada to investigate radar detectability of icebergs. The work was carried out cooperatively with Mobil Oil. Four flights were also undertaken by the Convair during the MIZEX experiment northwest of Spitsbergen. This work was supported by the U.S. Office of Naval Research. The Environmental Research Institute of Michigan (ERIM) has produced radar image mosaics of the test area from different days which show ice pack structure, ice edge, ice and ocean features, and ice marginal zone motion.

Some preliminary analysis of the data has been carried out. In an open ocean environment it is possible to detect icebergs, bergy bits, sea-ice strips and patches with good reliability, even in moderate to high sea states. It is much more difficult, however, to differentiate positively whether a target is a ship, iceberg or ice floe. The problem is particularly difficult for the detection of icebergs or bergy bits in a pack-ice background; our results indicate that shallow depression-angle geometry does enhance the target to sea-ice background contrast and does improve detectability of icebergs in sea ice. Further work is required on both target identification and iceberg detection in sea ice. Modelling and simulation work has shown that icebergs in the open ocean should be observable as bright targets on RADARSAT SAR imagery at larger incidence angles (35-45°) but that the probability of their detection at smaller incidence angles (20-30°) will be poor. Simulations of iceberg signatures in pack ice show that iceberg detection by the RADARSAT SAR will depend primarily on image feature identification and not on average iceberg to sea-ice radar contrast, this implies that only larger icebergs will be identifiable.

ACOUSTICS, COMMUNICATIONS AND TELEMETRY

(B. Dawe, R. Donnelly, J. Ryan and J. Walsh, ENG/MUN)

A general formulation and solution for the problem of determining the electromagnetic field resulting from a finite electromagnetic source placed above a horizontally layered isotropic medium has been developed. The results are being used to develop a comprehensive model to study the applications of HF radars to the problem of sea ice detection and tracking.

ELECTROMAGNETIC SCATTERING FROM SEA ICE

(B.P. Sinha, J. Walsh, ENG/MUN)

Sea ice has been modelled as a dielectric spheroid bathed in an equivalent homogeneous and isotropic medium representing free space and sea water, to study electromagnetic scattering from the sea ice.

REMOTE SENSING OF SEA ICE

(D. Bajzak, ENG/MUN)

Research is in progress on obtaining sea ice and sea surface data using pictorial and digital images of aerial photography and satellite imagery. The techniques of analysis include the use of a VP-8 image analyzer, a scanning micro-densitometer and computer processing.

ATMOSPHERIC ICE AND CLIMATE

ADSORPTION OF SULPHUR DIOXIDE ON ICE

(H.A.M. Chew, SID/NHRI/EC)

A simulation of the environmental condition of adsorption/absorption of sulphur dioxide on/in ice is being carried out in the laboratory. Now under investigation are the adsorption/absorption of sulphur dioxide at -5°C as a function of time.

ATMOSPHERIC ICING OF TRANSMISSION LINE CONDUCTORS

(L. Makkonen and J.R. Stallabrass, DME/NRCC)

Dr Lasse Makkonen, of the Institute of Marine Research, Helsinki, Finland, is working for a year in the Low Temperature Laboratory, Division of Mechanical Engineering, NRC, having been awarded an N.S.E.R.C. Visiting Fellowship. He is conducting research on the icing of transmission lines and has developed a time-dependent numerical model. Experiments are being performed in NRC's icing wind tunnel to simulate ice accretion on cables of various diameters with realistic torsional stiffnesses. The results of the experiments will be used to test the validity of the icing model.

SNOW CONCENTRATION MEASUREMENTS

(J.R. Stallabrass, DME/NRCC)

Measurement of the mass content (density) of falling snow in the air continues to be made at a test site in Ottawa in order to determine the long-term statistical distribution of snow concentration. Such statistics are needed to provide realistic design and test requirements for means of alleviating or preventing the ingestion of snow by air-consuming equipment. Correlations between measured concentration and visibility will permit extrapolation of the Ottawa data to any region where visibility data is available.

CLIMATE

(W.R. Rouse, GEOG/McM)

The advective influence of sea ice on the climate of the Hudson Bay Lowlands was studied. Atmospheric and soil heat balance parameters are being studied at the coast and inland to understand the overall thermal regime during onshore and offshore winds and to study the impact on longevity of the snow cover, depth to the soil frost table and longevity of the sea ice in late winter and early summer.

ICE PHYSICS AND ENGINEERING

ICE PHYSICS

(N.K. Sinha, DBR/NRCC)

The vertical salinity and density profile, fabric, texture and microstructure of first-year ice were examined in the field. The ice cover survived the melt season. Subsequent examinations of the second-year ice and new (first-year) ice beneath it showed that the textural anisotropy observed earlier had been maintained. This work was carried out in conjunction with the RADARSAT experiment at Mould Bay.

Assistance was provided to CANARCTIC Shipping Co. Ltd. to develop an optical system for identifying different types of sea ice under actual field conditions as part of their program to avoid near-ship hazards.

Seasonal variations in the temperature profiles of multi-year floes in Eclipse Sound and Lancaster Sound have been measured.

Strength and deformation data collected in the field (Mould Bay) for unconfined uniaxial compressive loading conditions were analyzed to examine the rate sensitivity strength. Strength tests were also carried out on ice brought back from the field to the laboratory using the closed-loop MTS test machine. Similar results were obtained both in the field and the laboratory. Tests were also carried out to determine the rate sensitivity of Poisson's ratio. A new confining frame for conducting plane strain strength tests has been used in the field and in the laboratory.

The cracking activity in S-2 ice and accumulation of damage during constant load creep tests have been analyzed. A new theory has been proposed and evaluated for predicting the time and strain dependence of damage in ice.

A program has been initiated to examine the mechanical properties of multi-year and iceberg ice at loading rates and conditions comparable to ship impact with such features. This work is being carried out in support of the Canadian Coast Guard.

ICE FRICTION

(J. Molgaard, P.N. Smith, L.C. Wong and R.M. Harvey, ENG/MUN)

Design work is proceeding on test equipment for studying the friction between ice and other materials. The ice samples used will range in size up to a diameter of about 10 cm. Other test parameters are normal loads up to at least 10,000 N at sliding speeds from zero to 10 km/h and temperatures between -40°C and 0°C. The test materials and surfaces will be typical of those in commercial use at the water line on icebreakers, other ships and stationary structures in ice-infested waters.

IMPACT, CREEP AND COMPRESSION OF NATURAL AND LABORATORY GROWN ICE

(B. Michel, D. Blanchet, N. Marcotte, F. Fonseca, G. Rivard and P. Shoiry, Civil Engineering/Laval)

A laboratory tank 5 m x 4 m is used with a 2 m stroke piston to push indentors of variable geometry into a floating sheet of controlled fresh-water and saline S_2 ice. The latest series of tests were made in the range of transition from brittle to ductile failure.

Ice having the crystallographic characteristics of the Arctic ice pack was produced artificially, and creep tests are being carried out with a constant load at strain rates between 10^{-9} and $10^{-6}s^{-1}$.

Ice blocks have been provided by Mobil Oil Canada Ltd. and taken from drifting icebergs on the Labrador coast and the ice shelf in Greenland. Uniaxial tests in tension and in compression were done under fast loading rates.

ICE MECHANICS
(D.B. Muggeridge, H. Hamza and A.A. Tehrany, ENG/MUN)
A theoretical and experimental program has been undertaken to investigate the creep and fracture behaviour of fresh-water ice covers. The finite element method was used to solve the nonlinear problem of creep bending of a plate.

Experimental studies are underway to evaluate the fracture toughness of ice in terms of the critical value of the stress intensity factor in the opening mode of failure. The effects of strain rate, grain size and temperature on the fracture toughness of fresh-water and saline ice have been investigated. A theoretical fracture analysis of the impact of a large ice floe with a large offshore structure has also been done.

ICE FORCES ON AN INCLINED PLANE
(G.W. Timco, DME/NRCC)
Tests are currently being carried out to investigate the ice forces on a 45° inclined plane in the ice tank of the Hydraulics Laboratory, NRC. The parameters which are being varied include the structure height and width, ice thickness and strength, and both the speed and frictional characteristics of the ice-structure interaction. The load-time curves for both the vertical and horizontal directions are being analyzed using time-series analysis and the variance spectral density and peak frequencies in the spectrum are obtained. A theoretical model is being developed which will try to identify and quantify each of the individual force components in the interaction process.

ADVANCED ICEBREAKING CONCEPTS
(M.J. Hinchey, ENG/MUN)
An investigation of icebreaking using high speed air cushion vehicles or hovercraft, moving on their own over an ice sheet, has been initiated.

LIGHT SCATTERING PROPERTIES
(G.P. Johari, SID/NHRI/EC)
The effects of temperature and pressure on the Raman spectrum of ice and ice clathrate containing tetrahydrofuran have been measured. The results relate the distance of separation of water molecules with the frequency of intramolecular vibrations, one paper has appeared in Nature (Vol.303, pp. 604-605, 1983) and two are due to appear in the Philosophical Magazine.

ELECTROMAGNETIC PROPERTIES
(G.P. Johari, SID/NHRI/EC)
The effect of dissolved nitrogen on the radiofrequency spectrum of ice over a range of temperature and hydrostatic pressure is being investigated.

