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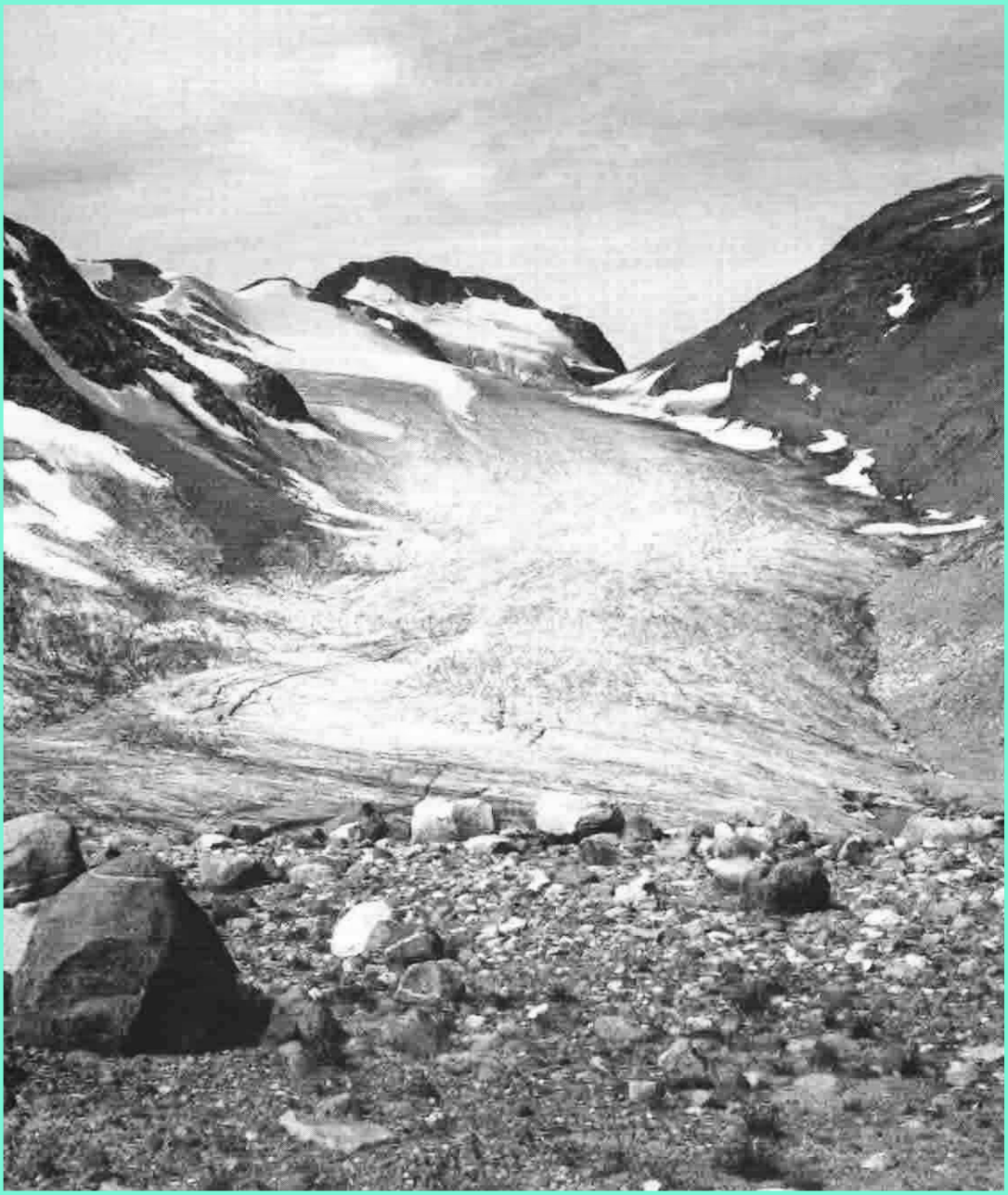

50th ANNIVERSARY

of the

INTERNATIONAL GLACIOLOGICAL SOCIETY

1986

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This will be celebrated in Cambridge, England,
7-12 September
with a Symposium on Remote Sensing in Glaciology.

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Watch for future announcements

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ICE
NEWS BULLETIN OF THE
INTERNATIONAL GLACIOLOGICAL SOCIETY

NUMBER 68 1st ISSUE 1982

CONTENTS

This issue of ICE profiles the Cold Regions Research and Engineering Laboratory which is playing host to our meeting this year on Applied Glaciology and which is the focus of much current glaciological research in the United States.

European members should note that the Western Alpine Branch will be meeting in September (Glaciological Diary). Participants in the excursion will move out from Brig in two groups. The route of the first will be as follows - Fiesch/Eggishorn/Märjelensee/Aletschgletscher/Place Concordia/Roti Chumma/Chatzulecher/Aletschwald/Riederfurka/Riederalp/Mörel/Brigue. That of the second, looking at avalanche problems, will be - Lötschental/Fafleralp/Langgletscher/Fafleralp/Brigue/Fiesch/Eggishorn/Kühboden/Bettmeralp/Riederalp/Riederfurka/Riederalp/Mörel/Brigue.

The Northeastern North American Branch (NENA) will meet early in 1983. Details will be published in the next issue of ICE.

COVER PICTURE. Woolsey Glacier, British Columbia, Canada, 1978. One of the original Canadian IHD representative glacier basins (Environment Canada).

RECENT WORK

CANADA

GLACIER STUDIES – GENERAL

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

GLACIER INVENTORY OF CANADA

(C.S.L. Ommanney, M.M. Strome and J.W. Clarkson, S&ID/NHRI/EC*)
Glacier inventory work was limited to the Iskut River basin of British Columbia. Over 2000 glaciers have been identified and partial measurements made. Bibliographies of Ellesmere Island glaciers and ice islands have been completed.

GLACIER FLOW MODELLING AND HISTORICAL REVIEW

(E.D. Waddington, GPHYS/UBC)
A glacier flow model has been developed. It follows conventional lines in that it solves the mass conservation equation and Glen's flow law. Accurate solution of the former is shown to be more difficult than usually believed. A poor choice of numerical scheme can cause linear and nonlinear numerical instabilities; inappropriate attempts to suppress these instabilities can lead to results which look reasonable, yet are incorrect. A set of tests has been compiled to verify the correct behaviour of numerical solutions of the mass conservation equation.

Contributions made by de Saussure, Agassiz, Forbes, Tyndall, and Deeley before 1914, and the controversies involving viscous and regelation flow in the 19th century, and extrusion flow in the 20th are discussed in a review of glacier flow theories from 1700-1950.

WAVE OGIVES

(E.D. Waddington, GPHYS/UBC)
J.F. Nye's original work has been expanded and a linear systems representation of ogive generation found by convolution of a velocity gradient function with one for seasonal mass balance. This formulation shows immediately why many ice falls do not generate ogives by Nye's mechanism of annual topographic waves.

GLACIER STUDIES – ARCTIC

QUEEN ELIZABETH ISLANDS

(R.M. Koerner, D. Fisher, B. Alt, M. Parnandi and J. Bourgeois, PCSP/EMR)
The mass balances of the Meighen, Melville, Devon (NW side) and Agassiz (N. Ellesmere) ice caps were measured. In the northern Ellesmere boreholes drilled to bedrock in 1977 and 1979, down-the-borehole photography, closure rates, total vertical strain and temperatures were taken to compare to measurements made each year since the original drilling. Core samples to a depth of 20 m (age approx. 1910) on Agassiz Ice Cap and to 10 m near Mount Oxford were drilled to study acidity trends in the snow.

J. McAndrews (Royal Ontario Museum) completed pollen identification in the 1973 Devon Island ice core from 200 slides. A similar study of the N. Ellesmere 1977 core, very low in pollen concentration, is now underway. Analysis of the 1977 Agassiz core δO^{18} and microparticle distribution was completed and a preliminary report written. A study on increasing acidity in the snows of northern Ellesmere was submitted for publication. A comparison between ^{14}C productivity and δO^{18} records from the Camp Century and Devon Island cores nears completion. The ice texture of the northern Ellesmere ice core was studied and the by now characteristic nature of fine ice deposited during the last ice age was recognized. A study of about 20 years of Canadian High Arctic glacier mass balance results in terms of climatic trends and value as a "climate-watch" indicator was begun. An investigation by the University of Portland, Oregon, into iridium concentrations in several levels of the ice nears completion. From detailed analysis of summer synoptic conditions for extreme positive and negative mass balance seasons during the period of record, synoptic analogues were developed for periods such as the Little Ice Age, the Medieval Warm Period and Climatic Optimum. The effect of fluctuations in the ratio of winter to summer accumulation on the apparent annual temperature as represented by δO^{18} were investigated.

CO_2 IN GLACIAL ICE

(J.-C. Hillaire-Marcel, P. Pagé, GEOG/UQAM)
Equipment capable of determining the percent of CO_2 present in air bubbles in glacier ice was designed and built for use on PCSP cores from northern Ellesmere Island.

NORTHERN ELLESMERE ISLAND

(G.K.C. Clarke, B.B. Narod and B. Prager, GPHYS/UBC)
In June 1981 the UBC 840 MHz radar sounded 2000 line-km up to 800 m deep over the Ayles, Milne, M'Clintock and Ward Hunt ice shelves, the Milne and Disraeli glaciers and the highland glacier near Mt. Oxford.

GLACIER STUDIES – YUKON TERRITORY

MT. LOGAN ICE CORE STUDIES

(G. Holdsworth, S&ID/NHRI/EC)
In an operation (supported by AINA) the electro-mechanical ice core drill and 75 m of

core from the 103 m hole was retrieved. The hole was relogged for temperature, vertical strain rate and tilt and the top resurveyed for movement. G.K.C. Clarke (UBC) obtained additional ice depth profiles. This concludes the Mt. Logan field operation.

GLACIER SURGING, ST. ELIAS MOUNTAINS

(G.K.C. Clarke, M.G. Maxwell and D.A. Waldron, GPHYS/UBC; D.E. Thompson, JPL/CIT; S.G. Collins, Dartmouth; D.C. Gayton, McGill and D. Williams, Oxford University)

A large wave-like bulge reported in 1980 on Trapridge Glacier indicates a surge is likely in the next few years. The bulge is not propagating down-glacier, but is forming at the boundary between cold (downstream) and temperate (upstream) basal ice. The ice velocity is 30 m/a upstream from the bulge, and only 1 m/a downstream.

SURGING GLACIER STABLE ISOTOPE DISTRIBUTION

(E.D. Waddington GPHYS/UBC)

The use of stable isotopes to determine prehistoric surging patterns of valley glaciers has been investigated. A plausible elevation (O^{18}/O^{16}) relation and a simplified model of Steele Glacier ice trajectories have been calculated and isotope contours found for various times during the surge cycle. Surging leaves discontinuities in the isotope distribution but the effect is small and may be masked on the Steele Glacier, where only a small fraction of the accumulation zone takes part in surges.

GLACIER STUDIES – CORDILLERA

SURPRISE CREEK GLACIER, B.C.

(E.D. Waddington and G.K.C. Clarke, GPHYS/UBC)

A thickness survey using the UBC MkI monopulse radar system was completed on the Surprise Creek Glacier in July 1981 for Riocanex. The measurements were used to plan a drilling program and to correct geophysical surveys for the effect of ice overburden, during evaluation of a partially glacier-covered mineral property.

MT. EDZIZA AND MT. WADDINGTON AREAS

(G. Holdsworth, S&ID/NHRI/EC)

Reconnaissance site surveys were carried out for future ice coring. Both sites are temperate and 10-12 m cores are being analyzed for oxygen isotopes.

ICE-DAMMED LAKES

(G.K.C. Clarke and D.A. Waldron, GPHYS/UBC)

The likely magnitude of outburst floods on the Iskut and Stikine rivers is being assessed. Waldron has used Clarke's simulation model to examine Flood Lake. The model prediction agrees well with the 1979 flood and should be useful for flood magnitude. Flood Lake released in mid-August 1981 as predicted by Mokievsky-Zubok (S&ID/NHRI) discharging some 200 x $10^6 m^3$ of water into the Stikine River and raising its level about 2 m.

ISKUT RIVER AREA

(O. Mokievsky-Zubok, S&ID/NHRI/EC)

Mass balance studies on three glaciers were continued; ablation and accumulation were average. Yuri and Alexander glaciers downwasted 2.2 m and 2.0 m at the terminus respectively. Andrei Glacier lost 4.4 m of ice vertically at the terminus and retreated 29.5 m. Two small ice-dammed lakes, Natavas Lake in the More Creek watershed and a lake in the Forrest Kerr Creek watershed partially filled and discharged during the summer. A cooperative project with BC Hydro is underway to model probable maximum floods on glacier-fed rivers (J. Power, SWD/NHRI/EC).

TIEDEMANN AND BENCH GLACIERS

Studies to determine mass balance, response to climatic change and glacier-melt contribution began on two glaciers in the Mt. Waddington area. Vertical ice loss from the tongues was 8.1 m and 5.3 m respectively.

BRIDGE RIVER GLACIERS

Studies in cooperation with BC Hydro (J.R. Gordon) to determine glacier-melt contribution and to evaluate seasonal and operational forecast models continued. A Data Collection Platform provides hydro-met data.

MASS BALANCES, SW COAST MOUNTAINS

Measurements of winter and summer balances, meteorological variables and meltwater flow continued on two former IHD glaciers, Sentinel and Place; mass balance only was measured for Helm Glacier.

WEDGEMOUNT LAKE AND GLACIER

(W.A. Tupper, BCIT and Karl E. Ricker Ltd.)

The annual visit was in early autumn after 20-30 cm of new winter snow covered the snout The lower velocity profile and snow position were fixed by photo-theodolite. The profile had advanced an average of 12 m with some convergence of the stations. The new 1:10,000 scale map has now been scribed. Volumetric determinations of ablation zone ice losses are now being computed using terrain digitizing methods with the help of BC Hydro.

EMERALD GLACIER, YOHO NATIONAL PARK

(R.J. Rogerson, GEOG & GEOL/MUN)

30 measurements of the push-moraine made from 16 natural markers indicated a readvance of more than 2 m/a. 9 measurements on a nearby rock glacier showed no significant advance.

PEYTO GLACIER AND YOHO NATIONAL PARK

(J. Power, SWD/NHRI/EC)

Mass balance, meteorological and hydrological measurements continued in the Peyto Glacier basin. Stream gauging continued within the Kicking Horse basin of Yoho National Park.

WATER SURVEY OF CANADA GLACIER SURVEYS

(I.A. Reid and J.O.G. Charbonneau, WSC/EC)

A report summarizing the results of the recently terminated WSC terrestrial photogrammetric surveys of the Athabasca, Saskatchewan, Sentinel, Sphinx, Bugaboo and Kokanee

glaciers from 1959-1979 is being prepared. Volumetric and height zone changes will be computed using a contouring package.

GLACIER IN KARST TERRAIN, COLUMBIA ICEFIELD

(D.C. Ford and C.S. Smart, GEOG/McM)
In 1979/1980 McMaster studied the groundwater hydrology of the Castleguard karst terrain which abuts directly against the E. flank of the central mass of the Columbia Icefield. A solution of Rhodamine WT tracer dye, injected into an active moulin of the Saskatchewan Glacier, showed that much of the meltwater generated on the Icefield is routed via an underlying active karst system.

GLACIER STUDIES – LABRADOR

TORNGAT MOUNTAIN GLACIERS

(R.J. Rogerson, GEOG & GEOL/MUN)
Mass balance, ice movement and snout measurements were made of four cirque glaciers ranging in size from 1.6 - 2.4 km^2 in the summer of 1981. Snow depth was measured at over 400 points in mid-July and averaged 100-200 cm, densities exceeded 0.5 gm/l and the pack was isothermal. The highest snowline was about 1300 m a.s.l. Observations were made on the avalanche-type medial moraines characteristic of these glaciers. Push moraines were also noted along the front of the marginal snow aprons indicating a probable increase in the extend and/or activity of these features.

GLACIAL GEOLOGY

YUKON AND NORTHERN BRITISH COLUMBIA

The surficial geology and permafrost distribution along the Alaska Highway Gas Pipeline Project Right-of-way, including various alternative routes has been mapped at a scale of 1:10,000 for Foothills Pipeline (South Yukon) Ltd. and Westcoast Transmission Ltd. (V.N. Rampton, R.D. Thomas and S. Paradis, Terrain Analysis and Mapping Services, Carp, Ontario).

BRITISH COLUMBIA

A project on the Pine Pass area, Rocky Mountains has been completed and will be available once released by the Environmental Land Use Committee (ELUC) of the BC Government (Karl E. Ricker Ltd, Vancouver, B.C.).

The relationship between alpine environmental systems, weathering rates and water quality has been investigated at Miller Creek (O. Slaymaker and T. Gallie, GEOG/UBC).

ALBERTA

The stratigraphic and sedimentary properties of tills in the Edmonton area are being studied to determine their genesis (J. Shaw, GEOG/UofA).

The Council's geological surveying of near surface deposits continued with work on the Vermilion, Medicine Hat-Lethbridge, Sand River and Calgary map areas and the southern third of Alberta (L.D.Andriashek, S.R. Moran, M. Fenton, J. Oliz, C. Mougeot, I. Shetsen, S. MacKenzie, R. Gorekie, J. Visser, D.N. Proudfoot and R. Heumer, ALTA RES). Quaternary geological maps at 1:500,000 and 1:1,000,000 are in preparation for the latter area.

