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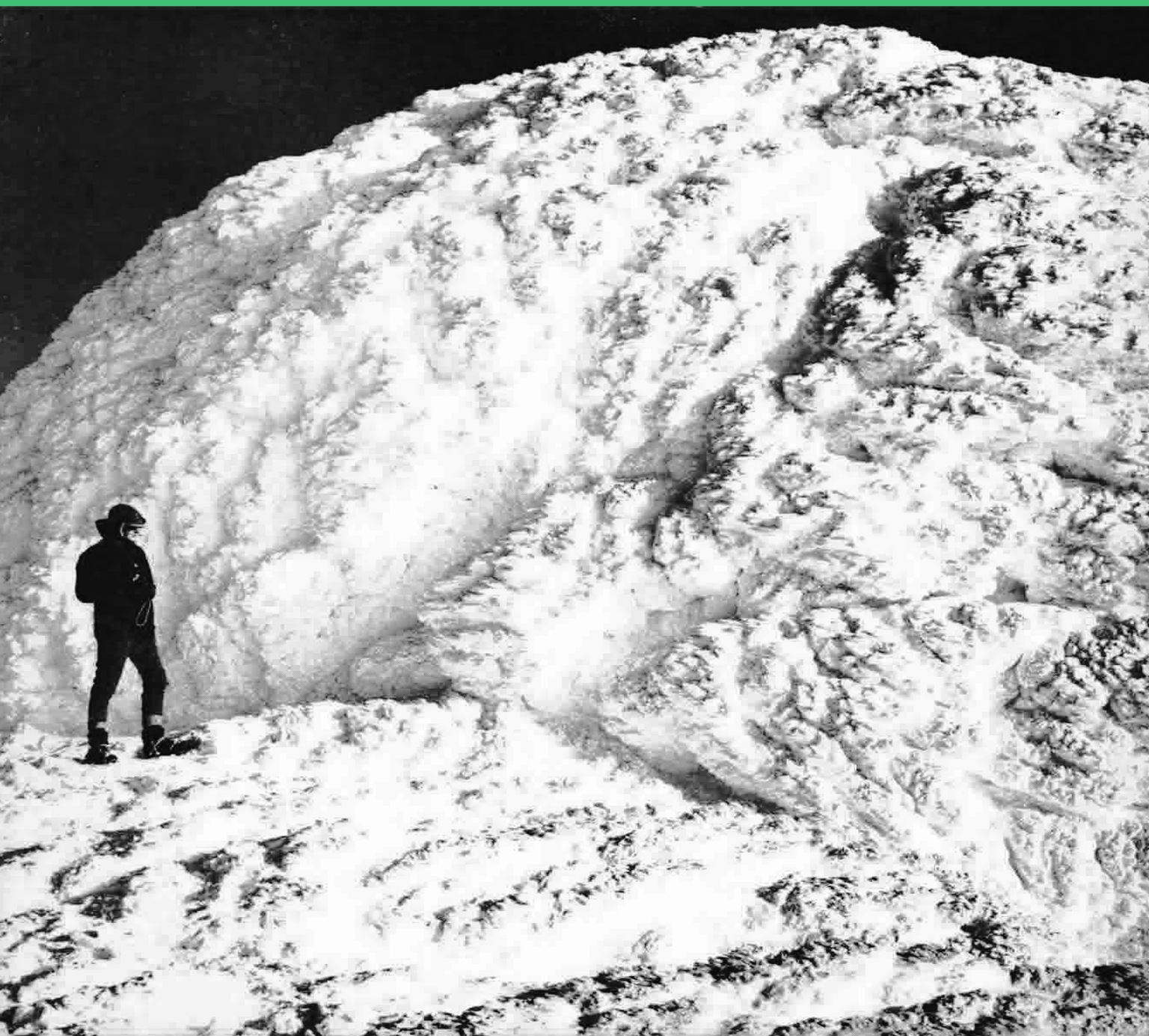
ICE



INTERNATIONAL GLACIOLOGICAL SOCIETY

SYMPOSIA WITH WHICH THE SOCIETY IS ASSOCIATED

1977 12-16 September, Cambridge, England: Physics and chemistry of ice.
(Organized by the Society, proceedings to be published in the *Journal of Glaciology*.)