ICE ENGINEERING
(R. Frederking and M. Sayed, DBR/NRCC)
Field measurements concerning rubble field and floating ice properties and behaviour were carried out around Tarsuit. These include porosity and strength profiles, temperatures and internal deformation in the rubble field as well as tide records and ice structure and salinity.

Analytical models of ridges and grounded rubble fields were developed. These estimate the forces in ice covers associated with ridge building and give an explanation of the role of grounded rubble in the transfer of loads to offshore structures.

Investigations of ice conditions and interactions at Adams Island were continued. An array of markers was set out on the ice around the island in March, 1983, and an electronic distance measuring device was used to measure their locations until mid-June. Consistent ice movements of 10 to 15 cm/day in a northerly direction were observed over the entire period. Measurements of current and wind were also made. Groups from Germany and Great Britain also participated, measuring stress and strain in the ice cover adjacent to the island. A maximum ice pressure of 300 kPa was measured.

A series of tests on the adhesion of saline ice to wooden piles was carried out over a range of loading rates, pile diameters and ice sheet thicknesses. Influence of the above factors on adhesive strengths was similar to that for fresh-water ice, but adhesive strengths were substantially lower for the case of saline ice.

Ice load measuring panels have been modified and reinstalled on a light pier in the St. Lawrence River. An instrumentation system including signal conditioners, telemetry and a data logger has been set up and is now operating.

STRUCTURAL OPTIMIZATION OF AVMR ICE TANK TOWING CARRIAGE
(M. Booton, ENG/MUN)
Natural frequencies and corresponding mode shapes, static elastic displacements, internal loads and internal stresses are obtained from finite element analysis, for optimization of proposed design of the Arctic Vessel and Marine Research Institute ice tank towing carriage.

STUDIES ON ARCTIC SNOWPACKS
(M.-K. Woo, P. Marsh and M.-A. Dubreuil, GEOG/McM)
A comparison between measured snow accumulation in small Arctic basins and that predicted from weather station data showed that the latter always underestimates winter snowfalls. A computer model to simulate ripening processes in Arctic snowpack showed that at very low temperatures, the meltwater percolating the snowpack or frozen ground refreezes, thereby releasing considerable latent heat to ripen the snow. In the Arctic snowpacks near Resolute Airport, considerable amounts of trace metals and dust were found to be incorporated with the snow due to human activities, which affected the radiation balance of the snow cover and advancement of the snowmelt by several days.

HYDROLOGIC STUDIES, INUVIK-TUKTOYAKTUK REGION
(J.C. Anderson, SWD/NHRI/EC)
Data continued to be gathered on snowpack water equivalent, river channel and culvert icings, precipitation, air temperature, river discharge, and suspended sediment, at a variety of tundra and taiga drainage basins, in order to provide data relevant to highway construction and other activities in the region.

SNOWMELT STUDIES, VANCOUVER, B.C.
(D.L. Golding, FORESTRY/UBC)
The 4 small snowmelt lysimeters installed in 1981 were supplemented in 1982 by two large (28 m^2) lysimeters, and instrumentation to measure energy fluxes during snowmelt.

The snow survey and lysimeter data compared favourably with that determined from the U.S. Corps of Engineers point source snowmelt equations for three rain-on-snow events during the winter of 1983. However, use of the equations was deemed unfeasible for a second study site in an old growth coastal western hemlock forest because of the variability of precipitation under the canopy and the absence of wind.

During the storm of 10 February, snowmelt along with the rain (194 mm in 1 1/2 days), increased the runoff rate from the lysimeter by only 10% over that which would have resulted from the rain alone. Runoff rates from the lysimeter were increased by 8% and 19% by snowmelt for the other two rain-on-snow events.

Runoff rates during the rain-on-snow events were generally less from the forest than from the open although the amount of the difference could not be assessed quantitatively.

AIRBORNE GAMMA SNOW SURVEYS
(J. Glynn, SWD/NHRI/EC)
A joint US and Canadian snow survey of Lake Superior was performed in March 1983 using both Geological Survey of Canada and the US National Weather Service airborne gamma ray spectrometer systems. The value of these snow water equivalent data in regulating lake levels will be assessed over a five year period.

RADIATION BALANCE AND SNOWMELT, SCHEFFERVILLE, QUEBEC
(W.P. Adams and P. Lafleur, GEOG/TRENT)
A study of aspects of the radiation balance at open and woodland sites was conducted throughout the melt period of 1983. Results are now being processed.

SNOW AND ICE COVER IN UNGAVA
(A.Champoux,B.Lauriol and F.Bonn, GEOG/SHER)
The behaviour of the snow cover and ice cover in Ungava between 1967 and 1980 has been studied using remote sensing techniques.

SNOW STRUCTURE
(R. Perla, S&ID/NHRI/EC)
The method of section preparation was applied to samples of seasonal snow by cutting as many as 50 parallel planes at 40 μm intervals through the sample. The plane surfaces are etched, polished with fingerprint powder for contrast, and photographed with incident light. The photographs are converted to video images, digitized, and studied (now in progress) using stereological methods. Section methods were extended to study samples that contained liquid water. Dyes were mixed into the liquid water at 0°C. The sample was frozen rapidly, the pore space was filled with a supercooled ester, the ester was frozen, and the specimen was cut, etched, and photographed as above.

SNOW GAUGES
(K.H. Jones and R.F. Hopkinson, AES/Regina)
Measurements obtained from the Fischer and Porter recording precipitation gauge fitted with a special large diameter Nipher shield, were comparable to those from the official AES Nipher-shielded snow gauge. A report has been prepared on a snow gauge/snow course comparison for selected stations in Manitoba and Saskatchewan.

SNOW AND AVALANCHES
(D.M. McClung and P.A. Schaerer, DBR/NRCC)
Impact pressures and seismic signals associated with avalanches were measured throughout the winter at Rogers Pass, B.C. A series of pipes with geophones was installed in the gully of the Tupper I avalanche to better define the speed of incoming debris along the incline when it strikes the pressure cells. Theoretical analysis of flow characteristics from small pressure cell

data was begun in relation to current mechanical fluidization models relevant to avalanche dynamics modelling.

In collaboration with the Norwegian Geotechnical Institute terrain parameters were analyzed for 200 avalanches. This analysis showed that avalanche runout can be defined relative to a reference point upslope from the runout zone. Maximum runout for a given path is then predicted statistically in terms of confidence limits. This results in a new approach to zoning and construction of avalanche atlases which removes the subjective methods now used.

The masses of all medium and large avalanches at 48 paths at Rogers Pass were measured. A predictive equation was developed for the mass of maximum avalanches at locations where snowfall and terrain parameters are known. Analysis was begun on the annual amount of snow brought down by avalanches.

Observations of maximum annual snow loads were continued at 15 locations in southern British Columbia. Good parabolic correlations were found between mean annual maximum snow loads and elevation, as well as 30-year maximum snow load and elevation. The results are applicable for the design of buildings, runoff forecasts, and predictions of the amount of avalanche snow.

Data were analyzed in collaboration with the Norwegian Geotechnical Institute in relation to measured snow creep pressures on a structure and their relation to snowpack properties. It was shown that maximum pressure is a function of both snowpack stiffness and depth integrated body force, whereas average pressure is sensitive only to the latter. This provides important information in regard to nonlinear constitutive behaviour.

A cold lab has been set up in Revelstoke, B.C. Snow samples were taken from Rogers Pass for analysis in the lab and a number of shear tests were completed. A study plot was arranged with Parks Canada near the top of Mt. Fidelity to obtain samples close to the avalanche fracture zone areas.

AVALANCHE DYNAMICS

(R. Perla, S&ID/NHRI/EC and K. Lied, Norwegian Geotechnical Institute, Oslo)

The Monte-Carlo particle model of snow avalanche dynamics was improved to include mechanisms of entrainment and deposition, and then applied to the Ryggfonn avalanche path (near Stryn, Norway) giving a reasonable simulation of measured speeds and debris deposition patterns. The model also predicts internal momentum distributions, but measurements are not yet available to test this feature.

PERMAFROST/GROUND ICE/GAS HYDRATES

PERMAFROST

(G.H. Johnston, T.H.W. Baker, V.R. Parameswaran and L.E. Goodrich, DBR/NRCC)

Regular ground temperature observations were continued at selected locations in northern Manitoba (Thompson, Lynn Lake & Churchill), in alpine permafrost in the western Cordillera and also in the High Arctic at Alert, N.W.T. Ground temperature measurements at the peat plateau site at Thompson were terminated on December 31, 1982. Processing of all data taken at this site since 1971 was undertaken.

Weekly ground temperature observations at the Inuvik airstrip were continued for DBR/NRCC by the Inuvik Research Laboratory and preliminary processing of data obtained in the past two years was carried out.

Trenches were excavated, surveys made and insulation samples taken at the Inuvik insulated roadway site in September 1982. Dempster site surveys were continued during visits in September 1981 and February and June 1983. Ground temperature observations at the Eagle River Bridge on the Dempster Highway were continued. Temperature and geometry data from a section of the Mackenzie Highway have been analyzed and corrected.