MANITOBA

The nature of the late glacial connection betweeen Lake Agassiz and Lake Superior, through the Lake Nipigon basin, is being evaluated (J.T. Teller, GEOL/Manitoba). About 9500 yrs BP the final Laurentide ice dam west of Lake Nipigon failed causing a catastrophic discharge >3000 km^3 from Lake Agassiz.

The Manitoba Department of Energy and Mines conducted a number of Quaternary and surficial geology mapping programs in the Province; in the Churchill and Thompson areas partly as further background for the 1:1,000,000 scale provincial surficial geology map (E. Nielsen and R.V.Yong); on the Bird Hill esker complex (G. Natalie) and in the Minto (H.D. Groom), Turtle Mountain (G. Conley) and Fisher Branch (H.D. Groom and C.W. Jones) areas.

ONTARIO

At the Dept of Earth Sciences, University of Waterloo, J. Coakley is beginning a study of the Late Quaternary history of Long Point, P. Finnamore mapped the Orillia-Fenelon Falls area to obtain data on the Kirkfield outlet of Lake Algonquin and J.Richard mapped the Hearst area to obtain data on the Cochrane advance in northern Ontario. P.F.Karrow surveyed raised shorelines of the Algonquin-Nipissing sequence on St.Joseph Island, collected additional samples for a mollusc study of glacial lake deposits around the Huron basin, cored the Rockwood buried valley near Guelph, and prepared papers on Guelph and Waterloo interstadial sites and a regional summary of the Quaternary history of the Great Lakes.

Reports of the activities of staff and contract geologists of the Engineering and Terrain Geology Section are published in the Ontario Geological Survey's Miscellaneous Paper 100. Studies into the origin, distribution and characteristics of Quaternary glacial deposits are undertaken in selected areas of Ontario. Additional research into geophysical properties of till and intertill sediments (E.V. Sado), esker sedimentology (C.L. Baker) and geochemical studies of till (P.J.Barnett) have been initiated. The Quaternary history and stratigraphy of Ontario is an ongoing project.

N.R. Gadd has summarized his recent work in a paper entitled "Late-glacial regional ice-flow patterns in eastern Ontario (Canadian Jo. Earth Sciences, 17(11) 1439-1453, 1980).

QUÉBEC

J.-M. Dubois (GEOG/SHER) started compiling data for a Quaternary map of Québec. Proceedings of the symposium on glacial lakes will appear in Géographie Physique et Quaternaire.

In the Eastern Townships M. Parent (Champlain Regional College of Lennoxville) is investigating the glacial history of the Appalachian piedmont, and students of GEOG/SHER are studying the glacial history of the Lake Memphrémagog (P. Boissonneault and C. Dubé), Weedon (G. Larocque) and La Patrie (A. Larocque) areas.

On the North Shore of the St. Lawrence River, a preliminary study of the largest morainal complex in Québec, between Baie-Comeau and Goose Bay, was completed by J.-M. Dubois and J.C. Dionne (GEOG/LAVAL). A 1:250,000 scale map of the soils left in the zones flooded by the Goldthwait Sea on the North Shore and Anticosti Island is being prepared. The island was glaciated during the upper Wisconsin.

SNOW

SNOW LOADS

(D.A. Taylor, Structures, DBR/NRC)

The 30-year return ground snow load is being reanalyzed in a joint project with AES. They are providing depth and rainfall data and DBR is analyzing ground snow densities using provincial and territorial hydrological data.

Instructions for the observation of snow loads on solar collectors on flat roofs were written and arrangements made for observers with Public Works Canada, the NRC Solar Energy Office and the Ontario Ministries of Housing and Energy. The latter have hired consultants in Guelph to study the influence of solar collectors on snow accumulation on flat roofs using a water flume and wind tunnel.

Observations of wind speed, direction, snow depths and densities on two-level flat roofs will be used for comparison with simulated snow drifting experiments in a wind tunnel.

Readings of snow depths and densities were made on 9 experimental roofs at NRC, Ottawa, at slopes between 0^{o} and 60^{o}, some covered with metal roofing and others with asphalt shingles. The field study of sloping roofs across Canada is not yet very active apart from a study of farm building roofs by Engineering Research at Agriculture Canada.

Field observations on snow loads and densities on one- and two-level flat roofs across Canada have stopped except for a new survey on roof loads in BC. Survey data are now being analyzed.

ARCTIC SNOW COVER – RESOLUTE, N.W.T.

(M.-K. Woo, GEOG/McM)

Basin wide snow surveys, based on terrain types, were carried out at several basins in the Queen Elizabeth Islands to enable comparison with weather station data for use in the water balance studies at Resolute, N.W.T.

Snow metamorphism and meltwater movement in snowpacks were studied near Resolute to determine factors influencing the timing and volume of water release (P. Marsh and M.-K. Woo, GEOG/McM). Studies include the importance of pre-melt stratigraphy and thermal conditions in controlling ice lens and basal ice growth and the effect of small scale variability in meltwater movement on predicting total meltwater release.

Energy balance measurements were made over a clean natural surface located 5 km from Resolute and over a dirty site close to the airport. This allowed analysis of the important factors which result in the advancement of snowmelt around towns and weather stations.

SOUTHERN COASTAL MOUNTAINS B.C.

(Karl E. Ricker Ltd, Vancouver, B.C.)

The record 1974 alpine level snowpacks on the leeward side of the Coast Mts were studied by comparing daily snowfall and monthly snow course records for windward, transitional and leeward sites in an area extending from Vancouver to Lillooet to Pemberton. Attention focussed on the daily records of the 1973/74 winter from Lizzie Creek basin, Lillooet Range. This site was compared to Whistler Mt. some 41 km to the west in the transitional zone. Daily temperature and snowfall fluctuations were surprisingly similar except snowfall in Lizzie often lagged that of Whistler by one day. Climax avalanches were recorded after one day of particularly heavy snowfall coupled with a dramatic rise of temperature.

DISTRIBUTION OF SNOW IN MOUNTAINS, B.C.

(P.A. Schaerer, BC Regional Station, DBR/NRC)

The depth and maximum water equivalent of snow on the ground were measured at different elevations on 15 mountains in southern British Columbia. Data from 1966-1979 has been analyzed (B.R. Claus, CIVIL/UBC). Satisfactory parabolic correlations were found between the mean as well as the 30-year maximum snow water equivalent and elevation.

SNOW DEPTHS AND DENSITIES ON ROOFS IN B.C.

(D.A. Taylor, Structures, DBR/NRC)

Density kits were made and 14 distributed to volunteers throughout BC. Two more observers had contracts with DBR to take readings in deep snow areas and four avalanche technicians with BC Highways made observations.

P. Anhorn took readings at Rogers Pass.

SNOW PROPERTIES

(R. Perla, S&ID/NHRI/EC)

Snow metamorphism was observed in the field and simulated in the laboratory by varying temperature boundary conditions. Preliminary attempts were made to describe metamorphism using the technique of polished sections.

MARMOT CREEK, ALBERTA

(D.L. Golding, FORRES/UBC)

Results of a study on the relationships between snow accumulation, melt and forest opening size have been applied to Marmot Cr. Experimental Watershed, near Banff. The objective is to delay the time of peak streamflow and to prolong snowmelt recession flow.

A start has been made on a study of snowmelt during rain-on-snow events in coastal BC. Snowmelt lysimeters have been installed at two sites (clearcut and uncut forest) in

the Jamieson Creek Experimental Watershed in the Greater Vancouver municipal catchments.

SNOW AND EROSION

(O.Slaymaker, T.Gallie and P.Jones, GEOG/UBC)
Weathering, erosion and transportation associated with nivation hollows at Miller Cr., Pacific Ranges, have been investigated.

SNOW TEMPERATURE VARIATIONS

(H. Granberg, GEOG/McG)
Snow temperatures were studied in the field using a new high resolution thermometer. Two distinct diurnal patterns were observed. A nocturnal one appears to be related to the unstable density stratification of the interstitial air. The other occurs in daytime and is apparently related to spatial variations in the surface pressure field generated by turbulence in the near-surface layers of the air. Both indicate snowpack ventilation.

The rapid and at times large temporal variations in the temperature of the near-surface layers of the snow cover suggest two new factors that need to be considered in an explanation of snow cover metamorphism. One is the movement of air within the pores of the snowpack which affects both heat and mass transfers. The other is the spatial variation in surface vapour pressure of the ice matrix that can be caused by rapid temporal variations in temperature combined with a spatial variation in the thermal inertia of the ice matrix. Both can help explain the rapid destructive metamorphism of new snow that is observed in nature but that is not predictable from surface curvatures using Kelvin's equation.

EFFECTS OF SURFACE DUST ON SNOW COVERS

(J.J. Drake, GEOG/McM)
Major effects of the mining and townsite combination at Schefferville, PQ, are that dust eroded from the mining area increases dust loading to the snowpack downwind, and that SO_2 generated in Schefferville lowers the pH of the snowpack within 10 km downwind of the townsite. This may eventually affect the distribution of permafrost in the ridges. There appears to be no regional pH lowering due to more distant pollution sources. The local effect is of significance to the interpretation of results from the CANSAP network.

A model of the effects of a dust cover on snowmelt rates, including changes in albedo and surface temperature, leads to realistic order of magnitude estimates of the conditions under which snowmelt will be advanced or retarded. The results agree with observations at Schefferville and Mt. St. Helens.

THE SNOWPACK AND THE NUTRIENT BUDGET

(M.C. English, GEOG/McG)
The role of a melting snowpack on the nutrient budget of a subarctic ecosystem at Elizabeth Lake, 6 km WSW of Schefferville, has been examined. Samples taken throughout the melt period were analyzed for NH_3-N, NO_2-N, NO_3-N, TP, TDP, Ca, Mg, Na, K and D/H. Conductivity and temperature were recorded during sampling.

A study on the snowcover of the lake by Adams and Roulet (GEOG/TRENT) has been completed.

The interaction of meltwater and the lake into which it drains was examined. Stratified sampling of the lake at several sites, during the melt period, using standard limnological methods was done for analysis of the same constituents. All perennial and intermittent streams flowing into the lake and the single outlet stream were gauged and samples taken for chemical analysis.

NEW BRUNSWICK

(R.B.B.Dickison & D.A.Daugharty, FORRES/UNB)
Two aspects of snow cover and snowmelt - variability with forest cover and topography, and effect of removal of forest cover - have been studied in the Nashwaak Experimental Watershed Project near Fredericton since 1973, prior to commercial clearcutting. The project is based on the paired watershed method, one 391 ha treated and one 660 ha control. Snow surveys at about 100 sites are conducted at 2- to 3-week intervals from January to the end of snow cover. Multiple linear regression analyses involving several site variables and measurements at a single index station give estimates of snow depth within a mean error of 30 mm. Distribution by 25 mm classes is calculated from a computerized spatial 1 ha grid model. The effect of forest removal has not yet been determined.

ACCURACY OF SNOW MEASUREMENTS

(B.E. Goodison, Can. Climate Centre <CCC>AES)
A project is underway to assess the accuracy of Canadian snow gauge measurements, particularly in low snowfall regions, to develop a Canadian shield for recording gauges and to improve the measurement of fresh snowfall at Canadian climate stations.

(B.E. Goodison, CCC/AES/EC; R.P. Richards, Environment/BC; P.E. Farnes, USDA-SCS and N. Peterson, California Water Resources)
The Western Snow Conference Working Group on Metrication is completing its assessment of new metric snow samplers for deep and shallow snowpacks, including recommendations for metric conversion and standardization.

(W.P. Adams, GEOG/TRENT)
The operational side of a comparison of Soviet and Canadian snow gauges has been completed and a preliminary presentation of results made.

AVALANCHES

PINE PASS AREA, ROCKY MOUNTAINS, B.C.

(Karl E. Ricker Ltd, Vancouver, B.C.)
Within the Upper Brazion and Upper Moberley watersheds, including that part of the Pine River drainage bisecting the two areas, historic and recent avalanche tracks were mapped at a scale of 1:20,000. As part of the forenoted ELUC process the study also evaluated both road routes and potential mine sites.

FAILURE OF ALPINE SNOW

(D.M. McClung, BC Regional Station, DBR/NRC)
In collaboration with C.J. Stethem (on contract), data were collected on slow plane strain shear failures of alpine snow at Whistler, B.C., and work was initiated on micro-structural analysis of shear failures. Shear failures of homogeneous samples at low normal stresses initiate by a series of tension cracks at isolated sites which subsequently link to form a major slip surface in the central portion of the sample.

INDEX OBSERVATIONS FOR SNOW STABILITY

(P.A. Schaerer, BC Regional Station, DBR/NRC)
Under contract, C.J. Stethem at Whistler and J. Tweedy at Kootenay Pass carried out shovel shear tests and shear frame tests with a 100 cm^2 and a 250 cm^2 frame during days of avalanche hazard. The tests proved to be useful for the prediction of avalanche hazard when they were made carefully. The 100 cm^2 shear frame yielded more reliable data than the other. Results of the 1978-80 studies were presented to the 1980 Avalanche Workshop. The guidelines for making weather, snowpack and avalanche observations in avalanche safety operations were rewritten and approved by staff of the industry. These guidelines are now applied in all operations in Canada.

CHARACTERISTICS OF AVALANCHES IN MOTION

(D.M. McClung, BC Regional Station, DBR/NRC)
A large plate with a 196,000 m^2 loading surface was reinstalled in the Tupper I slide path at Rogers Pass, B.C. Impact pressures on this plate, as well as on smaller cells nearby, were successfully measured and compared for several wet avalanches; seismic signals were also obtained. The results showed that the signals on the large plate yielded a much steadier flow pattern than the smaller cells as well as much smaller peak pressures because the large plate integrates many particle impacts. A possible experimental problem was identified because the large plate has load cells designed to withstand larger pressures than anticipated, hence sensitivity is marginal for small wet avalanches.

AVALANCHE RUNOUT DISTANCE

(D.M. McClung, BC Regional Station, DBR/NRC)
Avalanche speed data for Rogers Pass were analyzed and correlated with avalanche path parameters and runout distances in an attempt to develop simple scaling laws relating maximum velocity to path parameters. A study was initiated to define avalanche dynamic parameters for the existing models used by consultants for these measured speed data.

MAGNITUDE – FREQUENCY OF AVALANCHES

(P.A. Schaerer, BC Regional Station, DBR/NRC)
The masses of 345 avalanches at Rogers Pass were measured. The data collected from 1966-1981 at 28 avalanche paths were analyzed with the objective of developing models for the prediction of the possible maximum avalanche for given terrain. No conclusive results were obtained at the end of the reporting period largely because the sampling period is too short.

LAKE AND RIVER ICE

CORNWALLIS ISLAND, N.W.T.

(R. Heron and M.-K. Woo, GEOG/McM)
Studies continued on the factors controlling ice melt on a small lake. A model is being developed to predict lake ice conditions.

STE-ANNE RIVER, QUEBEC

(B. Michel, IML/CIVIL/LAVAL)
A heat budget is being made on a reach of the Ste-Anne river to study border ice and ice cover formation. The break-up of the river will be documented.

BIOLOGICAL ROLE OF LAKE SNOW AND ICE COVER

(W.P. Adams and D.C. Lasenby, GEOG/TRENT)
Work continued in the Kawartha Lakes, South Ontario, and in the vicinity of Elizabeth Lake, Labrador. The study of the roles of snow and ice in the light regime of lakes in winter is close to completion; that on winter oxygen budgets continues. Work on phosphorous loading is essentially complete.

DUGOUT ICE THICKNESS IN THE PRAIRIES

(D.W. Lawson, Hydrology Division, PFRA/REE)
In March 1976 a 4-year study to estimate ice thickness, its monthly and annual variability and the role of temperature, snow cover, orientation and water depth on 40 dugouts in the Prairies was initiated. Results will aid in the design of dugouts and reservoirs for both farm and municipal water supply.

SEA ICE

DYNAMICS OF SEA ICE TRANSPORTED BOULDERS

(J.J. Drake and S.B. McCann, GEOG/McM)
Analysis of the ability of ice floes to move isolated boulders on tidal flats shows that flotation competence depends on ice thickness and floe size, and is sufficient to transport most of the boulders reported from eastern Canadian tidal flats. Analysis of movement of grounded boulders by lateral ice thrust has shown that, on both deformable and non-deformable beds, rolling rather than sliding will occur. Rolling could account for most of the observed short-distance transport of large boulders.

(J.-M. Dubois and B. Lauriol, GEOG/SHER)
In collaboration with J.T. Gray (GEOG/UofM) a remote sensing study of the dynamics of ice and glacial blocks in Ungava Bay, Nouveau-Québec, has been completed.

SHORT RANGE PREDICTION OF SEA ICE MOTION

(V.R. Neralla and S. Venkatesh, AES/EC)
The joint Government/Industry program (see 1980 report) to develop a short range prediction model for forecasting sea ice motion over the Beaufort Sea area has been completed and a report is in preparation. For further validation and testing of the model, another set of data was collected in April 1981.