1978 15-19 August, Ottawa, Canada: Glacier beds: ice-rock interface.
(Proceedings to be published in the *Journal of Glaciology*.)

21-25 August, Ottawa, Canada: Dynamics of large ice masses.
(Organized by the Society, proceedings to be published in the *Journal of Glaciology*.)

1979 12-17 August, Fort Collins, Colorado, USA: Snow in motion: avalanches and blowing snow.
(Proceedings to be published in the *Journal of Glaciology*.)

1980 25-30 August, Geilo, Norway: Processes of glacial erosion and sedimentation.
(Organized by the Society, proceedings to be published in the *Journal of Glaciology*.)

Further details are given on page 14 of this issue of ICE.

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ICE

NEWS BULLETIN OF THE

INTERNATIONAL GLACIOLOGICAL SOCIETY

NUMBER 53 1st ISSUE 1977

CONTENTS

1977 DUES. Please note that, in accordance with our normal practice, members who have not paid their dues will not receive Nos. 79 and 80 of Vol. 18, Journal of Glaciology, until they do. The "bonus" volume for members this year (Vol. 19, No. 81, Proceedings of the Symposium on Applied glaciology) will also be held in the Society's office until the 1977 dues have been received.

DINNER 15 SEPTEMBER 1977. The Symposium Dinner will be held on this day in Newnham College. Members of the Society who are not participating in the Symposium on Physics and chemistry of ice will be very welcome. The cost will be £6. Please book your ticket at the Society's office before 1 September.

LIST OF MEMBERS. A new list has been prepared and is now with the printers. Copies will be mailed (surface post) to members during July.

COVER PICTURE. View of the top peak of Snaefellsjökull, Iceland, completely covered with glassy ice. This ice disappears in summer, exposing the black rock. Photograph by Hjalmar R. Bardarson, P.O. Box 998, Reykjavík, Iceland.

RECENT WORK

CANADA

GLACIER STUDIES—GENERAL

GLACIER INVENTORY OF CANADA

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

Reduced manpower resulted in somewhat limited progress on the basic glacier inventory in 1976. The inventory of the St. Elias Range is being extended into the northern Coast and Boundary Ranges (S.G. Collins); that covering Yoho National Park is about 50% complete. Bibliographies of the St. Elias, Glacier and Mt. Revelstoke National Park, Mt. Robson Provincial Park, the Columbia Icefield, rock glaciers and ice core drilling in Canada are being compiled. Arrangements have been made for Canadian cooperation with and input to the Temporary Technical Secretariat for the World Glacier Inventory in Zürich.

GLACIER STUDIES—ARCTIC

AUTOMATIC WEATHER STATIONS, NORTH WATER

(F. Müller, ETH/MU)

Six unmanned OTT automatic weather stations operated during the 1975-76 winter in the North Water area. The Coburg Island (5 months) and Cape Hershel (1 month) stations were reoccupied to collect further data on climate, sea ice distribution and thickness and the mass balances of Laika and Leffert glaciers. The Carey Islands stations were removed and shipped south in August. Five stations were left to operate during the 1976-77 winter. Data from the six major stations for 1972-76 are completely analysed.

COBURG ISLAND

(F. Müller, ETH/MU)

The long-term mass balance study of Laika Glacier, begun in 1973, was continued. Mass balance data are available for 3 years for the glacier and for the Laika Ice Cap for two years, 1974/75-1975/76. Englacial temperatures were measured on a longitudinal profile using thermistor strings installed in 1975. The surface velocity was surveyed at the narrowest part of the glacier.