Several unloaded piles embedded in permafrost in Inuvik, N.W.T., were excited using calibrated hammers, and the response from these piles was recorded on magnetic tapes. Static and dynamic creep tests in the laboratory with piles in frozen soils were continued. An electro hydraulic shaker has been installed and will be used for dynamic loading of piles.

Deformation behaviour and strength of frozen reconstituted clayey soils and sand-ice materials of different compositions were studied at various temperatures under uniaxial and triaxial conditions.

Data on the electrical freezing potential of permafrost has been obtained from field electrode assemblies at Inuvik and Illisarvik (Richards Island), N.W.T. The combined TDR and thermal conductivity probe has been installed in connection with an insulated basement study to locate the freezing front in freezing soils.

A summary report on recommended procedures for classifying and laboratory testing artificially frozen ground was prepared by the International Working Group on Frozen Soil Testing.

Unconfined compression tests have been performed on artificially frozen saline sands with pore water salinities of 0 to 45 ppt. These tests were performed at nominal strain rates in the range 10^{-7} to $10^{-3} s^{-1}$ and test temperatures of -6°C and -10°C. The most dramatic changes in strength and deformation occur when the pore water salinity increases from 0 to 10 ppt, beyond 10 ppt the changes are less dramatic.

A computer study was carried out to explore the application of a generalized least squares time stepping technique to heat flow problems.

FROST ACTION
(E. Penner, L.E. Goodrich and O.J. Svec, DBR/NRCC)
Frost action investigations are being carried out with temperature determined at the ice lens for controlling rates of freezing, as opposed to one-step freezing. Several runs were also done with artificially made varved clay to determine under what conditions the ice lens forms. With the precise control of the ramp rates using a computer, the rate of heaving changes during the formation of the lens, from initiation of one lens until it stops growing. In addition the flow of water mirrors the heaving rate changes.

A numerical model for frost heave using a method with a pseudo coupling between moisture and heat flow has been modified and tested.

A test building was completed and instrumented to measure heat loss from insulated basements.

TRIAXIAL TESTS ON PERMAFROST
(S.J. Jones and H.A.M. Chew, SID/NHRI/EC)
A series of constant strain-rate tests, at different hydrostatic pressures, were completed on frozen sand/ice samples of different compositions (with V.R. Parameswaran, DBR/NRCC). Results are to be published in the Proceedings of the 4th International Conference on Permafrost.

CHANNEL BANK EROSION IN THE MACKENZIE DELTA
(M.F. Lapointe, SWD/NHRI/EC)
An investigation is being carried out on the relative importance of different channel-bank erosion processes,at work during break-up and the succeeding high-flow period. Preliminary observations indicate that during these periods limited mechanical scouring of cut banks by ice floes accompanies hydrothermal melting of bank materials, and their entrainment by the flow stresses. The occurrence of thermoerosional niching in these fine-grained bank materials is also being studied, to determine the control exerted by segregated ice content in conjunction with the hydrothermal and hydrodynamic processes.

PERMAFROST HYDROLOGY
(M.-K. Woo, J.J. Drake, P. Steer, N. Roulet and B. McMillan, GEOG/McM)
In the High Arctic continuous permafrost region, snowmelt was found to be the main source of water supply for slope run-off. Three-quarters of the annual precipitation was snow and streamflow was mainly due to snowmelt. In the Low Arctic, hydrological responses to snowmelt, rainfall and evaporation in wetland, as well as thawing of the active layer, were studied. Effects of the proposed uranium mining tailing disposals on the thermal and hydrological environments in the permafrost region was also studied.
(A. Wankiewicz, SWD/NHRI/EC)
Seasonal heat flow between an Arctic river and its stream bed was simulated. Results were compared with observed ground temperatures beneath two streams near Inuvik. Heat dispersion by flowing ground water beneath the channel produced intense heat flow in summer and autumn beneath the Rengleng River channel. The 2 m of bed frost that formed after cessation of streamflow in winter absorbed latent heat from spring runoff for 16 days.

AUFEIS
(A. Wankiewicz, SWD/NHRI/EC)
Analysis was completed on the winter temperature observations at stream aufeis sites near Inuvik, N.W.T. The temperature records showed that mid-winter overflows occurring just prior to stream flow cessation derive from conduits beneath the channel ice cover, occur over a 5-day period, and are widespread along both channels observed. Those occurring after stream flow cessation derive from groundwater flow in the sub-channel talik, occur over a 16-day period, and are localized along the channel.

ICE BUILD-UP IN BURLAP CREEK, Y.T.
(R.O. van Everdingen, Groundwater/NHRI/EC)
Three time-lapse cameras have again been installed at km 1817 on the Akaska Highway to monitor build-up of icing in Burlap Creek. Ground movements in the upper reach of the icing area are to be monitored by repeated level survey.

FIELD MEASUREMENTS OF RHEOLOGICAL PROPERTIES OF FROZEN SOILS AND ICE
(B. Ladanyi and J.R. Murat, CINEP, Ecole Polytechnique, U. de M.)
This on-going project has involved several field and laboratory studies in the last ten years. Essentially, two different methods have been investigated: (a) measurement of creep properties of frozen soils and ice by means of borehole creep and relaxation tests using a pressuremeter and interpretation of test results using the finite element method, and (b) a static cone penetration test for the determination of creep properties of frozen soils and ice, for the design of piles embedded in permafrost. The latter method appears to show good promise in connection with the offshore permafrost problems.

BEHAVIOUR OF FROZEN SOILS AT CRYOGENIC TEMPERATURES
(B. Ladanyi and J. Bourbonnais, CINEP, Ecole Polytechnique, U. de M.)
Thermal and mechanical properties of frozen soils (a uniform sand and an undisturbed clay from Belgium) and polycrystalline ice at very low temperatures (to -165°C) were studied in connection with the underground storage of liquified natural gas (LNG). At cryogenic temperatures,the behaviour of soil materials is closely related with their unfrozen water content at these temperatures, which is affected by their grain size and mineralogy.

GEOPHYSICAL SURVEYS OF PERMAFROST
(M.K. Seguin, GEOL/Laval)
Electrical resistivity measurements have been carried out in 60 locations in the Nostapoka region and in 75 locations in the Sheldrake region. From these data, the permafrost distribution in the region east of Hudson Bay can be mapped. Samples of different lithology will also be analyzed for thermal conductivity.

Many geomorphological and physical features suggest the degradation of zones of palsas in some regions. From statistical analysis, the thickness of discontinuous permafrost in regions of frozen minerals or vegetation can be predicted.

FLOATING ICE/LAKES, RIVER AND SEA

SNOW AND ICE COVER OF LAKES, HYDROLOGICAL AND BIOLOGICAL ASPECTS
(W.P. Adams, C.H. Taylor, D.C. Pierson and J.R. Glew, GEOG/Trent)
Three small water bodies in southern Ontario were studied, focussing on chemical and biological aspects of the winter cover. In the northern Québec/Labrador area studies of spatial distribution of snow and other forms of ice on Elizabeth Lake, Labrador and on Knob Lake, Québec, were continued.

A new project was begun on Colour Lake, Expedition Fiord, Axel Heiberg Island, NWT. A detailed survey was made of the late winter cover on this lake. Water column and ice samples are being analyzed for conductivity, major ions, various trace metals, etc. The focus of the study is the role of the premelt moat. A separate project was conducted on biological aspects of sea ice off Resolute, Cornwallis Island, N.W.T.

RIVER ICE JAMS, MACKENZIE BASIN, N.W.T.
(T.D. Prowse, SWD/NHRI/EC)
During a four week period in the Spring of 1983 an intensive field study of ice jam processes was undertaken at the confluence of the Liard and Mackenzie rivers. The design of the field program was based on a set of guidelines being developed by the NRC Working Group on River Ice Jams and coordinated by T.D. Prowse.

During break-up, the downstream advance of the break-up front was monitored by light aircraft using an Enviropod 35 mm remotely-controlled camera system and a field portable video camera amd recorder. Two 16 mm time-lapse cameras were also located on the ground at the mouth of the Liard River. Hydrometeorological observations near the confluence included ice surveys, water level and velocity measurements, and the measurement of energy balance of the ice sheet prior to break-up. Once a jam was established water temperatures were measured using an infrared radiation thermometer at the leading edge of open water and in holes within the jam. The jam remained intact for just over one week which offered a unique opportunity to study the processes which lead to the deterioration and final release of ice jams. Preliminary results suggest that although the processes of break-up and jam lodgement are primarily hydromechanical, hydrothermal processes play a large role in the deterioration of ice jams. Relevant hydrologic and climatic data records are now being analyzed to determine the long-term, relative importance of hydro-thermal and mechanical forces to break-up and ice jamming. An associated study, to determine the long-term frequency and magnitude of backwater produced by ice jams in the Fort Simpson area is continuing.

