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ICE

INTERNATIONAL GLACIOLOGICAL SOCIETY

1978 ANNUAL GENERAL MEETING

This will take place on Thursday 24 August in Ottawa, Canada, during the week of the Society's Symposium on Dynamics of large ice masses.

It will be followed by a Dinner, which is both the Society's Annual Dinner and the Symposium Dinner. Members of the Society not attending the Symposium will be very welcome at the Dinner.

Details about the AGM and the Dinner will be circulated later.

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ICE

NEWS BULLETIN OF THE INTERNATIONAL GLACIOLOGICAL SOCIETY

1st & 2nd ISSUES 1978 NUMBERS 56 & 57

CONTENTS

DOUBLE ISSUE. This double issue of ICE clears the Editor's files of an accumulation of reports and news and is published midway between the normal dates for the 1st and 2nd issues of the year. The Editor will welcome further reports and news for the 3rd issue, which will be published at the end of November. Members will, she hopes, appreciate the fact that savings in postage, wrappers, printing of covers, and clerical time have been made with this double issue — in a year when rising costs threaten to overtake our income.

COVER PICTURE. Regular pattern in the snow cover on sea ice near Mawson, Antarctica. The distance between crests is about 4 m and the prevailing winds blow along the line of crests. The pattern was possibly caused by erosion of snow eddies set up around a discontinuity in 30 m high icecliffs, 200 m upwind. Photograph by Ian Allison, Meteorology Department, University of Melbourne, Parkville, Victoria, Australia 3052.

RECENT WORK

CANADA

GLACIER STUDIES—GENERAL

GLACIER INVENTORY OF CANADA

(C. S. L. Ommanney, GD*)

Twenty-nine basins, mainly in the Columbia River headwaters, were added to the glacier inventory. Areas were measured for glaciers in 8 major basins of the St. Elias inventory. Work continues on the bibliography which now contains over 2 100 entries. Support was provided for a resurvey of the Virginia Glacier, Baffin Island (G. van Cochran). Data on 42 Canadian glaciers were compiled for the Permanent Service on the Fluctuation of Glaciers. Two major glaciers in western Canada, the Illecille-waet and the Columbia, are advancing.

GLACIER STUDIES—ARCTIC

MER DE GLACE AGASSIZ, ELLESMERE ISLAND

(R. M. Koerner, PCSP)

A 337 m core was drilled to bedrock in May. A field-modified 35 mm Minolta camera, mounted below the drill, showed the bedrock to consist of loose, angular rock fragments. A 10 m pit was dug and sampled for O^{18}, micro-particles and chemistry. Borehole diameters (for vertical strain rate measurements) and temperatures were taken and an inclinometer survey (by Eastman Surveys) made. Strain nets were surveyed in and around the borehole site and a series of radio echo-soundings made. When repeated these measurements will yield surface strain rate and, hopefully, absolute surface velocity. Over 3 000 samples have been analysed by the Geophysical Isotope Laboratory, directed by Dr. W. Dansgaard. Though broadly similar to the Devon Island ice cap results the δO^{18} values for the Mer de Glace also show intriguing dissimilarities.

AERIAL PHOTOGRAPHY

(K. C. Arnold, D. A. Sherstone, A. C. D. Terroux, GD)

With PCSP support and a Wild RC-10 aerial camera glacierized areas on Axel Heiberg and Ellesmere islands were photographed in July and August.

AXEL HEIBERG ISLAND

(F. Müller, ETH/MU)

Mass balances were measured on White and Baby glaciers. The 1977 summer was warmer than normal so annual balances were markedly negative with an equilibrium line $>$ 1 200 m a.s.l. Analyses of the 16-year mass balance series (1959/60-1974/75) are ready for publication.

*For abbreviations used see Ice, No. 50, 1976, p. 16.

Surveys of the White and Crusoe snouts and the Thompson push-moraine were made. Automatic and manned weather stations continue to be operated in support of the program.

Thermal drilling on White Glacier, started in 1974, was continued using the same open-system hot water drill. Thermistor strings were drilled to depths of 85-185 m at 4 new sites in the accumulation area and one in the ablation area. There are now 17 deep temperature profile sites along the longitudinal axis.

A study was made of the filling and draining mechanisms and sedimentation of a glacier-dammed lake between White and Thompson glaciers and the effects of the draining on the peri-glacial area observed. The internal drainage of White Glacier was studied by dye injection into moulins.

Large scale stereo orthophoto maps of the Expedition Area glaciers are being made by the Photogrammetric Section of NRC (M. C. van Wijk) in a joint project with ETH/MU, the Technological University of Vienna, the PCSP and the GD. Using black and white, colour and thermal infra-red imagery, and by comparison with the large scale 1959 maps, detailed information on glacier velocities, glacier changes, vegetation, moraines, etc. will be obtained.

MEIGHEN ISLAND ICE CAP

(R. M. Koerner, PCSP)

The 1975-76 mass balance was $+8.3$ g/cm^2, all as superimposed ice, and the winter 1976-77 balance, measured in April, was 8.7 g/cm^2.

DEVON ISLAND ICE CAP

(R. M. Koerner, PCSP)

The mass balance of the NW side was $+17.1$ g/cm^2 for 1975-76 and the winter balance, August 1976 to mid-April 1977, was 11.0 g/cm^2/a. Analysis of the core continues with particular concentration on the lowest 20 m and the setting up of an automated atomic absorption system (with graphite furnace) for determining metallic elements. A close relationship exists between micro-particle concentration and ice crystal size, the particles radically slowing down crystal growth (D. Fisher and R. M. Koerner.) B. Alt continues her study of climate/mass balance relationships on the ice cap.

NORTH WATER

(F. Müller, ETH/MU)

With the data collected in 1977 there is now a fairly high quality 4-year mass balance series for "Laika" Glacier. The 1976-77 balance year was markedly negative though winter accumulation was greater than normal. Data collected

for Leffert Glacier and an unnamed glacier near Cape Hershel are less reliable. Studies are continuing on the Greenland side with 10-15 m cores being taken for analysis of electrical conductivity, ß activity, Pb^{210}, tritium and O^{18}/O^{16}.

BYLOT ISLAND
(R. N. W. DiLabio, W. W. Shilts, R. A. Klassen, GSC)
Till and debris in transport were collected from lateral moraines and associated glaciers on the SW side of Bylot Island. Preliminary results indicate that 1) debris in 4 of the 5 glaciers sampled had differing and distinct trace element chemistry; 2) there are significant vertical compositional changes in debris bands; 3) peat in growth position on a clast of outwash in shear planes over 20 m above the sole of the glacier is modern, 120 C^{14} years old, and 4) more than 99% of the debris in the ice and moraines is derived from Precambrian terrain.

BARNES ICE CAP
(R. LeB. Hooke, GG/UM)
A hole was drilled approximately on the equilibrium line, 8.1 km from the divide, and cores from the hole were studied. Deformation and temperature measurements were obtained from this hole and from two others, 6.1 and 9.75 km from the divide respectively. Most of the deformation occurs in a 10-20 m thick band of bubbly ice of Pleistocene age at the base of the ice cap. The change from extending strain above the equilibrium line to compressive strain below has an observable effect on the fabric.

Fabric studies are underway in a new shaft, about 75 m from the margin in the zone of deformed superimposed ice. The objective of this work is to investigate the progressive change in fabric with increasing strain.

GLACIER STUDIES—YUKON

ALCAN PIPELINE
(G. J. Young, C. S. L. Ommanney, M. Strome, S. G. Collins, GD)
A preliminary study was conducted to assess the influence of glacier-fed streams (primarily the effect of jökulhlaups) on major river crossings along the proposed Alcan pipeline route. The crossings of the White, Donjek and Slims rivers and the area around Haines Junction were defined as potential hazard areas.

KLUANE LAKE RESEARCH STATION
(Arctic Institute of North America)
The Institute's Kluane Lake base is now open year-round. The two projects listed below were assisted.

MOUNT LOGAN
(G. Holdsworth, GD)
A portable triodetic dome was erected on the NW col in preparation for a drilling operation in 1978. Remeasurement of the network of accumulation markers indicated below normal snowfall.

HAZARD GLACIER
(G. K. C. Clarke, GA/UBC)
Ice temperatures were measured in the 3 holes drilled in 1976. Near surface temperatures ranged from −5.0°C to −6.0°C; basal temperature was at the melting point in 2 holes and −2.7°C in the third. As the glacier surges these measurements may relate to the mechanism.

GLACIER STUDIES—CORDILLERA

BERENDON GLACIER
(W. H. Mathews, GEOL/UBC, O. Mokievsky-Zubok, GD)
Using electromagnetic detectors, tuned accumulation markers were relocated, ablation measured and stake movement determined on the South Arm.

MASS BALANCE: WESTERN
(O. Mokievsky-Zubok, GD)
Measurement of winter and summer balances, meteorological variables and the recording of meltwater flow continued on Sentinel and Place glaciers. Mass balance only was determined for Helm Glacier. Specific net balances were −1.33, −1.46 and −1.25 m H_2O respectively.

HYDROCHEMISTRY OF MELTWATER
(O. Mokievsky-Zubok, GD)
In cooperation with the Water Quality Branch (J. L. Zeman) studies continued within the Sentinel Glacier basin to: a) obtain a datum from undisturbed systems at high altitudes for comparison with eco-systems in lower altitudes subject to certain land and water use, and b) establish a regional classification of the hydrochemical characteristics of various glacier meltwaters.

WEDGEMOUNT GLACIER AND LAKE, COAST MTS.
(K. E. Ricker Ltd., W. A. Tupper, BCIT, E. D. Waddington, GA/UBC)
Maps have been produced from the 1949, 1951 and 1973 aerial photography and a styrofoam model of the lake and tongue constructed. The triangulation net has been extended and the terrestrial photogrammetric survey repeated; it indicated a 20 m retreat for 1976-77. The maximum depth in the lower part of Wedgemount Glacier is 150 m, according to the UBC radio echo-sounder.

WATER MANAGEMENT IN REMOTE BASINS
(O. Mokievsky-Zubok, GD)
Studies of the Bridge River headwaters glaciers continued to determine the effect of glaciers on basin runoff and to evaluate seasonal and operational forecast models for a downstream hydro-power reservoir. A climatological station was established and suitable gauging and relay station sites investigated. Bridge, "Sykora" and "Zavisha" glaciers had negative balances of −0.51, −0.51 and −0.26 m H_2O respectively.

YOHO NATIONAL PARK
(G. J. Young, GD)
The hydrology and climatology of several small glazierized catchments were monitored. Aerial photography and thermal infra-red imagery of the Wapta Icefield was obtained in August for new mapping.

GLACIER SURVEYS
(I. A. Reid, J. O. G. Charbonneau, AHD)
The Athabasca and Saskatchewan glaciers were resurveyed by terrestrial photogrammetry. Maps and reports from the previous biennial surveys are in preparation.

COLUMBIA ICEFIELD
During the summer of 1977 a remapping of the Columbia Icefield was undertaken jointly by the GD, AHD, UBC and the Department of Energy, Mines and Resources. Mapping and interpretation of surface features is based on new aerial photography and thermal infra-red imagery. The survey control was established using a helicopter-based inertial survey system. Ice thickness was determined with the UBC radio echo-sounder and snow densities by a portable profiler.

RADIO ECHO-SOUNDING
(G. K. C. Clarke, E. Waddington, D. Jones, B. B. Narod, GA/UBC)
The maximum thickness of the Columbia Icefield, measured with the UBC monopulse radar, was 365 m. Efforts are now being directed at developing a magnetic tape cassette recording system for the sounder to reduce its weight. The present system is portable and has now been tested successfully on several temperate glaciers; for loan or information contact GA/UBC.

PEYTO GLACIER, ALBERTA
(G. J. Young, GD)
Basic monitoring of mass balance, stream flow and local meteorology was continued on Peyto Glacier.

An orthophoto map, stereomate and digital terrain model of the ablation area of the glacier were produced using the Gestalt Photomapper II. Preliminary results indicate this will become a most useful tool for future glacier mapping.

SIMULATION OF GLACIER FLOW
(J. J. Emery, Civil Engineering/MC)
Preliminary studies on ice flow, that emphasized the basal ice-rock interface, are being extended to examine field cases such as the surge of the Barnes Ice Cap and the flow of ice ramps. The finite element method programs are being modified to include temperature, mass balance, basal flow and sliding, and three-dimensional influences.

GLACIAL GEOLOGY

STUDIES BY GSC AND OTHERS
Detailed individual project reports on investigations by GSC scientists are published annually in the *Current Research* series. Summaries of only the most glaciologically relevant projects are given here under their appropriate categories. Information on the work of the following can be made available on request—S. Blachut (N. Ontario), J. J. Clague (BC), A. Dreimanis (till genesis) P. A. Egginton (mud boils), R. O. van Everdingen (Karst), P. F. Karrow (till), B. Luckman (Jasper Park).

SNOW STUDIES

NORTHWATCH
(A. F. Gregory, Gregory Geoscience Ltd.)
Gregory Geoscience Ltd., Ottawa, has completed the third year of NORTHWATCH. Weekly reports monitor and predict snow and ice conditions in the Yukon and N.W.T. The program uses observations of snow line and ice on water bodies from satellite imagery and heating degree-days from meteorological data to predict snow and ice break-up. The recently developed snowmelt model has a general accuracy of ± 2 days for a forecast 3 weeks in advance. Studies are also being carried out on sea ice deformation processes, particularly in the Beaufort Sea and Baffin Bay.

SNOW ACCUMULATION IN SMALL FOREST OPENINGS
(D. L. Golding, R. H. Swanson, N. Forest Res. Centre, DOE)
Results are essentially the same as those reported last year. The greatest snow accumulation occurs in 2H openings (H = mean height of adjacent forest), averaging 45% more than in uncut forest and 13% more than in the largest opening, the 6H. By the time the snow has disappeared from the forest, the 1H has the most snow remaining, about 13% more than in the 2H and 350% more than the 6H. Ablation rates are lowest in 1H openings, being 31% higher in the uncut forest.

SNOWPACK ABLATION DURING CHINOOKS
(D. L. Golding, N. Forest Res. Centre, DOE)
The program described in last year's report continues. From January through March 1976 evaporation was as high as 88 mm H_2O above tree line and 53 mm in forest openings. Maximum daily evaporation was 10 mm above tree line and 5 mm below. At a given elevation, chinook intensity along the foothills was no greater at major mountain gaps than where no gaps existed.

WATER PERCOLATION
(A. Wankiewicz, Hydrology Res. Div.)
The results of field investigations using specially designed tension lysimeters and tensiometers to measure flux and water pressure in snowpacks are being prepared for publication. The experiments show how to interpret measurements of water pressure in snow packs and its relation to liquid water flux. Tests were also done on the penetration speed of meltwater waves into the snow.

SNOW SURVEYS

(H. Loijens, GD)

Gamma-ray techniques are being used to obtain information on snow cover in the Lake Superior basin so as to refine the 6-month prediction of water levels for the Great Lakes.

(W. P. Adams, GEOG/TU)

The program of snowfall and snow cover studies is being continued. Comparative measurements have been made with a Tretyakov snow gauge.

MODELLING

(J. Power, GD)

The sensitivity of the SSARR flood forecasting model to errors in meteorological inputs when simulating snowmelt events has been studied. Flow simulations during spring snowmelt are quite strongly affected by errors in the temperature input and to a much lesser degree by errors in the precipitation input. The St. John River basin is being used to test the historical simulation accuracy of the SSARR model compared to that of the National Weather Service model.

AVALANCHES

(R. Perla, GD)

The Snow Physics Section (GD) established an office and laboratory on the east slope of the Rockies at Canmore, Alberta, a location that provides convenient access to field sites, with support from the University of Calgary. Cold laboratories and observations plots were maintained in Banff National Park, in cooperation with Parks Canada, at Rogers Pass, in cooperation with DBR, and at Whistler Mt., in cooperation with Garibaldi Ski Lifts Ltd. Principal studies include the mechanism of shear failure of snow and of avalanche release (with D. M. McClung, GD), physics of snow creep and glide (D. M. McClung), the impact force of snow (with P. A. Schaerer, DBR) and the physics of skiing (with B. Glenne, University of Utah).

(A. A. Salway, DBR)

Work continues of the development of more sophisticated time series models for avalanche hazard evaluation using data from the Rogers Pass and Fidelity Mt. observatories for 1965-76. Several new approaches are under investigation involving different combinations of meteorological and snowpack structure variables.

(P. A. Schaerer, DBR)

In the winter of 1976-77 three avalanche events at Tupper I (Rogers Pass) were monitored by load cell and geophones. Two events produced pressure and seismic records from which reliable estimates could be made of the speed of avalanches, impact pressure on a loading surface of 650 mm^2 and flow heights. Observations continue on the amount of snow contained in avalanches at Rogers Pass.

(B. H. Luckman, GEOG/Western Ontario)

Measurements of debris accumulation and erosion by snow avalanches on 7 scree slopes in Surprise Valley, Jasper National Park (52°47'N, 117°37'W) were carried out for the ninth consecutive year and continue to show great year to year and site to site variability. Mean annual debris accumulation values average 0-5 mm/a over the 9-year period.

FLOATING ICE—SEA

REMOTE SENSING

(D. G. Lindsay, PCSP)

The systematic series of airborne sea ice reconnaissance surveys conducted by the PCSP from April through October, 1977, marked the 17th consecutive year of this program. Observations of the sea ice conditions in the channels of the Arctic Archipelago between Alert and Tuktoyaktuk and from Baffin Bay to the Arctic Ocean were made 8 times during the season. The majority of surveys were concentrated in Parry Channel and the Queen Elizabeth Islands. Compared to previous years, the 1977 results were good because of the generally fine weather. The *Sea Ice Atlas of Arctic Canada 1969-1974* was completed and, like its predecessor (1961-1969), is available from the Canada Map Office.

(F. Müller, ETH/MU)

LANDSAT images are being used to analyse the 1972-75 sea ice cover which will be plotted on a computerized base map. Ice thickness and shore ice observations were made at Coburg Island and near Cape Hershel. Emphasis is now on analysis of field data from Kane Basin (1973-75) and Jones Sound (1976). Five automatic OTT weather stations operated during the winter 1976-77 and a good data recovery rate was achieved.