AES ICE BRANCH ACTIVITIES

An unusually mild ice season in the Gulf of St. Lawrence and generally a good ice year in the Arctic provided for an uneventful operational ice support season. Highlights included the implementation of the joint Canadian/Danish NOAA satellite receiving station at Søndre Strømfjord, Greenland, for covering northeast Arctic waters; increased ice reconnaissance coverage in the Arctic Archipelago during late freeze-up, and support of the M/V Arctic and CCG icebreaker St.Laurent during a late season probe into Strathcona Sound; and a number of climatological studies completed including ice atlases for the Arctic and Eastern Seaborn and publication of several of the annual Ice Summary and Analysis series.

The Branch participated in a Spring experiment on winter ice dynamics in the Beaufort Sea (WIEBS 81), played a lead role in a Fall RADARSAT experiment in Mould Bay, NWT, and performed a series of monthly iceberg surveillance flights along the Labrador coast during the summer.

ARCTIC ICE

(D.F. Dickins Associates Ltd., Vancouver, BC)

For Dome Petroleum Ltd, the important characteristics of different sea ice regimes along tanker routes east and west bound from the Canadian Beaufort Sea, through the NW Passage and around the coast of Alaska, have been summarized for the Beaufort Sea Production Environmental Impact Assessment. A report on the interaction of oil and gas with ice and cleanup techniques was prepared. This work involved three simulated blow-outs of Prudhoe Bay crude and compressed air in 15 m of water beneath a sea-ice sheet. The route from the Gulf of Boothia to James Bay through Fury and Hecla Strait was surveyed photographically on 20 April 1981 for ice type, ridging and lead statistics applicable to possible deep draft vessel transits later in this decade.

For the Baffin Island Oilspill Project (EC) nine time-lapse cameras were used to survey shoreline ice conditions between Cape Hatt and Eclipse Sound at break-up and freeze-up.

LABRADOR ICE DYNAMICS MODEL

(T.E. Keliher, W.W. Denner and J.S. Foley, NICOS/MUN)

A model of the Labrador ice pack has been developed and used for simulating mesoscale ice dynamics for two short periods. Initial results have indicated that the major modelling difficulty is specification of surface currents; wind data obtained from surface weather maps and the viscous ice rheology of the model are adequate. Additional simulations are being made for periods when current measurements are available. When possible, digitized wind and ice data sets will be used. Thermodynamic effects are being added.

ADAMS ISLAND ICE INTERACTION STUDY

(R. Frederking, DBR/NRC)

A bathymetric survey has been carried out in the waters surrounding Adams Island.

ICE FORCES IN TARSUIT ARTIFICIAL ISLAND

(R. Frederking, DBR/NRC)

Through the Technical Advisory Committee on Beaufort Sea Structures, advice was provided to the Department of Indian and Northern Affairs (DINA) on the adequacy of ice loads assumed for the design of the caisson retained structure at Tarsuit.

MACRO-SCALE CRACKING IN SEA ICE, NANISIVIK

(R. Frederking, DBR/NRC)

Preliminary observations of macro-scale cracks have been made around the dock at Nanisivik, Baffin Island. They included movement measurements and surface profiles which suggest that crack growth is an intermittent process.

BEARING CAPACITY OF ICE COVERS

(R. Frederking, DBR/NRC)

An easily deployable gauge for measuring strains in an ice cover has been developed. Assistance was provided to DINA in evaluating proposed modifications in the design of ice platforms.

ICE ADHESION FORCES ON PILES

(R. Frederking, DBR/NRC)

A series of tests on a 10 cm diameter polyethylene pile were carried out to determine the influence of transverse strains (Poisson's effect). When the pile was loaded in such a way as to be in tension, adhesion strength was half that measured when the pile was in compression.

TEXTURE, FABRIC AND GROWTH OF 1ST-YEAR SEA ICE

(N.K. Sinha, DBR/NRC)

Textural anisotropy was related to the water current under the ice sheet. The brine layer spacings depend on the growth rate and hence the weather conditions during the growth period. A theory has been developed for predicting the growth of sea ice on the basis of weather and snow cover conditions.

Assistance was provided in determining ice characteristics during ice breaking trials of the M.V. Arctic and in setting up a portable sea-ice field laboratory for the High Arctic.

SEA ICE RHEOLOGY

(J.R. Must and L. Lainey, CINEP/UofM)

Methods have been developed for measuring deformations caused by tensile and compressive stresses applied on a beam and for determining Poisson's ratio for sea ice. Longitudinal and transverse strains in sea-ice beams subject to stresses between 10-600 kPa/s and temperatures of -5^{o} - -40^{o}C revealed the following empirical law.

$$\mu = 0.24\left(\frac{\dot{\sigma}}{\dot{\sigma}_1}\right)^{-0.29} + \mu_D$$

where $\dot{\sigma}$ is the variation rate of stress, $\dot{\sigma}_1$ represents a unit stress rate and μ_D is the dynamic value of Poisson's ratio. Work on the influence of anisotropy on the rheological properties of ice continues.

LAKE AND SEA ICE AND FLOATING ICEBERGS

(J. Crawford, R. Inkster, W. Jeffries, M. Kirby, R. Lowry and J. Sutton, INTERA)

Intera Environmental Consultants Ltd, Ottawa, have completed an ice dynamics model which operates in a fine scale, site specific mode in the Beaufort Sea, but which can be used at a larger scale to provide boundary conditions for fine scale operation. A shipborne digital image processing system which extracts information from both ship's radar and airborne SAR/SLAR systems for realtime use on the ship, has been developed and field tested.

An automated data collection and analysis system has been built for laser profiles of sea ice and used to analyze Alaskan data. A procedure has been developed for computing the above water volume of icebergs and modelling the below water volume, using high quality stereo photography.

Several projects looked at applications of high resolution radars to sea ice surveillance problems. These included parameter studies of SARs, comparisons of scatterometer with SAR returns, digital classification techniques using multi-channel SARs, observations of multiyear floe size distributions and continuing work on obtaining quantitative ridge size information from SAR signatures.

BAFFIN BAY ICEBERG PROJECT

(B. de Young and T.E. Keliher, NICOS/MUN)

A detailed study of a medium sized iceberg in Baffin Bay was carried out (with the US Coast Guard Research and Development Center). Local currents were measured using drogued buoys with transponders and were found to be quite small. Many CTD casts were taken with the USCGC Evergreen system and the NICOS fast response system. There was a surprising lack of large scale structure in the water column.

ICEBERG DRIFT

(R.J.Anderson, E.G.Banke and S.D.Smith, BIO)

Iceberg drift tracks off the coast of Labrador are being hindcast from drillship wind and current reports using an adaptive model. The model can represent more than half the tracks investigated with reasonable accuracy (approx. 1 km rms error) over periods of 1-2 days up to 2-20 km from the drillship.

(R.T. Dempster, C.C. Hsiung, ENG/MUN)

Field data on iceberg drift has been analyzed and further work on short term iceberg drift is in progress. A study on the effect of wind and waves and a detailed parametric analysis will determine the relative importance of the various environmental parameters.

ICEBERG SCOURING

(T.R. Chari, A.S. Reddy, G.R. Peters and H.P. Green, ENG/MUN)

A mathematical model for iceberg scour has been generalized to account for cohesion and internal friction of sediments. Sea trials were conducted jointly with BIO to study seabed characteristics in the Hibernia and Ben Nevis areas of the Grand Banks. Lab tests are in progress with pipeline models to interpret the effect of scouring during installation.

(J.V. Barrie, C.P.G. Pereira and C.M.T. Lynas, C-CORE)

Iceberg scouring risks and critical values of seabed stability are the object of several studies with the Atlantic Geoscience Centre (GSC) from Lancaster Sound to the Grand Banks. The influence of icebergs, wave and current stresses are an integral part of these programs and new information has recently been collected by a submersible. The inability to obtain adequate surficial cores may soon be remedied by a seabed-deployable geotechnical corer recently developed by C-CORE. Using International Ice Patrol data, a probabilistic iceberg flux map has been developed for the northeastern Newfoundland Shelf.

(C.F.M. Lewis and S.M. Blasco, BIO)

A data base of ice scour morphology was derived from sidescan sonar records from the Baffin, Labrador shelves and the Grand Banks of Newfoundland and is being analyzed statistically. The present rates of ice scouring and sedimentary processes are being evaluated at selected sites by mapping the seabed on an annual to semi-annual basis in cooperation with the offshore oil and gas industry.

ICEBERG DECAY

(B.D. Bowen and C. Dutton, ENG/MUN)

Lab experiments are in progress to identify the major parameters affecting the melting of icebergs. Temperature and salinity profiles are being made and interpreted.

ICEBERG IMPACT PROBABILITIES

(D.V. Reddy, M. Arockiasamy and P.S. Cheema, ENG/MUN)

Impact probabilities of icebergs with offshore structures are being evaluated using the Monte Carlo method. Iceberg shapes are simulated using observed data.

MAGNETIC TAPE RECORDING SYSTEM FOR UBC RADAR

(B.B. Narod and G.K.C. Clarke, GPHYS/UBC)

In the UBC 840 MHz radar system the signal is sampled and recorded with a synchronous clock as a synthetic audio signal on magnetic tape. The data can be played back and examined in the field, and subsequently digitized in the laboratory and transferred to a computer for plotting and signal processing.

UBC DIGITAL 1-10 MHz MONOPULSE RADAR

(B.B. Narod and G.K.C. Clarke, GPHYS/UBC)

A back-portable digital impulse radar for glacier surveys and geotechnical applications has been developed. A micro-processor controls sampling A-to-D conversions, and data storage and retrieval from cassettes. Data files can be displayed on an oscilloscope in the field and transferred to a large computer in the laboratory. It can easily be adapted to other entirely different data acquisition applications.

REMOTE SENSING SNOW COVER EXPERIMENT

(B.E. Goodison, CCC/AES/EC; R. Herrington, WRB/EC; A. Banga, ENV/Saskatchewan; J. Glynn, NHRI/EC; T. Carroll, U.S. Nat. Weather Serv.)
Over ten Canadian and US agencies are cooperating in a study to develop the capability of mapping areal snow cover (extent, depth,w.e.) in the Canadian Prairies. The experiment will integrate ground-based, airborne and satellite data. Ground snow surveys, suited to Prairie conditions, and airborne gamma will be used as "standardized surface measurements" to correlate with Nimbus 7 Scanning Multi-Channel Microwave Radiometer (SMMR) data and NASA airborne SMMR data.

SAR FOR DISCRIMINATING SNOW COVER PROPERTIES

(B.E. Goodison, CCC/AES/EC)
The 1981-82 RADARSAT experiment will assess the feasibility of using C- and X-band synthetic aperture data (SAR) for determining snow depth, state of ground and snowmelt and the effect of land cover, terrain roughness and diurnal and seasonal variations on measurement capabilities.

(A. Wankiewicz, SWD/NHRI/EC)
The feasibility of controlling snow cover properties on one acre plots was assessed in the winter of 1980-81. Within snow plots being used as SAR targets, wetness was artificially controlled by irrigation and mass by selective removal and use of snow fences.

SNOW COVER MAPS OF THE SAINT JOHN RIVER BASIN

(Hydrometeorology Division, AES/EC)
A semi-automated technique using multi-spectral digital data from the NOAA-6 satellite was used to determine the areal extent of snow cover in the Saint John River basin, NB.

SNOW AND ICE IN UNGAVA

(B. Lauriol and A. Champoux, GEOG/SHER)
A remote sensing study of snow and ice in Ungava between 1967 and 1980 is underway.

STEP FREQUENCY RADAR TO MEASURE ICE THICKNESS

(K. Iizuka, A.P. Freundorfer, J. Nielsen, L. Yang and B. Maillard, Electrical ENG/UofTT)
Details of step frequency radar measurements at Duclos Point, Lake Simcoe, Ontario, were reported in Freundorfer's B.Sc. thesis "Spatial filtering used in the step frequency radar". A field test was also carried out for detecting metallic and non-metallic targets imbedded in the soil. The quality of the reconstructed image of some targets was high enough that their general shape could be recognized.

FRESH WATER ICE AND SEA ICE

(S.Y.K. Tam, MPB Technologies Inc., St. Anne de Bellevue, Québec)
Sensors under development include a VHF synthetic pulse sea-ice sensor, a C-band ice sensor and a C-band scatterometer. Work on the former has concentrated on the development of an airborne broadband antenna and the design, test and manufacturing of the electronics suitable for field operations in the Arctic. The C-band radar employs simple signal generation and detection techniques and is developed for thickness measurements of ice of low salinity. The C-band scatterometer for measuring scattering cross sections of ice surfaces is in the design stage.

CCRS ACTIVITY IN REMOTE SENSING OF SEA ICE

(L. Gray, R.K. Hawkins and C.E. Livingston, CCRS; L.D. Arsenault, Cold Regions Remote Sensing, Stittsville, Ontario)
The acquisition and analysis of sea-ice data based on measurements with active and passive airborne microwave sensors and supported by aerial photography and infra-red thermometry for ground truthing continued in 1981. The purpose is to improve airborne radar for ice reconnaissance and to use a combined active (132.3 GHz) and passive signature (19.4 GHz) to classify sea ice. CCRS plans to extend and consolidate the current data base of microwave sea-ice results.

APPLICATION OF ESMR AND SMMR TO ICE DYNAMICS

(V.R. Neralla and S. Venkatesh, AES/EC)
Work is continuing on the application of ESMR and SMMR data to sea-ice dynamics studies.

SHORE-BASED RADAR ICE MEASUREMENTS

(S. Parashar, C. Gosselin, G. Stapleton and R. Worsfold, Remotec Applications Inc., St. Johns, Nfld (REMOTEC); R. Stacey, FOC/Ottawa)
Radar data (photographs of the PPI scope and video tape recordings) obtained in 1979 from the shore-based facility established by the Federal Government on Bylot Island, NWT, are being analyzed. The results will be used to assess the role of shore-based radars for ice surveillance in comparison with ship-borne, airborne and satellite measurements.

APPLICATIONS OF HF RADAR

(K.A. Butt, G. Gidney, P. Jeans, R. Raymond and M.C. Roche, C-CORE)
A skywave HF doppler radar from the Communications Research Centre near Ottawa has produced wind vector plots for the Labrador Sea. Refinements of data processing and analysis techniques are underway. Detection of the pack ice edge appears feasible.

Evaluation of the US designed ground wave doppler radar (CODAR system) for Canadian requirements has begun. It has potential application to operational problems of sea ice and icebergs and can measure surface currents and other ocean variables. A study of HF propagation over sea ice is underway and will include a field program in the Arctic in 1982.

DETECTION OF OIL POLLUTION IN ICE

(S. Parashar, B. Dawe, J. Snellen, G. Stapleton and R. Worsfold, REMOTEC)
The role and utility of various remote sensing techniques for detecting oil in marine ice conditions has been assessed through a review of oil-ice interaction mechanisms and

the techniques being used. In one example, a digitally enhanced LANDSAT MSS image was used. In another, the oil-in-ice detection capabilities of four sensors (impulse radar, ultrasonic device, microwave radiometer and gamma ray spectrometer) were tested in the laboratory. An integrated system concept suitable for detecting and monitoring oil in ice infested water is being developed.

(B. Dawe, S. Parashar, J. Ryan and R. Worsfold, REMOTEC; M. Fingas, EPS/EC)
Subsequent digital analysis of LANDSAT data showed that oil from the tanker "Kurdistan", wrecked on 15 March 1979 in Cabot Strait, could be detected. At the time of the spill attempts to track the oil in open water using imagery from LANDSAT and TIROS-N were unsuccessful.

PERMAFROST AND GROUND ICE, GAS HYDRATES

ACTIVE LAYER HYDROLOGY
(P. Steer and M.-K. Woo, GEOG/McM)
Hydrological observations were made on a typical slope near Resolute, NWT, to determine the magnitude of surface and subsurface flows.

PERMAFROST HYDROLOGY
(A. Wankiewicz, SWD/NHRI/EC)
Analysis was completed of 10,000 ground temperature measurements from thermistor networks to depths of 13 m in arctic river valley cross sections and channels. Research sites were rivers in regions of continuous permafrost, with drainage areas of 600-1200 km^2 where the river freezes solid in winter. The climate varied from that of the Mackenzie Delta area to Melville Island. Aufeis is a recurring feature of channels near Inuvik. Results will be presented as isotherms on valley cross sections, on time and depth diagrams and as temperature depth profiles.

AUFEIS, N.W.T.
(J.C. Anderson, SWD/NHRI/EC)
Aufeis accumulation thicknesses were monitored in culverts along the Dempster Highway near Inuvik and large aufeis formations on Hans Creek (68°52'N, 133°33'W) and Stanley Creek (68°35'N, 133°35'W) were surveyed.

PERMAFROST DISTRIBUTION
(G.H. Johnston, DBR/NRC)
Regular ground temperature observations were continued at selected locations in northern Manitoba to obtain information on permafrost conditions in the northern part of the discontinuous permafrost zone. Those in the alpine permafrost of the western Cordillera and at Alert, NWT, were also continued.

DEMPSTER HIGHWAY PIPELINE PROJECT
(Karl E. Ricker Ltd, Vancouver, B.C.)
The ramifications of a chilled pipeline on frost heave and solifluction and those of a warm flow mode on thaw settlement and solifluction were evaluated. Aufeis and icing problems were also studied. More drilling and a change of construction plans are needed for various portions of the route due to periglacial conditions.