RIVER HEAT FLUX
(A. Wankiewicz, SWD/NHRI/EC)
Winter heat flow beneath a shallow, ice-covered, stream was analyzed. A non-uniform flow model was used to represent friction generation and heat transfer to ice in both shallow and deep sections of the channel. Ice cover development in two Arctic streams, near Inuvik, NWT, was simulated. The model confirmed winter observations of flow constriction at shallows to a narrow conduit. The dimension of the conduit was found to be air-temperature dependent in both the modelled and observed results.
(P. Marsh, SWD/NHRI/EC)
A study to investigate changes in water temperature and convective heat flux during spring break-up was initiated. The primary objective is to improve our understanding of the heat flux from the river water to the overlying ice cover, and document its importance in the removal of ice from the river. Field work was conducted near the confluence of the Liard and Mackenzie rivers.

YUKON RIVER BREAK-UP AT DAWSON CITY, Y.T.
(S.C. Bigras and J.C. Anderson, SWD/NHRI/EC)
In a pilot project to test the effectiveness of 16 mm time-lapse cameras for recording break-up, two systems were placed on a ridge northwest of Midnight Dome, overlooking the Yukon River. The resolution permitted accurate determination of the pattern and sequence of break-up along selected reaches of the river.

LAKE REGIMES, MACKENZIE DELTA, N.W.T.
(S.C. Bigras, SWD/NHRI/EC)
The potential impact of increased flow regulation on Delta lake levels and the interaction between connected and unconnected lakes and their channel systems is being assessed by monitoring water levels at nine sites along the eastern sector of the Delta from April to September. Climatological and hydrochemical data were collected to identify spatial or temporal trends that may exist.

DYNAMICS OF FLOATING ICE - ST. LAWRENCE RIVER
(B. Michel, CIVIL ENG/Laval)
Photogrammetric studies are being made from the Québec bridge on the St. Lawrence River, to establish the constitutive relation controlling the movement of large concentrations of ice floes subject to tidal and wind forces.

CREEP TESTS ON CIRCULAR SEA ICE PLATES
(R. Tinawi and L. Gagnon, CINEP, Ecole Polytechnique, U. de M.)
Long-term behaviour of circular simply supported plates of sea ice under a sustained static load that represents 50% to 75% of the instantaneous failure load was studied under isothermal conditions between -5°C and -4°C. The experimental results were compared with an in-house axisymmetric anisotropic solid finite element program. Attempts will be made to evaluate and predict the long-term behaviour of these plates through the introduction of a corresponding reduction in transverse shear modulus and to carry out a simple linear analysis for the prediction of the bearing capacity of floating ice covers under sustained loads.

FAILURE ENVELOPE OF GRANULAR SEA ICE
(G.W.Timco,DME/NRCC; R.Frederking,DBR/NRCC)
The three-dimensional failure envelope for granular/discontinuous - columnar sea ice has been investigated over a range of nominal strain rates from 9×10^{-6} to 4.4×10^{-4} s^{-1} by using confined compression tests. Both the applied load and side confining load were measured. The tests were performed on samples cut from a solid block of ice in the Beaufort Sea which structurally was granular with some banding of discontinuous - columnar ice to a depth of 1.2 m. The results indicate the overall shape and size of the failure envelope of this ice, and show that although the shape is independent of loading rate, the size increases with loading rate. An analytical expression has been derived which mathematically describes the failure envelope in three-dimensional space.

WAVE PROPAGATION IN ICE SHEETS
(O.H. Grande, V.M. Arunachalam, G.B. Guy and D.B. Muggeridge, ENG/MUN)
Wave lengths and wave amplitudes were measured on artificial ice sheets in the laboratory, in order to determine the validity of the theoretically derived dispersion relationships for the propagation and attenuation of gravity waves entering an ice field.

McMURDO SEA ICE STUDY
(S.J. Jones, SID/NHRI/EC)
The sea ice in McMurdo Sound, Antarctica, was studied as part of a joint oceanographic project with the Frozen Sea Research Group (IOS/FOC). Thin sections were cut and temperature, salinity and density determinations made. Samples were shipped back to Ottawa where they arrived, almost in the liquid phase, in August 1983.

ICEBERG STATISTICS
(D. Mudry, P.W. Coté, R. Chagnon and F.E. Geddes, ICAD/AES/EC)
During the summer of 1983, a manual laser analysis program was again conducted using summer students. An additional 21,500 km of laser tracks were analyzed for ice ridge heights and frequency on a per kilometre basis. This brings the total number of kilometres analyzed to just over 113,000. A SLAR catalogue has been prepared which shows the areas imaged by the side-looking airborne radar and the time of the year. Flights up to 1 May 1983 are contained in this catalogue. Some preliminary iceberg data base design work was initiated.

ICEBERG : DIMENSIONS, FLUX, COLLISION RISK, AND DESIGN CRITERIA
(D.M. Nazarenko, T.D. Miller, I.S. Hotzel and D.E. Pearson, Offshore Research/Petro Canada)
Physical dimensions for 600 icebergs were extracted from aerial photographs collected during a spring survey of the Labrador Sea. Length, width, height and waterline area were measured while draft and mass were estimated from the freeboard dimensions. This data provides a base for comparison with data collected as part of offshore oil exploration programs.

Iceberg flux in the Labrador Sea was estimated using existing knowledge of the iceberg distribution and the regional currents. Yearly estimates of iceberg flux was 6-15 per km. Bathymetrically zoned estimates range from 25-35 icebergs per km per year for the marginal trough through 5-13 icebergs per km per year on the bank and 5-9 icebergs per km per year for the slope.

The risk of collision between an iceberg and an offshore structure was estimated from observed results, geometric probability, and Monte Carlo simulation of iceberg drift. The latter two corroborated the observed results in the Labrador Sea gathered during offshore drilling programs.

Data necessary for the design of offshore structures on the Grand Banks of Newfoundland was obtained from characterization of the iceberg environment in terms of physical parameters, areal densities and kinematics, and from an evaluation of impact probabilities.

The program simulates iceberg impact on a structure, evaluates the risk of collision and derives probabilistic kinetic energies associated with collision events.

DRIFT OF IDEALIZED ICEBERGS
(D.B. Muggeridge, K. Shirasawa and N.P. Riggs, ENG/MUN)
Non-dimensional solutions for the equation of motion are introduced as an aid to understanding the movement of icebergs. Frictional force and drag coefficients for semi-immersed objects as a function of speed of the object were studied, in order to understand the mechanism of motion of real icebergs during deceleration after the change of external forces such as wind, current and towing.

ICEBERG DRIFT
(R.T. Dempster, C.C. Hsiung and A.F. Aboul-Azm, ENG/MUN)
A numerical model has been developed to predict the iceberg drift trajectories from the known or derived information regarding the iceberg characteristics and the environmental forces affecting the motion of an iceberg, such as the forces due to winds, currents, Coriolis effect, geostrophic effects and waves. The model has given satisfactory results for tabular icebergs. Modelling for other iceberg configurations is in progress.

PREDICTION OF ICEBERG TRAJECTORY
(M. Booton and N. Hookey, ENG/MUN)
Optimal estimation theory was used to estimate and predict iceberg trajectory. Current investigations model the iceberg dynamics and use a Kalman filter (optimal estimator) in order to smooth out the effects of random fluctuations in input noise (wind, current, etc.) and observation noise (radar tracking errors, etc.).

ICEBERG SCOUR
(T.R. Chari, G.R. Peters, A.S. Reddy and H.P. Green, ENG/MUN)
The mathematical model for iceberg scour has been extended to icebergs of various shapes. Tests are ongoing in a 14 m x 3 m tank with 50 cm wide iceberg models with different types of frontal cutting edge in a medium to dense cohensionless soil. Theoretical and experimental work is underway to examine the uplift of scouring icebergs in relatively still soil. To delineate the zone of influence beneath the scour, tests are continuing with an instrumented pipeline buried in the soil.

SIMULATION OF ICEBERG SHAPES
(D.V. Reddy, M. Arokiasamy and P.S. Cheema, ENG/MUN)
In order to establish the risk factors involved in drilling operations in the Labrador Sea, it is necessary to establish the iceberg impact probabilities. The Monte Carlo method was used to simulate the above-water and below-water profiles based on a set of observed icebergs. A Monte Carlo type fault tree analysis was then applied to determine the iceberg impact probabilities for this extended data base.

MOTION ANALYSIS OF AN ICEBERG IN REGULAR WAVES
(V.M. Arunachalam & D.B.Muggeridge, ENG/MUN)
A combined theoretical and experimental study of iceberg motion has been made. The wave exciting forces and hydrodynamic reaction forces are computed via three dimensional potential flow theory. The motion of the berg is then computed under the assumption of small amplitude linear motion. The computed motion in surge and heave were compared with experimental results in wave tank studies. The icebergs were made of paraffin wax. Two shapes of bergs, cylindrical and box type, were studied. The computed results compare quite satisfactorily with the experimental results.

WAVE-INDUCED MOTIONS OF SMALL ICEBERGS
(J.H. Lever, E. Reimer & D.Diemand, ENG/MUN)
Experimental wave tank studies were conducted to determine the kinematics of small bergs and bergy bits in storm waves typical of the Grand Banks region, and it was found that the kinetic energy of small bergs and bergy bits could approach that of much larger icebergs. Small icebergs and bergy bits in storm conditions thus pose a significant environmental hazard to Canadian east coast drilling operations.