(NORCOR, Yellowknife)

Over 40 000 line km of 70 mm colour transparencies of sea ice were obtained from flights in the Parry Channel—Queen Elizabeth Islands area. This imagery has been analysed according to ice type, pressure ridges, concentration and floe size. A detailed comparison is currently underway evaluating High Arctic marine shipping routes using low level imagery, visual mapping and LANDSAT mosaics. Monthly mean statistics of ice conditions along 47 potential shipping legs from the Gulf of St. Lawrence to the Sverdrup Basin for 15 years have been combined using a variety of sources and LANDSAT imagery. Access to some 10 000 seismic data points provided an excellent statistical base for multi-year ice thickness probabilities within the Sverdrup Basin.

(R. D. Worsfold, C-CORE/MUN)

The Remote Sensing Group at C-CORE has been working on remote sensing of Forteau Bay and Cartwright, thermal infra-red studies over the Grand Banks, time lapse photography of ice movement, synthetic aperture radar applied to sea ice and icebergs, and other ocean-related satellite applications.

(Moira Dunbar, DREO)
A report on the SLAR imagery collected during the joint Canadian/British ice-profiling exercise carried out in the Arctic Ocean in 1976 has been completed and is in press. Processing and analysis of the profiles is well advanced at the Scott Polar Research Institute and interim reports have been produced.
(R. O. Ramseier, SURSAT Project Office, EMR)
Planning for Canadian participation in the SEASAT-A experiment is proceeding following government approval and the establishment of a special office. Interest will focus on the Labrador Sea/Grand Banks area and the shear zone of the Beaufort Sea.

ICE DRIFT IN ROBESON CHANNEL
(Moira Dunbar, DREO)
The drift data acquired in 1972-74 are now being analysed at DREO and will be published in 1978.

REGIONAL STUDIES
(NORCOR, Yellowknife)
In a field study of a large, grounded, multi-year ice pile-up off Cornwall Island the following parameters have been measured—tide, meteorological, current, water salinity and ice movement.
(J. R. Marko, IOS)
Results of a study of rectilinear leads and internal motions in the ice pack of the western Arctic Ocean have been published in the *Journal of Geophysical Research*, 1977, Vol. 82, 979-987.

RESEARCH
(A. J. Allan, C-CORE/MUN)
The Sea Ice Group at C-CORE has been working on the following—structural damage due to grounding ice ridges (Strait of Belle Isle), thermal strain of fast ice (NE Newfoundland), wave induced fracture of ice (NE Newfoundland and Strait of Belle Isle), impulse radar estimates of thickness and brine volume of sea ice), (NE Newfoundland), ice movement prediction (Hazen Strait), artificial ice platform creep (Melville Island), Operation Early Probe (ice samples and observations in Baffin Bay and Lancaster Sound), and tidal action of fast ice against a dock (Strathcona Sound, Baffin Island).

The Centre is working on the development and improvement of continuously reading strain instruments, a medium range telemetry system for use in sea ice work, and is investigating the efficiencies of various types of storage batteries at low temperatures. Various foams are being examined for their ability to prevent freezing. Analysis is underway into the crystal structure of ice formed under turbulent conditions.
(N. K. Sinha, DBR)
Preliminary crystallographic studies on sea ice structure as a function of depth were made on a limited number of cores obtained from Strathcona Sound in the winter of 1975-76.
(R. Tinawi, Ecole Polytechnique, Montreal)
Studies are underway on the long-term bearing capacity of sea ice.
(D. J. McEachern, Imperial Oil Production Research, Calgary)
Work by Imperial Oil scientists continued on large scale indentation tests (up to a 2 m indentor penetrating a 60 cm thick ice sheet a distance of 3 m). This work refined estimates of the most probable maximum force to be exerted on an artificial island.

As a complementary program, *in situ* ice stress transducers were installed around two of Imperial's artificial islands. Extensive observations of the accumulated ice rubble fields in the vicinity of the islands were made.

The interaction of multi-year ridges and a section of a caisson-retained island were modelled in the Imperial Oil Test Facility. The ridges were modelled as ice beams with a rectangular cross section frozen into a surrounding ice sheet.

The behaviour of oil amongst ice floes was simulated in a cold room. The floes were agitated slowly and the dispersion of oil released from a single point observed. Areal density of the ice cover was varied.
(Fenco Consultants Ltd., Calgary)
Research and engineering studies are being undertaken in the following main areas—ice platforms (design, construction and monitoring), ice surveying, ice breaking using reinforced vessels and rotating ice cutters, protection of pipelines from floating ice scour, ice testing for strength, salinity, etc.

The following have been or are being developed—borehole jack, frazil ice measurer, pressure transducer system for monitoring ice deflection, wireline ice movement gauges, strain gauge system for ice sheets and pads, and ice mass location by aerial photogrammetry.

ICEBERGS
(A. J. Allan, C-CORE/MUN)
An irregularly-shaped iceberg was sounded using impulse radar (NE Newfoundland); Labrador Sea iceberg distribution maps have been prepared; iceberg sounding is being monitored (Saglek Bank).
(B. Sukhov, NORDCO Ltd., Nfld.)
Research is continuing into the measurement of iceberg draft, the underwater profiling of icebergs, and iceberg scouring in the Strait of Belle Isle.
(J.-G. P. Napoleoni, GA/UBC)
A theoretical analysis and attempt to construct a predictive model for iceberg drift trajectories is being completed.
(R. H. Goodman, Innovative Ventures Ltd. [IVL], B. B. Narod, IVL & GA/UBC, G. K. C. Clarke, GA/UBC)
The UBC 840 MHz airborne radar was used to sound the depth of floating icebergs of the Labrador coast. Icebergs with a draft of 130 m were successfully sounded but the echograms were complicated by the large amount of diffraction.

AIR CUSHION TECHNOLOGY

(R. G. Wade, Canadian Coast Guard [CCG])

A Bell Voyageur ACV is being used for operational icebreaking in eastern Canada. Ice up to 1 m thick can be broken at about 20 knots and clearance rates of up to 15 km^2/h have been achieved. Using different techniques about 3 km^2 of 6 m thick frazil under a 50 cm ice cover have also been cleared at a much slower rate.

The CCG has also conducted trials of an air cushion platform attached to the bows of a light icebreaker and later to other vessels. The trials were extremely successful, enabling the icebreaker, which by itself could navigate in 30-35 cm ice, to operate at nearly 9 knots through 45 cm ice, 5 knots through 55 cm ice and 3 knots through 70 cm ice.

FLOATING ICE—RIVER & LAKE

KEEWATIN, N.W.T.

(B. J. Grey, GD)

The progression of break-up on the Thelon and Kazan rivers was studied by ground and helicopter traverses and aerial and time-lapse photography. Morphologic and ice damage features have been described.

MACKENZIE VALLEY, N.W.T.

(K. C. Arnold, D. A. Sherstone, A. C. D. Terroux, GD)

With PCSP support and a Wild RC-10 aerial camera some 150 photo hours were flown in support of various research programs. The ice break-up, development and destruction of ice jams in the lower Liard and along the Mackenzie Rivers were photographed. In July and August the lower Mackenzie Delta, Boothia Peninsula, Melville and Cornwallis islands were flown. The negatives are held by the National Air Photo Library.

(R. M. Hardy & Assoc. Ltd., Calgary)

Photographic recordings of the break-up were taken at various locations for 880 km along the river. The study confirmed that ice block gouging of banks and ice jam induced scour at proposed pipeline crossings is small. The Mackenzie River, east of Fort Simpson, was found to be susceptible to backwater caused by jams occurring near Fort Simpson.

(P. A. Egginton, GSC)

Tree age on the actively flooded banks of the Mackenzie River is limited by ice activity during periods of backwater. In many reaches, tree age varies with elevation above river as a simple linear or power function. Maximum tree age at a given elevation is indicative of the return period of ice events of sufficient magnitude to uproot or crush the trees. The maximum yearly ice thickness at Fort Simpson is found to correlate with the maximum yearly backwater from ice jamming.

(D. K. MacKay, J. C. Anderson, GD)

Various basins in the Liard River, Wrigley and Mackenzie Delta regions are being monitored with specific attention to snowmelt and rainfall floods, and aufeis, among other factors.

LAKE ICE, ONTARIO

(W. P. Adams, GEOG/TU)

Studies of the ice and snow on lakes in south-central Ontario, Coon Lake, Lake St. George and Big Cedar Lake, are continuing.

AUFEIS

(B. J. Grey and D. K. MacKay, GD)

A state-of-the-art report has been prepared for the Working Group on the Hydraulics of Ice-covered Rivers.

(R. M. Hardy & Assoc. Ltd., Calgary)

Investigations into aufeis included detailed geophysical surveys at the larger river crossings along the Yukon coast to identify and delineate areas of unfrozen ground and the source areas for some of the several major springs on the Coastal Plain.

FRAZIL ICE

(B. Michel, UL)

A new project is underway to study the temperature of nucleation of frazil particles. A theory has been developed that explains frazil formation by surface nucleation, taking into account the effects of the three-dimensional boundary layer and evaporation. A laboratory tank specially equipped with an agitator is used to study these effects.

(T. O'D. Hanley, Campion College)

Following a survey of nucleation theory with respect to frazil formation, aimed at identifying the mechanisms which lead to formation of frazil at unusually small supercoolings provided the water is turbulent, it was concluded that frazil is initiated either by nucleation in a highly supercooled layer near the air-water interface (Michel) or by tiny ice crystals falling into the water from above (Osterkamp).

HYDRAULICS RESEARCH

(T. M. Dick, CCIW)

The following projects are being worked on at the Canada Centre for Inland Waters—diversion of spilled oil under river ice by cut slots on the ice cover and barriers imbedded in the ice cover, movement of an oil slick under a river ice cover, the ice cover resistance of the Beauharnois Canal, the development of a frazil ice measuring instrument, the formation of an under-hanging dam and ship passage, and mapping of ice jamming flood risk areas in the Atlantic region.

RADAR MEASUREMENT OF ICE

(A. P. Annan, J. L. Davis, GSC)

In tests on the Rideau Canal (Ottawa) it was found that the radar method could distinguish whether streams and shallow lakes are frozen to the bottom. This has important implications for water supplies in northern communities.

LABORATORY STUDIES

GLACIAL ABRASION

(W. H. Mathews, GEOL/UBC)

Experiments have continued on simulated glacial abrasion using a grindstone of ice plus crushed quartz turning slowly between stone plates.

MECHANICAL PROPERTIES OF ICE

(S. J. Jones, GD)

Work on ice under hydrostatic pressure, reported last year, continues.

(B. Michel, UL)

The program of uniaxial testing of ice samples in the brittle and ductile range is completed. An initial study has been made on the biaxial behaviour of an ice plate of columnar ice tested with a square edge indentor. The program is being extended to other types of ice, including sea ice, and other forms of indentors.

(N. K. Sinha, DBR)

Results of creep experiments conducted on columnar-grained ice have been used to propose a rheological model of polycrystalline ice. This model has been used successfully to explain the short- and long-term deformation response of ice; it could also be used to develop a criteria for failure.

The dual method of etching and replicating in conjunction with observing the replica by scanning electron microscope has given additional insights into the physical processes involved during ice deformation.

SINGLE CRYSTAL DEFORMATION

(S. J. Jones, GD)

Studies of deformation close to the melting point are now complete. Results were reported at the Physics and Chemistry of Ice Symposium.

OPTICAL PROPERTIES OF ICE

(T. C. Sivakumar, G. P. Johari, GD)

Light scattering measurements on polycrystalline ice are being made.

ELECTRICAL BEHAVIOUR OF ICE

(G. P. Johari, GD)

A report on the electrical behaviour of ice along and perpendicular to the hexagonal axis was presented at the Physics and Chemistry of Ice Symposium and will be published.

THERMAL PROPERTIES OF ICE

(G. P. Johari, GD)

A report on this study of ice in the vitreous form has been published in the *Philosophical Magazine*, 1977, Vol. 35, No. 4, 1077-1090. Some results were presented at the Physics and Chemistry of Ice Symposium.

BEARING CAPACITY OF ICE

(B. Michel, UL)

A laboratory study has been completed on the ductile deformation of an ice beam under a constant load. An experimental study is beginning on the time dependent deformation of a circular ice plate, loaded at the centre.

ICE ENGINEERING

(R. M. W. Frederking, DBR)

A sabbatical year was spent at the Ice Tank of the Hamburg Shipbuilding Research Institute. Studies on the flexural behaviour of ice, an analytical model of ice action on an inverted conical structure, operation of an ice testing tank and ice breaking trials on an Arctic supply vessel were made.

The results of a pilot project to observe ice behaviour and measure ice forces on a wharf at Strathcona Sound have been analysed and reported. Work is continuing on the development of improved ice force gauges.

RAMAN SPECTRA OF ICES

(J. E. Bertie, Chemistry, Univ. of Alberta)

Current and continuing work involves the measurement and interpretation of the Raman spectra of Ices II and IX, and of the infra-red spectrum of Ice VIII.

GROUND FROST AND PERMAFROST

GENERAL

(A. Judge, Earth Physics Branch, Dept. of Energy, Mines and Resources)

A total of 86 permafrost thickness determinations, based on deep temperature measurements in northern drillholes, have now been published. Additional sites were added in the Mackenzie Delta bringing to 38 the number of instrumented wells in that area. A description of a numerical model suitable for deriving additional data on the physical parameters of the surrounding formation from the rate of return to thermal equilibrium of the drillhole is now in press.

Combined seismic and thermal studies of the permafrost and gas hydrates beneath the offshore areas of the Beaufort Sea have continued to map the distribution pattern. A spring hydraulic drilling program of 25 holes to 60 m depth, with the GSC, outlined permafrost conditions at a degrading shoreline in Shallow Bay (68°50'N, 136°W) and across the north side of the Mackenzie Canyon (69°30'N, 136°W). The results show the considerable local variability of subsurface temperature and ice content.

Studies and measurement of the thermal properties of frozen and unfrozen soils have continued. Collected data has been analysed to find universal models connecting thermal and other physical properties. A paper outlining a simple method of determining the thermal conductivity of soil solids has been prepared.

(B. Ladanyi, Ecole Polytechnique, Montreal)

Current research projects include *in situ* measurement of the geotechnical properties of frozen ground and ice, the long-term bearing capacity of foundations in permafrost and the rheological behaviour of frozen granular soils.

DISTRIBUTION

(R. J. E. Brown, DBR)
Ground temperature observations are being taken at Churchill (Manitoba), Rankin Inlet (N.W.T.) and several locations along the proposed Polar Gas pipeline route west of Hudson Bay for information on permafrost conditions across the boundary between the discontinuous and continuous zones. Regular ground temperature observations are also being made in the Rocky Mountains (SW Alberta), and on mountain summits in southern British Columbia to obtain information on alpine permafrost. A revised and updated version of the *Permafrost Map of Canada* will be published in 1978.

(K. E. Ricker Ltd. for Envirocon Ltd.)
An analysis of all available data on permafrost distribution, the extent of its occurrences and the environment for the four contending pipeline routes—the Alaska Highway (Alcan), the Klondike Highway, the Robert Campbell Highway and the Tintina Trench—was completed for the Environmental Assessment Panel. A summary of the findings can be found in *Routes: an environmental comparison of alternative pipeline corridors in the Yukon Territory.*

(K. E. Ricker Ltd. for the GSC)
Occurrences of permafrost were examined in the field and drill records of the Department of Public Works reviewed in the preparation of a special geotechnical and environmental legend for a map of valley floor deposits (prepared in 1967) of the Dempster Highway from 0 km to 139 km.

(R. M. Hardy & Assoc. Ltd., Calgary)
Areas of continuous and discontinuous permafrost were delineated by magnetic induction methods in the Mackenzie Valley, in northern Alberta, along the Alaska Highway in the Yukon, and along the Arctic Coastal Plain.

(C. B. Crampton, GEOG/Simon Fraser Univ.)
An extensive survey of permafrost in northern British Columbia has been completed. At present an analysis procedure based on synergism for modelling and predicting the ice content of permafrost, utilizing the kind of imprecise data associated with field work, is being developed.

(J. T. Gray, GEOG/Univ. of Montreal)
Investigations are being made into permafrost in the Shickshoc Mountains of the Gaspe and in the Leaf Bay sector of the Labrador Trough.

STRUCTURES IN PERMAFROST

(G. H. Johnston, V. R. Parameswaran, DBR)
Field observations at a polystyrene-insulated road test site on the Mackenzie Highway near Inuvik (installed in 1972) were continued. An instrumented, polyurethane-insulated, test site was installed in March 1977 at Mile 237 on the Dempster Highway.

Observations were made at regular intervals on ground temperatures at the Eagle River bridge and are continuing; the foundations have been instrumented.

(D. Sego, Civil Engineering/Univ. of Alberta)
The mechanical behaviour of ice under low stresses is being studied to obtain a flow law for use in foundation design. Tests are being conducted in constant uniaxial stress, constant strain rate (triaxial), simple shear and axial symmetric punching. Test temperatures are between $-0.5°C$ and $-4.0°C$. The best fit through the data gives a Glen type law with $n=4.4$.

FROST ACTION

(T. O'D. Hanley, Campion College)
A study has been initiated to assess the effect of voltages generated between the frozen and unfrozen portions of freezing soils on the freezing rate, soil type, water content and other factors.

(P. H. Groenevelt, Univ. of Guelph)
Research continues on the dual gamma apparatus in order to obtain refined data concerning ice lens formation and water movement in frozen soils as well as a project on pressure distributions in frozen soils.

(E. Penner, DBR)
Soil temperature data have been collected from three Ottawa arenas and analysed as part of a study of frost action under these structures. Manual temperature readings, now on a bi-monthly basis, are being continued to establish long-term trends.