ISOTOPIC ANALYSIS OF ACCUMULATION RATES

(F. Müller, ETH/MU)

12 m cores were taken at 3 locations on Ellesmere Island and one on the Greenland Ice Cap. They were studied in the field using classical stratigraphical methods and the a.c. electrical conductivity measured. Melted samples were delivered to the University of Bern (H. Oeschger) for $^{18}O/^{16}O$ analysis and to the University of Innsbruck (W. Ambach) for total β activity analysis.

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

RADIO ECHO SOUNDING

(R. M. Koerner, PCSP)

Using a 620 MHz (Goodman) high resolution echo-sounder 4 ice caps were sounded in a search for a 1977 borehole site. In transects down the S and NW sides of the Devon Island Ice Cap depths were of the order of 300-700 m, the thicker ice being on the S side. The 6 x 3 km grid on a central Ellesmere Island ice cap with transects E down Cadogan Glacier and W revealed ice thickness much greater on the E side with the bed of the glacier below sea level for several km. The 14 x 15 km grid on Mer de Glace Agassiz (N. Ellesmere) showed rugged bedrock topography with ridges parallel to those exposed. Depths range from 100 m on the latter to 800 m in the valleys. Soundings on the top of the main Axel Heiberg Island ice cap revealed very rugged, mountainous, topography under the ice with depths from 100-700 m. Ice depths on the W side (Thompson Glacier) were 400-500 m compared to about 200 m on the E side.

MASS BALANCE

(R. M. Koerner, PCSP)

Low-order accuracy mass balance networks were set up across the central Ellesmere Island ice cap and down the E side of the Axel Heiberg Island ice cap to provide background data for possible future boreholes.

AERIAL PHOTOGRAPHY

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

With Polar Continental Shelf Project support and a Wild RC-10 aerial camera two ice caps near Grise Fiord, Ellesmere Island, were photographed. The annual coverage of selected glaciers on this and Axel Heiberg Island was prevented by poor weather.

WARD HUNT ICE SHELF SURVEY

(H. Serson, Dept. National Defence)

The Ward Hunt Ice Shelf and Ice Rise networks were remeasured between June 16 and 17. Positive net balances were +0.001 for the former and +0.039 m H_2O for the latter. There was further indication that the large variation in the Ice Shelf data may be caused by periodic filling and draining of the troughs.

ELLESMERE ISLAND STUDIES RELATED TO CLIMATIC CHANGE

(H. Serson, Dept. National Defence)

On June 11 the accumulation network of the small ice cap near St. Patrick's Bay was measured and a negative net balance of −0.72 m H_2O for 1975-76 found.

WHITE GLACIER, AXEL HEIBERG ISLAND

(F. Müller, ETH/MU)

Deep drilling using an open system hot-water drill reached the bed at a depth of 160 m in the tongue area (270 m a.s.l.) and at 200 m higher up-glacier (360 m a.s.l.); a third hole at 340 m a.s.l. had to be discontinued at a depth of 150 m. Cables with thermistors at 15 m intervals were frozen in. It is planned to drill 3 further sites in the accumulation area.

Mass balance observations were made throughout the summer and the stake network resurveyed. All data since 1960 is being compiled for publication in 1977.

The automatic weather stations at Moraine Profile and Point Alec were serviced, extensive repairs being required to the latter.

The tongues of Thompson, White and Crusoe glaciers were resurveyed.

BABY GLACIER, AXEL HEIBERG ISLAND

(F. Müller, ETH/MU)

An intensive mass balance study was carried out during 1976. Analysis of this data and compilation of data from previous years will form the basis of a Master's thesis (Diplomarbeit).

MEIGHEN ISLAND ICE CAP

(R. M. Koerner, PCSP)

The 1974-75 annual mass balance was $+5.4$ g/cm^2 and the winter 1975-76 balance, measured in mid-June, was 15.1 g/cm^2. Bad weather precluded measurements on Melville Island.