BERGY BIT IMPACT ON SEMI-SUBMERSIBLES
(M. Arokiasamy, A.S.J. Swamidas and D.V. Reddy, ENG/MUN)
The effect of the impact of ice floes on the motion response of the semi-submersible drill rigs is determined using coupled degrees of freedom and close-form solutions, and limit analysis procedures.

ICE FORCES ON TUBULAR JOINTS
(M. Arokiasamy and P.S. Cheema, ENG/MUN)
The effect of ice forces on the fatigue life of tubular joints of offshore monopod structures is determined using fracture mechanics and corrosion fatigue crack growth data.

IMPACT FORCES ON FLOATING STRUCTURES
(M. Arokiasamy, D.V. Reddy and A.S.J. Swamidas, ENG/MUN)
The response of a moored semi-submersible to bergy bit impact, irregular wave, wind and current is determined. Using cyclic symmetry option available in MSC/NASTRAN code, the structural displacements and stresses/forces are determined and the factor of safety examined.

V.R. Parameswaren

JAPANESE SOCIETY OF SNOW AND ICE

(NIPPON SEPPYO GAKKAI)

The Japanese Society of Snow and Ice (JSSI, Nippon Seppyo Gakkai) has had a long history, since its birth in 1939, comparable to that of the International Glaciological Society. At first, it was established as the Japanese Association of Snow and Ice (Nippon Seppyo Kyōkai). The word Kyōkai (association) has a more inclusive meaning than Gakkai, which means a professional society, and the use of this name might reflect the fact that membership of the association at its formation was not only restricted to researchers but included people who were involved in the actual work of snow removal, prevention of frost heaving of railroads, forestry, architecture, etc., in the northern part of Japan.

The seed for the association was planted at a colloquium called "Yuki no Kai (Meeting on Snow)", which was organized by H. Yamaguchi and T. Hirata in 1933. Yamaguchi was then the Director of the Research Station for the Agricultural Economy of Snowy Regions (RSAE-SR) and Hirata was at the Central Forestry Experimental Station, both organizations were affiliated with the Ministry of Agriculture and Forestry of the Japanese Government. In the early decades of the 1900s, severe crop failures over a number of years in the Tohoku District (northern part of Honshu Island) became a serious political issue in Japan. Recognizing the importance of scientific research on snow for a proper understanding of disasters due to snow and coldness in this region, they held a colloquium every month to hear reports on research activities on snow, exchange information and discuss urgent regional problems with various scientists and interested people.

Those who were acquainted with each other from the colloquia naturally wished to organize an association and more than 500 became founding members. They elected Dr Hirata as the chief director (later the President) of the Association. Following the opening ceremony on 16th March, 1939, three special lectures were given; "Snow and health" by Dr Kojima, a medical scientist and President of the Japanese Association of Ski Sport, "Snow fall and weather mechanisms" by H. Hatakeyama, a meteorologist with the Central Meteorological Observatory, and "Mechanics of deposited snow" by Dr M. Kuroda, a metallurgist in the Institute of Physico-Chemical Research. From April 1939, the Association published "Geppo (monthly bulletin)" in which original papers on subjects dealing with snow and cold climate as well as review papers and introductory lectures were included. One of these lectures, on "Snow crystals" by Dr U. Nakaya, who was carrying out his famous work on artificial snow crystals, appeared in the 3rd issue of "Geppo". After 1941 the publication changed its name to "Seppyo (Snow and Ice)". This year, 1941, was when the Institute of Low Temperature Science (ILTS) was established at Hokkaido University.

Even during World War II, the publication of "Seppyo" continued without interruption thanks to the enormous efforts of its editorial board, although Vol.7, published in 1945, had only one issue with 12 pages. However, real difficulties for the Association were encountered after the war ended because of extraordinary post-war levels of inflation and the loss of members due to this distressing situation continued for several years. The financial problem was gradually overcome with the help of the Union of Prefectures in Snowy Regions, a regional-political association which promoted the adoption of laws to improve the living conditions of people in the snowy regions in Japan. The Association could, of course, supply various data to further their objectives. In 1944, the Association published a commemorative volume entitled "Ten years research on snow and ice", which reviewed research activities during the ten years since its establishment.

Major issues related to snow and ice after the war in Japan were snow hydrology, to develop hydroelectric power as Japan's main energy resource, and the protection of power lines for her national railroads from snow accretion, icing and avalanches. Many papers on these problems appeared in "Seppyo", and hydroelectric power companies and the Japan National Railway (JNR) helped the Society financially. Owing to the active research on snow in the forestry experimental stations since Hirata, the secretarial bureau of the Society was maintained in the Central Forestry Experimental Station, for nearly a decade, thanks to the voluntary efforts of Dr T. Shidei (present Vice President). In spite of such help and efforts at recovery, the publication of "Seppyo" was sometimes behind schedule by as much as one year in the early 1950s.

In 1955, Dr M. Kuroda (second President of the Association since 1950) proposed the dissolution of the Association and the creation of the Japanese Society of Snow and

Ice. However, this decision did not mean any discontinuity in the real activities of members, but it ushered in a period of reforms for the snow and ice research community. The motivation for reform could be attributed to rapid developments in fundamental research on snow and ice at universities and other institutions in the 1950s and to the worldwide growth of research on glaciology and cold environments. As Dr Kuroda declared, "the period of enlightenment" was over and a new era for the science of snow and ice was beginning. This was the same year the late Dr Shoda initiated his famous systematic research on avalanches at the Snow Experiment Station of the JNR in Shiozawa, Niigata Prefecture north of Tokyo. Shoda and the late Mr A. Fukui (Japan Meteorological Agency) were real promoters for reform of the organization and publication of "Seppyo".

After the reforms, the Society established its secretarial bureau and editorial board in the Japan Meteorological Agency and has held an annual scientific meeting as well as an annual general meeting regularly. The annual scientific meeting moves from place to place every year; several large cities, like Tokyo, Sapporo, Morioka, Sendai, Niigata, Fukui, Nagoya, etc. have hosted it and it will be held in Kyoto in 1984. The publication of "Seppyo" is once again regular; a bi-monthly publication until Vol.32 (1970) it has been quarterly since Vol.33 (1971).

The recovery of the Society reflected the economic development of Japan since the 1960s during which time various types of snow and ice research were in demand, for example, snow removal, forecasts of snow and avalanche prevention on the super-highway systems in northern Japan, ground freezing associated with soil stabilization techniques and LNG/LPG tanks, etc. The number of snow and ice researchers has increased from this period owing to an increase in the research sections of ILTS and the establishment of new laboratories for snow and ice studies in Nagaoka and Shinjo, both belong to the Science and Technology Agency of the Government. Another aspect of research appearing in "Seppyo" is Arctic and Antarctic glaciological work in which many young scientists became involved following the IGY in 1957. Antarctic glaciology in Japan has been conducted by cooperation between the National Institute of Polar Research (NIPR), established in Tokyo in 1973 (formerly the Polar Section of the National Science Museum), and the universities. Many members of the Society have been associated with it, not only as members of expeditions but also as planners of projects.

The average number of pages in one volume of "Seppyo" in recent years exceeds 200. It may be worth mentioning here that "Seppyo" accepts original papers written in English, although papers are generally written in Japanese with an English summary at the end. Seven English-language papers have appeared since 1975 including two papers written by Chinese glaciologists. In addition, special issues containing reports from the glaciological expedition to Nepal, headed by Dr K. Higuchi, were published in a completely English edition in 1976 and 1977. Other international activities which have been developed are invitations of foreign glaciologists. On the occasion of the 30th anniversary of the Society, in 1968, Dr M. de Quervain was invited from Switzerland as a guest speaker to a symposium on deposited snow. In 1979, when a symposium on glaciology in Asia was held at the annual meeting in Nagoya, Prof. Shi and Mr Huang, from China, and Mr Updkyay and Mr Mulmi from Nepal were invited. At present, it is not unusual to see foreign scientists staying in some Japanese institutions related to snow and ice, participating the annual meeting of the Society.

A remarkable contribution by the Society to the snow and ice community has been its continued publication of a bibliographical review of the study of snow and ice in Japan, published approximately once a decade. The first and the second issues of this publication, "Abstracts of Bibliographies on Snow",I and II, were published by the RSAE-SR in 1939 and the National Institute of Agricultural Economy in 1960, respectively. They were edited by a committee of the Society and included some foreign papers, but the next three were restricted to Japanese papers. The third one, which included bibliographies from 1950-1958, was published in 1960 as No.3 of "Research on Snow and Ice", the Society's special publication series which will be described next. The fourth, covering the 1959-1968 bibliographies, was published as an inclusion in "Seppyo", divided according to their categories into the Vol.34 and 35 (1972-1973) issues. The fifth one, for the 1969-1978 bibliographies, was again published in "Research on Snow and Ice" as No.6. This was one of the largest ever and included 4397 bibliographies with review papers on 26 categories of snow and ice science written by experts in the editorial committee, chaired by the late Dr D. Kuroiwa. Reviews and bibliographies of this type are useful for readers as well as for reviewers to obtain information on results of current research and perspectives on various topics of snow and ice research.