(E. Bourget, BIOLOGIE/UL)
Freezing of beach sediment during exposure to cold air and subsequent thawing upon immersion have been analysed in a strong tidal environment near Rimouski (Quebec). After an air temperature drop to $-6.0°C$ freezing temperatures penetrated above the high tide mark to 15 cm and at the mid-tide point to 5 cm. The effects on erosion are being studied.

(R. M. Hardy & Assoc. Ltd., Calgary)
Field and laboratory studies of frost heave indicate that overburden pressure has a significant influence on the rate of heave. Designs have been developed using insulated pipe and heat tracing cables to eliminate the frost heave problems in pipelines. The frost heave characteristics of sea bottom sediments near Melville Island have been studied in the laboratory.

STRENGTH OF FROZEN GROUND

(T. H. W. Baker, V. R. Parameswaran, DBR)
A study has been carried out on the effects of four end restraint conditions on the unconfined compressive strength of frozen Ottawa sand. The tests were performed at a medium strain rate of 0.07%/mn and with different specimen length/diameter ratios. The compliant platen, developed by K. T. Law at DBR, performed very well and a series of tests was completed using strain rates ranging from 10^{-7} to 10^{-2}/s. Tests to measure the strength of artificially frozen sand containing 14% moisture have been done under uniaxial compression at $-6.0°C$, at strain rates varying between 10^{-7} and 10^{-1}/s.

THAWING

(F. Müller, ETH/MU)

The seasonal course of active layer development was followed at 5 sites using pits and hammered probes to determine its depth at two-weekly intervals. The differing importance of climate (mainly air temperature), soil type and vegetation is being assessed on Axel Heiberg Island.

(R. M. Hardy Assoc. Ltd., Calgary)

Over 100 thaw settlement tests have been conducted on permafrost samples of glaciolacustrine silts and clays, tills, sand and peats, etc., taken along a route from Norman Wells (N.W.T.) to Zama Lake (Alberta). Correlations between thaw strain parameters and frozen bulk density and initial frozen water (ice) content were obtained and used to make settlement predictions.

Extension to thawing slope stability theory has been developed to include the effect of insulation and gravel. Design concepts have been established and testing has confirmed that the theory is applicable.

CREEP PROPERTIES

(R. M. Hardy & Assoc. Ltd., Calgary)

Creep tests were conducted on undisturbed frozen samples from 5 different sites near the proposed Arctic Gas pipeline route. Long-term tests have been performed typically to durations of up to 100 days, at stresses from 70 to 300 kN/m^2, and at temperatures from -1°C to -3°C. The data have been interpreted in terms of secondary creep and suggest that undisturbed ice-rich silt at low stress levels creeps at rates somewhat less than those reported for ice at similar stresses and temperatures. In the average or higher stress regions there was good agreement between the creep response of ice and ice-rich soils.

THERMAL REGIME

(L. E. Goodrich, DBR)

A one-dimensional numerical technique for treating heat flow with latent heat has been developed; it has also been extended to include the snow/ground thermal interaction.

Thermal conductivity field probes continue to be read regularly at the Ottawa test site. A similar program is now fully operational at the Thompson Field Station. Two new conductivity logger apparatuses have been constructed. A laboratory study to evaluate the thermal conductivity probes is now underway.

(A. Wankiewicz, Hydrology Res. Div.)

The thermal regime and ground water conditions have been investigated under rivers which freeze to their beds in areas of continuous permafrost. Lines of thermistor strings were installed in 18 m deep boreholes in the river beds on Melville Island and near Inuvik (N.W.T.).

MAPPING TECHNIQUES

(A. K. Sinha, GSC)

Theoretical studies on the detection and delineation of permafrost by electromagnetic means were conducted in 1976 and 1977. It was observed that a multi-frequency (1 KHz—1 MHz) horizontal coplanar system with coil separation of 3 m may be used to detect permafrost at depths of up to 30 m. Techniques of interpretation of data were developed and the generalized computer program to obtain the response of an n-layer lossy dielectric medium to dipolar excitation was developed and published.

(A. P. Annan, J. L. Davis, GSC)

High frequency (1-1 000 MHz) electromagnetic methods have been applied to a number of permafrost problems. The radar method was shown to be a rapid and reliable tool for mapping active layer thickness near Leaf Bay (Ungava). Time-domain reflectometry was found to be a good technique for monitoring active layer development with time and could also determine water distribution in the unfrozen zone. Borehole radar used in the Involuted Hill (N.W.T.) experiments indicated that the dielectric constants range from 2-5 and that the attenuations range from 0.2-5 dB/m at 50-100 MHz for the top 5 m of frozen material.

FROST MOUNDS

(R. O. van Everdingen, Hydrology Res. Div.)

A number of frost mounds of the frost blister type have been studied at the site of a group of cold springs east of Bear Rock, near Fort Norman (N.W.T.). They varied in height from 2-3 m with horizontal dimensions of 26-48 m and contained a domed layer of ice up to 85 cm thick over a cavity up to 70 cm high. Time-lapse cameras have been installed to study the time and speed of their growth.

PALSAS

(M. K. Seguin, J. Crépeau, GEOG/UL)

Geophysical investigations into palsas in the Poste-de-la-Baleine area of New Quebec included geothermal, electrical resistivity and refraction seismic surveys. Electrical resistivity soundings and geothermal profiles are particularly useful for outlining the three-dimensional geometry of the palsas. Thermal, geomorphological, lithological and ganulometric data allow a better understanding of the genesis, development and evolution of the palsas and their mode of formation.

C. S. L. Ommanney

FRANCE

CENTRE TECHNIQUE DU GÉNIE RURAL, DES EAUX ET DES FORÊTS

(Technical Center for Water and Forest)

GLACIERS

Supervised glaciers

For many years, a big number of French glaciers were supervised by the Forest and Water Administration. About 16 years ago, many observations were stopped. We are now organizing an aerial survey for 20 glaciers. Each 3 years, aerial pictures are collected for the following glaciers:

Mont Blanc range

1. Tour — 2. Argentières — 3. Mer de Glace — 4. Bossons — 5. Taconnaz — 6. Bionnassay — 7. Tré-la-Tête.

Vanoise range

8. Sources de l'Isère — 9. Sources de l'Arc — 10. Mulinet — 11. Grand Méan — 12. Evettes — 13. Arnès — 14. Gebroulaz.

Oisans range

15. Pilatte — 16. Chardon — 17. Selle — 18. Glacier blanc — 19. Glacier noir — 20. Sarennes.

Mass balance

Since 1948, the mass balance of the small cinque-glacier of Sarennes (about 100 ha) is calculated. The 75-76 season was characterised by very small accumulation (33 cm water equivalent) and great ablation (240 cm water equivalent, 207 ice ablation). This is one of the worst mass balances for Sarennes.

SNOW STUDIES

In the two experimental snow fields of Col de Porte and Autrans, we try to understand the interaction of the forest and the snow cover. More than 200 snow sticks are randomly placed in the Autrans forest (Vercors) and twice a week data are collected; mathematical treatment is given to separate different parameters.

Snow pressure is measured on various types of avalanche defence works. Wind effect is also studied for better snow control.

AVALANCHES

At Lautaret, artificial release of avalanches is continued and a lot of data registered (in collaboration with the Laboratory of Special Physical Application).

The exploitation of the "powder snow avalanche model" (water model, with Mecaflu) continues. Pressure and density profiles are measured. A mathematical model (with C.T.G.R.E.F. ANTONY) for powder snow avalanches is today operational. The morphological profiles and snow heights are introduced, and principal parameters are obtained (V, D, h).

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France.

INSTITUT NATIONAL DES SCIENCES APPLIQUEES

In "Ice" n°48, it was said that our research on ice had been involved with 4 topics:

- ultrasonic properties of plastically deformed ice,
- microplasticity and low frequency internal friction of ice,
- X ray topographic study of ice single crystals,
- dynamic behaviour of dislocations in ice.

This work has been improved and new results have been obtained.

ULTRASONIC PROPERTIES OF ICE

A new device able to measure both attenuation and sound velocity variations during plastic deformation has been built. Then during a compression (traction) test, it was observed that the increase in attenuation induced by plastic deformation begins just when the maximum in the curve σ-ϵ occurs.

The change in attenuation and sound velocity does not appear to be stress dependant.

LOW FREQUENCY INTERNAL FRICTION OF ICE

It has been confirmed that the high temperature (250-273K) internal friction is due to dislocation movements. Indeed, the anelastic behaviour of ice in this temperature range is very similar to that of dislocation as it is observed by X-ray topography.

Nevertheless, measurements done in a wide range of stress ($3{,}5.10^3 < \tau < 1{,}5.10^6$ Nm^{-2}) and the study of the effect of doping ice with HF, does not allow us to interpret the experimental data in terms of previous models of dislocation glide, showing, thus, a need for a different model of dislocation movement in ice.

Other results on ageing and doping effect have been obtained by the low frequency internal friction technique.

X-RAY TOPOGRAPHIC OBSERVATION

Measurements of the velocity v_d of dislocation in ice have been made : a linear dependence on stress is observed at low temperature ($\sim$ 250K) but the velocity varies more rapidly with stress when the temperature is increased. Experimental data corresponds to $v_d \text{ sh} \frac{v_a \tau}{kT}$ with the activation volume v_a increasing with the temperature so that, at low temperature, the sinh low is reduced to a linear one.

The same observations done on ice doped with HF show two features:

(i) the velocity v_d increases only slightly (v_d is multiplied by a factor about 2 by doping ice with about 10ppm HF)

(ii) the velocity of dislocation is more stress dependent and this stress dependence is observed at lower temperature.

DYNAMIC BEHAVIOUR OF DISLOCATIONS IN ICE

To interpret the preceding experimental data, it is necessary to have a new model of dislocation glide in ice in agreement with the actual plastic behaviour of this material. So we have developed a theory based on the following assumptions:

(i) dislocations in ice have a non crystalline extended core.

(ii) the dislocation glide occurs by transitions from one state of configuration of H_2O molecules to another, through cooperative movements of H_2O molecules in the core of dislocations.

A relation between the velocity v_d of linear defects and shear stress or temperature as obtained. This relation appears to be in good agreement with experimental data.

CONCLUSION

These results are very useful for the knowledge of the plastic behaviour of ice single crystal. But, to improve the understanding of the behaviour of natural ice, it is necessary to study the other defects such as low angle boundaries, and grain boundaries in ice and their interaction with dislocations. So, we expect to pursue our research in that direction.

C. Maï, J. Perez, J. Tatibouët and R. Vassoille

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NORWAY

MASS BALANCE STUDIES AT SELECTED GLACIERS 1975/76

The Norwegian Water Resources and Electricity Board (NVE) is a Government organization. One of its sections within the Hydrology Division, Glaciology Section, has undertaken glaciological investigations at four glaciers in Southern Norway and two glaciers in Northern Norway during 1976. The Norwegian Polar Institute (Norsk Polarinstitutt) has investigated three additional glaciers in Southern Norway. The longest series of observations have been made at the glacier Storbreen in Jotunheimen (observed by Norsk Polarinstitutt) and Nigardsbreen, an outlet glacier from the Jostedalsbreen ice-cap (performed by NVE). The series of mass balance investigations started on Storbreen in 1948 and on Nigardsbreen in 1962. The investigations on glaciers in Northern Norway started in 1970, in the Svartisen area.

Alfotbreen

This glacier is traditionally receiving the heaviest winter accumulation due to its location in a maritime part of the country. In March the total winter accumulation was determined. The snow depth was then about 7 m. An additional accumulation of about 2.5 m occurred up to 5 May when the final snow survey was made by depth measurements at 115 points. The heaviest snow accumulation amounted to almost 10 m, the total winter balance was 21 · $10^6 m^3$ of water which equals 4.4 m water equivalent evenly distributed over the entire glacier surface. This is 23% more than the average for the period 1963-1975.

Observations of the ablation were made in June, July, August, September and October. The total ablation was only 85% of the average for the period 1963-1975. It amounted to 13.7 · $10^6 m^3$ which equals 2.9 m water equivalent. The

glacier experienced a positive net balance all over its surface and old glacier ice was never exposed during that summer. This caused, naturally, a relatively high albedo and only during one single year since the measurements started in 1963 did we observe a higher glacier growth on Ålfotbreen (1973). The glacier has now experienced positive net balances during six consecutive years.

Blomsterskardbreen

Although no stakes were found when the glacier was visited at the end of September 1976, it is possible to calculate the net mass balance also for this year because the glacier was photographed on 21 September 1976 (Fjellanger Widerøe, Mission No. 5282). It is supposed that the summer season had just ended then. The temporary snow line couuld be easily transferred from the photographs on to a topographic map of the glacier, and its height is supposed to directly indicate the equilibrium line height; it was determined to be about 1 210 m a.s.l. It seems that it is a linear correlation between the height of the transient snow line and the net balance, thus the net balance could be calculated. It amounted to +1.4 m which indicated that the glacier has increased in thickness by 6.3 m water equivalent since the fall of 1969; corresponding to 0.9 m/year.

Comparing this with the results from Ålfotbreen it seems that the mass balance on both these glaciers are very like; during the period 1970-76 Ålfotbreen had an annual net positive balance of 0.82 which is very close to that of Blomsterskardbreen. The distance between the glaciers is 205 km but they are both situated in an area of extreme maritime climatic conditions. All glaciers in this part of the country have had, as an average, a positive mass balance during the last few years.

Nigardsbreen

The final snow survey was made at the end of April, when the total snow depth ranged between 3.5 and 8 m. The total winter balance amounted to 138.9 · $10^6 m^3$ of water. This corresponds to 2.88 m of water equivalent evenly distibuted on the glacier surface. This is 25% more than the average since 1962 and only once (1967) was a higher snow accumulation ever observed on Nigardsbreen.

Due to generally nice summer weather with many hot days the ablation proved to be higher than the average—in total 119.6 . $10^6 m^3$ of water was removed from the glacier. This is approximately 30% more than during an average summer for the period 1962-76. The specific summer balance amounted to 2.48 m of water equivalent evenly distributed on the entire glacier surface. In spite of this large melt the net balance amounted to +19.3 · $10^6 m^3$ of water, corresponding to 0.40 m of water equivalent evenly distributed on the glacier surface. This amount is quite near the average annual glacier growth since 1962. The equilibrium line was situated at 1 540 m a.s.l. Meteorological observations were made in the period 15 June-1 September.

The discharge from the glacier has been observed annually since the glaciological studies started at Nigardsbreen. During the period from 1 June to 1 September, a total amount of 139.4 · $10^6 m^3$ water passed the gauging station at the outlet of the lake Nigardsvatn. The maximum daily discharge was observed on 10 July, amounting to 2.7 · $10^6 m^3$ water whereas the main daily discharge was 1.5 · $10^6 m^3$ water. Most of this water originates from the glacier melt because almost 75% of the basin above the gauging station is glacierized.

Hardangerjøkulen

Hardangerjøkulen, which is a dome-shaped ice-cap in south-western Norway, is not observed entirely, but a west-facing outlet glacier, Rembedalskåki, has been selected as representative for the ice-cap. The total winter balance corresponded to 2.45 m of water equivalent evenly distributed on the glacier surface. A hot summer gave a summer balance of 2.30 m of water equivalent.

Storbreen

The valley glacier Storbreen in Jotunheimen has been observed since 1948 by Dr Olav Liestøl in Norsk Polarinstitutt. This is one of the longest observations series in the world. The winter accumulation was 30% higher than during the last 27 years, namely 1.80 m of water equivalent, whereas the summer melt amouted to 1.90 m of water equivalent. The mass balance turned out to be negative; the figure −0.10 m of water equivalent is indicated by Liestøl.

Hellstugubreen

Hellstugubreen is also a valley glacier in the Jotunheimen area but it is situated slightly east of Storbreen and, due to the fact that the gradient for annual mass balance seems to be very steep in this area, it has a different mass exchange than Storbreen.

The winter accumulation was measured in the middle of May when the snow pack ranged between 0.1 m and 5 m. The thickness was measured in 140 points whereas the snow density was measured in two points. The resulting winter balance amounted to 3.83 · $10^6 m^3$ of water which corresponds to the specific figure 1.16 m of water equivalent. Due to a very hot and dry summer the summer balance proved to be no less than 36% higher than the average for the period 1963-75. A higher summer melt has been observed only during two previous summers (1963 and 1969). The total summer balance amounted to 6.29 · $10^6 m^3$ water corresponding to 1.89 m of water equivalent.

The net balance turned out to be negative; the glacier lost 2.46 · $10^6 m^3$ of water which corresponds to −0.73 m of water equivalent. This glacier has shown a negative mass balance during all the years of observation since 1968, apart from 1974 when it has a positive mass balance.

Gråsubreen

Gråsubreen is the easternmost glacier in Jotunheimen and also the highest situated glacier under study. Both winter accumulation and summer melt are traditionally smaller on this glacier than on any other of the glaciers under study.

The winter balance amounted to 1.6 · $10^6 m^3$, corresponding to 0.62 m of water equivalent. This is slightly less than the average winter balance for the period 1963-1975.

The summer was very warm and due to a relatively thin snow cover on the middle and the higher parts of the glacier, ice and firn were exposed very early in the melt season and the albedo was consequently unusually low on most parts of the glacier. Radiation contributes significantly to melt on this glacier (about 70%). The total summer balance amounted to 4.1 · $10^6 m^3$ of water which corresponds to 1.62 m of water equivalent evenly distributed on the glacier surface. This is slightly less than in 1975 but is still 155% of the average summer balance for the period 1963-1975.

The net balance is therefore negative, −1.0 m of water equivalent, which is the second highest deficit ever measured on this glacier. The equilibrium line was situated higher than the highest parts of the glacier, i.e. the glacier was entirely below the equilibrium line in 1976.

Høgtuvbreen

This valley glacier in Northern Norway, situated south-west of the main part of the Svartisen ice-cap, has been investigated since 1971 but this series of observations will be discontinued because sufficient hydrological data have been collected for the planning of a hydro-electric development in this area. The final snow survey was made at the beginning of May when the snow pack amounted to more than 5 m on the tongue and more than 10 m in the firn basin.