INSULATED ROAD STUDIES
(G.H. Johnston, DBR/NRC)
Review and processing of data collected in previous years at the Mackenzie Highway site near Inuvik was continued and visits were made to the test sites in September 1980 and June 1981. At this time level surveys were conducted at the Dempster Highway test site to supplement ground temperature observations made several times during the year.

MACKENZIE HIGHWAY EMBANKMENT STUDY
(G.H. Johnston, DBR/NRC)
Observations were continued at the site until February 1981 when all monitoring equipment was removed. Final cleanup and surveys were made in June 1981.

ALASKA HIGHWAY GAS PIPELINE PROJECT
(V.N. Rampton, R.D. Thomas and S. Paradis, Terrain Analysis Services Ltd, Carp, Ontario)
The surficial geology and permafrost distribution along the gas pipeline right-of-way has been mapped at 1:10,000 for Foothills Pipeline (South Yukon) Ltd and Westcoast Transmission Ltd. Permafrost is continuous from the Alaska border to the Donjek River where the uppermost eolian and alluvial materials are very ice rich and till below 4 m depth has low ice content. Taliks occur locally due to anomalous groundwater flow and beneath major rivers and lakes. Between the Donjek River and Kluane Lake taliks become more abundant. South of Kluane Lake the permafrost is discontinuous, but locally ice rich, and is most common under stands of dense spruce. Along the B.C. section of the route permafrost is sporadic, being restricted to isolated areas north of the junction of the Beatton River and Milligan Creek at high elevations, on north-facing slopes and under thick organic deposits. The permafrost is relatively warm; fine-grained sediments often contain only isolated ice crystals.

INUVIK AIRSTRIP STUDY, NWT
(G.H. Johnston, DBR/NRC)
A program of ground temperature measurements at the Inuvik airfield was reinstated in June 1981 after a lapse of about 5½ years. A report on the earlier measurements was presented to the 4th Canadian Permafrost Conference.

VIBRATIONS ON PILE FOUNDATIONS IN PERMAFROST
(G. Pernica, V.R. Parameswaran and G.H. Johnston, DBR/NRC)
Comprehensive measurements of vibrations transmitted to piles supporting the Inuvik powerhouse were carried out in September 1980.

EAGLE RIVER BRIDGE FOUNDATION STUDY
(G.H. Johnston, DBR/NRC)
Ground temperature observations and level surveys were made periodically throughout the year.

PERMAFROST STUDIES AT THOMPSON, MANITOBA

(G.H. Johnston, DBR/NRC)

A topographical survey of a peat plateau was made and thermal conductivity and ground temperature measurements continued.

Ground and air temperatures were measured continuously and level surveys and soil thermal conductivity measurements were made periodically throughout the year at gravel and pavement-surfaced sites kept clear of snow.

ELECTRICAL, THERMAL AND ELASTIC PROPERTIES

(B.I. Pandit and M.S. King, GEOL/SASK)

The physical properties of sand, silt and clay permafrost from the Beaufort Sea were found to be similar to those of onshore samples from the Mackenzie River. Laboratory measurements on the compressional wave velocities agreed well with those inferred from seismic and temperature surveys at the sample sites.

A correlation was found between the compressive strength of frozen and unfrozen iron ore and the dynamic elastic modulus calculated from the ultrasonic velocities and density. A linear relationship exists between the former ores of roughly the same porosities and the square of the compressional-wave velocity.

Compressional and shear wave velocities of propane gas hydrates and ice were measured as a function of temperature ($-16.5^{o}C$ to $+2.4^{o}C$) and stress (0.53-2.1 MPa). Below $0^{o}C$, the respective velocities were 3.25 km/s and 1.65 km/s for propane hydrates and 3.86 km/s and 2.04 km/s for ice. Amplitude data seems to suggest that wave attenuation is higher in hydrates than in ice.

STRENGTH AND DEFORMATION OF FROZEN SOILS

(T.H.W. Baker, DBR/NRC)

Compliant platens have been manufactured and sent to several consulting firms for testing. Time-domain reflectometry has been used to provide quality control in preparing artificially frozen sand specimens. A non-contacting transducer will be used in the volume change apparatus. Varved samples of permafrost from Thompson, Manitoba, have been tested in unconfined compression at various orientations to the varves. Results were compared to specimens without varves. All of this clayey silt material had a remarkably uniform total water content.

DEFORMATION BEHAVIOUR OF FROZEN NATURAL SOILS

(V.R. Parameswaran, DBR/NRC)

Frozen reconstituted natural soils from Norman Wells (clayey silt), Thompson and Inuvik (siltey clays), and frozen sand-ice material with various percentages of sand are being tested at various temperatures (-2^{o} to $-30^{o}C$) with varying moisture contents in unconfined compression and in confined compression (S.J. Jones, S&ID/NHRI/EC). The object is to study the effect of unfrozen water content on the strength and deformation behaviour of frozen natural soils. In such fine-grained material the unfrozen water content plays a dominant role in determining the strength and bearing capacity down to much lower temperatures tnan in sands and silts.

ICE-LENS/SOIL INTERACTION BEHAVIOUR

(E. Penner, DBR/NRC)

The heave rate equation $dh/dt = ae^{-b\ P/T}$ used to relate ice lens growth to P/T ratios was previously shown to hold for a wide range of soils studied. The relationship would be more fundamental if the cold side temperature T at the sample end was replaced by the ice-lens/soil interface temperature since this determines the suction and hence the driving force for rate of ice-lens growth. Introduction of the X-ray technique has made these measurements possible.

This was investigated by running a series of heaving experiments with a highly frost susceptible soil, Leda clay. It appears that for fairly impermeable soils the relationship between the (dh/dt) and (P/T) is not improved and more experiments are required with other soil. A paper on the results "The rise and fall of ice segregation temperatures in soils" was presented at the 4th International Permafrost Conference.

NUMERICAL MODEL FOR FROST HEAVE

(O.J.Svec, DBR/NRC)

A cornerstone of this project is development of the (analytical or empirical) relationship between suction potentials versus overburden pressure and heat extraction. A general form of the equation has been prepared. A two-dimensional finite difference program based on uncoupled heat and mass flow was modified to accommodate moisture flow due to freezing suction potentials. Two additional existing programs (one- and two-dimensional) have been evaluated for possible use in this project. The experimental study of heat flow around a model chilled gas pipeline has been completed and reported. Some preliminary design work has been carried out concerning a monitoring station for the Alaska gas pipeline.

EFFECTS OF FREEZING ON GLACIAL TILLS

(B. Ladanyi and P. Garand, CINEP/UofM)

A study of ice segregation in a glacial till from the James Bay area has been completed. It provided information that will result in a better prediction of frost heaving in compacted glacial tills used in the construction of dykes and dams in the North. Particular attention was given to the effect of compaction energy on heaving and the possibility of extrapolating experimental results.

COLD ROOM STUDY OF DILATOMETRIC METHODS FOR MEASURING RHEOLOGIC PROPERTIES OF PERMAFROST

(B. Ladanyi and H. Eckhardt, CINEP/UofM)

A series of pressuremeter creep tests on creep and dilatometric relaxation tests were made in a cold room to evaluate the validity of such tests in controlled conditions. A cylindrical container of 90 cm diameter and 50 cm height was built to obtain thick cylinders of frozen soil and apply an exterior confining pressure on them during tests in

the centre hole. The tests permitted measurement of the properties of frozen soil in known conditions, as well as the observation of all phenomena associated with such tests in a drill hole and in particular the formation of radial cracks. The study clarified several of the problems encountered during in situ tests.

MECHANICAL BEHAVIOUR OF PERMAFROST

(B. Ladanyi, J. Arteau and J. Bourbonnais, CINEP/UofM)

Cold room studies, begun 3 years ago, are still in process. The first, dealing with the laws of oedometric consolidation of frozen sands saturated with ice, is designed to improve the prediction of foundation settlement. The second is developing a theoretical concept to express properties of frozen soil in terms of effective stress; impossible so far due to the difficulty of directly measuring stress in interstitial ice. The third study is designed to measure the mechanical properties of soils frozen at very low temperatures (to -165°C) in relation to the underground storage of liquified natural gas, in particular the thermal cracking of samples.

LABORATORY STUDIES OF MODEL PILE FOUNDATIONS

(V.R. Parameswaran, DBR/NRC)

Creep of piles in frozen soils under static loads was studied earlier as well as the effect of a superimposed alternating load. It was found that an alternating load as small as 3-5% of the static load doubles the rate of displacement of piles in frozen soils. Further systematic studies are continuing.

ELECTRICAL FREEZING POTENTIALS

(V.R. Parameswaran, DBR/NRC)

Electrical potentials and currents generated during freezing of water and moist soils onto a metallic substrate have been measured in the lab. A couple of electrode assemblies have been fabricated to study freezing potentials developed in permafrost in the field. One was installed in the drained Illisarvik Lake on Richards Island and the other at Inuvik by J.R. Mackay (GEOG/UBC).

TIME-DOMAIN REFLECTOMETRY

(T.H.W. Baker, DBR/NRC)

Time-domain reflectometry (TDR) was used to monitor movement of the freezing front at a sandy loam field site in conjunction with a field program operated by Agriculture Canada. Results were correlated with ground temperature measurements. Laboratory freezing tests were continued using Rideau clay as a typical fine-grained soil. Thermocouples were used to measure temperature profiles. Preliminary results using X-ray techniques showed excellent correlation with the TDR measurements.

ICE PHYSICS/ICE ENGINEERING

WINTER ROADS AND ICE BRIDGES

(K.A. Adam, Interdisciplinary Systems Ltd., Winnipeg)

The following studies were undertaken for Foothills Pipe Lines (Yukon) Ltd: updated bibliography on winter roads and ice bridges, engineering specification for building an ice aggregate work pad, construction and test of an ice work pad for pipeline construction trials at Quill Creek, Yukon, and evaluation of long-term effects on terrain and vegetation of winter road trials at Norman Wells and Inuvik, NWT.

For the Melville Island component of the Arctic Pilot Project the following studies are ongoing: reconnaissance of terrain and vegetation along the proposed route, analysis of weather records for nearby stations, development of building methods for winter roads in the High Arctic, and field testing and evaluation of snow fencing, snow manufacturing and snow bonding techniques.

In the Baker Lake area full-scale models of a 3.5 km water supply access road and a solid waste management site and its access road are being studied.

ICE BEHAVIOUR ON STRUCTURES

(M. Arockiasamy, D.V. Reddy, A.S.J. Swamidas, H. El-Tahan, Ocean Engineering Group ENG/MUN)

Response of semi-submersible drill rigs subject to ice floe impact is under study. The structure, cable elements and the mechanical components are modelled using finite elements. Ice forces are estimated from ice-force records. The structural responses analyzed include the wave, wind and current forces.

(B. Michel, IML/ENG/LAVAL)

A laboratory tank, 5 x 4 m, is used with a 2 m stroke piston to push indentors of variable geometry into a floating sheet made of different types of ice, including sea ice. The first series of tests dealt with extrusion, shear and buckling by vertical face indentors for high rates of loading.

MECHANICAL PROPERTIES

(D.B. Muggeridge, H. Hamza and A.A. Tehrany, ENG/MUN)

Creep and bending of fresh-water ice plates was analyzed by the finite element method. Fracture toughness was evaluated using a three point bending compact specimen. The effect of strain rate, grain size and temperature on the fracture toughness is being investigated.

(S.J. Jones, S&ID/NHRI/EC)

The effect of grain size on the strength of ice has been investigated, the effect of hydrostatic pressure on the secondary creep of ice is being studied and triaxial compression tests are being carried out on sand/ice mixtures to determine the effects of different quantities of sand on the strength.

(B. Michel, IML/ENG/LAVAL)

The long range program to study the mechanical properties of ice by uniaxial testing of ice samples in the brittle and ductile range has been extended to simulated Arctic ice.

(G.W. Timco, DME/NRC)

The uniaxial and plane strain compressive

strength of carbamide (urea) model ice has been measured at low strain rates ($10^{-3}sec^{-1}$) for scale factors of $5 > \lambda > 40$. The results are of importance in analyzing tests of dynamic ice-structure interactions using modelling techniques.

STRENGTHS OF FRESH-WATER ICE

(G.W. Timco, DME/NRC; R. Frederking, DBR/NRC)

A series of tests were performed to measure flexural, shear and compressive strengths, fracture toughness and strain modulus of samples of fine-grained columnar fresh-water ice under identical experimental conditions. The results will serve as base-line values for similar tests carried out in the field.

(N.K. Sinha, DBR/NRC)

Investigations on unconfined compressive strength of S-2 ice have been carried out at -5^{o} and at $-30^{o}C$ in addition to further tests at $-10^{o}C$. Non-constancy in the strain rates for constant cross-head rate tests, observed at $-10^{o}C$ earlier, also occurs at other temperatures. Increase in strength with decrease in temperature, observed during these tests, is considered useful. Theory also supports these conclusions.

A series of comparative tests of compressive strength, flexural strength and fracture toughness were carried out on fine-grained (~2 mm) columnar ice.

STRENGTH AND DEFORMATION OF 1ST-YEAR SEA ICE

(N.K. Sinha, DBR/NRC)

Strength tests were carried out in the field on freshly recovered first-year sea ice. Although the horizontal unconfined strength showed less scatter, the vertical strength varied greatly; sample preparations and test machine performances have to be improved to get consistent results.

The effect of test system stiffness on the strength does not allow examination of the effect of brine volume on strength. When strengths were plotted as a function of the stress rate, more consistent results were noted. This is consistent with previous observations that the use of loading stress rate as the independent parameter might eliminate some of the ambiguities resulting from variation of the test system stiffness on test conditions.

ICE FRICTION

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

Design work is proceeding on test equipment for studying the friction between ice and other materials. Ice samples of 10 cm diameter will be tested at temperatures of $-40^{o}C$ to $0^{o}C$. Test materials and surfaces will simulate those of icebreakers and other ocean structures.

ADHESION OF ICE TO PILES

(V.R. Parameswaran, DBR/NRC)

Adfreeze strength of fresh-water ice to various materials was measured from small scale model piles. The force of adhesion measured on a steel pile was compared to that calculated as a function of charge concentrations at the metal-ice interface based on the electronic band theory of solids. The measured values were in the same order of magnitude as the calculated values of force of adhesion.

FAR INFRARED SPECTRUM OF ICES

(S.P.Tay, D.D. Klug and E. Whalley, CHEM/NRC)

Infrared spectra, frequencies and absorptivities of Ice VI, VII and VIII in the range 500-4000 cm^{-1} near room temperature and at pressures up to 100 kbar have been investigated.

ELECTROMAGNETIC PROPERTIES

(G.P. Johari, S&ID/NHRI/EC)

A comprehensive review on the electromagnetic spectrum of ice, extending from the sub-audio to ultraviolet frequencies, was written for Contemporary Physics. A detailed report on the effect of dissolved gases on the dielectric properties of ice was published in the Journal of Chemical Physics (75(3),1333-40).

INTERNAL STRESSES IN LAKE ICE

(B. Michel, IML/ENG/LAVAL)

The development of a micro-pressure transducer to measure the internal stresses in Lake St-Joseph, Québec, produced by wind and thermal expansion is progressing.

ACOUSTIC EMMISSIONS IN ICE

(N.K. Sinha, DBR/NRC)

Preliminary studies were carried out to examine the acoustic emissions in S-2 ice during constant load creep tests using the locator system recently acquired. Freezing the detectors on the sample works better than using a liquid provided by the manufacturer. Ambient cold room noise elimination capability of the device was found to be excellent. The major problems encountered were caused by the end conditions of the specimen and the surface quality of the platens. Several types of platens were examined.

In order to understand the processes responsible for the production of acoustic emissions, visual observations were made of crack formation and a literature survey made.

ATMOSPHERIC ICE AND CLIMATE

POLYNYA PROJECT – DUNDAS ISLAND EXPERIMENT

(G. den Hartog, CCC/AES/EC)

Analysis of the 1980 Dundas Island data has been completed. Major results include characterization of the unstable boundary-layer over the open water in terms of mean wind and temperature profiles as well as fast response temperature and wind speeds. Mean daily sensible heat flux accounts for the largest heat loss from the surface and averaged 200 W/m over a 21-day period in March; the open water area was about $2.4 \times 10^{5}m$. Prolonged cold spells with low wind speeds coupled with low tidal currents cause the polynya to decrease in size or even freeze over (e.g. 1979); it opens up with high winds coupled with peak tidal currents. Bottom topography is also important in the formation of the open water.

NUMERICAL STUDY ON THE BOUNDARY-LAYER FLOW

(A.K. Lo, CCC, AES)

The model includes heat balance and vapour conservation equations as well as the usual mass continuity, x-momentum and turbulent energy equations. The Glushko-type mixing length relationship is used to close the system. During the numerical calculations, a fully implicit finite difference method was used and stable numerical solutions were obtained for a fetch over 1 km. This model predicts that the heat flux through the polynya is about two orders of magnitude larger than through mature ice which is in good agreement with published results.

SENSIBLE HEAT LOSS – DUNDAS ISLAND POLYNYA

(R.J.Anderson, E.G.Banke and S.D.Smith, BIO)

A field study of sensible heat loss in March 1980 from the surface of the polynya was very successful. Eddy-correlation measurements in the atmospheric surface layer are being analyzed to obtain sensible heat flux values.