SUBMARINE OBSERVATIONS OF CALVING GLACIER FRONTS, S. DEVON ISLAND

(B. D. Bornhold, S. M. Blasco, P. McLaren, GSC)

Studies in Cuming Inlet and Croker Bay focussed on the marine margins of three small outlet glaciers of the Devon Island ice cap. Sidescan sonar, grab sampling, coring, suspended particulate matter collection and diving observations were carried out. Sidescan sonar profiles parallel to the ice fronts revealed fissures extending more than 75 m into the ice and ledges of ice several tens of metres long. Poor visibility and deep water precluded abundant observations of the glacier margins. In all cases a very steep ridge of unstable boulder moraine was parallel to the ice front. The proximal and distal slopes were approximately 45°. The seaward slope was mantled with silt derived from the release of rock flour from the melting glacier ice. The area of active sedimentation was small.

DEVON ISLAND

(R. M. Koerner, PCSP)

The mass balance for the Devon island ice cap for 1974-75 was -6.9 g/cm^2. The mean net balance for the 14 years 1961-75 is -6.7 g/cm^2. A final set of inclinometer measurements was made in the 1971 and 1972 boreholes. P. Winter, Earth Physics Branch, EM & R, repeated gravity ties between the borehole site and Resolute Bay, first made in 1971, and found no change in ice thickness.

During June a programme to measure the sonic (high-frequency seismic wave) velocity in the boreholes was carried out by the University of Wisconsin (C. R. Bentley). In the 1971 hole only a short section, between depths 151 and 178 m, could be logged. In the 1927 hole, with less closure and a higher fluid level, the depth range between 80-270 m was successfully logged. The normal increase of velocity with depth was observed to 210 m. At greater depth it decreased rapidly downward, a completely unexpected result. Velocities were less with short receiver spacing than with long and most were substantially less than would be expected in solid ice of any fabric indicating a decreasing effect of closure with distance from the hole. The flow of ice around the hole seems to have rotated the ice crystal orientation to a substantial inclination and cracked the neighbouring ice. Travel times were used to determine changes in the 1972 hole diameter. There is a linear decrease in radius to 120 m ($\sim$ 5 mm) no change from 120-210 m, and a linear decrease, totalling 13 mm, from 210-270 m. It also appears that there are decompression effects which have changed the densities in the core relative to those *in situ*.

Field trials and measurements were made on the ice cap with a new Phase-Sensitive Radio Echo sounder by a three-man team from Bristol University (M. E. R. Walford). See account in ICE 51, p. 8.

BARNES ICE CAP, BAFFIN ISLAND

(G. Holdsworth, GD)

Three continuously recording 5 m wire strain meters (Cambridge type) were installed at several sites within the South Dome surge area (K. Evans, Cambridge University). Strains over 5 m gauge lengths generally showed a smooth behaviour and at one site a quasi-periodic variation (11 day period) seems to exist independent of temperature or pressure changes. Strains over the various 50 and 500 m lines measured concurrently during a three week period in May were irregular, even considering the much larger errors in measurement involved.

(R. LeB. Hooke, GG/UM)

Three holes were completed along the Trilateration Net Flow line. That at the equilibrium line reached 161 m, one 2 km upglacier from there 223 m and the third, 1 km downglacier from the first 98 m; about 10, 20 and 40 m respectively from the bed according to sounding data.

The 98 m hole, designed for temperature studies alone, showed -8.7° at the bottom and a nearly constant .0201°C/m gradient over the lowest 65 m.

The other two were designed for fabric, temperature and deformation measurements, but due to casing failure in the 161 m hole only fabric data was obtained there. The ice near the top of both is fine-grained (3-5 mm) with random fabric. With increasing depth grain size increased to 1-2 cm and a diffuse single-maximum fabric with c-axes generally vertical develops. Below about 110 m this splits into two maxima roughly at right angles to the direction of shear. Below 170 m weak third maximum appears in the deepest hole. Both holes bottom in bubbly white ice of Pleistocene age which is fine-grained (3-5 mm) with a single maximum fabric. Preliminary temperature measurements in the 223 m hole indicate a basal temperature about -6.2°C and a basal gradient of about .02°C/m.