The total winter balance amounted to 9.5 · $10^6 m^3$ of water which corresponds to 3.66 m of water equivalent equally distributed on the entire glacier surface. This is the second highest winter balance ever observed since the observations started in 1971.

The summer balance turned out to be very low; a smaller summer balance has been observed only once, in 1975. The reason is partly that it was a cool summer in 1976 and partly the very high winter accumulation caused a high albedo almost throughout the entire summer. The summer balance amounted to 7.5 · $10^6 m^3$ of water, corresponding to 2.75 m of water equivalent. The net balance turned out, of course, to be positive also in 1976. No less than 2.36 · $10^6 m^3$ water was left on the glacier, corresponding to +0.91 m of water equivalent. A higher mass increase on this glacier was observed only in 1973.

Discharge observations were performed in the period from 9 July–2 October. The total discharge amounted to 17.15 · $10^6 m^3$ of water which corresponds to a mean water discharge of 2.31 m^3/sec. This is about 90% of the average for the last five years.

Engabreen

All glaciers in Northern Norway received large amounts of snow during the winter of 1975/76. When the total accumulation was measured on 20 May no less than 7-10 m of snow had arrived. The total winter balance amounted to 146.8 · $10^6 m^3$ of water or 3.86 m of water equivalent. This is 120% of the average accumulation during the five previous years, and a higher accumulation was found only in 1973.

The summer was fairly cool and the summer balance amounted to only 55.1 · $10^6 m^3$ of water or 1.45 m of water equivalent. This is the lowest ablation ever measured since the observation series started in 1970. It is only 60% of the average for the period 1970-1975. The summer mean temperature was 0.7°C lower than the average in this period, and at the meteorological station in Glomfjord the monthly temperatures for July and August were 1.9°C cooler than normal. (The "normal" period being 1931-1960.)

The net balance amounted to 1.7 · $10^6 m^3$ water or +2.5 m of water equivalent. A slightly higher positive balance was measured in 1973. The glaciological year 1976 is the fourth consecutive year of positive mass balance on Engabreen.

At the observation hut (880 m a.s.l.) the following meteorological parameters were observed or recorded throughout the entire summer season: precipitation, temperature, air moisture, wind speed, cloud cover and short-wave incoming radiation. At a point in the accumulation basin (1 360 m a.s.l.) only precipitation and temperature were measured.

The total discharge from the lake Engavatn was only 120.8 · $10^6 m^3$ water for the period 1 June to 15 September which is almost a record in low water discharge, amounting to a daily mean of only 1.13 · $10^6 m^3$ water.

Comparison between mass balance on various glaciers

The mass balance was in 1976 measured at 9 glaciers, 7 in Southern Norway and 2 in Northern Norway. The east-west variations are fairly well covered by the various selected glaciers in Southern Norway, whereas the two glaciers in Northern Norway are just located around the Svartisen area so that very little can be said

about the mass balance conditions on other glaciers in that part of Scandinavia. (Observe however that mass balance investigations are carried out at Storglaciären in Northern Sweden.) The glaciers in the west had a year of positive mass balance whereas glaciers in the east, i.e. in the Jotunheimen area, had a year of negative mass balance. This result is thought to be based on the fact that the winter precipitation was unusually high in the coastal zones, so even a relatively warm summer in Southern Norway was unable to melt all this snow, and the balance turned out to be positive in the maritime areas. In the Svartisen area a slightly higher winter precipitation than normal was also observed but the summer was extremely cool which, in turn, caused the positive mass balance in this area.

Bondhusbreen

A sub-glacial water intake has been constructed under one of the major outlet glaciers from the Folgefonni ice-cap, to divert the meltwater for hydro-electric power production.

A tunnel system under the ice in this valley makes it possible to observe the ice/bedrock interface during the winter. Ice velocity observations have been made in caves constructed by ice melting along the glacier bottom. The daily movement was some 10-20 cm/day, whereas the surface velocity was in the order of 40-55 cm/day. Due to a hydrostatic ice pressure of some 150 m, the caves were quickly deformed (and completely closed within a few days), so good measurements of ice movement were extremely difficult.

Some of the water intake shafts gave no water in 1977—only glacier ice came down into the tunnel system, whereas running water was collected in some other shafts, which were dry during the previous summer.

Further investigations are undertaken to find reasons why only fractions of the existing meltwater flow are being collected in the diversion tunnel, and new intake shafts are being constructed.

SEDIMENT TRANSPORT AT SELECTED GLACIERS IN NORWAY, 1976

General

Studies of sediment transport in selected Norwegian glacier streams have been carried out during the last few years for two main reasons: the solid matter in glacier streams might cause various difficulties if the water is utilized for water power production. It is therefore a vital concern for water power engineers to obtain data on the amount of sediment transported by glacier streams in areas where water power production is planned for the future.

There is also a scientific interest in such data, because the rate of glacier erosion has been under discussion for a long time. A cooperation is established between the Norwegian Water Resources and Electricity Board (NVE) and the Department of Physical Geography at the University of Stockholm to take care of the scientific part of the sediment study. Some of the data is collected and processed by the University of Stockholm but the main part of the data is handled by NVE. It is planned to collect all suitable data from a series of years to produce a scientific paper on the subject.

Detailed studies of sediment transport in glacier streams have been performed continuously in Norway since 1967 when 3 selected streams were studied. During the following years a larger number of streams have been investigated, at the maximum 8 glacier streams were observed during a single summer. Some investigations of particular glaciers have been terminated during recent years because a sufficient amount of data had been collected for special engineering purposes. The longest series of observations is connected to the stream from the Nigardsbreen outlet glacier from the Jostedalsbreen ice-cap. This stream is still under observation and, in addition, the sedimentation in the lake in front of the glacier has also been studied. The coarse material deposited on the delta is being measured annually by an accurate survey of its growth. Some of these results are included in this report. Similar studies are also made at Engabreen, an outlet glacier from the Svartisen ice-cap in Northern Norway. Results from the studies at Engabreen are also reported in this publication.

Two persons are normally based at each measuring site throughout the main part of the melt season, i.e. from the beginning of June to the middle of September. At most of the glaciers where such sediment transport studies have been performed, also mass balance studies have been made.

Water samples are taken in 1-litre plastic bottles in a turbulent part of the stream and this water sample is filtered in the field and the filter paper is sent to the laboratory in Oslo for ashing. Samples are normally taken both at the inlet and the outlet of the lake near the front of the glacier at a frequency of 5 per day at the lake inlet and 3 per day at the lake outlet. However, during periods of high water discharge or rapidly increasing runoff, samples are taken every hour because experience has shown that sediment concentration is then high and rapidly changing. The river discharge is continuously recorded by an automatic water gauge. All data from the sediment sampling and from the gauge are punched on cards and most of the calculations and diagram construction are made by computer.

Two glacier streams were investigated in 1976, the stream from Nigardsbreen (where the series started in 1968) and at that from Engabreen (where investigations started in 1969).

Water samples for determination of suspended load are taken at the inlet and the outlet of the lake situated close to the glacier front, whereas bottom load is determined by repeated surveys of the delta where the coarse material is continuously accumulating.

The meteorological conditions during the summer of 1976 can be characterized by the words cool and dry. This resulted in a discharge which was about 15% lower than the average for the last ten years. There was no significant rise in discharge after the field crew left the stations, so it is anticipated that only small amounts of sediments were transported during the fall. Consequently, the most important part of the drainage period was covered by frequent sampling and the results are therefore considered reliable.

Nigardsbreen

No really large flood occurred from Lake Nigardsvatn in 1976, the highest daily discharge was recorded on July 10 when 2.7 $10^6 m^3$ water discharged. A lower maximum daily discharge has been observed only once during the last ten years (1971). The total discharge from May to October amounted to 174 · $10^6 m^3$ which is 5% lower than the average annual discharge for the last ten years.

In total 11 750 metric tons of suspended sediment were transported into the lake in the period from May 25 to September 15, whereas the transport of suspended sediment out of the lake amounted to only 1 650 metric tons. This means that 86% of the suspended load were deposited in the lake. This is slightly higher than the average which is 77% for the last 9 years.

Before and after the observation season proper it is anticipated that some, but relatively small, amounts of sediment were moved by the stream. It is assumed that this transport amounted to about 400 metric tons before the observation season and 300 metric tons after the season. The total transport of suspended load from Nigardsbreen should then be 12 450 metric tons in 1976.

Studies of delta growth (see also next section) indicates that the total accumulation of 4 680 m^3 coarse material have taken place in 1976. This corresponds to 9 360 metric tons of coarse material. If this amount is added to the suspended load one could calculate an average bedrock thickness which must have been removed to produce this amount of debris. It is obvious that such a calculation may be quite misleading because a much higher erosion takes place under certain parts of the glacier whereas almost no erosion may take place elsewhere. However, similar calculations are traditionally made every year for all the glaciers under study. For Nigardsbreen 1976 it was found that the average erosion under the entire glacier amounted to 0.17 mm. This figure is based on the assumption that the density of the bedrock is 2.7 g/cm^3.

Delta surveys in the inner part of Lake Nigardsvatn

A number of survey points were marked along the lake shore in 1968. A relatively dense network was established near the delta to make possible repeated soundings along fixed profiles. In total, eight such profiles have been surveyed every year by accurate depth measurements in 253 single points. The annual delta growth has been calculated. The maximum accumulation occurred during the summer of 1972 when no less than 19 500 metric tons were accumulated. This corresponds to an average vertical delta growth of 35 cm. The mean growth for the years 1968-1976 is 22 cm.

Engabreen

The discharge from the glacier during 1976, was lower than ever recorded, i.e. since 1969. The glacier has had a positive mass balance during recent years and front observations indicate that the glacier has started to advance again after several decades of retreat.

In total 11 900 metric tons of suspended sediment were transported into the lake and 1 115 metric tons were moved out of the lake during the observation period. More than 90% of the suspended material settled in the lake. This is a higher proportion than the average for the previous years which is 84%. The figures are, in general, higher than for Nigardsvatn, a fact which is easy to explain because Engabrevatn is larger and deeper than Nigardsvatn.

Based upon variations in water discharge before and after the observation period proper, it is anticipated that the stream carried some additional 1 400 metric tons of suspended sediment. Consequently, it is assumed that the total transport of suspended sediment from Engabreen amounted to 13 300 metric tons in 1976.

The delta at the lake inlet was repeatedly surveyed to make possible a calculation of the bottom load during the entire melt season 1976. The calculations revealed that 6 400 tons of coarse material had settled on the delta. Some problems were encountered in obtaining this figure because landslides seemed to have taken place near the outer parts of the delta.

The total amount of solid particles moved by the glacier stream amounted to 18 300 metric tons, of which the suspended material accounted for 65% (this percentage is the same as in 1975). If this total amount of debris should be evenly distributed under the glacier, it corresponds to an average layer of 0.18 mm. This apparent erosion compares well with similar figures obtained earlier and with figures obtained at Nigardsbreen.

Conclusions

The reliability of the observations is thought to be fairly good, because the sampling frequency is always immediately increased when the water discharge seems to increase rapidly. However, rapid variations in suspended sediment concentration are often observed—it seems that small "clouds" of suspended sediment are formed at certain occasions. To try and record the existence of such clouds and to determine the representativity of single water samples experiments have been started with an instrument which record the water turbidity. The instrument was, however, taken by the stream during a flash flood in 1976 and was partly destroyed. A new instrument will be installed in 1977.

As a general result of the direct studies of bottom load (by delta surveys) it has been shown that the bottom load accounts for almost 50% of the total transport of solid matter from the glaciers. This figure is, however, only valid when the samples are taken close to the glacier front.

G. Østrem

U.S.A.

OHIO STATE UNIVERSITY, INSTITUTE OF POLAR STUDIES

GLACIER BAY, ALASKA

In the 1977 summer three projects were initiated. Samples of bottom sediment were taken in front of six tidewater glaciers. They were obtained in water depths up to 500 m and included the top 10 cm of sediment. Three different types of bottom sediment were distinguished on the basis of their structure and texture that were related to different conditions of the ice and water at the ice front. The 1978 season will be devoted to expanding the sampling by coring the bottom sediment.

Powell

Rythmite sequences in glaciolacustrine sediment from Adams and Muir Inlets were measured and sampled to construct a varve chronology and pollen stratigraphy for part of the Neoglacial. Work will be extended to Wachusett Inlet during the 1978 season.

Goodwin

Study of the modes and rates of formation of ice-contact deposits in this recently deglaciated area continued. Next year retreat of several glaciers will be studied in a program to determine current outwash development rates. Objective of this research is to develop a model for the conversion of tidal inlets to lakes to outwash plains followed by glacier erosion, events that are recorded in the post Wisconsin stratigraphic record of many inlets in this area.

McKenzie

PALEOCLIMATIC ICE CORE RECORDS FROM THE TROPICAL PERUVIAN QUELCCAYA ICE CAP

The Quelccaya ice cap is located 13°50'S, 70°50'W, reaches an elevation of 5 645 meters and covers an area of 70 km^2. The Institute of Polar Studies, working in conjunction with members of the Peruvian Institute of Geology and Mining and Electroperu, has undertaken a multi-year investigation of this ice cap. The main objective of the program is to record a much needed paleoclimatic record from this tropical ice cap. During the past three field seasons, snow samples have been collected for microparticle, oxygen isotope and ß activity measurements in order to evaluate the quality of the paleoclimatic record which can be obtained from this ice cap. We have established an automatic meteorological station on the summit of the ice cap so that the microparticle, oxygen isotope and ß activity variations can be related to variations in meteorological conditions. Results of the surface snow studies of the Summit Dome of the Quelccaya ice cap indicate a meaningful detailed climatic record can be recovered from this tropical ice cap. Plans call for drilling 100 meter ice cores in 1979, with drilling to bedrock when the appropriate drill becomes available.

Lonnie Thompson

During the glaciological field studies, investigations have been made of the forms, genesis, and speleothems of glacier caves on the western margin of the ice cap. This study has resulted in the delineation of two new types of caves. (Results are being prepared for publication.)

Lonnie Thompson and Gary McKenzie

A CONTINUOUS MICROPARTICLE PROFILE FROM THE 101 METER SOUTH POLE CORE

During three days in November 1974, a 101 meter core was recovered at the site of the new Amundsen-Scott South Pole Station. We obtained one-quarter sections of this core for a detailed microparticle analysis.

A total of 6 218 samples representing the entire South Pole core have been analyzed for microparticle concentration and size distribution. The core has been dated using annual particle variations and represents an accumulation period from 1974 to approximately 961 A.D. Microparticle concentration are twofold higher during the "Little Ice Age" period (1400 to 1800 A.D.). The elemental analyses of selected samples, final synthesis of all the data and comparison with core parameters such as $\delta^{18}O$; Gross Beta

activity and ice chemistry should provide an informative climatic chronology for the past millenium. (To be published as Ph.D. Dissertation, June 1978.)

Ellen and Lonnie Thompson

MICROPARTICLE VARIATIONS IN SURFACE CORES FROM THE ANTARCTIC PENINSULA

Microparticle concentration and size distribution have been measured for firn cores from the Antarctic Peninsula collected by the British Antarctic Survey. These cores have been collected from sites in which there are problems interpreting the annual oxygen isotope variations because of fractionation and exchange during snow metamorphism involving meltwater. In two 5-meter cores collected from Graham Land plateau (66°00'W, 67°32'S) we found an interpretable microparticle record (Thompson, 1977). We have recently completed a detailed microparticle analysis of 4 10-meter firn cores, two from the snow dome near Rossini Point (72°30'S, 72°50'W) and two from Horse Point (71°18'S, 67°29'W). In all a total of 1 155 samples were processed. The microparticle stratigraphy will be compared with oxygen isotope, conductivity and ß activity measurements made on firn samples collected at these same sites. One of the main objectives of the micro-particle studies is to determine how meltwater affects the microparticle stratigraphy.

Lonnie Thompson

MICROPARTICLES, ICE SHEETS AND CLIMATE

The results of two initial studies of microparticle variations in the Byrd Station and the Camp Century deep ice cores have been published. The research was conducted to clarify the relationships between atmospheric turbidity and climate by presenting the particle concentration and size distribution from sections of these two ice cores. In both cores the highest concentrations of particles occur where O^{18}/O^{16} ratios exhibit the greatest negative values. During the Wisconsinan Glacial Stage (>10 000 years B.P.) the concentration of small diameter particles (0.65 to 0.82 μm) was as much as 100 times greater than the mean Holocene (<10 000 years B.P.) concentrations in the Camp Century core and more than 4 times greater than mean Holocene values for the Byrd Core. Elemental composition and morphology of the microparticles suggest that most of the particles of Wisconsin age in the Bryd core are of volcanic origin and in the Camp Century core are of continental (eolian) origin. Results published in the Institute of Polar Studies, Report No. 64.

Lonnie and Ellen Thompson

ROSS ICE SHELF PROJECT (RISP)

The 1977-78 RISP field season was marked by two major achievements, completion of the Ross Ice Geophysical and Glaciological Survey (RIGGS) and successful penetration of the ice shelf at the RISP drill camp (82°22'S 168°38'N).

The RIGGS program visited nearly 200 sites over four field seasons providing complete coverage of the shelf with measurements of ice thickness and velocity, surface strain rates, bottom depth, accumulation, and mean annual temperature. The survey work was conducted by Twin Otter aircraft operating from six temporary base camps. Tidal Gravity measurements were made at these six camps and a few additional sites.

At the J-9 Drill site an access hole was drilled through the shelf using a flame-jet drill developed by Browning Engineering Corporation. Once drilling began about 9 hours was required to produce a 30-80 cm diameter hole through the 420 meted ice thickness. The hole was redrilled every 3-4 days as freezing reduced its diameter.

Over a three week period scientific measurements were conducted through this access hole. 11 gravity cores, up to one meter length, were collected. An equal number of undisturbed surface samples (up to 14 cm length) were obtained with a sphincter shampler. Biological programs included the collection of several hundred amphipods, one a new species, and ine isopod (serolis). Temperature profiles in the water column were acquired by three independent methods and many water samples were collected including large volume samples obtained by pumping. Bottom photographs were obtained on several camera lowerings. Two species of fish were photographed on separate lowerings.