V.R. Parameswaran

CHINA

The year 1978 was a memorable one in the history of Chinese glaciology for it marked the reorganization of the Lanzhou Institute of Glaciology and Cryopedology (LIGC), Academia Sinica, the visit of a delegation of glaciologists to Switzerland, France and England, and the holding of the First Symposium on Glaciology and Cryopedology, at which 178 papers were given. In 1980 the Chinese Society of Glaciology and Cryopedology was founded. Developments in Chinese glaciology from 1978 to 1980 are described below.

KARAKORUM

After a detailed investigation of the 59 km long Batura Glacier (Pakistan) in 1974-75 a 3rd expedition, led by Wang Wenying, returned to the glacier in 1978. Between December 1975 and June 1978 the snout had advanced 30.34 m. A surging glacier at the source of Baltbare Ditch, on the eastern bank of the Hunza River 18 km south of Batura, was also investigated. The glacier is 8-10 km long and had blocked the Hunza River in April 1974. From December 1974 to October 1978 the glacier advanced 1.8 km. Survey data seems to indicate that the surge has peaked. Because the Quaternary deposits in the Baltbare Ditch were largely overridden it has been concluded that a flow of similar magnitude is unlikely for another 100 years. The Karakorum Highway, built by China and Pakistan, follows a route recommended by Chinese glaciologists in front of the Batura Glacier and Baltbare Ditch. A study by Zhang Xiangsong on the variations of 15 glaciers along the highway from the 1960's to the present shows a small readvance during a general period of recession. Of the 15, 5 are advancing, 7 retreating and 3 stationary. A report on the Batura Glacier research, edited by Shi Yafeng, Zhang Xiangsong and Bai Zhungyuan, with English abstracts and a 1:60,000 scale colour map was published by the Science Press in Beijing in 1980.

QILIAN SHAN

A detailed investigation of the glaciers in the Qilian Shan, on the northern border of the Qinghai-Xizang Plateau, was carried out in 1958 and 1959. This work was continued from 1975-1979 by a joint expedition of the LIGC and the Geography Department of Lanzhou University under the direction of Xie Zichu. The glaciers in the Qilian Shan are generally small, <10 km long, with movement averaging 30-40 m/a. Along the 800 km range precipitation decreases from NE to SW and the snowline varies from 4400-5200 m a.s.l. Temperatures in the active layer near the snowline varied from -4°- -5°C in Lenglongling Glacier in the east to -12.8°C in Laohugou No.12 Glacier in the west. In August 1977, Huang Maohuan observed that in three 16 m holes in the Yanglong he No.5 Glacier the temperature at the lower limit of the active layer in the percolation zone at 4835 m a.s.l. was -4.9°C, 7.8°C higher than the average air temperature, and that in the other two holes, at 4648 m and 4513 m, near the snowline and on the tongue, the temperature was -8°C and -5.9°C, 4°C and 2.9°C higher than the average air temperature respectively. The formation of ice was mainly by superimposition, secondly by percolation, with condensation observed only in a few glaciers above 5100-5200 m a.s.l. The glaciers were evidently healthier than at the end of the 1950's and early 60's. The mass balances measured on four glaciers from 1975-1978 were all positive with a maximum three year total of 769 mm H_2O for the July First Glacier. On the northern slope of the Qilian Shan, the 22 glaciers being measured were generally in a state of recession. Lenglongling Glacier, in the eastern section, had a recession rate of 12.5-22.5 m/a during 1956-1976. In the middle and western sections the rate was slower at 10.0-7.1 m/a for the same period. While in the southwestern part, 6 of the 9 glaciers observed advanced; up to a maximum of 1 km from 1966-1976. The mean annual air temperature from 1966-1976 at 600 mb was 0.8-1.3°C, lower than that from 1957-1966, and precipitation was slightly higher. This might account for the positive balances, the reduced rate of recession and the advances. Analysis of cypress tree rings (*sabina prewalskii kom*) for 912, 935 and 1022 years shows that the

climate in the Qilian Shan changed from warm to cold and back some 4-5 times over an average interval of about 100 years. It is estimated that the cooling trend which started in the 50's should last until the end of this century. In the future the glaciers in this area may well change from a state of retreat to one of advance.

XIZANG

Since 1973, a group from the Qinghai-Xizang Plateau Comprehensive Scientific Investigation Team, Academia Sinica, jointly led by Li Jijun, Lanzhou University and Zheng Benxing (LIGC), has been investigating the glaciers in the southern part of the Xizang Plateau and has discovered two centres of glacierization. One is in the Nianqingtanggula with a glacierized area of about 8000 km^2, including glaciers at the easternmost end of the Himalayas. Kaqing Glacier, at 33 km, is the longest with a snowline at 4500 m and a tongue descending to 2530 m. This area has developed due to the influence of high precipitation (1200-3000 mm/a) from the strong Indian monsoon which enters the Qinghai-Xizang Plateau from Assam and the valley of the lower Yaluzangbu Jiang. The mass balance, intensity of ablation, heat exchange, ice temperature and motion, etc., all resemble those of the maritime glaciers in the Alps and are quite different from those of the continental glaciers found in northwestern China. The other major glacierized area is the west Kunlun Shan, in the northwestern part of the Plateau. Here the total glacierized area also approaches 8000 km^2, the snowline ranges from 5400-6000 m, and the longest glacier at 30km has a terminus at 5120 m and a snowline at 6000 m. The physical characteristics and conditions of glaciers in this area still remain to be studied. According to evidence of Quaternary glaciation on the Qinghai-Xizang Plateau, there were at least four glacial periods, the greatest being in the Middle Pleistocene when the altitude of the Plateau was about 3000 m and that of the Himalayas 4500 m. There were many piedmont glaciers and a small 3600 km^2 ice cap was discovered at Maidka Basin (31°N, 93°E) but there was no sign of a large ice cap covering the Plateau. Following this glaciation there was rapid uplift and the climate became much drier, restricting the growth of glaciers. By the last glaciation the Plateau had attained a height of about 4000 m and the Himalayas 5500 m. Only long valley glaciers developed. In May 1980, at the Symposium on the Qinghai-Xizang Plateau, organized by Academia Sinica in Beijing, more than 20 scientists from China, Japan, the USA and the UK presented 17 papers on various aspects of glaciers.

TIAN SHAN

In the summers of 1977 and 1978, a group of glaciologists led by Su Zhen (LIGC) investigated the West Qiong Tailan Glacier on the southern side of Tumuer Peak (7435 m), the highest peak in the Tian Shan. The glacier is 25 km long with a snowline at 4500 m and its terminus at 3084 m. Annual precipitation was 750-800 mm near the snowline, 900-1100 mm in the accumulation basin at 5200-5250 m or 1300-1550 mm H_2O based on snow pit calculations. Annual net ablation on the tongue is 2618 mm H_2O with a maximum of 5972 mm. With half the glacier covered by a 20 cm layer of debris overall ablation is reduced. The ice formation process is similar to that in the Qilian Shan, superimposed ice around the snow line for a range of 300 m, for some 400 m above this zone by percolation and above 5200 m by condensation. It is estimated that ablation stops at about 5900 m and that above this there may be a zone of recrystallization. In an 18 m hole near the snowline the temperature at the bottom of the active layer was -1.8° - -3.2°C, approaching that of the Tian Shan but much higher than the Qilian Shan. Gravity measurements gave a maximum depth of 302 m at 3850 m and a mean of 243 m, maximum flow was 62.6 m/a with an average of 48.3 m/a. Analysis of 60 snow samples gave an average tritium content for glacier ice of only 19 TU as opposed to that of newly fallen rain or snow at 300 TU. Glacier hydrology, meteorology and Quaternary glaciations were also investigated. A geomorphological map of Tumuer Peak at a scale of 1:200,000 was published by the LIGC. It was determined that there are 509 glaciers west of the Muzhaerte River valley with a total area of 2746 km^2.

In 1980 observations of mass balance, ice motion, meltwater, etc., on the No.1 Glacier of the Urümqi River glaciological station, in the central part of the Tian Shan, were resumed. A tunnel about 30 m long was dug to observe ice movement over the bed. Investigations and analysis of the constituents, the petrological and mineralogical composition of glacial sediments since the last glaciation, and of the shape of the glacial valley have been carried out.

ALTAI SHAN

In 1980, a group from the LIGC, headed by Liu Chaohai, worked in the Altai Shan. The biggest glacier on the southern slope of the Altai in China is the Halasi Glacier, 10.3 km long it rises to 4073 m a.s.l. and descends to 2406 m with a snowline at 3100-3200 m. Annual precipitation at 3380 m a.s.l. was estimated from a snow profile at 700-800 mm. Snow fall occurs mainly in winter and spring. The flow rate near the firn line is 74 m/a and 35 m/a at the tongue. From 1959-1980 the Halasi Glacier retreated 424 m and among five other small glaciers 4 retreated from 42-206 m and one advanced 20 m. At least two Quaternary glaciations could be ascertained. The length of the glaciers during the first one reached 100 km with snouts descending to 1400 m while in the second they reached 40 km with tongues down to 1700 m. Many lakes on the

southern slope of the Altai have formed from glacial erosion and moraine blockage. Research by Tong Boliang showed that the lower limit of discontinuous permafrost is 2200-2300 m (descending to 2000 m in the eastern part) where the annual temperature is between -5.4°C and -6.7°C. This is mainly due to the relatively thick snow cover in the winter. Continuous permafrost has its lower limit at 2800-2900 m where the mean annual temperature drops to -9.4°C to -11.5°C.

GLACIER INVENTORY

Following the Riederalp Workshop on the World Glacier Inventory in September 1978, China began an inventory in accordance with the international guidelines. The work is being directed by Wang Zongtai and Liu Chaohai. Air photos and maps are carefully checked and field parties sent to representative glaciers for verification. The glacier inventory of the Qilian Shan was completed in 1980. In this region there are 2859 glaciers with a total area of 1972.5 km^2 and a water storage of 95.437 km^3. Twelve maps of glacier distribution based on drainage basins have been prepared at a scale of 1:250,000. According to Liu Chaohai's statistics there are 416 glaciers with an area of 293.2 km^2 on the Chinese side of the Altai. Work is continuing on the Tian Shan. With topographical maps and LANDSAT images available conditions are favourable for a complete survey of Chinese glaciers. The total area of glaciers in the mountains of west China was found to be 56,500 km^2; about half the area of glaciers in central Asia. Zhang Xiansong selected 116 glaciers on the Qinghai-Xizang Plateau for a study of glacier variations using LANDSAT images from the 1970's, maps from the 1960's and other data: 35 are advancing, 62 retreating and 19 stationary which is in agreement with the general world trend.

PERMAFROST ALONG THE QINGHAI-XIZANG HIGHWAY

Since 1960, repeated investigations of permafrost along the Qinghai-Xizang Highway have been carried out. In 1979-80, a map of permafrost characteristics and distribution along the Highway, at a scale of 1:600,000, was prepared by Tong Boliang and others of the Permafrost Division of the LIGC. The boundary between seasonal frozen ground, discontinuous and continuous permafrost generally corresponds to a mean annual temperature of -2.5°C and -3.6°C. It is already known that the thickest permafrost, over 120 m, lies in the Kunlun Shan and Tanggula Shan and on the plateau surface between them. There are several penetrating talik regions in the permafrost area. The distribution of underground ice exerts a great influence on the construction of the highway. Permafrost in this area is divided into five categories according to the temperature in the frozen ground, the ice content and the thickness of permafrost: small ice content, large ice content, rich ice content, saturated ice content, and soil with an ice layer. The classification is used in engineering construction by integrating it with changes in the permafrost table to determine the design height for the asphalt road surface. Cheng Guodong has suggested that the thick ground ice layer formed due to a repeated segregation process. Geophysical methods were applied in the surveys. Electric sounding permitted mapping of the thick layer of ground ice and seismometry was used to determine the depth of the permafrost table and loose Quaternary sediments; the latter's application to other permafrost problems has also been studied. Creep tests on ground ice in situ and heaving experiments in the field and laboratory are in progress.

PERMAFROST INVESTIGATIONS IN NORTHEAST CHINA

Another large area of permafrost lies in NE China. Guo Dongxin (LIGC) studied the permafrost distribution there and maintains that the boundaries between the continuous permafrost, isolated talik permafrost, discontinuous permafrost and seasonal permafrost coincide with the mean annual temperatures of -5°C, -3°C and -1°C respectively. A small scale map of permafrost distribution has been prepared on which different types of high mountain permafrost and seasonal permafrost south of the above mentioned zones have been plotted and the different stages of historical development shown. According to paleopermafrost relics and other data, the present extent of continuous permafrost may be the result of superimposition of modern cooling on the Late Pleistocene glacial and the permafrost south of this zone (including alpine permafrost) may reflect recent coldness.

LABORATORY RESEARCH ON PERMAFROST

Wu Ziwang and others have studied the creep and long-term strength of permafrost, developed a method for determining the limit of long-term strength, carried out preliminary tests on the thawing pressure of permafrost and systematic experiments on its compression strength, measured the physical and mechanical properties of permafrost and snow and ice by an ultrasonic method, and obtained elastic moduli and Poisson's ratio data. Chen Xiaobo and others have undertaken experiments on the various properties of water-saturated sand and gravel while freezing (such as pore water pressures, freezing forces, etc.), on normal heaving forces, and on the calculation of anti-heaving deformation in freezing. Ding Dewen and others started a study on the application of a thermo-mechanical method to calculate the heaving force in freezing and developed tests for permafrost heaving. Based on laboratory and field experiments, preliminary specifications for thermal and mechanical parameter tests on permafrost have been proposed.

INSTRUMENT DEVELOPMENT

Zhang Jinhua and others (LIGC) have designed and built a thermal drill capable of reaching 35 m. Wang Liangwei and Zhu Guocai have constructed a quartz thermometer accurate to 0.01°C for a multi-channel recorder. In 1980, the former headed a group which designed telemetry and digital equipment now being used to monitor ice and air temperatures and radiation at the Tian Shan Station with a range of 3 km in the mountains and 18 km in the plains. Zhu Guocai directed the manufacture of a 26 kg radio-echo sounder that has obtained good results in the Tian Shan and is now being widely used in the field.

Shi Yafeng

SOUTH AFRICA

SUB-ANTARCTIC KERGUELEN ISLAND

(K.J. Hall, University of Natal)

From March to April 1981 K.J. Hall joined a research team led by Prof. J. Nougier (Avignon). On Péninsule Loranchet, studies were made of features around the margins of the present-day glaciers of Presqu'île de la Société de Géographie and the NE margin of the Cook Ice Cap, of evidence of former glaciations in the area, and of periglacial features, particularly sorted stripes. On Péninsule Courbet investigation of till sections at Cap Digby was undertaken as well as collection of peat samples for pollen analysis and ^{14}C dating.

Contrary to earlier reports, it seems that Kerguelen Island was completely covered by ice during the last glacial. An E.L.A. of ~200 m has been reconstructed for the Alpine stage of glaciation. There is evidence of ice flow transverse to the main valleys during the period of total ice cover and of ice cap growth in the W spreading gradually to the E.

A strong relationship between sorted stripe genesis and wind direction was obtained. Analysis of the peat samples (L. Scott, Bloemfontein) and of the stratigraphic sequence from Cap Digby is still in progress. The results of the glacial and periglacial work will be compared with those from sub-antarctic Marion Island (see ICE, No.64, 1980, p.2)

SWITZERLAND

This report covers work carried out in 1979 and 1980 by the following Swiss institutions: Gletscherkommission der Schweischerischen Naturforschenden Gesellschaft (GK), Versuchsanstalt für Wasserbau, Hydrologie und Glaziologie an der ETH Zürich (VAW), Geographisches Institut an der ETH Zürich (GGEZ), Eidgenössisches Institut für Schnee- und Lawinenforschung, Weissfluhjoch-Davos (SLF), and Abteilung "Low Level Counting" und Nukleare Geophysik des Physikalischen Institutes der Universität Bern (LLC). It is based on reports submitted to the GK.

ANNUAL SURVEY OF GLACIERS (GK & VAW)

Though continued glacier observations in the Swiss Alps date back even more than 100 years the year 1979 has marked the 100th anniversary of systematic reports on the behaviour of a multitude of snouts. From a sample of 5 termini, when F.A. Forel initiated the survey in 1880, the number of observed glaciers grew within 20 years to 50 and has since surpassed 100, weather permitting. The 100th report on glacier variations for 1978/79 gives a ratio of 47 advancing to 52 retreating glaciers with 10 stationary, and the 101st report, for 1979/80 shows 73 advancing, 27 retreating and 9 stationary.

Mass balances in four basins have varied in 1978/79 from mildly positive in the central part of the Alps (Aletsch, average annual balance for the glacierized area $\bar{b}_a$ = 162 kg/m^2) to strongly negative further south (Gries, $\bar{b}_a$ = -886 kg/m^2); in 1979 the mass balance was strongly positive throughout, varying from 719 kg/m^2 (Gries) to 1534 kg/m^2 (Aletsch).

The large number of advancing glaciers for 1979/80 reflects not only the particular balance year but also the dynamic response to a longer series of positive mass balances. It seems that sliding at the bed is a controlling factor, as evidenced by strong velocity increases observed on various glacier tongues and by the high speed at which some termini advance. An impressive example is Findelengletscher where the advance suddenly began in the winter of 1979/80 at an annual rate of 80 m/a. The snout is rapidly approaching the water intake structures of the Grande Dixence power company. A change in the mode of glacier motion is probably responsible for a relatively fast response of the glacier to climatic change, a faster adjustment than one would expect from kinematic wave theory.