"Research on Snow and Ice" is the monograph series published by the Society. It started in 1953 with No.1, of which the title was "For the Development of Hydroelectric Resources". No.2 (1955) was entitled "Melting of Snow and Snow Survey" and No.4 (1970) was "A Manual for Measurement of Snow Cover". They were all related to various topics of snow including falling and deposited snow, avalanches, drifting snow and snow accretion, reflecting the extensive research activity on snow in Japan during the 1950s

and 1960s. No.4, the above-mentioned manual, was translated into English for the convenience of foreign scientists. No.5 (1973) was on "Problems and Counter Measures Related to Snow and Ice Effects on Power Transmission Lines".

Since 1966, the Society has had three types of award; the award for scientific achievement, the award for distinguished services and the one for encouraging young scientists. The last one is called the Hirata Prize after the first President's name. Several tens of people have been honoured and inspired by these awards in the last 18 years.

At present, the Society has approximately 800 regular members, 84 associate members and 161 group members. Honorary members include former Presidents of the Society, Dr K. Aki (the third President, 1957-1963), Dr H. Hatakeyama (the fourth, 1964-1967), and Dr Z. Yosida (the immediate past President, formerly Director of ILTS, Hokkaido University, 1968-1982). Other honorary members are aged, most distinguished contributors; Mr S. Seki, formerly with the JNR, Mr S. Hori, formerly with Tokyo Electric Power, and Mr K. Takahashi, formerly with the National Forestry Experimental Station.

The President of the Society is Mr Toshikazu Kawakami, a long-time contributor ever since he has been with the JNR. The Society's secretarial bureau now resides at, Room 308, Bancho-haimu, Niban-cho 1-2, Chiyoda-ku, Tokyo 102. The Society has one regional branch in Hokkaido with 200 members. The President of this branch is Dr S. Kinosita, the Director of the ILTS, Hokkaido University. Several standing committees and internal research groups are organized within the Society; the Planning Committee (Chairman, M. Inoue), the Editorial Board (Chairman, K. Kusunoki), the International Committee (Chairman, T. Kawakami), the Committee for Polar Snow and Ice (Chairman, A. Higashi) and six research groups including solid state studies of snow and ice, drifting snow, avalanches, urban snow disasters, frozen ground and glacial data center.

The names of the above research groups may reflect the research interests of the Society's members, but a somewhat more quantitative measure to indicate the present-day interests of members was the program of the annual science meeting held in Tokyo, November 1983. The three day meeting consisted of two parallel sessions divided into 16 categories as follows, with the number of presentations in parenthesis; Physics of ice (15), Frozen ground and frost heaving (16), Lake and sea ice (5), Accretion of snow and ice (10), Avalanches and snow on slopes (6), Mechanical properties of deposited snow (7), Melting of snow (14), Snow on roofs (11), Snow removal and disposal (11),Snow patches, glaciers and ice sheets (25),Snow and transportation (10), Metamorphism and distribution of snow (11), Falling snow phenomena (16), Utilization of snow (2), Methods of measuring snow (12), Snow crystals (10) and Drifting snow (10).

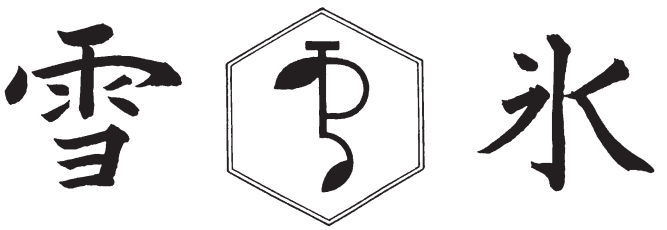
Readers may notice in the above statistics that many contributions related to the main theme of the IGS-84 Symposium to be held in Sapporo next September. The co-sponsorship of the Symposium is the natural outcome of such common interests of the JSSI. It is strongly anticipated by many members of the JSSI that they will have good opportunities to discuss their interests with people of similar interests from overseas at this occasion.

Akira Higashi

Preliminary information about the Japanese language of snow and ice for participants of the IGS-84 Symposium.

Yuki (snow, bottom left) and kōri (ice, bottom right)

When snow and ice are formed into a compound noun, the word "Seppyo" is used. It is derived from the transliteration of the Chinese characters "Setus" (Snow) and "Pyo" (ice). The symbol of the Society, adopted in 1978 to commemorate its 40th anniversary, is shown below (centre). It was designed by A. Ushimura, a member of the Society, as a cursive form of the Chinese character for snow.



WESTERN ALPINE BRANCH ANNUAL MEETING

The Western Alpine Branch of the International Glaciological Society held its 12th meeting at Vallouise from 15-18 September 1983. After a reception and meal the participants repaired to a local hostelry in the company of the President, Louis Reynaud. On a rainy Saturday, everyone set off for the Pré de Mme Carle and from there went to the snout of the Glacier Noir where several studies have been carried out by scientists from the Laboratoire de Glaciologie of CNRS. Under continuous rain the group climbed to the Glacier Blanc shelter and continued on to the Ecrins shelter, the rain having given way to snow. As a result of the bad weather the ascent of the Barre des Ecrins was abandoned by Group A but Group B was more fortunate and, taking advantage of a break in the weather, managed to reach the Lac de l'Eychauda despite very high winds. The traditional banquet was held in the evening. The general assembly took place in the magnificent Maison du Parc des Ecrins on the Sunday and the following papers were presented:

L. Reynaud: Distribution of mass balance in the Alps and in Scandinavia.
A. Bezinge: Glacier dynamics and the effects on moraine formation in Valais.
F. Valla: Alaska and the 1984 tour.

The new executive for the Section will be:

President:	G. de Marliave
Vice President:	A.M. Faidutti
Secretary:	G. Bocquet
Treasurer:	F. Valla

CURRENT RESEARCH IN SNOW AND ICE

30 March 1984, CRREL, Hanover, New Hampshire, U.S.A.

On the 30th March, 1984 a one day meeting on Current Research in Snow and Ice was held at the Cold Regions Research and Engineering Laboratory in Hanover, N.H. The idea for the meeting was conceived during the Northeast North America (NENA) Branch biennial meeting of the IGS the previous year at Waterville Valley, N.H. Several researchers, primarily from CRREL and the University of New Hampshire, thought a one-day local meeting for the "off-year" from the Branch meeting would provide some good exchange and keep the U.S. component a little more active in between the NENA meetings. Terry Tucker, Steve Ackley and Sam Colbeck from CRREL and Erland Schulson of the Ice Research Laboratory at Dartmouth College agreed to host the event. Despite a late winter blizzard the day before which paralyzed the east coast, we had twenty-four presentations on snow and ice topics with a total audience of around fifty participants. Representatives of CRREL, Dartmouth College, the Massachusetts Institute of Technology and the following universities - New Hampshire, Massachusetts, New York (Albany), Maine, British Columbia and The Ohio State - presented papers. The meeting was divided into five sections: ice mechanics, ice accretion, remote sensing of snow and ice, physics and chemistry of snow, and physics of glaciers and ice sheets. The occasion was particularly marked by the emphasis on graduate student participation which accounted for about half the presentations. The Ice Research Laboratory at Dartmouth graciously hosted the social event following the meeting where the usual lubricants contributed greatly to the free and easy exchange that was started during the meeting.

The consensus was that the meeting was highly successful, despite the weather. Limiting the meeting to one day of presentations simplified travel arrangements and made participation by a larger number of students possible. We plan to continue to hold such a meeting either in the "off-year" between Branch meetings or in association with the NENA meeting when it is held in the U.S.

Ice Mechanics

W.D. Hibler III: Mesoscale sea ice fluctuations.
N. Cannon: Grain size effect on the maximum compressive strength of ice.
R. Lee: The effects of strain-rate on the tensile strength of ice.
J. Richter-Menge: Confined compression tests on sea ice.
D. Sodhi: Ice-structure interaction tests.
G. Cox: Ice stress measurements.
N. Hubler et al.: Dynamic friction of metals and ice.
M. Ferrick: Effect of ice cover on river wave behaviour.

Icing Research

K. Egelhofer: Icing on transmission lines.
J. Howe and G. Gosselin: Recent work at Mt. Washington.
D. Minsk: Sea spray icing research.
V. Lunardini: Freezing and thawing of systems with phase change occurring over temperature range.

Remote Sensing of Snow and Ice

Y.Q. Jin: Theoretical models for interpretation of experimental data from snowpacks and snowfalls.
C.T. Swift: An algorithm to measure sea ice concentration with microwave radiometers.
J.K. Lee: Anisotropic random medium model for active remote sensing of sea ice.
R.T. Shin: Theoretical models for microwave remote sensing of snowpack.
K. Sivaprasad: A new direct inverse method for reducing echo sounding data.

Snow Cover Physics and Chemistry

P. Mayewski et al.: Production of a time record of acidic anions from Dye-3,Greenland.
A. Hogan: A "heavy" snowfall at South Pole, 15 Jan 1984.
W.B. Lyons et al.: Results of a pilot study of chemical determination from a snowpit on Quelccaya Ice Cap, Peru.
M.J. Spencer et al.: Chemical results from a snowpit atop Heard Island, Indian Ocean.
D. Powers: Thermal convection in snow.
J. Johnson: Audibility within and outside deposited snow.