J. Clough

SIR CHARLES WRIGHT:
A CANADIAN TRIBUTE

by

R. F. Legget[1] and L. W. Gold[2]

Sir Charles Wright (1887-1975) lived such a many-faceted life that it would require a fair sized volume to do even summary justice to his many achievements, public and private. It is greatly to be hoped that a worthy biography will be prepared while vivid memories still enliven the minds of his many friends, young and old.

Tribute to his winning personality has already been paid in the pages of the *Journal of Glaciology* (Jacobs and Hattersley-Smith 1977). In the second of these statements, reference is made to Sir Charles' concern for fundamental research into the properites of snow and ice, and of the corresponding interest which he had in Canadian work in this field. It seems appropriate to record a further personal tribute from two more of his friends, with special reference to this little known contribution of Sir Charles Wright to the advance of glaciology.

Despite the importance of snow and ice in the Canadian economy, little study of these materials had been carried out in Canada prior to the years of the Second World War. A few individuals had made notable but isolated contributions such as Barnes (1928) in his work on the ice of the St. Lawrence, and Brown and Clarke (1932) with their studies of ice pressure against dams. At the Ottawa laboratories of the National Research Council of Canada, Barnes and Maass studied the specific heat and latent heat of fusion of ice in 1930, Doyle and Sproule made measurements of the elastic properties of ice in 1931; Klein began his notable work on the properties of snow and the design and performance of aircraft skis in 1938.

It was, therefore, the more remarkable that, when the Council established in 1944 a committee to direct research into problems with the operation of tracked vehicles, Dr C. J. Mackenzie (then President) designated this body the Associate Committee on Soil and Snow Mechanics, with a percipient appreciation of what its peacetime role would be. During an official visit to Switzerland in 1946, Legget (Chairman of the Committee) was asked by Swiss pioneer workers in this field how Canada had discovered the link between soil and snow mechanics which it had taken them ten years to determine.

With the coming of peace, the Associate Committee turned its attention to non-military problems; snow and ice research loomed large. Jointly with the parallel Associate Committee on Geodesy and Geophysics, the Committee convened a meeting in Ottawa on 17 and 18 September 1947. J. Tuzo Wilson and R. F. Legget, the Committee Chairmen, presided. Legget had come to know Sir Charles Wright through Professor Griffith Taylor (of the University of Toronto) who had married the sister of Lady Wright, both ladies being sisters of Sir Raymond Priestley. Sir Charles had just taken up residence in Victoria, B.C., prior to his later return to official duty in Washington at the time of the Korean crisis. He was therefore invited to the meeting and was an interested participant throughout the two days (NRC 1947).

Seventy people attended the meeting, representatives of both interested research workers and all main branches of the national economy affected by snow and ice (such as railways, highway departments and hydro-electric authorities). The valuable contributions made to the discussions by Sir Charles are still remembered appreciatively by some of those who were present. His authorship (with Priestley) of the pioneer volume of *Glaciology* more than thirty years previously acted almost as a spur to Canadian action. His benign presence made him the "elder statesman" of the meeting and yet, as Jacobs and Hattersley-Smith have recorded, he was just at the start of his second and third scientific careers. A later comment of his own was that "Very rudely, I fear, I expressed surprise that I was still able to understand the papers there given in spite of the lapse of time since I abandoned Glaciology."†

Over one hundred problems involving snow and ice were suggested during the two days of deliberation. These were later reviewed by Dr Marcel de Quervain in the year which he spent in Canada as a guest of the Division of Building Research, National Research Council of Canada, and have formed the base on which work programmes have been steadily developed. Formation of the subcommittee on Snow and Ice of the Associate Committee (since renamed as that on Geotechnical Research) was a direct

outcome of the 1947 meeting; it continues its good work today. Equally important was the confirmation that the meeting gave unanimously for an immediate start in Canada on fundamental research into snow and ice as materials, strongly urged by Sir Charles in one of his contributions to the meeting. A small Snow and Ice Section was therefore established in 1948 within the then-new Division of Building Research of NRC. In 1954 it began work in the first cold room specially designed for snow and ice studies in Canada, constructed in the newly occupied building housing the Division.

On almost all his subsequent visits to Ottawa, Sir Charles would be in early touch with one of us (RFL) to inquire about the progress being made with the work in this new laboratory. Whenever possible, he would visit the Division to see the research that was underway and to talk to the people that were doing it. The photograph with this note was taken during a visit by Sir Charles in 1966, and shows him discussing the investigations being carried out in the laboratory with Dr Gold (then Head of the DBR Snow and Ice Section). Copies of all DBR/NRC papers on snow and ice were sent to him, at his request, and always acknowledged, often with pithy and helpful comments. Only in 1974, when he was 87, did he ask that the sending of papers be stopped.

So meticulous was Sir Charles in commenting on the reports of DBR/NRC work thus sent him that one one occasion his letter of acknowledgement came from Bryd Station, Antarctica. After thanking Legget for the latest papers, he described the under-snow facilities at the Station, and explained that "Some of the labs are only reached from above — those ½ to 1½ miles away are entered by ladders up to 65 ft long. I find I don't negotiate these ladders as well as I used to — all very sad!"†

Sad? Nothing was sad about this great man.

† Reproduced by kind permission of the daughters of Sir Charles Wright.

[1] Director, DBR/NRC. 1947-1969.
[2] Assistant Director, DBR/NRC.

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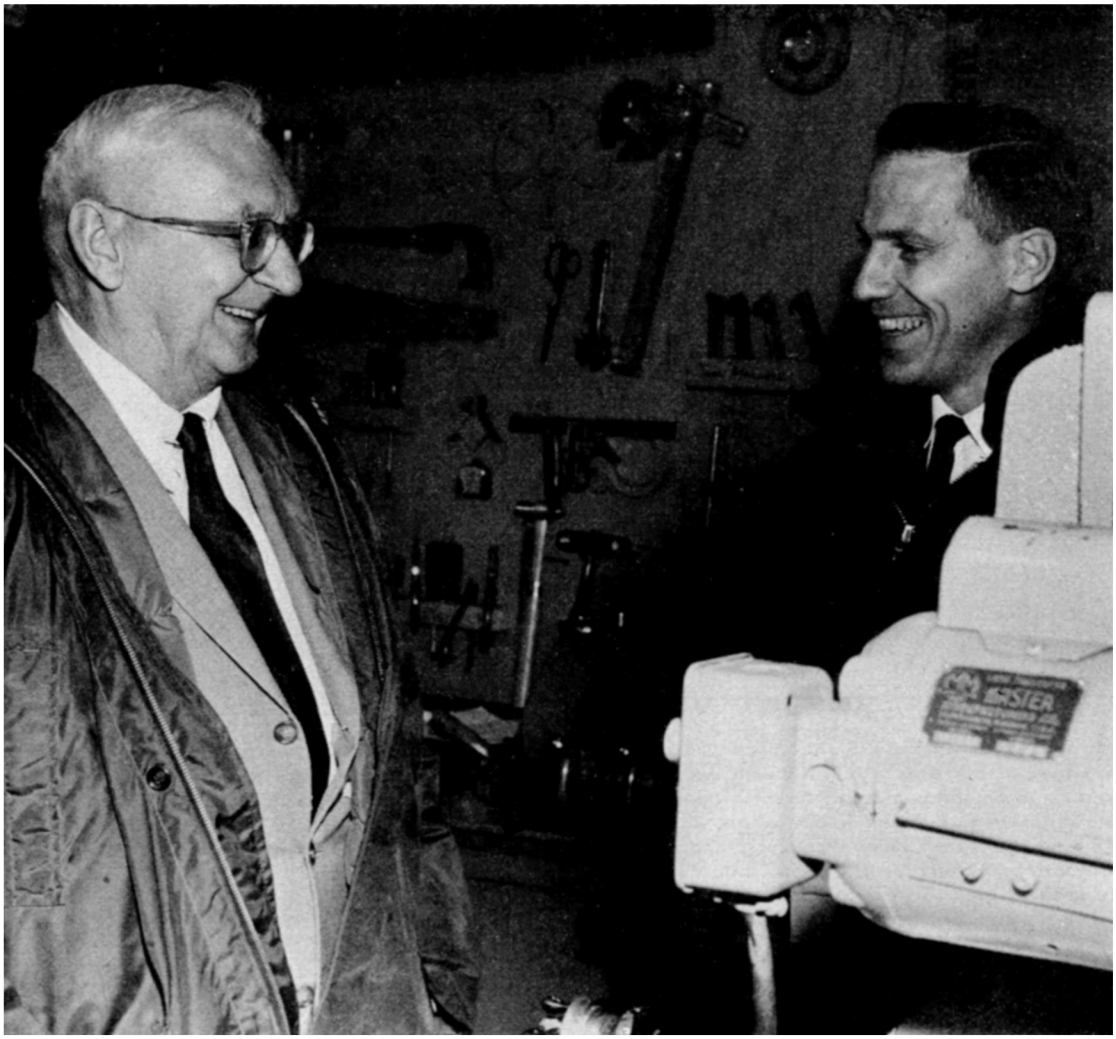
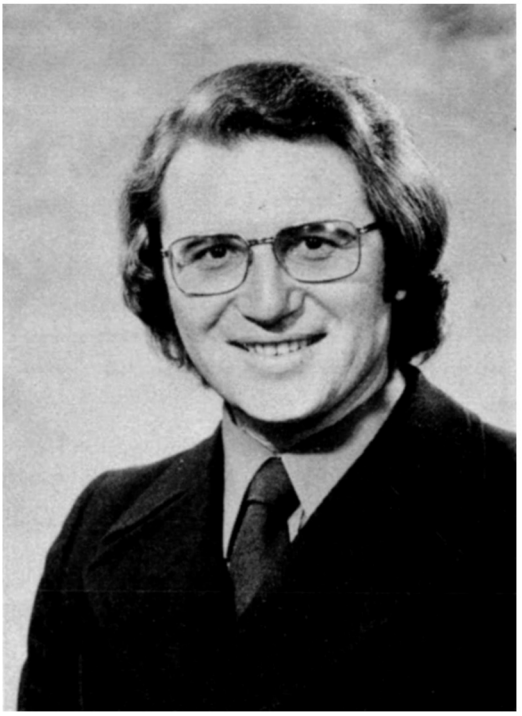


Sir Charles Wright and Dr. Lorne Gold



ROBERT VIVIAN

Born in December 1936 in Voiron, Isère, in the shadow of the Alps, Robert Vivian was from an early age an enthusiast for the mountains. Leisure pursuits were supplemented in his school and college days by scientific work and his professional life has been almost entirely devoted to alpine glaciology and geomorphology.

A Baccalauréat in experimental sciences in 1954 was followed by first degree courses at the University of Grenoble in regional, general and historical geography. The theoretical examinations were taken in 1959 and the practical ones in 1960, with distinction. In 1961 and 1962, Vivian taught in a school in Albertville and gained a teaching diploma. After a two-year break for military service, during which he worked on interpretation of air photographs, he moved to the Institute of Alpine Geography in the University of Grenoble. His appointment was as Assistant, but promotion to Maître-Assistant came after two years, in 1966, first of all on a temporary basis then, in 1968, on a fully recognised basis. In 1972, further promotion occurred, to the highest level of Maîtres-Assistants.

Beginning with his earliest days as a student at the University, Robert took part in many glaciological projects in the nearby mountains. By the time he took up the post at the Institute, he had already published papers and attended conferences on specialised glaciological subjects. In 1963 he spent 6 weeks and in 1964 8 weeks in Spitsbergen, on a French expedition, studying small glaciers and glacial morphology at high latitudes. In 1968 and 1970 he went on French expeditions to Nepal and Tibet to study various aspects of glaciation in the Himalayas.

At the Institute of Alpine Geography, his teaching encompassed courses and practical work on cartography, laboratory techniques, problems encountered in mountain environments, rocks and minerals, glacial geomorphology and glaciology, polar regions, and general courses on the geography of the U.S.A. and the Soviet Arctic. But his main interest was, and still is, the glaciers of the western Alps. It was this subject that he chose for his thesis for the highest doctorate it is possible to get in France: Doctorat d'Etat. This study included the role of water in the work of glaciers, present glaciation and recent fluctuations, and the modelling of mountain scenery by glaciers. The thesis received many compliments from the examining jury and the Doctorate was awarded with honorable mention in 1974. As a result, Vivian became qualified as a full Professor in the University, with the title "Maître de Confé ences".

His main research work is concerned with the processes beneath a glacier, and he has worked with colleagues from other organizations, from Switzerland and Italy as well as from

France, on the glacier d'Argentière. This work has been a milestone in such glaciological research, and scientists from many countries have visited "Glaciolab" and have read and heard about the experiments.

Robert has taught special courses in other universities in France, and in Switzerland, Belgium and the U.S.A. He organized the first meeting of the French Branch of the International Glaciological Society, the most active of our four branches and now re-named the Western Alpine Branch. He has served on the Council of the Society and serves on several committees and commissions of French national scientific bodies. He has helped in several west European countries with radio and television programmes on glaciers in general and on the sub-glacier work in particular.

His wife, Huguette, has a research post with the French National Scientific Research Council, and his son has just completed his schooling in Grenoble. Their strikingly modern home has been the scene of many glaciological reunions; visitors are made to feel as welcome there as they are during professional visits to the laboratory high up under the glacier d'Argentière.

INTERNATIONAL GLACIOLOGICAL SOCIETY

BRANCH NEWS

BRITISH BRANCH

The 1978 meeting of the British Branch was held in Manchester on 14 April 1978, at the Department of Geography, University of Manchester. A full programme of fourteen papers covered a wide range of topics:

Continuous surface strain measurements on Erebus Glacier tongue, Antarctica — D. J. GOODMAN

Crystal orientation fabrics in relation to structure and strain in Griesgletscher, Switzerland — M. J. HAMBREY

Radioecho sounding — experiments in the laboratory — M. E. R. WALFORD

Sledge-borne radioecho sounding of an ice rise — R. D. CRABTREE

An approach to glacier simulation — J. S. GILL

Equilibrium profile of ice shelves — T. J. O. SANDERSON

Catastrophies, flow-fields and sea ice — J. F. NYE

Recent glacier recession on South Georgia — R. J. TIMMIS

Laboratory studies of glacial erosion — N. W. RILEY

Glacial action and loess formation — I. J. SMALLEY

The flow of ice treated as a Newtonian viscous fluid, round a stone at the bed of a glacier — E. M. MORRIS

Rock glaciers of the Yukon Territory, Canada — P. G. JOHNSON

The time lag distributions of a small glacial catchment — M. G. C. READ

Temporal variations in chemical composition of meltwaters from Gornergletscher, Switzerland — D. N. COLLINS

A short Branch Meeting followed the sessions. It was decided that next year's meeting would probably take place in Newcastle-upon-Tyne.

WESTERN ALPINE BRANCH

The next meeting of the Brench will take place on 7-10 September 1978 in the Alpes Graies (Ruitor-Sassière). The registration fee of 100 Ff for members of the Society who have paid their 1978 dues and of 130 Ff for others will include cold meals on the 8th and 9th and the banquet on the 10th.

The programme will include lectures, films, reception by the Mayor of Bonneval, study tours to nearby glaciers (Ruitor, Rhême Golette) and mountains in this historically and glaciologically interesting area astride the borders of France and Italy.

For further information, and for registration forms, write to François Valla, IGS Section des Alpes Occidentales, c/o Nivologie CT-GREF, B.P. 114, 38402 St. Martin d'Hères, France.

NORTH EAST NORTH AMERICAN BRANCH

The North-east North American branch of the International Glaciological Society will hold its next biannual meeting on 2-4 March 1979. This will be an informal meeting, where preliminary results can be aired before a critical but, we hope, friendly audience. It will be held at Capricorn Ski Lodge on Sugarloaf Mountain in Kingfield, Maine. Several field trips to the nearby ski slopes will be arranged under the theme: "Competitive Applied Glaciology". The Lodge is easily reached by car, and there will be transport from Bangor to Sugarloaf.

Further details can be obtained from: Bob Thomas, Institute for Quaternary Studies, Boardman Hall, University of Maine, Orono, ME 04473. Tel: (207)581-2286.

JOURNAL OF GLACIOLOGY

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

I. Whillans:
Surface mass balance variability near "Byrd" station, Antarctica, and its importance to ice core stratigraphy.

R. Souchez and R. D. Lorrain:
Origin of the basal ice layer from Alpine glaciers indicated by its chemistry.

S. L. McCabe and F. W. Smith:
A mechanical test procedure for avalanche snow.

H. F. Engelhardt, W. D. Harrison and B. Kamb:
Basal sliding and conditions at the glacier bed as revealed by borehole photography.

A. Wankiewicz and Jan de Vries:
Instruments and methods: An inexpensive tensiometer for snow-melt research.

G. D. Osborn:
Fabric and origin of lateral moraines, Bethartoli Glacier, Garhwal Himalaya, India.

W. A. Gell:
Ice-wedge ice, Mackenzie Delta-Tuktoyaktuk Peninsula area, N.W.T., Canada.

W. A. Gell:
Fabrics of icing-mound and pingo ice in permafrost.

G. Thom:
Disruption of bedrock by the growth and collapse of ice lenses.

J. Hnatiuk, A. Kovacs and M. Mellor:
A study of several pressure ridges and ice islands in the Canadian Beaufort Sea.

J. G. Job:
Numerical modelling of iceberg towing for water supplies — a case study.

D. M. Joncich, J. Holder and A. V. Granato:
A direct determination of an upper limit for the electrical charge on dislocations in ice.

R. M. Koerner:
Accumulation, ablation and oxygen-isotope variations on the Queen Elizabeth Islands ice caps, Canada.

H. W. Liu and K. J. Miller:
Fracture toughness of fresh-water ice.

P. A. Mayewski, J. W. Attig and D. J. Drewry:
Pattern of ice surface covering for the Rennick Glacier, northern Victoria Land, Antarctica.