AUYUITTUQ NATIONAL PARK, BAFFIN ISLAND
(R. G. Barry, INSTAAR)
With support from Parks Canada, INSTAAR supervised the installation of two long-term climatological stations in the Park and trained wardens in the basic observation routines and mass balance measurements. Stake networks were installed on "Boas Glacier" (46204J-68) and "Ugaliq Glacier" (46204D-87).

NEOGLACIAL MORAINES, BAFFIN ISLAND
(R. G. Barry, INSTAAR)
Lichenometric and weathering data were collected from Neoglacial moraines near Pangnirtung as part of a continuing study of Late-Holocene glacial chronology (P. T. Davis). Replicate coring of sediments in two lakes was carried out.

GLACIER STUDIES—YUKON TERRITORY

YUKON RESOURCE ATLAS
(F. F. Slaney & Co. Ltd., Karl E. Ricker Ltd.)
The acquisition of bibliographies and follow-up illustrations for each scientific endeavour on the 1:250,000 basemaps was concluded in 1976. The Atlas plates on meteorology, hydrology and glaciology, Quaternary geoscience and hydroelectric development will be of interest to glaciologists. The project will probably be published in late 1977 or early 1978.

MOUNT LOGAN
(G. Holdsworth, GD)
Semi-final preparations were made for a 1978 core drilling on the NW col as part of a climatic change study. Two 8 m cores were taken to substantiate results for the 1975 16 m core. Strain rates and movement measurements were made.

RADIO ECHO SOUNDING
(G. K. C. Clarke, B. B. Narod, GA/UBC)
Airborne surveys of the Backe, Hazard, Rusty and Trapridge glaciers were carried out using U.B.C.'s 840 MHz sounder. A single traverse was also flown over the NW col of Mt. Logan to aid in site selection of a corehole to extract the oxygen isotope record of climatic change.

HAZARD GLACIER
(G. K. C. Clarke, S. G. Collins, J-G. P. Napoleoni, B. B. Narod, GA/UBC)
Three holes, presumed to have reached the glacier bed, were drilled using a new hot water circulating drill. The deepest hole was 220 m and the maximum drilling speed 120 m/hr. The holes were instrumented with thermistor cables to allow future temperature measurements. A levelling survey was completed. Hazard Glacier is a surgetype glacier so these measurements are of particular interest.

GLACIER STUDIES—CORDILLERA

BERENDON GLACIER, B.C.
(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 of Berendon Glacier.

TCHAIKAZAN VALLEY GLACIERS, COAST MTS, B.C.
(Karl E. Ricker Ltd.)
The 1975 field work was analyzed and published in the Canadian Alpine Journal.

WEDGEMOUNT GLACIER AND LAKE, COAST MTS, B.C.
(Karl E. Ricker Ltd. and W. A. Tupper, BCIT)
All available aerial photography was reviewed for mapping. Control was established around the lake and terrestrial photogrammetry used to define the snout position. The glacier is still receding catastrophically, calving being the dominant process. Several moraines were identified and lichenometric measurements and dendrochronologic samples taken from each where available. Conifers on the climax distal moraine were slightly <50 years old though a 1951 moraine has yet to be colonized by woody species. Wedgemount Lake was sounded (max. depth slightly >60 m). The basin shallows markedly to the snout indicating a grounded tongue. A bathymetric map is being prepared and calculations made of volumetric ice loss from 1927 to 1976.

GLACIER MASS BALANCES: WESTERN CORDILLERA
(O. Mokievsky-Zubok, GD)
Measurement of winter and summer balances continued on Place and Sentinel, two former IHD glaciers. Helm Glacier was added in 1975. Specific net balances were $+0.87$, ± 1.48 and $+0.57$ m H_2O respectively. Summaries of measurements for the IHD period on Place and Sentinel glaciers, bibliographies and references to special studies are in press.