Glacier and Ice Sheet Physics

K. Jezek: Rheology of glacier ice.
B. Allen III: Glaciochemically derived mass balance for Rennick Glacier, Antarctica.
A.C. Fowler: The Nye-Kamb sliding theory in the presence of cavities.
D.R. Lindstrom: Pine Island Glacier of West Antarctica.
S.G. Collins et al.: Flow, thermal structure and subglacial conditions of a surging glacier.
D. Lawson: Glacial sedimentation studies in Alaska.

S.F. Ackley

NORTHEASTERN NORTH AMERICAN BRANCH MEETING (NENA)

Arrangements are being made to hold the next Branch meeting in the Eastern Townships of Quebec close to the U.S. border sometime in late February or March of 1985. The first circular will be distributed in the late Fall. The meeting is being organized by Stephen Jones and those wishing to be placed on the mailing list or requiring additional information should contact him at that time.

Dr Stephen J. Jones,
Arctic Vessel and Marine Research Institute,
Montreal Road Laboratories,
Building M-22,
National Research Council of Canada,
Ottawa, Ontario,
K1A OR6, Canada

OTTAWA GLACIOLOGICAL GROUP

In the final talk of the 1983/84 session, Dr Lorne Gold reviewed the history of Habbakuk: a science fiction-type idea to construct an aircraft carrier of ice during World War II. The Executive for the 1984/85 season will be as follows:

Chairman:	Michael W. Smith
Vice-Chairman:	Terry D. Prowse
Secretary/Treasurer:	Mohamed Sayed

Information on the forthcoming program will be distributed in September. Those wishing to have their names added to the distribution list should contact:

M. Sayed,
Geotechnical Section,
Division of Building Research,
National Research Council of Canada,
Ottawa, Ontario, K1A OR6

WORKSHOP ON SNOW PROPERTY MEASUREMENT

1-3 April 1985, Chateau Lake Louise, Alberta, Canada

Technical papers are being solicited for a Workshop in the general area of snow measurement. Papers dealing with all aspects of this topic including novel techniques or instruments, quality of existing data sources, and index measurements are invited. Papers which consider the interpretation of measurements in terms of fundamental snow properties are particularly welcome.

Topics:

- Snowcover distribution
  - precipitation measurements
  - water equivalent
- Blowing or drifting snow
- Snow structure and its changes
- Mechanical properties
- Electro-magnetic properties
- Thermodynamic and chemical properties

Organization:

Sessions will be organized to encourage a maximum of formal and informal discusion. At the beginning of each session papers will be summarized and compared by a general reporter. Authors will not normally present their own papers. After the summary report the session will be open for general discussion. A panel of 3 or 4 members will be present to facilitate the discussion.

Location, Time, Cost

April 1-3, 1985,
Chateau Lake Louise, Alberta,
Registration - $50.00
Rates (including meals) - $50/day (double)
- $78/day (single)

Important Dates:

Receipt of abstracts - 30 June 1984
Selection of papers - 31 July 1984
Preliminary program and registration form mailed - 31 October 1984
Receipt of papers - 31 December 1984
Receipt of registration forms and Workshop - 1-3 April 1985

Correspondence:

All correspondence concerning the Workshop should be addressed to:

P.A. Schaerer,
Division of Building Research,
National Research Council of Canada,
3904 West Fourth Avenue,
Vancouver, British Columbia,
V6R 1P5, CANADA

METEOROLOGY AND OCEANOGRAPHY OF NORTH AMERICAN HIGH LATITUDES

3-5 October 1984, Anchorage, Alaska, U.S.A.

The 1984 Arctic Science Conference (35th Alaska Science Conference) will include a symposium on meteorology and oceanography, cosponsored by the American Meteorological Society and the AAAS-Alaska Division. Topics to be discussed will include the following:

- All aspects of high latitude meteorology.
- Focus on time scales from less than a day to several months.
- Air-sea-ice interaction in the high latitudes of the North Pacific.
- Long-range forecasting for the Alaska region.
- Air pollution in the far north with special emphasis on the Fairbanks region.
- Variability and predictability of sea ice conditions in Alaska waters.
- Results from the Bering Sea MISEX (marginal ice zone experiment).

For further information contact:

Stuart Bigler,
National Weather Service,
P.O. Box 23,
Anchorage,
Alaska 99513, U.S.A.

ARCTIC OFFSHORE TECHNOLOGY CONFERENCE AND EXPOSITION

6-9 November 1984, Calgary, Alberta, Canada

The AOTC conference will concentrate primarily on current "state-of-the-art" drilling and downhole technology, examine the major ice-environmental concerns, assess the economics of development and take a look into future concepts of production.

The ever present considerations of ice impact on offshore arctic exploration will be dealt with in several in-depth technical features. Dr Roger Pilkington, Supervisor of Drill Systems Support for Gulf Canada Resources will be talking about instrumentation and environmental monitoring; Consultant Ken Croasdale will discuss recent developments in ice-structure interaction, and Esso Canada will present papers on the influence of artificial islands on land-fast ice or lack of, and on the effect of freeze-up and break-up on the artificial islands in the Mackenzie River at Norman Wells.

Further information may be obtained from:
Arctic Offshore Technology Conference,
#101 - 3009, 23 Avenue S.W.,
Calgary, Alberta,
T3E 0J3, CANADA

OFFSHORE MECHANICS AND ARCTIC ENGINEERING

17-22 February 1985, Dallas, Texas, U.S.A.

The 4th International Symposium on Offshore Mechanics and Arctic Enginering will be held in Loew's Anatol Hotel, Dallas, Texas, from 17-22 February 1985. Thirty technical paper sessions are being organized and will include the following topics:

Ice mechanics and ice forces.
Permafrost engineering and heat transfer.
Frost heave and water movement in freezing soil.
Ice-structure interactions.
Arctic offshore environments.

A special session on Mechanics and Properties of Ice is being organized by Dr D.S. Sodhi. It is hoped that this will include papers on compressive and flexural strength, constitutive relations, bearing capacity, thermal expansion, large-scale movement of sea ice, iceberg management, ice ride-up and pile-up phenomena, pressure ridge formation, etc. It is expected that some papers from this session will be published in the Journal of Energy Resources Technology.

For further information contact:

Dr D.S. Sodhi,
U.S. Army Cold Regions Research and Engineering Laboratory,
72 Lyme Road,
Hanover,
New Hampshire 03755, U.S.A.

7TH YORK QUATERNARY SYMPOSIUM

21-23 August 1985, Lethbridge, Alberta, Canada

The 7th York Quaternary Symposium will be held at the University of Lethbridge from 21-23 August 1985 and will be followed by a three-day post-conference tour. The conference theme will be The Paleoenvironmental Reconstruction of the Late Wisconsin Deglaciation and the Holocene and will be organized into the following sessions:

1. The post-glacial stratigraphic record.
2. Paleoecology and biostratigraphy.
3. Paleoclimatology and paleohydrology.
4. Paleopedology.
5. Field trip.

Paper presentations are planned to last about 25-30 minutes followed by 5-10 minutes of discussion and the proceedings volume will be published in early 1986.

Field trip coordinators will include, among others, Dr A.M. Stalker (geologist), Dr J. Dormaar (soil scientist), Dr C. Pielou (biogeographer), Dr G. Osborn (geologist), Dr G. Beke (hydrologist) and Dr C.B. Beaty (geomorphologist).

For a copy of the first circular and more information contact:

Dr René W. Barendregt,
Quaternary Symposium,
Department of Geography,
The University of Lethbridge,
4401 University Drive,
Lethbridge, Alberta,
T1K 3M4, CANADA

NEWS

AWARDS

Hans Röthlisberger was named Professor by title (Titularprofessor) by the Swiss Federal Government Cabinet on 5 March 1984. This is the same honour that was conferred a few years ago on another of our Swiss glaciologists: Peter Kasser. The citation in the press release records that Hans is chief glaciologist at the Laboratory of Hydraulics, Hydrology and Glaciology at ETH in Zürich, giving lectures and guiding field courses in glaciology since 1972; and that in his research he has concentrated on the intra- and sub-glacial drainage channels, becoming one of the founders of glacier hydraulics. It also notes that he undertakes consultancy work on problems relating to glacier avalanches, drainage of ice dammed lakes and subglacial water intakes for hydropower, including the safety aspects.

Svenn Orvig, Professor of Meteorology and Dean of Science at McGill University, was awarded the Patterson Medal of the Atmospheric Environment Service of Canada at the Annual Meeting of the Canadian Meteorological and Oceanographic Society in Banff, Alberta. In announcing the award on 3 May 1983, the Federal Minister of the Environment cited "Dr Orvig's oustanding contribution to our understanding of the climate of polar regions" and his "major influence on the character and scientific standards of professional meteorology and climate research in Canada". He received the President's Prize of the Canadian Branch of the Royal Meteorological Society in 1964, and the Andrew Thomson Prize in Applied Meteorology from the Canadian Meteorological Society in 1977.

Permafrost: a bibliography, 1978-1982 is the latest issue in the Glaciological Data series of the World Data Center A for Glaciology <Snow and Ice> (WDC-A). It represents their first major undertaking in permafrost and was compiled for participants at the Fourth International Conference of Permafrost, held in Fairbanks, Alaska. The publication was prepared by the WDC-A with support from CRREL. Eight pertinent machine-readable data bases were searched using broad subject categories to arrive at the approximately 4000 citations. The primary source was the Cold Regions Bibliography Project of the Library of Congress.