C. Raymond and K. Tusima:
Grain coarsening of water-saturation snow.

R. J. Small:
The formation of medial moraines on Alpine glaciers.

R. H. Thomas and C. R. Bentley:
The equilibrium state of the eastern half of the Ross Ice Shelf.

J. Tobarias, P. Saguet and J. Child:
Instruments and methods: Determination of the water content of snow from the study of electromagnetic wave propagation in the snow cover.

Short note —

P. A. Mayewski and J. W. Attig:
A recent decline in available moisture in northern Victoria Land, Antarctica.

SYMPOSIUM ON THE PHYSICS AND CHEMISTRY OF ICE (Vol. 21, No. 85)

E. Whalley:
The distortion of a water molecule in ice.

D. W. Davidson and J. A. Ripmeester:
Clathrate ices — recent results.

H. Engelhardt and B. Kamb:
X-ray determination of the structure of ice IV.

D. D. Klug and E. Whalley:
Origin of the high-frequency translational bands of ice I.

P. Faure and A. Chosson:
The transitional lattice-vibration Raman spectrum of single-crystal ice Ih.

J. F. Nagle:
Configurational statistics.

O. E. Mogensen and M. Eldrup:
Vacancies in pure ice studied by positron annihilation techniques.

M. Eldrup, O. E. Mogensen and J. H. Bilgram:
Vacancies in HF-doped and in irradiated ice by positron annihilation techniques.

J. H. Bilgram and H. Gränicher:
Interaction of point defects in ice.

G. C. Camplin, J. W. Glen and J. G. Paren:
Theoretical models for interpreting the dielectric behaviour of HF-doped ice.

G. W. Gross, I. C. Hayslip and R. N. Hoy:
Electrical conductivity and relaxation in ice crystals with known impurity content.

M. Hubmann:
Effect of pressure on the dielectric properties of ice Ih doped with NH_3 and HF.

N. Maeno and H. Nishimura:
The electrical properties of ice surfaces.

A. Loria, E. Mazzega and U. del Pennino:
Measurements of electric properties of ice Ih single crystals by admittance techniques and thermally stimulated depolarization techniques.

K. Itagaki:
Dielectric properties of dislocation-free ice.

B. Dorner:
Inelastic neutron scattering and its application to ice.

M. Varrot, G. Rochas and J. Klinger:
Thermal conductivity of ice in the temperature range 0.5 to 5.0 K.

I. Golecki and C. Jaccard:
Radiation damage in ice at low temperatures studied by proton channelling.

G. P. Johari and S. J. Jones:
The orientation polarization in hexagonal ice perpendicular to the c-axis.

G. Noll:
The influence of the rate of deformation on the electrical properties of ice monocrystals.

B. Stauffer and W. Berner:
CO_2 in natural ice.

N. D. Hargreaves:
The radio-frequency birefringence of polar ice.

K. C. Jezek, J. W. Clough, C. R. Bentley and S. Shabtaie:
Dielectric permittivity of glacier ice measured *in situ* by radar wide-angle reflection.

L. T. Traub and P. W. F. Gribbon:
The activation energies of temperate snow samples.

R. W. Whitworth:
The core structure and the mobility of dislocations in ice.

J. Perez, C. Mai and R. Vassoille:
Co-operative movement of H_2O molecules and dynamic behaviour of dislocations in ice Ih.

R. Vassoille, C. Mai and J. Perez:
Inelastic behaviour of ice Ih single crystals in the low-frequency range due to dislocations.

N. K. Sinha:
Observation of basal dislocations in ice by etching and replicating.

C. V. McKnight and J. Hallett:
X-ray topographic studies of dislocations in vapor-grown ice crystals.

Y. Mizuno:
Studies of crystal imperfections in ice with reference to the growth process by the use of X-ray diffraction topography and divergent Laue method.

H. Shoji and A. Higashi:
A deformation mechanism map of ice.

D. R. Homer and J. W. Glen:
The creep activation energies of ice.

S. J. Jones and J. G. Brunet:
Deformation of ice single crystals close to the melting point.

N. K. Sinha:
Short-term rheology of polycrystalline ice.

R. C. Lile:
The effect of anistrophy on the creep of polycrystalline ice.

R. W. Baker:
The influence of ice-crystal size on creep.

N. W. Riley, G. Noll and J. W. Glen:
The creep of NaCl-doped ice monocrystals.

S. A. Rice, W. G. Madden, R. McGraw, M. G. Sceats and M. Bergren:
On the relationship between low-density amorphous water and ice Ih.

J. H. Bilgram and H. Güttinger:
Dynamical processes at the ice-water interface during solidfication.

O. Buser and C. Jaccard:
Charge separation by collision of ice particles on metals: electronic surface states.

L. Couture:
Optical obsorption spectra of H_2O ice doped with yterbium chloride $YbCl_3$.

Patricia L. M. Plummer:
Molecular orbital calculations of water-ice surface interactions.

T. O'D. Hanley:
Frazil nucleation mechanisms.

A. Higashi:
Structure and behaviour of grain boundaries in polycrystalline ice.

M. Matsuda and G. Wakahama:
Crystallographic structure of polycrystalline ice.

P. Duval:
Anelastic behaviour of polycrystalline ice.

T. Hondoh and A. Higashi:
X-ray diffraction topographic observations of the large-angle grain boundary in ice under deformation.

S. C. Colbeck and N. Parssinen:
Regelation and deformation of wet snow.

D. J. Goodman and D. Tabor:
Fracture toughness of ice: a preliminary account of some new experiments.

K. Tusima:
Anistrophy of the kinetic friction on a single crystal of ice.

INTERNATIONAL GLACIOLOGICAL SOCIETY

Carleton University, Ottawa, Canada, 21-25 August

SYMPOSIUM ON DYNAMICS OF LARGE ICE MASSES 1978

PROGRAMME OF SESSIONS

(a) indicates longer papers
(b) indicates shorter papers
(c) indicates very short papers

Please note that the positioning of individual papers may change, for example if some authors do not arrive.

MONDAY 21 August
0900 - 0915 Opening of the Symposium.

SESSION 1: ICE SHEETS, PRESENT

0915 - 0955	Invited Paper	Budd, W. F.	Ice sheet dynamics.
0955 - 1035	Invited Paper	Whillans, I. M.	Dynamics of the ice sheet near Byrd Station, Antarctica.
1100 - 1220	(a)	Lliboutry, L.	Flow of a cold ice-sheet over bedrock perturbations.
	(a)	Boulton, G. S. & Jones, A.	Flow of ice sheets over deformable beds.
	(b)	Hutter, K. & Legerer, F. J.	First order stresses and deformations in glaciers and ice sheets.

SESSION 2: ICE SHEETS, PRESENT (continued)

1400 - 1520	(a)	Johnsen, S. J., Rasmussen, K. & Reeh, N.	Theory of deformations within ice sheets due to bottom undulations.
	(a)	Overgaard, S. & Rasmussen, K.	Study of deformation within ice sheets due to bottom undulation of radio echo sounding.
	(b)	Reeh, N.	Surface contours and flow pattern of a perfectly plastic three-dimensional ice sheet with arbitrary bottom and edge topography.
1545 - 1735	(a)	Mae, S.	Basal sliding of the Mizuho Plateau ice sheet, East Antarctica.
	(b)	Naruse, R.	Thinning of the ice sheet in Mizuho Plateau, East Antarctica.
	(b)	Orheim, O.	Mass outflow of Antarctica between 29°E and 44°W.
	(b)	Rose, K. E.	Characteristics of ice flow in Marie Byrd Land, Antarctica.
	(b)	Young, N. W.	Measured velocities of interior East Antarctica and the state of mass balance within the IAGP area.

TUESDAY 22 August

SESSION 3: ICE SHEETS, PRESENT (continued)

0900 - 1030	(a)	Budd, W. F. & Young, N. W.	Results from the IAGP flowline study inland of Casey.
	(a)	Raynaud, D. Lorius C. Budd, W. F. & Young, N. W.	Interpretation of data from an ice core in Terre Adelie by modelling the ice flow along an IAGP flowline.
	(a)	Russell-Head, D.S. Budd, W. F.	Ice sheet flow properties from combined borehole shear and ice core studies.
1055 - 1225	(a)	Raymond, C. F. Hooke, R. LeB, Hotchkiss, R. L. & Gustafson, R. J.	Calculations of velocity and temperatures in a polar ice mass using the finite element method.
	(a)	Lessow, H. A. & Gudmandsen, P.	On the stratification in polar ice caps observed by radio echo sounding.
	(a)	Robin, G. de Q.	Evidence against and factors preventing surging of the Antarctic ice sheet.

(TUESDAY, continued)		SESSION 4: ICE SHEETS, PRESENT (continued)	
1400 - 1530	(b)	Gow, A. J. & Kohnen, H.	The relationship of ultrasonic velocities to C-axis fabrics and relaxation characteristics of ice cores from Byrd Station, Antarctica.
	(b)	Overgaard, S. & Gudmandsen, P.	The topography of the Greenland Ice Sheet derived from radio echo sounding.
	(a)	Colbeck, S. C. & Gow, A. J.	The margin of Greenland Ice Sheet at Isua.
	(b)	Emery, J. J., Hanafy, E. A., Holdsworth, G. H. Mirza, F.	Finite element simulation of the Barnes Ice Cap.
1555 - 1745	(a)	Thomas, R. H.	The dynamics of marine ice sheets.
	(b)	Allison, I.	The mass budget of the Lambert Drainage Basin, Antarctica.
	(c)	Zwally, H. J.	Ice sheet surface elevation and changes observable by satellite radar altimetry.
	(c)	Baker, R. W. & Gerberich, W. W.	The effect of crystal size and dispersed solid inclusion on the activation energy for creep of ice.
	(c)	Yuen, D. A. & Schubert, G.	The role of shear heating in the dynamics of large ice masses.
	(c)	Hoar, S. L. & Langway, C. C.	Physical properties profile of the deep ice core from Camp Century, Greenland.
WEDNESDAY 23 August			
		SESSION 5: ICE SHEETS, PAST	
0900 - 1020	(b)	Lingle, C. S. & Clark, J. A.	Ice volume contained in the expanded 18,000 years B.P. Antarctic Ice Sheet, and sea level change at the West Antarctic Ice Sheet margin between 18,000 years B.P. and the present.
	(a)	Hughes, T., Schilling, D. Denton, G. & Lingle, C.	Ice sheet reconstruction for the CLIMAP 18,000 years B.P. Experiment.
	(a)	Boulton, G S. & Williams, L. D.	Modelling Pleistocene ice sheets over Europe.
1045 - 1215	(b)	Denton, G. Anderson, B. & Hughes, T.	A second look at the proposed Late Wurm Arctic Ice Sheet.
	(b)	Hughes, T., Fastook, J. & Denton, G.	Ice sheet disintegration for the CLIMAP 120,000 years B.P. Experiment.
	(b)	Drewry, D. J.	Late Wisconsin reconstruction for the Ross Sea Region, Antarctica.
	(c)	Birchfield, G. E.	Spectral response of an ice age-continental ice sheet model.
	(c)	MacAyeal, D. R.	A catastrophe model of the Paleoclimate.
		SESSION 6: ICE SHELVES	
1400 - 1445	Invited Paper	Thomas, R. H.	Formation, flow and disintegration of ice shelves.
1445 - 1530	Invited Paper	Robin, G. de Q.	Ice shelves: a review.
1555 - 1745	(a)	Bentley, C. R., Clough, J. W. Jezek, K. C. & Shabtaie, S.	Ice thickness patterns and the dynamics of the Ross Ice Shelf.
	(b)	Neal, C.	Dynamics of the Ross Ice Shelf as revealed by radio echo sounding
	(c)	Kirchner, J. F., Bentley, C. R., Robertson, J. D., Jezek, K. C. & Clough, J. W.	Lateral density differences at a site on the Ross Ice Shelf, Antarctica, from seismic measurements. *combined with* Vertical electromagnetic sounding on the Ross Ice Shelf, over a location exhibiting bottom crevassing.

(WEDNESDAY afternoon, continued)	(c)	Kirchner, J. F., Bentley, C. R. & Albert, D. G.	Seismic short refraction studies on the Ross Ice Shelf, Antarctica.
	(c)	Shabtaie, S., Bentley, C. R. & Greischar, L. L.	Electrical resistivity sounding of the structure of the Ross Ice Shelf, Antarctica.
	(c)	Heron, M. H. & Langway, C. C.	Dating of Ross Ice Shelf cores by chemical analysis.

THURSDAY 24 August

SESSION 7: SEA ICE

0900 - 0945	Invited Paper	Rothrock, D. A.	Modelling sea ice features and processes.
0945 - 1030	Invited Paper	Hibler, W. D.	Large scale modelling of sea ice.
1055 - 1225	(a)	Coon, M. D. & Pritchard, R. S.	Energy considerations in sea ice dynamics.
	(a)	Ackley, S. F.	Mass balance of the Weddell Sea pack ice.
	(b)	Feldman, U. & Howarth, P. J.	Predicting the motion of ice floes.
	(b)	Neralla, V. R. & Liu, W. S.	A simple model to calculate the compactness of ice floes.
	(c)	Wiesnet, D. R.	Satellite studies of freshwater ice movement on Lake Erie.

Afternoon Tour of Gatineau Hills, lunch en route. (See overleaf.)
1900 Symposium Banquet at the Hunt Club. (See overleaf.)

FRIDAY 25 August

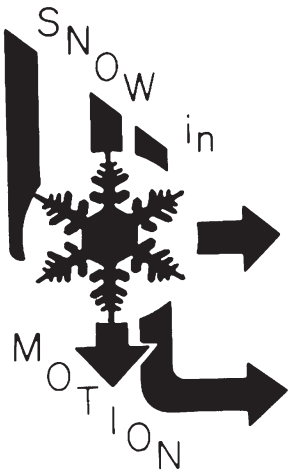
SESSION 8: VALLEY GLACIERS

0900 - 0945	Invited Paper	Meier, M. F.	Surging glaciers.
0945 - 1035	(a)	Hodge, S. M.	Instability of calving glacier terminus.
	(b)	Williams, R. S., Thorarinsson, S., Bjornsson, H. & Gudmundsson, B.	Dynamics of Icelandic ice caps and outlet glaciers.
1100 - 1230	(a)	Thompson, D. E.	Application of fluid-instability analysis to glacier flow.
	(a)	Fowler, A. C.	The use of a rational model in the mathematical analysis of a polythermal glacier.
	(a)	Waddington, E. D.	Numerical modelling of glacier flow.
1400 - 1445	(c)	Nakawo, M.	Deduction of glacier flow from a distribution of elongated bubbles.
	(c)	Williams, F. M.	Wave ogives as second order effects in the creep of large ice masses.
	(c)	Bindschadler, R.	Longitudinal stress gradients and base shear stress of a temperate valley glacier.

SESSION 9: DISCUSSION & SUMMARY

1445 **General discussion**
Summary and recommendations
1700 (at latest) **Closing of the Symposium**

SCIENTIFIC SYMPOSIUM ON



Fort Collins, Colorado, USA

12-17 August 1979

Sponsored by:

USDA Forest Service
Rocky Mountain Forest and Range
Experiment Station
and
International Glaciological Society

2nd circular

June 1978

ORGANIZING COMMITTEE

Richard A. Sommerfeld, U.S. Forest Service; M. Martinelli, Jr., U.S. Forest Service; Hilda Richardson, Sec. Gen., International Glaciological Society.

PAPERS COMMITTEE

P. M. Föhn, Switzerland; J. W. Glen, Journal of Glaciology; T. E. Lang, U.S.A.; T. Nakamura, Japan; R. I. Perla, Canada; U. Radok, Australia.

General information about the Symposium may be obtained by writing:

Dr. R. A. Sommerfeld,
Rocky Mountain Forest and Range Experiment Station,
240 West Prospect Street,
Fort Collins, Colorado 80521, U.S.A.

Information on registration and accommodation may be obtained by writing:

Snow in Motion,
c/o Office of Conferences and Institutes,
Colorado State University,
Fort Collins, Colorado 80523, U.S.A.

A Symposium on avalanches and blowing snow will be held at Colorado State University, Fort Collins, Colorado, U.S.A. It is sponsored by the Mountain Snow and Avalanche Research Project of the Rocky Mountain Forest and Range Experiment Station, U.S. Forest Service and the International Glaciological Society. Registration will be on Sunday, August 12, and the sessions will be held Monday, August 13 through Friday, August 17, 1979.

TOPICS

I. Snowcover stability evaluation and avalanche prediction
   A. Statistical approach
   B. Physical approach
   C. Casual-intuitive approach
   D. Avalanche warnings and public education in avalanche awareness.

II. Snow and avalanche mechanics
   A. Theoretical considerations
   B. Field and laboratory measurements
   C. Modeling efforts
   D. Interaction of avalanches with stationary objects.

III. Avalanche zoning
   A. As a technical problem
   B. As a socio-political problem
   C. Current zoning situations in various countries.

IV. Wind transport and deposition in irregular terrain
   A. Theory
   B. Measurements
   C. As a factor in avalanche areas
   D. Application of control techniques.

These topics were selected after an appraisal of current trends in snow and avalanche research. We feel the socio-economic aspects related to avalanche warnings, public awareness, and zoning are especially deserving of recognition at the present time.

PAPERS

The Papers Committee will be happy to consider papers on any of the above or closely related topics. Special consideration will be given papers covering new concepts or innovative ideas. Papers of a strictly operational nature will not be accepted. All papers and presentations will be in English.

Submission of Summaries

A detailed summary, not exceeding three pages, of each proposed paper will be due by October 31, 1978. They must be submitted on paper of international size A4 (210 x 297 mm), double-spaced, with wide margins. They should be sent to Dr. R. A. Sommerfeld, Rocky Mountain Forest and Range Experiment Station, 240 West Prospect Street, Fort Collins, Colorado 80521, U.S.A.

Selection of Papers

Papers will be accepted or rejected on the basis of the summaries. Each summary will be assessed independently by members of the Papers Committee. Acceptance or rejection will be on the basis of scientific merit and relevance to the topics listed above. Because of the large number of papers indicated by responses to the first circular, we are considering the possibility of a poster session for papers of merit but of limited interest. Authors will be notified of the final status of their papers in January 1979. Time allotted for presentation or poster session arrangements, as appropriate, will be included at that time.