HYDROCHEMICAL MODEL OF GLACIER MELTWATER

(O. Mokievsky-Zubok, GD)

In co-operation with the Water Quality Branch (J. Zeman), the hydrochemistry of the Sentinel Glacier basin was investigated to determine the characteristics of various glacier meltwaters and to develop a regional classification.

ROLE OF GLACIERS IN WATER MANAGEMENT IN REMOTE BASINS

(O. Mokievsky-Zubok, GD)

Three glaciers covering an area of 120 km^2 at the headwaters of Bridge River, B.C., were studied to determine the effect of glaciers on overall drainage basin runoff and to evaluate seasonal and operational forecast models for a downstream hydro-power reservoir. The glaciers "Bridge", "Sykora" and "Zavisha" had positive net balances of +0.83, +0.83 and ±1.10 m H_2O respectively.

GLACIER SURVEYS

(I. A. Reid, J. O. G. Charbonneau, AHD)

During August the Bugaboo, Sphinx and Nadahini glaciers were surveyed by terrestrial photogrammetry. The Sentinel and Kokanee glaciers were completely snow covered and not surveyed. The Water Survey of Canada in Calgary (L. Warner) surveyed the Saskatchewan and Athabasca glaciers.

MT. SIR SANDFORD AREA, B.C.

(J. S. Marsh, CEG)

Work on the glaciers and microclimate in the Mt. Sir Sandford area of the Selkirk Mts. was continued. The snouts of the Haworth, Silvertip and Sir Sandford glaciers were surveyed and a baseline and survey cairns established for future studies. A map at a scale of 1:5,000 is being prepared and the glacier snout positions in 1912, 1949, 1966 and 1975 have been plotted from aerial photographs. Mesoclimatic variations and glacier winds in the upper valley of Palmer Creek were studied. The 1975 results will be published shortly.

GLACIER HYDROLOGY, YOHO NATIONAL PARK, B.C.

(G. J. Young, GD)

In conjunction with the continuing studies on Peyto Glacier a wider ranging investigation of the influence of glaciers on alpine stream hydrographs has been initiated in Yoho National Park. The hydrology and climatology of several small catchments (some glacierized, others ice free) are being monitored to assess seasonal and daily contributions of glacier melt to stream flow.

GLACIER MASS BALANCES: EASTERN CORDILLERA

(G. J. Young, GD)

A basic monitoring of mass balance, stream flow and local meteorology was continued on Peyto Glacier. The programme on Wolsey and Ram glaciers has been terminated.

PEYTO GLACIER MAP

(W. E. S. Henoch, GD)

A new multicoloured edition of the Peyto Glacier map with shading, bedrock portrayal and interpretive text was produced at a scale of 1:10,000. The map combines accuracy and artistry to satisfy needs ranging from glaciological research to tourism.

SNOW STUDIES

SNOW COVER, AXEL HEIBERG ISLAND

(F. Müller, ETH/MU)

A study of distribution and melting of the snow cover of the tundra was carried out. Regular measurements of snow courses were made together with weather observations and recording of global radiation. Analysis of this data, together with compilation of snow course data from earlier years will form the basis of a Master's thesis (Diplomarbeit).

SNOW COVER, SOMERSET ISLAND, BOOTHIA PENINSULA

(B. J. Grey, GD)

Based on interpretation of snowmelt conditions using satellite imagery (mainly LANDSAT) for 1973, 1974 and 1975, along potential routes of the Arctic Islands Pipeline, a general correlation was found between elevation and snow melt, although accumulation and redistribution factors were seen to modify this relationship.

BAKER LAKE, N.W.T.

(J. P. Chyurlia, B. J. Grey, GD)

Work along the proposed route of the Arctic Island Pipeline consisted of a basin hydrologic study near the settlement of Baker Lake to assess snow melt peaks. Also the pipeline crossing sites at rivers south of Baker Lake (to the boundary of the N.W.T.) were examined for signs of ice jam formation and resultant erosion. Detailed study was made of the break-up of the Kazan and Thelon Rivers.