ALETSCHGLETCHER MASS BALANCE

The Aletschgletcher has been under investigation by VAW for more than 30 years. Net accumulation and ablation is measured each year at a number of locations and altitudes. Annual elevation change is measured at fixed points and profiles and flow rates recorded. The Jungfraujoch Research Station serves as a base for field work in the accumulation area.

With a maximum precipitation and minimum runoff 1977/78 set records for mass gain. As a mean increase in ice thickness distributed

over the glacierized area, the positive balance amounted to 2m - the highest value since 1922. The following year was almost in balance but 1979/80 brought a further gain of 1.7 m of ice. The net balance for 1978/80 amounted to a mass gain of some 500 x $10^6 m^3$ of ice.

The thickening was not evenly distributed over the whole glacier. The largest increase in height was 3 m on the Ewigschneefeld neve, while the glacier tongue was still shrinking. A consistent velocity increase has now been noticed over most of the length of the tongue.

THE RHONEGLETSCHER PROJECT (GGEZ)

Combined ice, water and energy balance studies were initiated in 1979 in the hydrological basin of the Rhone River above Gletsch. Besides mass balance studies on Rhonegletscher and Muttgletscher, the program includes climatological observations at various altitudes outside and within the glacierized area, at the planetary boundary layer and in the free atmosphere. Emphasis has been placed on the formation and decay of the snow cover off the glaciers and on runoff gauging. Radar soundings were carried out to extend knowledge of the bed configuration known from seismic soundings dating back to 1931. On 26 July 1980, Fritz Müller, the father of the project, died of a heart attack at the edge of the glacier while guiding a field excursion. The project is being continued by his students.

SWITZERLAND AND HER GLACIERS

The book "Switzerland and her glaciers: from the Ice Age to the present", published by the Swiss National Tourist Office (SNTO) and the geographical publishers Kümmerly + Frey in collaboration with VAW has recently been made available in English. It describes the relationship between glaciers, climate and man throughout the past, the present and the future. It is divided into eight chapters: Traces of the Ice Age, Climate Following the Ice Age, Historical Documents, Recent Fluctuations of Glaciers, Glacier Inventory, Information Stored in Ice, Destructive Power of Glaciers, Glaciers and Electric Power and a Bibliography. Ordering information was published in the 3rd Issue of ICE, 1981, p.25.

COLLE GNIFETTI PROJECT

(LLC, VAW and Institut für Umweltphysik der Universität Heidelberg, Germany)

Investigation of high alpine neve and ice on Colle Gnifetti (4454 m a.s.l.) was continued. Many samples were collected, primarily on the surface of the col and at shallow depths but also in a 27 m hole drilled with a SIPRE coring auger. Larger, uncontaminated samples were extracted from an 80 m ice-cliff for environmental studies. A stake network was established for strain and accumulation measurements, and deformation measurements were made in the 1977 deep bore hole.

GLACIOLOGICAL RESEARCH OF LLC

LLC teams participated in the Colle Gnifetti project and in GISP, the "Greenland Ice Sheet Program". Samples from the Colle Gnifetti were analysed for $^{18}O/^{16}O$-ratios, tritium, electrical conductivity, pH and gas content. Space charge effects were also investigated on cores. Preliminary studies of core specimens from Camp Century and Byrd Station, covering a time span of about 50,000 years, indicate that during the Ice Age the CO_2 content of the air was some 30% less than today. At the Laboratorium für Kernphysik an der ETH Zürich, facilities are being developed to allow mass- and element-spectrometric determinations of ^{14}C, ^{10}Be and ^{36}Cl, using the Van de Graaff tanden accelerator, while LLC is developing new techniques for extraction and preparation of specimens for dating ice samples. Two samples, about 250 kg each, were cut from the cold Grenzgletscher ice on the tongue of Gornergletscher (see VAW research) for ^{14}C and possibly ^{39}Ar dating.

SNOW RESEARCH OF SLF

Research continued on snow drift across mountain ridges, using a new chain of automatic anemometers and sensors measuring the heat exchange between air and snow. A run-off model for snow-melt for the hydrological test basin Dischma was developed further in cooperation with specialists from NASA (Dinwoody Creek, Wyoming).

In the field of snow mechanics, friction coefficients of a number of avalanches were determined using the avalanche's reach; a study was begun of the correlation between acoustic emissions from the snow and the stability of the sloping snowcover, with a view to improving avalanche forecasts; a research program was set up for measuring avalanche velocities; and, the mechanical properties of the bonds between ice grains forming the snow were studied in the laboratory.

In relation to forestry problems, a study was started of the distribution and development with time of a snow cover in a wooded area, as well as the effect of the forest on local avalanche formation. A study of the winter survival chances of seven species of tree with and without a snow cover has clearly shown what a favourable role the former plays. The long-range study of afforestation with and without avalanche protection continued at the Stillberg research slope (Dischmatal/Davos) and a new test site was installed in a zone favourable to the gliding of the snow cover.

In the field of snow physics, numerical avalanche forecasts were applied during the winter 1979/80; methods for analysing the snow structure were developed and applied to various natural types of snow as well as to artificial snow produced by snow making machines in Savognin. Techniques for remotely measuring the snow surface were investigated in collaboration with the University of Berne.

RESEARCH PROJECTS OF VAW

Subglacial water pressure was investigated on Gornergletscher in relation to various phases of the melt season and to the drainage of the ice-dammed Gornersee in 1979. The main part of the program consisted of continuous piezometric measurements in deep drill holes. Using a hot-water drill, a maximum depth of 430 m was reached in 7½ hours. Additional measurements included the movement of the glacier, water temperature in the ice-dammed lake, seismicity (Geophysical Institute of ETH) and dye tracing (Geographical Institute of the University of Berne) in connection with the discharge of the lake. Independently, a team from the University of Manchester (Collins) continued run-off chemistry and sediment-load studies begun in previous years. Preliminary studies of short-term movement fluctuations in relation to subglacial water pressure were carried out on Findelengletscher in 1980 in preparation for a future, more intensive, investigation.

On Colle Gnifetti, temperature, depth to bedrock and strain rate measurements were continued from previous years (see Colle Gnifetti Project). Ice temperatures were also measured in deep drill holes in the Grenzgletscher ice of the Gornergletscher; ice which originates at a high altitude on and below Colle Gnifetti. The top 150 m of the Grenzgletscher ice was found to be nearly isothermal at -3.5^{o} to -4.0^{o}C as compared to -14^{o}C at Colle Gnifetti; higher temperatures were measured below that depth. Seasonal movement studies and temperature measurements were carried out on the Grubengletscher (Saas Valais) and on an adjacent rock glacier.

K. Hutter has written a book on the theoretical aspects of ice mechanics and glacier ice sheet physics entitled "Theoretical Glaciology, Vol.1". It will be published in 1982 as Volume 3 of Monographs in Environmental Fluid Mechanics (G. Csanady, Editor) by the Reidel Book Company.

ICE PHYSICS

(Institut de Physique, Univ. de Neuchâtel)

Surface disorder near the melting point has been further investigated and literature on prefusion phenomena studied. For ion beam analysis at 1-3 MeV, a refrigerated sample holder with 3 translational and 3 rotational degrees of freedom and a "high pressure" diffusion chamber have been developed and built. Preliminary experiments with protons and helium nuclei have shown that channelling in single crystals is possible for such projectiles, but complicated by sputtering. These phenomena will be subject to further detailed study.

CONSULTANT WORK OF VAW

Observations in relation to the risk of large ice avalanches were continued on the Allalingletscher and the Glacier de Gietro. Both tongues show a moderate to fast advance. Estimates of the risk of ice avalanches were also made in connection with further hydro and other engineering projects. The long-range climatological and mass balance studies on Griesgletscher, including the interaction of the storage lake and glacier, were continued. Further consultant work was concerned with the problem of capturing water subglacially, ice pressure against structures on glacierized peaks and ridges, and frozen lakes used for various winter sports activities. Documentation on case histories of ice avalanches and floods caused by the outbreak of ice-dammed lakes and water pockets is being collected.

GRANDE DIXENCE POWER CO. – APPLIED PROBLEMS

The engineers of Grande Dixence are frequently faced with glaciological problems such as the correlation of run-off with climatological factors for optimizing pumped storage; sediment load from glacial waters; ice avalanches and glacier advance (see Annual Survey of Glaciers). Their experience, observations and photographic records represent a valuable contribution to glaciological activity in Switzerland.

TEMPORARY TECHNICAL SECRETARIAT FOR THE WORLD GLACIER INVENTORY (TTS)

Following the death of Fritz Müller, the Director of this project, the collection of world-wide data is being continued at the Geographical Institute of ETH (GGEZ) by Karl Scherler.

Hans Röthlisberger

U.S.A.

UNIVERSITY OF MINNESOTA

(R.LeB. Hooke, Department of Geology and Geophysics, University of Minnesota)

For the first time in 13 years the Barnes Ice Cap camp was not occupied but data processing continues. One most interesting result has been the identification of a layer of isotopically ($\delta^{18}O$) less negative ice beneath the white ice, previously shown to be of Pleistocene age, near the base of the ice cap. This ice is also white (due to a high bubble content), but it contains morainal material, in contrast to the isotopically more negative white ice. The less negative isotopic composition of this dirty white ice is interpreted as indicating that the ice was once at the pressure melting point, and that water produced during sliding was lost either to groundwater or to a subglacial stream system. Isotopic analyses were done by H.B. Clausen at the Geophysical Isotope Laboratory in Copenhagen.

COLD REGIONS RESEARCH AND ENGINEERING LABORATORY U.S. ARMY CORPS OF ENGINEERS

Hanover, New Hampshire, U.S.A.

The Cold Regions Research and Engineering Laboratory (CRREL) of the U.S. Army Corps of Engineers is the primary U.S. laboratory concerned with studying the characteristics of cold regions. CRREL conducts both basic and applied research in the many fields of cold regions science and technology and makes the results available to other organizations throughout the world. CRREL's basic research includes investigations of the properties of snow, ice and frozen ground, as well as climatological and ecological studies. Its applied research seeks to find the solutions to construction, transportation and other problems encountered in both the Arctic and Antarctic as well as in more temperate cold regions.

CRREL was created in 1961 by combining two existing Corps of Engineers organizations: the Arctic Construction and Frost Effects Laboratory and the Snow, Ice and Permafrost Research Establishment. Between them the two labs brought together at CRREL a group of research personnel with expertise in virtually all major aspects of cold regions science and technology.

As a result, the CRREL staff is quite diverse, with specialists from many different backgrounds. The total staff numbers about 300, including more than 100 research scientists and engineers. These researchers include civil, hydraulic, electrical, chemical and mechanical engineers, and agronomists, biologists, chemists, geographers, geologists geophysicists, glaciologists, meteorologists, physicists and soil scientists. In addition, scientists and engineers from other institutions often pursue long-term research projects at the laboratory.

CRREL's main research facilities are located in Hanover, New Hampshire, about 1-1½ miles north of Dartmouth College. The main laboratory building contains 24 coldroom laboratories, many capable of achieving temperatures of -30°C or below. Along with the cold laboratories are chemistry, physics, and electronics labs with highly specialized equipment for research at below-freezing temperatures.

In 1978 an Ice Engineering Facility was completed that is used for studying the problems caused by ice in waterways. It contains a large refrigerated area in which rivers, harbours and lakes can be modelled, a tilting refrigerated flume for frazil and ice jam research, and a large test basin in which ice force problems can be studied under carefully scaled conditions.

A Frost Effects Research Facility, to be completed in 1983, will be devoted to the study of frost action in soils. This laboratory will contain refrigerated research areas for large-scale testing of pavements, foundations and underground utilities at below-freezing temperatures, and will permit the study of freeze-thaw cycles in a controlled setting.

CRREL also has an Alaskan Projects Office at Fairbanks with a research and support staff that helps CRREL's projects in Alaska and conducts its own investigations. In Fox, Alaska, CRREL excavated and helps to maintain a research tunnel in permafrost, the only facility of its type outside the U.S.S.R.

CRREL RESEARCH

Most of CRREL's projects are conducted by either its Research Division, which pursues most of the basic research for the laboratory, or its Experimental Engineering Division, in which most of the applied studies are performed. Research is also conducted by engineers at the Alaskan Projects Office and in the Technical Services Division, both of which also function in a support role. Technical Services Division personnel have been at the forefront of deep ice core drilling technology in the polar regions (H. Ueda*, D. Garfield, J. Rand).

RESEARCH DIVISION

CRREL'S Research Division is divided into three sections: The Snow and Ice Branch, Earth Sciences Branch, and Geophysical Sciences Branch.

The research conducted by the Snow and Ice Branch is probably the most familiar to International Glaciological Society members. Several personnel from this Branch are engaged in research on the basic properties of snow (S. Colbeck) and of sea ice (W. Weeks), modelling of ice drift in the Arctic Ocean (W. Hibler), and predicting the extent of

Sea ice pressure ridge in Beaufort Sea

ridging and ice pack break-up along the Alaskan coast. Recent sea ice studies have been conducted in the Beaufort Sea (G. Cox) and also in the Weddell Sea (S. Ackley) as part of the Joint U.S.-U.S.S.R. Weddell Polynya Expedition. Freshwater ice covers are also extensively studied (A. Gow), and the results have been applied to problems of winter navigation on inland waterways (G. Ashton). Methods of minimizing ice accretion on aircraft, ship superstructures and communications antennas have been addressed (K. Itagaki), and a current project is seeking to prevent frost accumulation on the Air Force Space Shuttle (M. Ferrick). Prediction of the rate and amount of spring runoff is a topic of continuing interest (S. Colbeck), as have been investigations of atmospheric boundary layers over snow and ice (E. Andreas) and the electromagnetic properties of ground ice and sea ice (S. Arcone). Major contributions are also being made in the area of polar ice core studies (A. Gow, J. Cragin).

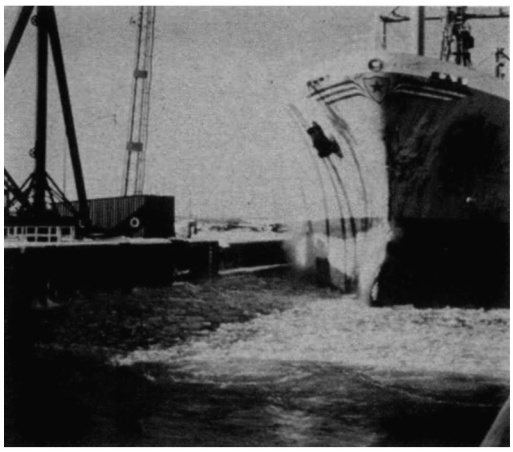
The Earth Sciences Branch's research projects include work on the physical and biological characteristics of cold regions. Of particular concern has been the effect of petroleum exploration activities on the environment in the Far North, particularly in permafrost regions (J. Brown). Also, the climate, soils and biology have been studied to obtain baseline data for comparison with those from disturbed areas (R. Haugen). The potential environmental effects of constructing new reservoirs have been studied (L. Gatto, H.McKim), and the winter regime of existing impoundments is now receiving attention (T. Jenkins, D. Leggett). The chemical and biological processes that occur during the treatment of wastewater (I. Iskandar, A. Palazzo) are another major concern of researchers in this Branch, and a long-term project involves study of the depositional processes of an Alaskan mountain glacier (D. Lawson).

The Geophysical Sciences Branch is primarily interested in the effects of winter weather on electro-optical transmissions through the atmosphere. This research is concerned with the performance of the guidance systems used in modern weapons during heavy snowfall and other adverse weather conditions (G. Aitken).

EXPERIMENTAL ENGINEERING DIVISION

The Experimental Engineering Division has four sections: the Ice Engineering Research Branch, the Applied Research Branch, the Civil Engineering Research Branch, and the Geotechnical Research Branch.

The Ice Engineering Research Branch was formed soon after completion of CRREL's Ice Engineering Facility in 1978. Since then two large-scale refrigerated models have been constructed to study (1) the optimum orientation and design of an ice control structure for Port Huron, Michigan (D. Sodhi) and (2) ice jamming phenomena on a small river in Vermont (D. Calkins). Several techniques have been developed for ice control at locks used



High flow screen (foreground) preventing ice from entering lock

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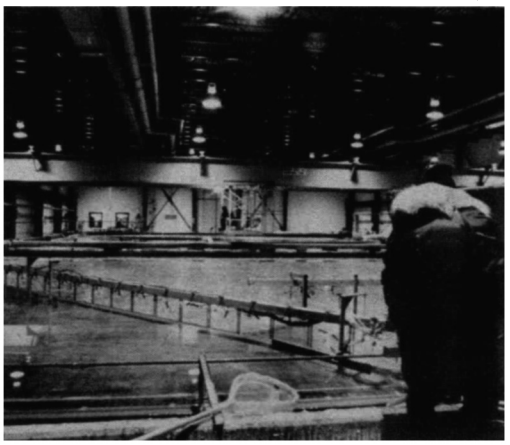
*Names provide a point of initial contact for more information on specific subjects.

for winter navigation (B.Hanamoto, G.Frankenstein); in particular, two types of air bubbler systems - a low flow system to melt the ice cover, and a high flow "air screen" to prevent ice from entering the locks - are now in operation at several locations. Processes for frazil ice control have been studied in the refrigerated flume (S. Daly), while icebreaker research and simulation of the dynamic ice forces have been conducted in the large refrigerated test basin (F. Haynes).