Final Papers

Final papers should be sent to Dr. R. A. Sommerfeld, Rocky Mountain Forest and Range Experiment Station, 240 West Prospect Street, Fort Collins, Colorado 80521, U.S.A. **The last date for acceptance of final papers is June 15, 1979.** It is important that papers be received before this date so that they may be reviewed by the Editor of the Journal of Glaciology. Possible problems or questions can then be discussed by the author and the Editor at the Symposium.

Distribution and Publication

Copies of the detailed summaries will be distributed to all participants in January 1979. Preprints of the final papers will be distributed to all participants at registration.

The proceedings will appear as a special issue of the Journal of Glaciology. Papers accepted for full presentation will be considered for publication provided they have not been submitted for publication elsewhere. If papers

are accepted for a poster session, they will be considered for publication as a short note in the proceedings. All papers should be in English, prepared according to the instructions for paper preparation found on the inside back cover of the Journal. Maximum length will be 5,000 words or the equivalent including illustrations. Papers will be refereed according to the usual standards of the Journal of Glaciology before being accepted for publication. Members of the International Glaciological Society will receive the proceedings volume free. Others may place orders for the volume at time of registration or at the Society's Office.

ACCOMMODATIONS

Lodging and meals are available on the Campus of Colorado State University within walking distance of meetings. Lodging consists of suites of two bedrooms with a bath (toilet and shower) between. Each bedroom has two single beds and wash stand. Full maid service is provided daily. Meals are cafeteria style. Separate, small dining rooms are available adjacent to the cafeteria for the use of special interest groups which may wish to meet at meal times. The total cost for lodging and 3 meals per day, including a reception buffet Sunday afternoon and the Symposium dinner Thursday evening is $119.25 U.S. per person for double occupancy and $141.75 U.S. per person for single occupancy. An extra day (Friday) may be added at the rate of $11.00 U.S. per person for double occupancy and $15.50 U.S. per person for single occupancy. Family participation is encouraged and a schedule of reduced rates for children will be sent upon request.

Other accommodations are available in Fort Collins with costs ranging between $8.00 and $30.00 U.S. per person per night for lodging. Most of the cheaper accommodations are 3 to 5 km from the meeting site. The City contains a wide range of restaurants. There are a limited number of family accommodations with cooking facilities at motels in the area. Persons interested in these are advised to reserve them early since the Symposium will be during the tourist season. For those not living on campus, individual meals can be purchased at Colorado State University at a daily cost of approximately $9.00 U.S.

REGISTRATION AND RESERVATIONS

The registration fee for the Symposium is $60.00 U.S. and is required from all participants. Reservations for accommodations at Colorado State University are made by sending full payment for Symposium registration and lodging and meals. In order to reduce bookkeeping costs, partial payments are not acceptable. **Payment can be sent anytime after January 1, 1979 and before July 16, 1979.** Reservations and registrations can be cancelled with full refund at any time before 5 p.m., Friday, August 10, 1979. Persons not wishing to use University accommodations will be sent the appropriate information on receipt of their response form.

PAYMENT

Payment will be accepted in any bona fide form, made payable to Colorado State University. It should be mailed to Snow in Motion, c/o Office of Conferences and Institutes, Colorado State University, Fort Collins, Colorado 80523, U.S.A.

TRANSPORTATION

Denver's Stapleton Airport is the closest international airport. Commuter air service, limousine service, rental automobiles and bus service are available from the Denver Airport to Fort Collins. The Forest Service can also provide a limited amount of transportation for larger groups by advanced arrangement.

MONEY CHANGING

The changing of foreign currency in Fort Collins is very inconvenient. Currency can be changed at Stapleton Airport in Denver, any day between 0630 and 2100 MST, or at the major Denver Banks during working hours.

SOCIAL EVENTS

A buffet reception will be available Sunday afternoon, August 12. The Symposium dinner will be held Thursday, August 16. It will be an outdoor barbeque at the Lazy B Ranch near Estes Park, Colorado. Transportation between Fort Collins and Estes Park is provided at no extra cost. Cost of the reception and the dinner are included in the cost of accommodations at Colorado State University. Persons not using the CSU accommodations can purchase a ticket for the reception buffet for $6.50 and for the dinner, $9.70 U.S.

TOURS OF LOCAL AREAS

Fort Collins is located on the eastern edge of one of the most scenic areas in the United States. Also, several major government and university scientific facilities are located in the general area. Of particular interest are the CSU Wind Tunnel and Hydraulics Laboratory in Fort Collins, Colorado, as well as the World Glaciological Data Center—B, the National Center for Atmospheric Research (NCAR), and the Environmental Research Laboratories of the National Oceanic and Atmospheric Administration (NOAA) 100 km south in Boulder, Colorado. Many one day tours are possible, either on commercial tour buses or in rental automobiles. Arrangements for these can be made during the Symposium.

POST SYMPOSIUM EXCURSIONS

Two post symposium bus excursions are planned; a four-day loop trip through the Colorado Rockies Front Range and, an eight-day trip through areas of scientific and scenic interest in the Western United States ending in San Francisco. The four-day tour will start on the morning of the 18th in Fort Collins and proceed to Telluride via Salida, Montrose and Ouray. Among the highlights will be a tour of the Red Mountain Pass Area, the San Juan Avalanche Project, and a ride on the scenic Silverton to Durango narrow gage railroad. Overnight stops will be Telluride (18), Durango (19), and Grand Junction (20). The trip will terminate in the afternoon of the 21st at Denver's Stapleton Airport. The total trip is about 1600 km. Cost for transportation and lodging will be approximately $120.00 U.S.

The longer tour will follow the same itinerary to Durango. From Durango it will proceed to Grand Canyon National Park, Arizona; Bryce and Zion National Parks, Salt Lake City, Alta, Great Salt Lake, Utah; Reno, Nevada; Donner Pass and San Francisco, California. Overnight stops will be in Telluride (18), Durango (19), Grand Canyon (20), Bryce Zion (21), Salt Lake City (22, 23), Lake Tahoe (24), and San Francisco (25). The length of the trip will be approximately 3600 km. Cost for transportation and lodging will be approximately $330.00 U.S. From San Francisco many other interesting areas on the West Coast of the U.S. are accessible. Transportation on both tours will be on Trailways buses. These are comfortable, air conditioned buses with reclining seats and toilet facilities. Tour guides will be provided for some of the more interesting portions of the trips. An attempt has been made to keep the schedule from being rushed so that time may be spent at interesting points. In general, a choice of meals, ranging in price and quality, will be available at each stopping point. Trailways personnel are knowledgeable about particularly good places to eat.

A deposit of $50.00 U.S. is required by July 1, 1979 to secure a place on either excursion. The number of places is limited by the accommodations available at some of the stops so, interested persons are urged to send their deposits early. Deposits will be returned upon written notice of cancellation before August 1, 1979.

CALENDAR

October 31, 1978	Last date for receipt of detailed summary
January 1, 1979	First date for sending payment for accommodation and registration
June 15, 1979	Last date for receipt of final papers
July 1, 1979	Last date for excursion deposits
July 16, 1979	Last date for payment of CSU accommodation fees including registration
August 1, 1979	Last date for full refund excursion cancellation
August 10, 1979 (1700 MST)	Deadline for full refund accommodation cancellation
August 12, 1979	Afternoon reception buffet
August 13-17, 1979	Symposium Sessions
August 18-25, 1979	Post Symposium Tours

Response Form

Scientific Symposium on Snow in Motion

12-17 August, 1979, Fort Collins, Colorado, USA

REGISTRATION

Name of Participant .....

Title .....

Address .....

.....

FEE US$ 60.00 $ ———

Accompanied by: .....

.....

Accommodations at Colorado State University* (CSU)

☐ I would like accommodation for ——— persons $ ——

☐ Number of people ——— (at US$ 119.25 per person — double occupancy)

☐ Number of people ——— (at US$ 141.75 per person — single occupancy)

☐ I would like to receive information on the reduced rates for children at CSU.

☐ I would like to reserve room and meals for an extra day (Friday, August 18).

Number of people ——— (at US$ 11.00 — double occupancy) $ ———

Number of people ——— (at US$ 15.50 — single occupancy) $ ———

Accommodations in the city of Fort Collins

I would like to receive information on accommodations available in the city of Fort Collins.

TOURS

☐ I would like to reserve ——— places on the 4 day excursion. Cost for transportation and lodging approximately US$ 120.00 with a US$ 50.00 deposit by JULY 1 1979. $ ———

☐ I would like to reserve ——— places on the 8 day excursion. Cost for transportation and lodging approximately US$ 330.00 with a US$ 50.00 deposit by JULY 1 1979. $ ———

TOTAL payments included $ ———

* Remember if you are staying at CSU you must send full payment for Registration, Lodging and meals.

Make checks payable to Colorado State University.

Correspondence should be sent to:

"Snow in Motion",
c/o Office of Conferences and Institutes,
Colorado State University,
Fort Collins, CO 80523,
U.S.A.

INTERNATIONAL GLACIOLOGICAL SOCIETY

SYMPOSIUM ON PROCESSES OF GLACIER EROSION AND SEDIMENTATION

FIRST CIRCULAR

Geilo, Norway 25—29 August 1980

The Society will hold a symposium on Processes of glacier erosion and sedimentation in Geilo, Norway in 1980. Registration will take place on Sunday 24 August, and sessions will be from Monday 25 to Saturday 30 August.

TOPICS

The Symposium will be concerned with the erosional and depositional **processes** by which glaciers shape the surface of the earth.

PAPERS

The Papers Committee will be happy to consider any paper that provides new information on the above topic. Details about the submission of summaries and final papers will be given in the Second Circular, to be published in the summer of 1979. Dates for submission are firm ones and must be adhered to.

PUBLICATION

The Proceedings of the Symposium will be published in a special issue of the *Journal of Glaciology.* Papers will be refereed according to the usual standards of the *Journal of Glaciology* before being accepted for publication.

EXCURSIONS

Geilo is located near the highest point on the Oslo-Bergen railway, within easy reach of the glaciers Hardangerjøkulen and Ovnsbreen. These display a large variety of phenomena especially related to glacier sedimentation, and a one-day excursion will be conducted to these glaciers during the symposium week.

A four-day excursion will be arranged immediately following the Symposium. The first day will be down the Flåm Valley and along the Songnefjord, and will demonstrate numerous case examples of glacier erosion. The second day will be spent by Nigardsbreen, the most studied glacier in Norway, with special emphasis on erosional features and glacier hydrology. The third day will be in Jotunheimen, among the highest mountains of Norway, with visits to Vesle-Juvbreen and examination of ice-cored moraines. The fourth day will be spent in the region of the late glacial ice divide, with demonstration of all the related subglacial phenomena.

The excursions will be organized and guided by scientists from Norsk Polarinstitutt; Department of Geography, University of Oslo; Department of Geology, University of Bergen; and the Norwegian Water Resources and Electricity Board.

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.

ORGANIZING COMMITTEE

O. Liestøl
O. Orheim (Chairman)
J. L. Sollid
H. Richardson (Secretary General, IGS)

INTERNATIONAL GLACIOLOGICAL SOCIETY

SYMPOSIUM ON PROCESSES OF GLACIER EROSION AND SEDIMENTATION 1980

Family Name .....

First Name ..... Title .....

Address .....

.....

*I hope to participate in the Symposium, 1980 ☐

*I expect to submit a summary of a proposed paper ☐

*I hope to attend the four-day excursion ☐

*without obligation

TO BE SENT AS SOON AS POSSIBLE TO:

Secretary General, International Glaciological Society, Cambridge CB2 1ER, England.

FUTURE MEETINGS (of other organizations)

UNITED NATIONS EDUCATIONAL, SCIENTIFIC AND CULTURAL ORGANIZATION

International Hydrological Programme

INTERNATIONAL SYMPOSIUM ON THE COMPUTATION AND PREDICTION OF RUN-OFF FROM GLACIERS AND GLACIERIZED AREAS

Convened by the USSR National Committee for the IHP and organized in co-operation with Unesco, and with the support of the International Commission of Snow and Ice of the International Association of Hydrological Sciences.

Tbilisi (Georgian SSR), 3-11 September 1978

INFORMATION NOTE NO. 1

Origin and Purpose of the Symposium

The problem of run-off from glaciers and glacierized areas is of both great scientific and practical importance. At the present time, no scientific basis for the computation and prediction of glacier run-off exists, although the need for such computations is becoming urgent due to the growth of industrial development and highway construction in mountain and polar areas. This problem is important for many developing countries, situated in zones of insufficient precipitation. Many of the measures necessary to prevent natural disasters and and protect the environment in mountaineous areas require knowledge of glacier run-off. The main purpose of the Symposium will be to discuss the scientific results of recent studies on problems of run-off from glaciers and glacierized areas, particularly those conducted under the International Hydrological Programme, and to draw up the outline of a "Manual for the Computation and Prediction of Glacier Run-off" which will be the first of its kind.

Date and Place of the Symposium

At the kind invitation of the USSR National Committee for the IHP, the Symposium will be held in Tbilisi, he capital of the Georgian SSR, from 3 to 11 September 1978.

A Seminar of the Working Group on Ice, Water and Heat Balance of the ICSI of IAHS will be held in conjunction with the Symposium.

Provisional Programme

3 September	Registration of participants will begin at 0800h.
4-6 September	Symposium on the computation and prediction of run-off from glaciers and glacierized areas.
7 September	Tour of the City and its suburbs.
8-9 September	Seminar of the ICSI Working Group on Ice, Water and Heat Balance.
10 September	Study Tour to the glaciers of the Main Caucasian Range.

It is anticipated that a Bureau Meeting of the Commission of Snow and Ice of IAHS will be held during the Symposium, probably on 8 and 9 September 1978.

Provisional Agenda

The following topics will be discussed at the Symposium:

1. Direct measurement of heat exchange at the glacier surface.
2. Computation of glacier melting and ablation, from indirect data.
3. Liquid water on the surface, inside, and under glaciers: internal replenishment of glaciers.
4. Water-ice balance of glaciers and glacier basins: formation regime of run-off from from glaciers and glacierized regions.
5. Chemical composition and quality of snowmelt and glacier-melt waters.
6. Glacier-dammed lakes and their outbreak.

Papers Presented

Three types of papers will be presented:

(a) Review papers (thirty minutes will be allocated for the presentation of a review paper and twenty minutes for the ensuing discussion).

(b) Individual papers (twenty minutes for the presentation of an individual paper and fifteen minutes for the discussion).

(c) Short papers (ten minutes for the presentation of a short paper and ten minutes for the discussion).

Review papers will be presened by specialists invited by the Organizing Committee.

ICSI Seminar

The Seminar of the Working Group on Ice, Water and Heat Balance of the International Commission of Snow and Ice of the IAHS will comprise three sessions and the main discussions will be centred on problems of future investigations. The Seminar will have round-table sessions with open discussions on the following topics:

i Models of transformation of glacier-melt into the hydrograph of glacier run-off.
ii Internal replenishment of glaciers, and water loss in the glacier sequence.
iii The use of remote sensing for the assessment of the glacier run-off.
iv Methods of computation of the heat balance of the glacier surface.

Suggestions for other topics to be considered by the Seminar are invited by the Organising Committee.

Organization of the Symposium

In order that all papers presented at the Symposium constitute an ordered programme, the scientific preparation of the Symposium will be undertaken by an Organizing Committee composed of representatives of the USSR National Committee for the IHP, Unesco, and IAHS. The abstracts of papers to be presented at the Symposium will be preprinted and made available to participants at the meeting.

Working Languages

The Working Languages of the Symposium will be English and Russian. Simultaneous interpretation will be provided in these languages.

Papers and Abstracts

Only original papers will be accepted. These papers wil be selected by a screening committee on the basis of abstracts, and according to their significance and relevance to the topics of the Symposium. Papers, including abstract, illustrations, tables and references, should not exceed twelve pages. The papers should be in English and submitted in three copies.

Abstracts, not exceeding 20 to 30 lines, must be in English. They should be submitted to the Organizing Commitee in two copies not later than 1 April 1978.

Authors will be notified of the acceptance of their abstracts by May 1978. The complete texts of the accepted papers should be submitted during the meeting for inclusion in the Proceedings of the Symposium. The Papers will be followed by a discussion only if the author, or one of the authors, is present at the Symposium.

Participation

Specialists wishing to participate should apply for a provisional registration form and return one copy to Unesco *and* one copy to the Organizing Committee. The address of UNESCO and of the Organizing Committee are given below:

The Division of Water Sciences, Unesco, Place de Fontenoy, 75700 Paris, France.

Professor V. M. Kotlyakov, Organising Committee of the Symposium on the computation and Prediction of run-off from glaciers and glacierized areas, Academy of Sciences of the USSR, Staromonetny Street, 29, Moscow 109017, USSR.

Excursions

Thursday, 7 September — Excursion around Tbilisi and its historical sites, tour of the region and a visit to the ancient temple of Mitskheti.
Sunday, 10 September — Study tour to the glaciers of Kazbek in the Main Caucasian Range.

Information Note No. 2

A second Information Note, giving further details of the Symposium, its organization, place of meeting, excursions, hotel accommodation, etc., will be sent to all provisionally registered participants in June 1978.

UNITED NATIONS EDUCATIONAL, SCIENTIFIC AND CULTURAL ORGANIZATION

UNITED NATIONS ENVIRONMENTAL PROGRAMME

INTERNATIONAL COMMISSION ON SNOW AND ICE OF THE INTERNATIONAL ASSOCIATION OF HYDROLOGICAL SCIENCES

INTERNATIONAL WORKSHOP

on

WORLD GLACIER INVENTORY

Aletsch Ecological Centre, Riederalp, Ct. Valais, Switzerland, 17-22 September 1978.

FIRST CIRCULAR

Purpose of the Workshop

The Temporary Technical Secretariat for World Glacier Inventory (TTS) has entered Phase II of its operation. It is now of utmost importance to discuss the problems and prospects of the World Glacier Inventory at an International Workshop to be organised by the TTS.