MACKENZIE VALLEY, N.W.T.

(J. C. Anderson, J. N. Jasper, GD)

Snow melt peaks are being assessed at culvert sites along the route of the Mackenzie Highway. Icing of the culverts caused high velocities detrimental to fish passage. Snow water-equivalent was measured at snow courses throughout the valley.

REMOTE SENSING OF SNOW COVER

(H. L. Ferguson, S. Lapczak, AES)

In co-operation with other federal and provincial agencies, analysis continued on the use of LANDSAT, NOAA and aircraft underflight imagery for estimating basin snow cover, with

particular emphasis on the Saint John and Souris Basins. A Progress Report was presented at the WMO Workshop on Satellite Snow Studies.

GAMMA SNOW SURVEYS

(S. Lapczak, H. L. Ferguson, B. E. Goodison, AES)

Snowpack changes at a point were continuously monitored using a portable gamma spectrometer. Results are compared with standard measuring techniques. A drift in calibration, apparently related to a change in air temperature, was a problem.

SNOW SAMPLER ASSESSMENT

(B. E. Goodison, AES)

Field studies continued to determine the absolute accuracy of various snow samplers suitable for use in Eastern Canada. On the average it was found that most samplers over-measure snow water equivalent by up to 6%. Corrections for compression and blocking were not justified and only increased the error.

SNOW GAUGE ASSESSMENT

(B. E. Goodison, E. I. Mukammal, AES)

Tests on the accuracy of standard snow gauge measurements continued. Gauges tested included: M.S.C. Nipher shielded snow gauge; Universal recording precipitation gauge; Fischer and Porter recording precipitation gauge; Tretyakov precipitation gauge; and, a Wyoming shielded Universal gauge. Gauge catch/ground true ratios vs. wind speed and temperature have been analysed and initial correction curves have been determined. The Nipher shielded gauge and Wyoming shielded gauge have the highest gauge catch/ground true ratio at all sampled wind speeds.

ENERGY BALANCE FOR A SHALLOW SNOWPACK

(D. C. McKay, AES)

A complete energy budget was calculated for a shallow snow cover from measurements of net radiation and soil heat flux, and the turbulent fluxes of latent and sensible heat calculated using the eddy correlation technique. Results indicated the absence of any close relationship between net radiation and the sensible and latent heat fluxes during the diurnal cycle. The flux of heat into the snowpack was found to be a major component of the energy balance. Maximum evaporation from the snow surface was observed following the replacement of warm moist air masses by cold dry air masses. Work will continue and comparison to a bulk aerodynamic approach utilizing climate station data will be tested.

SNOW COVER IN CENTRAL ONTARIO

(W. P. Adams, GEOG/TU)

The programme to investigate the stratigraphy and distribution of the snow cover and the lake cover was continued.

SNOWPACK ABLATION DURING CHINOOKS

(D. L. Golding, N. Forest Res. Centre, DOE)

To determine the amount of snow pack ablation during chinooks and the frequency and intensity of chinooks relative to topographic location 19 sites on three transects were chosen in the Red Deer River Valley, between Nordegg and Kananaskis and on Pidgeon Mt. in the Bow River valley. At each site is located a battery-operated hydrothermograph and at every other site a monthly battery-operated wind direction and intensity recorder. Energy input will be calculated for 6 hr periods to provide estimates of evaporation, melt and condensation.

SNOW ACCUMULATION IN SMALL FOREST OPENINGS

(D. L. Golding, R. H. Swanson, N. Forest Res. Centre, DOE)

In order to determine, for small forest openings, mean water-equivalent at maximum snow pack, snow ablation rates during the melt season, and the distribution of accumulation and ablation within and adjacent to each opening 10 replications of 9 circular opening sizes were cut and slash burned. Since 1973 snow surveys have been conducted at maximum pack and 1-2 times during the melt period. Results show that the greatest snow accumulation occurs in 2H openings (H = mean height of adjacent forest), about 50% greater than in uncut forest and 15% greater than in the largest opening (6H). By the time the snow disappeared from the forest the 1H has the most snow remaining, about 13% greater than in the 2H and 350% greater than in the 6H.