Test basin in Ice Engineering Facility

Methods for minimizing damage from ice jams (S. DenHartog) and for ice control in navigational channels (R. Perham) and at power dams (A. Dean) are ongoing concerns.

In the Applied Research Branch, mobility in snow (R.Liston, G.Abele) has been extensively studied, particularly through the use of CRREL's instrumented test vehicle (W. Harrison, G. Blaisdell). Ice and snow control methods are another topic of continuing interest (D. Minsk), and a relatively new program is analyzing the use of military land mines in cold regions (D. Farrell, P. Richmond). Heat transmission systems (G. Phetteplace) and problems with heat transfer in areas with cold climates (V. Lunardini) are also being studied and applied to engineering problems. The engineering properties of frozen ground (E. Chamberlain, J. Stubstad) and ice and snow (D. Cole), particularly in regard to arctic facilities (A. Kovacs) are other important study areas.

The Civil Engineering Research Branch has been concerned with two major topics - the treatment of wastewater in cold regions (S. Reed, J. Martel), and prevention of winter damage to roads (T. Johnson) and buildings (W. Tobiasson). Infrared techniques for detecting moisture in roof insulation (C. Korhonen), developing snow load criteria for new construction, and improving the energy-efficiency of existing structures (S. Flanders, R. Munis) have been some of the concerns of the engineers in this Branch.

Much of the work in the Geotechnical Research Branch concerns research on frozen ground. CRREL's large soils laboratory is part of this Branch, and examination of frost heaving processes have received considerable attention (K. O'Neill). Applications of this research have been the development of designs for pipelines (W. Quinn), foundations (F. Crory), and roads and airfields in seasonal frost and permafrost regions (R. Berg). Geophysical methods for site analysis (P. Sellmann), site revegetation after construction projects (D. Gaskin), and the placement and repair of asphalt concrete (R. Eaton) have been other research topics.

An excellent source for information about cold regions science and technology is M. Mellor, who has worked in a variety of specialties in this field.

TECHNICAL INFORMATION

CRREL publishes approximately 100 technical reports, engineering technical letters and draft translations each year, along with a general interest newsletter. All CRREL publications can be obtained from the National Technical Information Service, Springfield, Virginia, 22151. Most are also available directly for the CRREL Publications Office.

The CRREL library contains one of the world's largest collections of material on cold regions science and technology, with approximately 30,000 "hard copy" books and articles, and 100,000 publications on microfiche from CRREL's international Bibliography on Cold Regions Science and Technology. Publications accessioned in the Bibliography are also available at the Library of Congress and through on-line search offered by the Systems Development Corporation, Santa Monica, California 90406.

A joint graduate program with Dartmouth College's Thayer School of Engineering leading to advanced degrees in Cold Regions Science and Engineering is also being conducted. Several CRREL staff members (S. Ackley, S. Colbeck, V. Lunardini, W. Weeks) serve as Adjunct Faculty in conducting this program, primarily in conjunction with the newly instituted Ice Research Laboratory at Dartmouth's Thayer School.

CRREL hosted the International Symposium on Ground Freezing in June and will, of course, be hosting the Second Symposium on Applied Glaciology in August. For general information about the laboratory, contact CRREL's Public Affairs Office at the following address:

USA CRREL,
72 Lyme Road,
Hanover,
New Hampshire 03755, U.S.A.

Telephone: 603-643-3200
(FTS 834-3200)

Ed Wright

SYMPOSIUM ON

ICE AND CLIMATE

MODELLING

SECOND CIRCULAR

Northwestern University,
Evanston, Illinois, USA.
27 June - 1 July 1983

Co-sponsored by American
Meteorological Society

General information about the Symposium may be obtained from:
The Secretary General,
International Glaciological Society,
Lensfield Road, Cambridge CB2 1ER,
England. Tel: Cambridge 355974.

Detailed information about arrangements in Evanston may be obtained from:
Johannes Weertman,
Department of Materials Science
and Engineering,
Northwestern University,
Evanston, IL 60201, USA.

The Society will hold an interdisciplinary Symposium on Ice and Climate Modelling, at Northwestern University, Evanston,Illinois, USA, in 1983. Registration will take place on Sunday 26 June and sessions will be from Monday 27 June to Friday 1 July.

1. PARTICIPATION

This circular includes a booking form for registration and accommodation. The form should be sent to the address given below before 1 March 1983 with the appropriate deposits, as indicated. (Registration fees cover organization costs, distribution of preprints of summaries to participants, and the Banquet.) Payments should be made in £ sterling or US$

- by sterling cheque payable to: International Glaciological Society Symposium and sent to the Secretary General at the Society's address;
- by sterling Bank transfer to: International Glaciological Society, Account No.54775302, and sent to the National Westminster Bank Ltd., 56, St. Andrew's Street, Cambridge CB2 1ER, England; or, for people resident in USA,
- by US$ check payable to: IGS 1983 Symposium, and sent to: W.F.Weeks, CRREL, 72 Lyme Road,Hanover, NH 03755, USA.

Registration Fees:

Participants.....	£68.00	US$120.00
Accompanying persons aged 18 or over.....	£17.00	US$ 30.00

LAST DATE FOR REGISTRATION BOOKINGS:
1 MARCH 1983

2. TOPICS

The Symposium will be concerned with the following topics:

1. Ice data for the present climate: continental and marine ice sheets, sea ice and snow cover.
2. Modelling of the present climate:
   a) atmospheric climate models, e.g. global climate models, energy balance models,
   b) oceanic climatic models,
   c) ice models,
   d) coupled atmospheric, oceanic and ice models.

3. Ice and climate data for the Pleistocene and the Holocene:
   a) reconstructions of the 18k bp climate and climate episodes in the Holocene,
   b) ice volume, ocean temperature time and series reconstructions.
4. Climate modelling of the Pleistocene and the Holocene:
   a) snapshot or episodic modelling, e.g. 18k bp or the Climate Optimum,
   b) time series modelling of ice volume, temperature, etc.

3. PROGRAMME

A detailed programme will be given in the Third Circular. On Sunday evening 26 June there will be an informal party; and on Thursday 30 June the Banquet will be held. Various local tours will be available for those interested and may be booked with a local travel agent when registering on Sunday 26 June.

4. ACCOMMODATION

Accommodation, meals and meetings will be at Northwestern University. Price per night will be as follows: for air-conditioned single occupancy rooms at a density of four rooms to bath...$25.00. This price does not include any food. A deposit of £28.00, or $50.00 for people resident in USA, must be paid when booking University accommodation. This deposit is returnable if notice of cancellation is received before 1 May 1983. There are some hotels nearby,charging about $45.00 for a single room and $52.00 for a double room. A list of these hotels may be obtained from J.Weertman (see address on page 2). Please make your own reservations if you wish to stay at an hotel.

5. PAPERS

(i) *Submission of Papers* Those participants who would like to contribute to the symposium should first submit a summary of their proposed paper in English; this summary should contain sufficient detail to enable the Papers Committee to form a judgement on the likely merit of the proposed paper, but should not exceed three pages of typescript. Summaries must be submitted on paper of international size A4 (210 x 297mm) with wide margins and double spaced lines. Summaries should be sent to: Secretary General, International Glaciological Society, Lensfield Road, Cambridge CB2 1ER, England.

LAST DATE FOR SUBMISSION OF SUMMARIES
1 OCTOBER 1982

(ii) *Selection of Papers*

Each summary will be assessed by the members of the Papers Committee, acting independently of each other, taking into account technical quality, relevance to the theme of the symposium and inter-disciplinary appeal. The Papers Committee will then invite a strictly limited number of papers for presentation, allowing time for inter-disciplinary discussion of broad issues and future co-operative modelling. The Committee will not necessarily confine the invitations to authors who have submitted summaries. It is hoped to notify authors of papers during January 1983.

(iii) *Distribution of Summaries*

The summaries of the accepted papers will be sent before the symposium by surface mail to all participants who have registered in good time.

(iv) *Submission of Final Papers and Publication*

The Proceedings will be published in the *Annals of Glaciology* by the International Glaciological Society. Papers presented at the symposium will be considered for publication elsewhere. Final typescripts of these papers should be submitted to the Secretary General, International Glaciological Society, Lensfield Road, Cambridge CB2 1ER, England, by 21 April 1983. They should be written in English and prepared in accordance with the instructions that will be sent to authors when they are notified about acceptance of papers for the symposium. The maximum length for papers will be 6000 words or the equivalent length including any illustrations. Papers longer than this and late papers will be excluded from the Proceedings Volume. The papers will be refereed and edited according to the usual standards of the Society before being accepted for publication. Speedy publication of the proceedings will depend upon strict adherence to deadlines by authors, referees and editors.

LAST DATE FOR SUBMISSION OF FINAL PAPERS:
21 APRIL 1983

6. SOCIAL EVENTS

(i) ICEBREAKER

On the evening of Sunday 26 June there will be an Icebreaker party.

(ii) BANQUET
The Banquet will be held on Thursday 30 June. In addition to being the main social event of the Symposium, it will also be the Annual Banquet of the International Glaciological Society.

(iii) TOUR 2 - 3 JULY
We hope to arrange a visit to the University of Wisconsin in Madison, travelling by bus on Saturday morning 2 July, staying overnight in Madison and returning to O'Hare Airport the next day. In Madison arrangements for our visit will be made by C.R.Bentley, head of the Geophysical and Polar Center. If you are interested in obtaining further information please write to the Secretary General of the Society before 1 October 1982.

METHODS OF MAKING PAYMENT

By cheque payable to: International Glaciological Society, and sent to: Secretary General, International Glaciological Society, Account No. 54775302*, and sent to National Westminster Bank Ltd., 56 St.Andrew's Street, Cambridge, CB2 3DA, England.

* Note: it is important to include your account number in your instructions to your bank, because the Society has several accounts at this address.

For people resident in the USA, by check to: W.F. Weeks, IGS 1983 Symposium, c/o CRREL, 72 Lyme Road, Hanover, New Hampshire 03755, USA.

DATES TO REMEMBER

1 October 1982 - last date for submission of summaries for consideration.
1 March 1983 - Last date for reservations: registration, accommodation.
21 April 1983 - Last date for submission of final versions of accepted papers, for consideration for publication in the Proceedings.

Registration, Accommodation
SYMPOSIUM ON ICE AND CLIMATE MODELLING
27 June-1 July 1983,Northwestern University, Evanston, Illinois, USA.

Mail to: Secretary General, International Glaciological Society, Cambridge CB2 1ER,England - BEFORE 1 March 1983.
See opposite for methods of making payment.

A REGISTRATION (please type in black ink)
Name of participant:
.....
(family name) (initials)
Address.....
.....
.....
Accompanied by(indicate age if under 18)

Name.....
Name.....

I send registration fee/s as follows:
(i) Participants.....
(£68/US$ 120 each) £...../$.....
(ii) Accompanying persons:
(£17/US$ 30 each) £...../$.....
(There is no registration fee for accompanying persons under the age of 18.)

TOTAL REGISTRATION FEE/S = £...../$.....

B ACCOMMODATION

Please reserve the following accommodation for the nights of 26 June-1 July 1983,for which I enclose a deposit of £28/US$50 per person.
*University dorm: number of persons.....
Dates.....through.....
or
*I prefer to make my own reservations elsewhere.
* delete as appropriate

TOTAL DEPOSITS FOR UNIVERSITY ACCOMMODATION FOR.....PERSON/S = £...../US$.....

C TOUR 2 - 3 JULY

Please reserve.....places on the tour, for which I enclose a deposit of £14/US$25 per person.
TOTAL DEPOSITS FOR TOUR = £...../US$.....

TOTAL PAYMENT (sections A,B,C)
Sent by cheque/Bank transfer,to Cambridge/Hanover - £.....US$.....

SYMPOSIUM ON
SNOW AND ICE PROCESSES AT THE EARTH'S SURFACE

FIRST CIRCULAR

Sapporo, Japan

2-7 September 1984

Co-sponsored by the Japanese Society for
Snow and Ice
with a meeting in Tokyo
1 September 1984

The Society will hold a symposium on Snow and ice processes at the Earth's surface, in Sapporo, Japan in 1984. The Japanese Society for Snow and Ice are co-sponsors of the event. Registration will take place on Sunday 2 September and sessions will be from Monday 3 to Friday 7 September. There will be a meeting with the Japanese Society for Snow and Ice in Tokyo on Saturday 1 September.

TOPICS

The symposium will be concerned with the following topics:

1. Mass and heat exchange at the snow/ice surface.

2. Physical and chemical processes associated with snow and ice (snow metamorphism, snow/ice accretion, drifting snow, ground freezing, etc).

3 Behaviour of airborne snow (blowing snow, avalanching, fluidization).

5. Sea ice drift and its effects.

PAPERS

The Papers Committee will be happy to consider any paper on the above topics.
Details about the summaries and final papers will be given in the Second Circular, to be published in the summer of 1983. Dates for submissions are firm ones and must be adhered to. The Committee may decide to invite review papers on some of the topics if submitted contributions do not give sufficient coverage.

PUBLICATION

The Proceedings of the symposium will be published by the Society in the *Annals of Glaciology*. Papers will be refereed according to the Society's usual standards before being accepted for publication.

ORGANIZATION

The main organization is undertaken at the Society's Headquarters office in Cambridge, England, while the local organization will be effected by members in Japan. The Society's Annual Dinner will be held during the week. We hope to arrange a package tour from Europe to Japan, with optional tours after the symposium. It may be possible to arrange a study tour of glaciological research stations in China, limited to 30 persons.

FURTHER INFORMATION

You are invited to attend the symposium and to return the attached form as soon as possible. The Second Circular will give information about accommodation, general programme, preparation of summaries and final papers. Requests for copies of the Second Circular should be addressed to the Secretary General, International Glaciological Society, Lensfield Road, Cambridge CB2 1ER, England.
Note: Members of the International Glaciological Society will automatically receive a copy.

ORGANIZING COMMITTEE

K. Kusunoki
S. Kinosita
A. Higashi
K. Higuchi
H. Richardson
T. Kawakami (J.S.S.I.)
G. Wakahama

INTERNATIONAL GLACIOLOGICAL SOCIETY
SYMPOSIUM ON SNOW AND ICE PROCESSES AT THE EARTH'S SURFACE, 1984

Family Name.....

First Name.....

Address.....

.....

* I hope to participate in the symposium in 1984 [ ]
* I expect to submit a summary of a proposed paper on topic no..... [ ]
* I am interested in the package tour arrangements from Europe [ ]
* I am interested in a post-symposium study tour to China [ ]

* *without obligation.*

TO BE SENT AS SOON AS POSSIBLE TO:
Secretary General, International Glaciological Society, Cambridge CB2 1ER, England.

FUTURE MEETINGS (of other organizations)

INTERNATIONAL SNOW SCIENCE WORKSHOP

21-23 October 1982, Montana State University, Bozeman, Montana, U.S.A.

This Workshop is being held to provide an opportunity for the exchange of ideas between those involved in the study of the theoretical, professional and recreational aspects of snow. It will consist of two days of discussion, a banquet Friday evening, with Dr E. R. LaChapelle as guest speaker, and a field trip to the Bridger Bowl Ski area on Saturday.

Topics:

The Workshop will address the following topics:

1. Snow metamorphism and classification
2. Avalanche control and prediction
3. Wind blown snow, creep and glide
4. Avalanche zoning
5. Grooming, packing and snow making
6. Safety and rescue

Presentations:

Those wishing to present a paper or poster session should submit an abstract to the Program Committee, care of John Montagne, by 1 June 1982. Accepted abstracts will be printed, bound and distributed at the start of the meeting. Non participants may purchase them at cost.

Registration:

A registration fee of $30 will be charged to cover workshop costs including the abstract volume. Commercial exhibitors will be charged a fee of $100. Further information about registration and the final program can be obtained from: Prof. John Montagne, Department of Earth Sciences, Montana State University, Bozeman, Montana 59717, U.S.A.

THE SEVENTH INTERNATIONAL CONFERENCE ON PORT AND OCEAN ENGINEERING UNDER ARCTIC CONDITIONS

5-9 April 1983, Helsinki, Finland

The 7th POAC Conference, being organized by Dr P. Jumppanen of the Technical Research Centre of Finland, will be held in Finlandia Hall in the heart of Helsinki.

The programme includes the following topics and will be partly divided into parallel sessions:

- Sea ice properties and conditions in cold regions
- Modelling the interaction between ice and structures
- Coastal and offshore structures and their ice forces
- Marine foundations
- Behaviour of materials and structures in Arctic seas
- Icebreaking technology including model testing
- Technical and economic aspects of navigation in cold regions
- Instrumentation technology and measuring systems in cold regions
- Offshore operations and the environment
- Underwater technology in Arctic seas

Papers:

Authors should submit a title and abstract (two-page limit) before 1 September 1982. Notice of papers selected for presentation will be given by the beginning of October 1982. Final manuscripts must be submitted by 15 January 1983.