The Workshop will be under the sponsorship of UNESCO, UNEP and the International Commission on Snow and Ice (ICSI) of IAHS.

Date and Place

The Workshop will be held at the Aletsch Ecological Centre, located at the elevation of 1900 m a.s.l., near the tongue of the Aletsch Glacier in the Swiss canton of Valais, from 17 to 22 September 1978.

Provisional Programme

17 September	Registration of participants beginning at 1700 h.
18-22 September	INTERNATIONAL WORKSHOP ON WORLD GLACIER INVENTORY including a one-day trip to the Eggishorn (2927 m), a mountain peak above the Aletsch Glacier.
23-24 September	Excursion to some glaciers in the Swiss Central Alps.

Topics

Main topics to be discussed are:

(a) Problems and techniques of glacier inventory data compilation (including remote sensing).

(b) Specific problems of glacier inventories: Antarctica and Greenland, rock glaciers, surging glaciers, firn line and eqiulibrium line, glacier classification and identification.

(c) Glacier fluctuations.

(d) Data handling and organization, the inventory data bank and retrieval system.

(e) Analysis of regional and global glacier inventories.

(f) The application of glacier inventories and and glacier fluctuation studies for the purpose of monitoring climatic change.

(g) Storage function of glaciers in the global, regional or local hydrological cycles.

Presentation of papers

There will be two types of papers:

(a) Invited papers from people known to be engaged in regional glacier inventories (twenty minutes for presentation and twenty minutes for discussion).

(b) Individual papers from other participants (fifteen minutes for presentation and fifteen minutes for discussion).

The working language is ENGLISH.

Abstracts of papers should be submitted to the Temporary Technical Secretariat for World Glacier Inventory not later than *15 April 1978* (two copies). The final papers will be mimeographed and distributed at the beginning of the workshop.

A final publication, including discussions, is envisaged.

Time-table

15 April	Declaration on interest in the Workshop. Submission of tentative title with abstract in 2 copies.
15 May	Second circular with registration form.
15 August	Submission of final paper in two copies and of registration form.

Excursions

A one-day excursion is planned during the Workshop to the top of the Eggishorn from which there is an excellent view of the Pennine and the Bernese Alps and the Aletsch Glacier.

After the Workshop a two-day excursion will lead us to several glaciers in the central part of Switzerland (Gries, Rhône, Unteraar and Stein glaciers).

Cost

The approximate cost for full board and lodging will amount to 200 Swiss francs. The two-day glacier excursion will cost about 150 francs.

In special cases financial support may be obtained.

Further information may be obtained from:

Dr Fritz Müller,
Department of Geography,
ETH,
Sonneggstrasse 5,
CH-8092 Zürich,
Switzerland.

INTERNATIONAL UNION OF GEODESY AND GEOPHYSICS

GENERAL ASSEMBLY 1979

First announcement of snow and ice symposia to be staged during the next General Assembly of IUGG, 3-15 December 1979 at Canberra, Australia:

(1) Sea level, ice sheets, and climatic change
Lead Association: IAHS.
Participating Associations: IAMAP, IASPEI, IAPSO.

Contributions to the symposium (provisional dates 7-8 December) are to review the knowledge of sea level changes due to all causes and identify those which resulted from changes in the large continental ice sheets; to assess the relative importance of the inherent and climatically caused changes in the shapes and volumes of ice sheets; and to interpret their basic role as causes or effects of climatic change.

Notice of potential contributions and requests for symposium circulars should be sent to the convener, Dr Uwe Radok, CIRES, University of Colorado, Boulder, CO 80309, USA.

(2) Ice, weather, and climate.
Lead: International Commission of Snow and Ice, IAHS.

Participants: International Commissions on Polar Meteorology and on Atmospheric Chemistry and Global Pollution, IAMAP.

Separate sessions are planned to consider the interactions of seasonal ice forms (snow, sea ice) and perennial ice (mountain glaciers, permafrost) with individual and ensemble (climatic) meteorological systems and processes.

Notice of potential contributions and requests for symposium circulars should be sent to the convener, Ian Allison, c/o Meteorology Department, University of Melbourne, PARKVILLE Vic. 3052 Australia.

GLACIOLOGICAL DIARY

1978

10–13 July
Third International Conference on Permafrost, Edmonton, Alberta, Canada. National Research Council of Canada. (M. K. Ward, c/o National Research Council of Canada, Ottawa, Ontario K1A 0R6, Canada.)

1–4 August
Symposium on Physics and mechanics of ice. Copenhagen, Denmark. (International Union of Theoretical and Applied Mechanics.)

7–12 August
IAHR Symposium on ice problems, Sweden. (Mr Bertil Köhler, Fack S 951 95, Luleå, Sweden.)

15–19 August
Symposium on Glacier beds: the ice-rock interface. Ottawa, Canada. Sub-Committee on Glaciers of the Canadian National Research Council. (C. S. L. Ommanney, Glaciology Division, Environment Canada, Ottawa K1A OE7, Canada.)

21–25 August
Symposium on Dynamics of large ice masses, Otawa, Ontario, Canada. International Glaciological Society. (Mrs H. Richardson, Sec. Gen., Cambridge CB2 1ER, England.)

3–11 September
Symposium on the Computation and prediction of run-off from glaciers and glacierized areas, Tbilisi, Georgian SSR, USSR. (V. M. Kotlyakov, Staromonetny 29; Moscow 109017, USSR.) (See p. 36 of this issue of ICE.)

7–10 September
IGS Western Alpine Branch meeting, Alpes Graies, France. (F. Valla, c/o Nivologie CT-GREF, B.P. 114, 38402 St. Martin d'Hères, France.) (See p. 24 of this issue of ICE.)

17–22 September
Workshop on World Glacier Inventory, Aletsch Ecological Centre, Riederalp, Ct. Valais, Switzerland. (F. Müller, Dept. of Geography, ETH, Sonneggstrasse 5, CH-8092 Zürich, Switzerland.) (See p. 38 of this issue of ICE.)

26–29 September
Meeting on Snow and run-off modeling, Hanover, NH, USA. (S. C. Colbeck, CRREL, Hanover, NH 03755, USA.)

1979

2–4 March
Northeast North American Branch IGS, meeting in Kingfield, Maine, USA. (R. H. Thomas, Institute for Quaternary Studies, Boardman Hall, University of Maine, Orono, ME 04773, USA.) (See p. 24 of this issue of ICE.)

24–28 April
Symposium on Electronics and avalanches, Graz, Austria. (Rr W. Fritzsche, Institute of Electronics, Technical University of Graz, Inffeldgasse 12, A 8010 Graz, Austria.)

12–17 August
Symposium on Snow in motion — Avalanches and blowing snow. Fort Collins, Colorado, USA. Rocky Mountain Forest and Range Experiment Station. Co-sponsored by International Glaciological Society. (Dr M. Martinelli, Rocky Mountain Forest and Range Experiment Station, Fort Collins, CO 80302, USA.)

3–15 December
International Union of Geodesy and Geophysics General Assembly, Canberra, Australia. Two glaciological symposia — see p. 39 of this issue of ICE.

1980

24–30 August
Symposium on Processes of glacial erosion and sedimentation. Geilo, Norway, International Glaciological Society. (Mrs H. Richardson, Secretary General, Cambridge CB2 1ER, England.) (See p. 35 of this issue of ICE.)

NEWS

AWARDS

Dr W. O. Field has been awarded the 1978 Busk Medal of the Royal Geographical Society, for his contributions to glaciological research and exploration in the northern hemisphere.

Dr T. E. Armstrong, who has served as Treasurer of the International Glaciological Society, has been awarded the 1978 Victoria Medal of the Royal Geographical Society for contributions to polar research. In 1977, Dr Armstrong was given an *ad hominen* promotion to the post of Reader in Arctic Studies, University of Cambridge, in recognition of his long and scholarly contribution to knowledge of those regions and of his considerable help to many people in different avenues of polar research.

Dr D. Kuroiwa was awarded the 1977 Hokkaido Sciences and Technology Prize by the Hokkaido Government, for his studies on snow and ice.

Dr G. de Q. **Robin** has received two senior doctorates recently in recognition of his eminent contributions to science. In 1977, the University of Cambridge awarded him the degree of Doctor of Science — the first time that a member of the Scott Polar Research Institute has achieved a Cambridge senior docorate. In 1978, Dr Robin was awarded a Doctorate of Philosophy *Honoris Causa* by the University of Stockholm.

PUBLICATIONS

Proceedings of the Workshop on the mechanical properties of ice (24-25 January 1977, Calgary, Alberta) have been published in Technical Memorandum No. 121 of the Associate Committee on Geotechnical Research, National Research Council of Canada. This can be obtained by addressing a request to: Publications Section, National Research Council of Canada, Building M-58, Ottawa, Ontario K1A 0R6, Canada. The cost of the publication is Can. $1.00 per copy.

GLACIOLOGICAL DATA

In October 1976, responsibility for the operation of *World Data Center A: Glaciology was assumed by the Institute of Arctic and Alpine Research, University of Colorado, in conjunction with the Environmental Data Service, National Oceanic and Atmospheric Administration, Boulder. At that time, it was decided that publication of *Glaciological Notes* in an accession bulletin format woud be superceded by a new publication through which WDC-A: Glaciology would seek to provide timely information on data availability to the international user community via an alternative format.

Glaciological Data, to be issued 3-4 times per year, will comprise a systematic bibliography and related data information on a selected theme. Our first issue deals with avalanches; number 2 is in preparation on arctic sea ice. These bibliographies will be as complete as we can at present make them, drawing on available computer-retrieval systems as well as printed bibliographies and holdings in the collection. In addition to the bibliographic information, we plan to include short contributions relating to the collection and dissemination of data for the particular topic of that issue. It is anticipated that a cycle of themes covering glaciology will last approximately two years.

Glaciology, as defined by the ICSU *Guide to International Data Exchange through the World Data Centres,* 1973, deals with the occurrence, properties, processes and effects of all forms of snow and ice in the atmosphere-earth-ocean system and with aspects of their past occurrence and effects.

The scope of glaciology spans an immense range of organizations concerned with data collection, monitoring, and research. In the United States, for example, snow cover is reported by the National Weather Service, NOAA, and mapped from satellites by the National Environmental Satellite Service, NOAA; snow depth and moisture content are measured by the Soil Conservation Service; sea ice, by the U.S. Navy and NASA, and so on. A similar situation prevails in most countries. A first task of WDC-A: Glaciology, in conjunction with WDC-B (Moscow), WDC-C (Cambridge) and the Permanent Services, is to identify and locate data sources of this type on a worldwide scale and then to collate information on the holdings, format and availability of these records. With present resources, it is anticipated that a first role of WDC-A should be to coordinate such

* See notes on World Data Centres on following pages.

information and act as a clearinghouse. Subsequently, based on this information and input from the user community, the shape of future activities in archiving quantitative data types can be evaluated.

We cordially invite your participation in the building of World Data Center A: Glaciology by the submission of pertinent materials and personal visits to use the facilities. Marilyn Shartran, Assistant Director, who is in charge of the day-to-day activities of the center, will appreciate suggestions for improving our user services. Scientific input to the center by the Institute of Arctic and Alpine Research will be forthcoming from its Director, Dr Jack D. Ives, as well as faculty J. T. Andrews, R. G. Barry and N. Caine and research associates.

Roger G. Barry

WORLD DATA CENTRES

*WDC-A, Glaciology is one of three international data centres serving the field of glaciology under the guidance of the International Council of Scientific Unions Panel on World Data Centres. It is part of the World Data Centres System created by the scientific community in order to promote worldwide exchange and dissemination of geophysical information and data. WDC-A endeavours to be prompt in its response to inquiries by the scientific community and to provide data and bibliographic services in exchange for copies of publications of data by the participating scientists.

The addresses of the three WDCs for Glaciology and of a related Permanent Service are:

World Data Centre A,
INSTAAR,
University of Colorado,
Boulder, Colorado 80309, U.S.A.

World Data Centre B,
Molodezhnaya 3,
Moscow 117 296, USSR.

World Data Centre C,
Scott Polar Research Institute,
Lensfield Road,
Cambridge, CB2 1ER, England.

Permanent Service on the Fluctuations of Glaciers,
Section on Hydrology and Glaciology,
Research Institute on Hydraulics and Soil Mechanics,
Federal Institute of Technology,
Voltastrasse 24,
8044 Zürich, Switzerland.

The World Data Centres follow the guidelines established by the International Council of Scientific Unions *Third Consolidated Guide to International Data Exchange through the World Data Centres, 1973.* The following description from the Guide details the form of the data accepted by the WDCs.

General. WDCs are prepared to accept raw, analyzed, or published data, including photographs. It is suggested that researchers submitting data to the WDCs do so in a form which will be intelligble to other users. Researchers should be aware that the WDCs are prepared to organize and store data which may be too detailed or bulky for inclusion in published works. It is understood that such data which are submitted to the WDCs will be made available according to guidelines set down by the ICSU Panel on WDCs in the *Guide to International Data Exchange.* Such material will be available to researchers as copies from the WDC at cost, or if it is not practical to copy the material, it can be consulted at the WDC. In all cases the person receiving the data will be expected to respect the usual rights, including acknowledgment, of the original investigator.

Fluctuations of Glaciers. The Permanent Service will be responsible for receiving data on the fluctuations of glaciers and will also receive such data as are generated by the International Hydrological Decade Project on Variations of Existing Glaciers. The types of data which should be sent to the Permanent Service are detailed in UNESCO/IASH (1969) *Variations of Existing Glaciers: A Guide to International Practices for Their Measurement.* These data should be sent through national correspondents in time to be included in the regular reports of the Permanent Service every 4 years (1964-68, 1968-72, etc.).

Projects of the International Hydrological Decade. In addition to the above, the International Hydrological Decade, 1965-74, sponsors an *Inventory of Seasonal and Perennial Snow and Ice Masses,* as well as a project of the *Combined Heat, Ice and Water Balances at Selected Glacier Basins.* Until such time as technical secretariats are established for these projects, data should be channelled through the World Data Centres.

In order that the WDCs may serve as information centres, researchers and institutions are requested:

To send WDCs reprints of all published papers and public reports which contain glaciological data or data analysis; one copy should be sent to each WDC or, alternatively, three copies to one WDC for distribution to the other WDCs.

To notify WDCs of changes in operations involving international glaciological projects, including termination of previously existing stations or major experiments, commencement of new experiments, and important changes in mode of operation.

NEW MEMBERS

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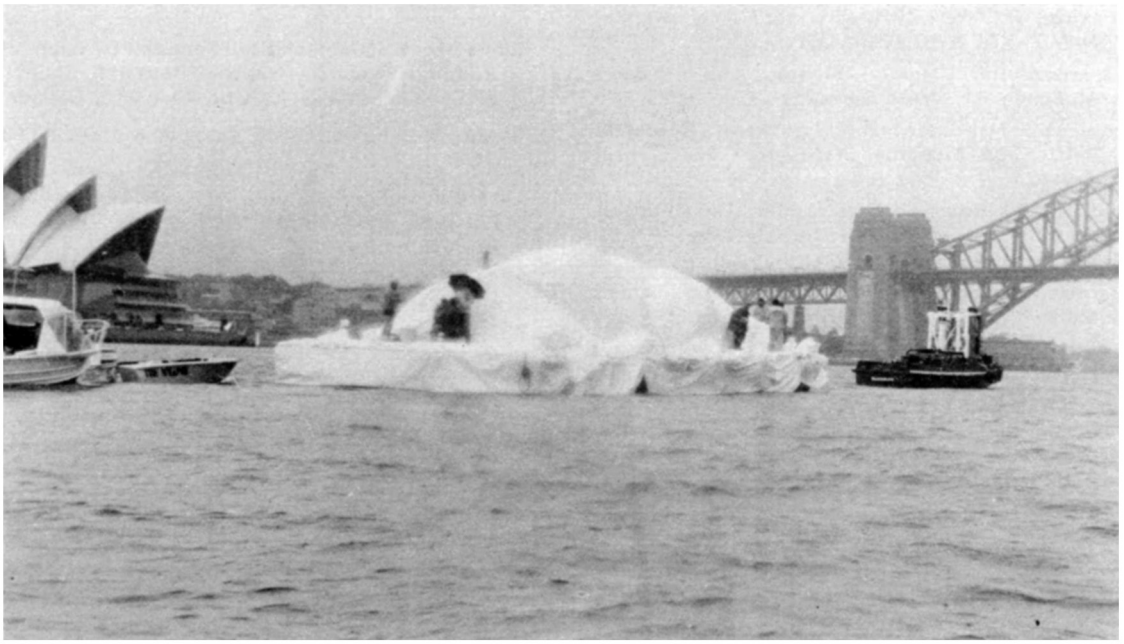
POSTSCRIPT



Photo—courtesy of "Sun-Herald" and John Fairfax & Sons Ltd., Box 508, G.P.O. Sydney, 2001 Australia.

While the Secretary General was visiting Australia at the beginning of April, she was gratified to read in the Sydney "Sun-Herald" about the towing of an iceberg into the Harbour. Investigations revealed that an eccentric millionaire named Dick Smith had pulled off the biggest April Fools Day joke in the history of the Harbour. In the gloom of early dawn his old barge covered in white plastic was sufficiently realistic to deceive the first few onlookers into believing that towing of icebergs for fresh water supplies had become a reality.

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 1978:

Private members	Sterling:	£10.00
Junior members	Sterling:	£4.00 (under 25)
Institutions, libraries	Sterling:	£20.00 for Volume 20 (Nos. 82, 83, 84) £20.00 for Volume 21 (Number 85)

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 of £0.50p per cheque. Thank you.

I C E

Editor: Hilda Richardson

This news bulletin is issued to members of the International Glaciological Society and is published three times a year. Contributions should be sent to Mrs H. Richardson, International Glaciological Society, Lensfield Road, Cambridge CB2 1ER, England.

Annual cost for libraries, &c, and for individuals who are not members of the Society: Sterling £3.00

Foister & Jagg Ltd., Abbey Walk, Cambridge