The bibliography offers both author and subject indexing; the latter being derived from the Cold Regions subject list. It was compiled and formatted using System 2000 on the DAMUS/Univac.

Copies of Permafrost are available at $5.00 (U.S.) from WDC-A: Glaciology, Campus Box 449, University of Colorado, Boulder, Colorado 80309, U.S.A.

The book Permafrost: Fourth International Conference, Proceedings is now available for $65.00 (U.S.) prepaid from the National Academy Press, 2101 Constitution Avenue, N.W., Washington, D.C. 20418. The 1524-page volume contains 276 papers covering a wide range of engineering and scientific topics. These include roads, embankments, airfields, excavations, frost heave, ground ice, hydrology, ecology mapping, planetary permafrost, remote sensing, periglacial features, soil mechanics, pipelines, piles, terrestrial and subsea permafrost, and others. The volume was produced in conjunction with the Conference, which was held in Fairbanks, Alaska, in July 1983.

Avalanche Safety for Skiers and Climbers, by K. Vickers (ISBN 0 906371 31 7) has been published by Diadem Books Limited. It is available in Europe for £7.95 from Cordee, 3a De Montfort Street, Leicester, LE1 7HD, U.K. and in North America from Rocky Mountain Books, Calgary, Alberta, Canada or Alpenbook, Seattle, Washington, U.S.A.

GLACIOLOGICAL DIARY

1984

16 July - 7 August
Western Alpine Branch, International Glaciological Society. Alaska, U.S.A. (F. Valla, Division Nivologique du CEMAGREF, B.P. 76, 38402 St Martin d'Hères, France)

14-17 August
ASCE Hydraulics Division Specialty Conference on Ice Engineering. Coeur d'Alene, Idaho, U.S.A. (Dr H.T. Shen, CRREL, 72 Lyme Road, Hanover, New Hampshire 03755, U.S.A.)

19-24 August
Snow and Ice Chemistry and the Atmosphere. Trent University, Peterborough, Ontario, Canada. (Dr W.P.Adams, Assoc. Dean of Arts & Science, Trent Univ., Peterborough, Ont., K9J 7B8, Canada)

27-31 August
7th International Symposium on Ice, Int. Assoc. for Hydraulic Research. Hamburg, West Germany. (Dr J. Schwarz, Ice Engineering Division, Hamburgische Schiffbau-Versuchsanstalt, P.O. Box 600 929, 2000 Hamburg 60,West Germany)

27-31 August
25th International Geographical Congress. Paris, France. (Comité d'organisation du 25e Congrès International de Géographie Paris-Alpes 1984, 19 rue Isidore Pierre, 14000 Caen, France)

2-7 September
Symposium on Snow and Ice Processes at the Earth's Surface. Tokyo and Sapporo, Japan. (Secretary General, International Glaciological Society, Lensfield Road, Cambridge CB2 1ER, U.K.)

20-21 September
British Branch, International Glaciological Society. University of Aberdeen, Aberdeen, U.K. (C. Gemmell, Department of Geography, University of Aberdeen, St. Marys, High Street, Old Aberdeen, AB9 2UF, U.K.)

3-5 October
Symposium on Meteorology and Oceanography of North American High Latitudes, 1984 Arctic Science Conference, 35th Alaska Science Conference. Anchorage,Alaska, U.S.A. (S.Bigler, National Weather Service,P.O.Box 23, Anchorage, Alaska 99513, U.S.A.)

17-19 October
CRREL/ARO Workshop on the Interaction of Microwaves with the Seasonal Snow Cover. Cold Regions Research and Engineering Laboratory, Hanover, New Hampshire, U.S.A. (Dr S.C. Colbeck, CRREL, 72 Lyme Road, Hanover, New Hampshire 03755, U.S.A.)

24-27 October
International Snow Science Workshop: a Merging of Theory and Practice. Aspen, Colorado, U.S.A. (ISSW Conf. Comm., c/o Mountain Rescue - Aspen Inc., Box 4446, Aspen, Colorado 81612, U.S.A.)

6-9 November
Arctic Offshore Technology Conference & Exposition. Calgary,Alberta, Canada. (AOTC, #101 - 3009, 23 Ave. S.W., Calgary, Alberta, T3E 0J3, Canada)

1985

17-22 February
Mechanics and Properties of Ice, Offshore Mechanics and Arctic Engineering Symposium. Dallas, Texas, U.S.A. (Dr D.S. Sodhi, CRREL, 72 Lyme Road, Hanover, New Hampshire 03755, U.S.A.

March
North-eastern North America Branch, International Glaciological Society. Eastern Townships, Québec, Canada. (Dr S.J.Jones, Arctic Vessel & Marine Res. Institute, National Research Council, Ottawa, Ontario, K1A 0R6, Canada)

April
IAWPRC International Conference on Water and Ice Pollution in Arctic Regions. Yellowknife, N.W.T., Canada. (Prof. W.A. Bridges, International Association on Water Pollution Research and Control, Box 3161, Halifax, Nova Scotia, B3J 3H5, Canada)

1-3 April
Workshop on Snow Property Measurement. Lake Louise, Alberta, Canada. (P.A. Schaerer, Division of Building Research, NRC, 3904 West Fourth Avenue, Vancouver, B.C., V6R 1P5, Canada)

5-7 August
The Fourth International Symposium on Ground Freezing. Sapporo, Japan. (ISGF 85, Institute of Low Temperature Science, Sapporo 060, Japan)

21-23 August
The Paleoenvironmental Reconstruction of the Late Wisconsin Deglaciation and the Holocene, 7th York Quaternary Symposium. University of Lethbridge, Alberta, Canada. (Dr R.W. Barendregt, Department of Geography, University of Lethbridge, 4401 University Drive, Lethbridge, Alberta, T1K 3M4, Canada)

26-29 August
Symposium on Glacier Mapping and Surveying, Reykjavik, Iceland. (Secretary General, Inter. Glaciological Society, Lensfield Road, Cambridge CB2 1ER, UK)

16-19 September
Hydraulic Effects at the Glacier Bed and Related Phenomena. Interlaken, Switzerland. (Dr A. Iken, Versuchsanstalt für Wasserbau, Hydrologie und Glaziologie, ETH-Zentrum, CH-8092 Zürich, Switzerland)

September
ICSI Symposium on Glacier Mass Balance, Runoff, Water Storage in Glaciers and Climate. Alma Ata, U.S.S.R. (Prof. V.M. Kotlyakov, Inst. of Geog., USSR Academy of Sciences, Staromonetny Street 29, Moscow 109017, U.S.S.R.)

1986

March or April
IHP 6th Northern Research Basins Workshop:River Ice Measurement Techniques. Canada. (Dr B. Goodison, Atmospheric Environment Service, 4905 Dufferin Str., Downsview, Ont, M3H 5T4, Canada)

1-10 July
I.A.H.S. 2nd Scientific General Assembly. Budapest, Hungary. (Dr A. Szöllösi-Nagy, VITUKI, H-1453 Budapest, Pf 27, Hungary)

30 August - 5 September
Symposium on Physics and Chemistry of Ice. Grenoble, France. (J. Klinge, Laboratoire de Glaciologie, B.P.53X, 38041 Grenoble Cedex, France)

7-12 September
Symposium on Remote Sensing in Glaciology, 50th Anniversary of the International Glaciological Society. Cambridge, England. (Secretary General, International Glaciological Society, Lensfield Road, Cambridge CB2 1ER, UK)

1987

31 July - 9 August
12th Congress of the International Union for Quaternary Research. Ottawa, Ontario, Canada. (J.J. Clague, Program Comm., Geological Survey of Canada, 100 West Pender Street, Vancouver, British Columbia, V6B 1R8, Canada)

9-25 August
General Assembly of the International Union of Geodesy & Geophysics (IUGG). Vancouver, Canada. (Prof. P. Melchior, Observatoire Royal de Belgique, Avenue Circulaire 3,B-1180 Brussels, Belgium)

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 1984

Private members	Sterling: £22.00
Junior members	Sterling: £11.00
Institutions, Libraries	Sterling: £55.00 for Volume 28 (Nos. 104, 105, 106)

Annals of Glaciology — prices vary according to size of volume. For further information, apply to the Secretary General.

Note — Payments from countries other than Britain should be calculated at the exchange rate in force at the time of payment. Please ensure that sufficient money is included to cover the bank charges. The Society needs the full payment, so bank charges should be paid by you. Thank you.

ICE

Editor: Simon Ommanney

This news bulletin is issued to members of the International Glaciological Society and is published three times a year. Contributions should be sent to Mr C. S. L. Ommanney, Snow and Ice Division, National Hydrology Research Institute, Environment Canada, Ottawa, Ontario, K1A OE7, Canada.

Annual cost for libraries, etc. and for individuals who are not members of the Society: Sterling £8.50.

All enquiries about the International Glaciological Society should be addressed to Mrs H. Richardson, Secretary General of the International Glaciological Society, Lensfield Road, Cambridge CB2 1ER, England.

Printed by Foister & Jagg Ltd., Abbey Walk, Cambridge, England