Visits and Tours:

A technical visit will be organized to the Wärtsilä Ice Model Basin and to laboratories of the Technical Research Centre of Finland and the Helsinki University of Technology. Post-conference tours will visit northern Finland, including a trip on an icebreaker, and shipyards on the western coast of Finland. The 7th West European Graduate Education Marine Technology School will be held in Helsinki from 21-31 March 1983 on the subject of Ships and Floating Structures in Sea Ice.

Important Dates:

1 September 1982	Abstract deadline
1 October 1982	Notification of acceptance
1 December 1982	Preliminary programme
15 January 1983	Registration, 1200 FIM Final manuscripts
15 February 1983	Late registration, 1500 FIM

Contacts:

All correspondence, abstracts and papers should be addressed to:

Sirpa Suomela
Secretary General POAC 83
Technical Research Centre of Finland
Laboratory of Structural Engineering
Betonimiehenkuja 1
SF-02150 Espoo 15 Finland

GLACIOLOGICAL DIARY

1982

2-5 September
"Aletsch" Excursion and Colloquium, Western Alpine Branch, International Glaciological Society. Brique, Suisse. (W. Good, Weissflujoch, Davos 7260, Switzerland)

21-23 September
International Symposium on Hydrological Research Basins and their Use in Water Resources Planning. Bern, Switzerland. (Dr M. Spreafico, Landeshydrologie, Postfach 2742, CH-3001 Bern, Switzerland)

21-23 October

International Snow Science Workshop. Montana State University, Bozeman, Montana, U.S.A. (Prof. J. Montagne, Dept. of Earth Sciences, Montana State University, Bozeman, Montana 59717, USA)

4-6 November
International Symposium on Hydrological Aspects of Mountainous Watersheds. Roorkee, India. (Organising Secretary, Int. Symp. on Hydrological Aspects of Mountainous Watersheds, School of Hydrology, University of Roorkee, Roorkee 247672, India)

1983

5-9 April
7th International Conference on Port and Ocean Engineering under Arctic Conditions (POAC-83). Finlandia Hall, Helsinki, Finland. (Sirpa Suomela, Secretary General POAC 83, Technical Res. Centre of Finland, Lab. of Structural Engineering, Betonimiehenkuja 1, SF-02150 Espoo 15, Finland)

27th June – 1 July
Symposium on Ice and Climate Modelling. Northwestern University, Evanston, Illinois, U.S.A (Secretary General, International Glaciological Society, Lensfield Road, Cambridge CB2 1ER, U.K.)

18-22 July
Fourth International Conference on Permafrost. University of Alaska, Fairbanks, Alaska, U.S.A. (Louis de Goes, Executive Secretary, Polar Research Board, National Academy of Sciences, 2101 Constitution Avenue N.W., Washington D.C. 20418, U.S.A.)

15-26 August
18th General Assembly of the IUGG. Hamburg, Federal Republic of Germany. (Dr. J.C. Rodda, Secretary General IAHS, Water Data Unit, Reading Bridge House, Reading, RG1 8PS, U.K.)

1984

18-23 August
Snow and Ice Chemistry and the Atmosphere. Trent University, Peterborough, Ontario, Canada. (Dr. R.M. Koerner, Polar Continental Shelf Project, EMR, 880 Wellington Street, Ottawa, Ontario, K1A 0E4, Canada)

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.)

REVIEWS

W.S.B. Paterson. The Physics of Glaciers. 2nd edition, Oxford, etc., Pergamon Press, 1981, 380 p., 91 figures, 23 tables. Paper, £7.25/US$17.50; Cloth £20.00/US$48.00.

The second edition of W.S.B. Paterson's excellent text book is now available. The content of the new edition is more than twice that of the first one. As before, the text is written for graduate students and senior undergraduates. It is a very valuable source of information for any scientist becoming involved in some field of glaciological research. There are more than 500 references to original papers and in addition, comprehensive review papers and proceedings of symposia on the subject are cited at the end of most chapters, as suggestions for "Further Reading". An outstanding feature of this book is

the masterly way in which the physical essence of complex problems is extracted to give a clear, simple and concise picture.

All chapters have been brought up-to-date, and most extensively rewritten. Three new chapters have been added: "Glacier Hydrology", "Structures and fabrics in Glaciers and Ice Sheets" and "Ice Core Studies". The first of these summarizes observations on glacier run-off and on water pressure in bore holes connected with the subglacial drainage system. The main concern then is the mechanics of water flow in ice (not firn). The theory of flow in large englacial channels and its application to jökulhlaups, flow in sheets at the glacier bed and what is known on intergranular flow are outlined. In the chapter on structures and fabrics the various features (foliation, folds, stratification, ogives, etc.) are clearly described and suggested mechanisms for their formation discussed. The second part of this chapter explains methods of measurement of size and orientation of ice crystals and describes the effect of deformation on ice fabrics in laboratory experiments as compared to observations on cores from glaciers and ice sheets. In "Ice Core Studies" the fundamentals of isotope methods are explained. The possibilities and problems of ice dating and climatic interpretations are outlined as well as the use of flow models for certain age determinations. A large amount of data and interpretation is presented and discussed.

The book deals comprehensively with the various aspects of the physics of glaciers and ice sheets; naturally though, some subjects have received more attention than others. The processes of erosion and deposition are not specifically treated in this book, probably because this is covered in other text books. References to research carried out in the Alps appear somewhat less comprehensive than those from English speaking countries. On the whole, however, the versatility of the documentation is impressive.

In order to keep the new edition at a still very modest price the original clear type script has been reproduced and reduced to the page format 227 mm x 143 mm. Although the printing obtained in this way is smaller and less easy to read than that of the first edition, this method was the best choice with respect to both cost and speed of publishing.

Almut Iken

Stephan Hastenrath. The Glaciation of the Ecuadorian Andes. A.A. Balkema, Rotterdam, 1980, 180 p., £10.00

Fluctuations in the volume and extent of glacier systems have increasingly received attention from international organizations interested in monitoring and understanding climatic change (e.g. UNESCO, World Meteorological Organization, International Association of Hydrological Sciences). Thus any assessment of short and long term glacier behaviour from regions where glaciers may be particularly responsive to variations in climatic parameters is to be greatly welcomed. The Andes of Ecuador are among three regions of the world where glaciers still exist close to the Equator and since some data are now available from New Guinea and East Africa, the author of this book considered it "timely to reassess the glaciation of the Ecuadorian Andes". Hastenrath's main aims in writing the book were to assemble an inventory of the current ice extent, to reconstruct glacier variations of the past few centuries, and to infer glacial-climatic events in the more distant geological past. To achieve these aims the author undertook fieldwork between 1974 and 1978, combined field observations with air photograph interpretation, researched literature and historical data from journals, sketches and photographs and interviewed mountaineers familiar with remote and lesser-known parts.

All of the resulting information is set out in eight chapters, the first of which is introductory, reviewing literature on the glacial history of Ecuador. The next two deal with physiographic structure and atmospheric circulation and climate respectively. I found the former disappointingly short at one and a half pages and very generalised, particularly since more detailed information on Quaternary volcanic activity would have been a most valuable and relevant contribution. In contrast the atmospheric chapter contains very detailed meteorological data on Ecuador; unfortunately they are not helpfully used at this point to aid an assessment of the distribution and general characteristics of existing ice masses. This omission is partly explained (but not necessarily excusable!) in Chapter 4 on the Western Cordillera in which "Fossil evidence of former glaciations is reviewed jointly with the present ice extent, because glacier systems are viewed as temporally continuous entities". Chapters 4 and 5 are the main meat of the book, providing details of morainic deposits on most presently and formerly glacier-covered massifs of the Western and Eastern Cordillera. The text here is very well complemented by sketches, maps and photographs.

Chapter 6 on Older Glaciations, just over a page in length, mainly summarises statements made in previous literature about glacial phenomena at remarkably low altitudes, e.g. down to 800 m in the Cuenca region. It would have been interesting if Hastenrath had critically considered the possibility that some supposed glacial traces were deposits resulting from debris flows, debris avalanches, volcanic mudflows, etc. Less than one page forms Chapter 7 on "Subnival Soil Forms": needle ice, fine earth stripes and polygons, stone polygons and stripe patterns are mentioned and the surprising paucity of patterned ground is ascribed to the abundance of

volcanic ashes unsuited to its development.

Chapter 8 presents the conclusions, among the most interesting of which are: the lower ice equilibrium limit in the western compared with the eastern cordillera; the greater ice extent in the eastern and parts of the southern sectors of individual mountains; an explanation that such asymmetry is due to the pattern of moisture supply, the dominant source being from the Amazon basin; that similar asymmetry of glacier extent is noted also in the relict moraines of the Wisconsin and Neoglacial periods; the summary of glacial history, which is given on p. 67 as "An early glaciation extended down to around 3500 m and lower, possibly at some time after 25,000 B.P., and retreated in several phases. This glacial event was followed by the deposition of thick layers of volcanic ash. Subsequently, glaciers advanced again down to around 4200 m. Ice retreat from these moraines may have begun a few 100 years ago, but around the middle of the 19th century at the latest. Recession, with indications of intermediate halts, has continued to the present".

The main text ends on p.69 but is followed by a further 90 pages containing maps (pp.70-87), Appendix I, giving a list of topographic maps, air photographs and satellite imagery (pp.89-93), Appendix II quoting historical sources (pp.95-117), Appendix III listing data supplied to the world glacier inventory (pp.119-124), Appendix IV presenting an article by T. Van der Hammen on "The Pleistocene changes of vegetation and climate in the northern Andes" (pp.125-145), references (pp.147-153) and an author index.

This book is a useful collection of information for enthusiasts on South America, the Andes and glacial history. It certainly draws attention to the sad lack of knowledge about glaciation in Ecuador and provides helpful pointers to particular localities that may be fruitful for detailed investigation.

Chalmers M. Clapperton

NEWS

NEW HEAD OF OCEANS AND ICE BRANCH OF GLAS

D.B. Rao has been named Head of the Oceans and Ice Branch at the Goddard Laboratory for Atmospheric Sciences (GLAS). The Branch is involved in basic and applied research on oceanic and cryospheric processes and their interactions with weather and climate with particular emphasis on remote sensing. Current work includes modelling of upper ocean dynamics, studies on coastal processes, ocean wave properties, sea ice and ice sheet models, and the development of oceanic and cryospheric data bases.

NATIONAL CENTRE FOR U.S. SNOW AND ICE DATA

A U.S. counterpart to the existing World Data Center-A for Glaciology has been established by the National Oceanic and Atmospheric Administration (NOAA) in Boulder, Colorado. It will be operated by the University of Colorado through the NOAA-University Cooperative Institute for Research in Environmental Sciences and directed by Dr Roger G. Barry.

It will provide services and guidance on data related matters, especially the development of standard procedures and formats for snow and ice data sets. It will also work to ensure that appropriate data management plans accompany the development of new observational systems and programs and that important historical data are preserved.

The centre's files include historical glacier photos of western North America; data from ice cores and echo sounding of ice sheets; charts, data, and satellite imagery on snow cover and sea ice conditions; information on Great Lakes ice conditions, and a major reference collection of published reports on all forms of snow and ice occurrence, properties, processes and their effects.

The mailing address is the same as the WDC-A:
NSIDC/WDC-A for Glaciology,
CIRES, Box 449,
University of Colorado,
Boulder,
Colorado 80309 U.S.A.

CANADIAN SNOW AND ICE DIVISION TO MOVE TO SASKATOON

The Canadian Government has announced that the National Hydrology Research Institute, of which the Snow and Ice Division is a part, will be relocated to Saskatoon within three years. A special building to house the Institute will be built in a research park adjoining the University of Saskatchewan campus. At present, the 10-member Division is scattered across the country in Hull, Ottawa, Calgary and Canmore.

CANADIAN AVALANCHE ASSOCIATION

In December 1981 a Canadian Avalanche Association was incorporated in the Province of British Columbia. The purposes of this association are as follows:

a) To represent persons who are professionally engaged in avalanche work in Canada.
b) To establish and maintain high standards of professional competence and ethics for persons engaged in avalanche safety programs.
c) To exchange technical information and to maintain communications between persons engaged in avalanche safety programs.
d) To establish and maintain standards of education in avalanche safety.
e) To organize training courses in all aspects of avalanche hazard control for professionals.
f) To promote and to act as a resource base for public awareness programs about avalanche hazards and safety measures.
g) To promote research and development in avalanche safety.

Active membership is available, on approval of the membership committee, only to those gainfully employed in avalanche-related activities in Canada on a full-time basis. A corporation or association is eligible for associate membership if involved in an avalanche-related activity or avalanche education on a part-time basis.

Further information on the Association may be obtained from its President:
Peter Schaerer
National Research Council
3904 West 4th Avenue
Vancouver, B.C.
V6R 1P5 Canada

AMS COMMITTEE ON POLAR METEOROLOGY

A new American Meteorological Society Committee on Polar Meteorology has been established by the AMS Council. The chairman of the Committee is Dr Gunter E. Weller of the Geophysical Institute, University of Alaska, and other members are S.F. Ackley, D.J. Baker, Jr., F.G. Carsey, G.F. Herman, A.W. Hogan, J. M.Mitchell, Jr., R.O. Ramseier and J.E. Walsh.

ATLAS OF THE SEASAT SYNTHETIC-APERTURE RADAR IMAGES OF OCEANS AND SEA ICE

The synthetic-aperture radar (SAR) on board SEASAT was an L band imaging radar that produced many images of the earth's surface with a resolution of 25 x 25 m. To introduce the general capabilities of the SEASAT SAR for observing oceans and sea ice, an atlas entitled "SEASAT Views Oceans and Sea Ice with Synthetic-Aperture Radar" has been compiled at the Jet Propulsion Laboratory by Lee-Lueng Fu and Benjamin Holt. Five of the 51 images presented show various types of sea ice, its structural changes and drift motions in the Beaufort Sea area. Most images are presented with supportive illustrations, including observations made concurrently by other sensors on board SEASAT or other satellites, weather maps, bathymetric charts, historical data, or the results of model calculations. The fundamental principles of a SAR and the characteristics of the SEASAT SAR system and its images are briefly described. A catalog of the SAR imagery including areal converage maps, tables of key orbital information, and tables listing digitally processed SAR images are provided. Free copies of the atlas, reference JPL Publication 81-120, can be obtained by writing to Documentation Review, Mail Stop 111-116B, Jet Propulsion Laboratory, 4800 Oak Grove Drive, Pasadena, California 91109.

AWARDS

Prof. Hans Weertman has been elected a Fellow of the American Geophysical Union in recognition of his contributions to the fundamental understanding of ice and rock mechanics.

The Royal Geographical Society has announced that Dr Edward Derbyshire is to receive its Back Award for his contributions to glaciology and geographical research in China.

PUBLICATIONS

THE LIVING ARCTIC

By Fritz Müller and published by Methuen Publications, Toronto, 1981, 233 pp., illus., $35

The Living Arctic is the English edition of Hoher Norden and Le Grand Nord, previously published by Atlantic Verlag, and uses the same magnificent colour plates. It documents Fritz Müller's vision of the Arctic and draws on his years of research in the north from Peary Land to Tuktoyaktuk but particularly on Axel Heiberg Island and around the North Water. Individual chapters deal with the boundaries of the Arctic, its weather and climate, the glaciers, the geology and landforms, the Arctic seas, living conditions, the Inuit, the resources, changing life styles and the history of discovery.

INTERNATIONAL GLACIOLOGICAL SOCIETY

CONFERENCE PROCEEDINGS VOLUMES

The following volumes of proceedings may be obtained from the Secretary General of the International Glaciological Society, Lensfield Road, Cambridge CB2 1ER, England, U.K.

JOURNAL OF GLACIOLOGY

Symposium on Remote Sensing in Glaciology (Cambridge 1974)
Volume 15, Number 73, 1975 ..... £10.00

Symposium on Thermal Regime of Glaciers and Ice Sheets (Burnaby 1975)
Volume 16, Number 74, 1976 ..... £10.00

Symposium on Applied Glaciology (Cambridge 1976)
Volume 19, Number 81, 1977 ..... £20.00

Symposium on Physics and Chemistry of Ice (Cambridge 1977)
Volume 21, Number 85, 1978 ..... £20.00

Symposium on Glacier Beds: the ice-rock interface (Ottawa 1978)
Volume 23, Number 89, 1979 ..... £20.00

Symposium on Dynamics of Large Ice Masses (Ottawa 1978)
Volume 24, Number 90, 1979 ..... £25.00

Symposium on Snow in Motion (Fort Collins, Colorado 1979)
Volume 26, Number 94, 1980 ..... £35.00

ANNALS OF GLACIOLOGY (replacing proceedings series in Journal of Glaciology)
Available to members of the Society at reduced prices.

Symposium on Use of Icebergs: scientific and practical feasibility (Cambridge 1980)
Volume 1, 1980 ..... £15.00

Symposium on Processes of Glacier Erosion and Sedimentation (Geilo, Norway 1980)
Volume 2, 1981 ..... £20.00

Symposium on Antarctic Glaciology (Columbus, Ohio, USA, 1981
Volume 3, 1982 ..... £40.00

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 1982

Private members	Sterling: £20.00
Junior members	Sterling: £10.00
Institutions, Libraries	Sterling: £45.00 for Volume 27 (Nos. 98, 99, 100)

Annals of Glaciology—see inside front cover of this issue of Ice.

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

ICE

Editor: 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 £6.00.

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.

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