AVALANCHES

(P. A. Schaerer, DBR)

Observations of avalanche impact pressures are continuing at two measuring sites at Rogers Pass. Observations at one avalanche permitted analysis of the variation of pressures across the height of the avalanche.

Runout distances of large avalanches were measured at several locations in southern British Columbia and are being analyzed.

Observations are continuing on the mass of avalanches at Rogers Pass and the variation with elevation of the snow on the ground at 15 sites in southern British Columbia.

AVALANCHE HAZARD EVALUATION

(A. A. Salway, DBR)

Numerical models for avalanche hazard evaluation in areas with inaccessible starting zones are developed and evaluated.

A study plot was established at Rogers Pass, B.C., from which three-hourly observations of snow depths, precipitation amounts, temperatures and humidity were obtained.

Models based on Fidelity Mt. data will be compared and contrasted with those obtained using data from the Rogers Pass observatory.

The analytical time series procedures have been extended and new combinations of meteorological and snow structure variables have been introduced, in an attempt to further improve the models.

AVALANCHE RESEARCH, CALGARY

(R. Perla, GD)

An Avalanche Workshop was held in Banff, Alberta, on November 1-4, 1976, in co-operation with the National Research Council, the B.C. Department of Highways, Parks Canada and the University of Calgary. 35 contributions covering avalanche control, forecasting and safety were discussed by the 129 participants. The Proceedings are being edited for publication. Snow and avalanche laboratories were maintained at Banff National Park and at Whistler Mt., B.C. Research continued on snow and avalanche conditions in the Canadian Rockies, the shear strength of large snow samples, the impact force of avalanches and the properties of snow slabs.

FLOATING ICE

AERIAL PHOTOGRAPHY

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

With PCSP support and a Wild RC-10 aerial camera photography was flown to monitor the break-up of the Mackenzie River with special emphasis on ice-jamming. The Trafalgar Lakes, near Resolute Bay, were flown twice for a radiation study. The artificial islands off the Mackenzie Delta, used for oil drilling, were photographed.

REMOTE SENSING OF SEA ICE, ARCTIC OCEAN

(Moira Dunbar, DREO)

A joint exercise between a Canadian Argus aircraft and a British nuclear submarine obtained coordinated top and bottom ice profiles in the Arctic Ocean. The profiles will be processed and analysed at the Scott Polar Research Institute and IR and SLAR data reduced at the same time at DREO.

SEA ICE DYNAMICS NORTH WATER

(F. Müller, ETH/MU)

Deformation and movement of fast ice, wind speed and direction were measured at three points 3 km apart with measurements of sea current and sea water temperature at a depth of 300 mm. The data from near the western boundary of the North Water (Jones Sound) will complement that collected in 1973-75 in Kane Basin at the northern boundary.

REMOTE SENSING OF THE NORTH WATER

(F. Müller, ETH/MU)

Albedo of the North Water was measured during one overflight. Data from the three 1975 flights are fully analysed and maps of surface temperature and albedo available. It is planned to overfly the North Water regularly during the winter to study conditions during the polar night. LANDSAT, NOAA-2 and -3 images of the North Water are being analysed.

ENVIRONMENTAL CONSEQUENCES OF LIGHT PENETRATION THROUGH SNOW AND ICE

(W. A. Adams, GD)

Field studies of the attenuation of solar radiation (300-1000 nm) were conducted on ice-covered lakes in the Inuvik and Resolute Bay regions, N.W.T., in May-June and a spectral distribution measurement programme on a lake near Toronto. Water quality is being correlated with the radiation regime of the lakes resulting from solar radiation/ice cover interactions. The study of light intensity and primary productivity under sea ice containing entrapped crude oil has been completed with a final site visit to Balaena Bay and publication of results.

ICE RESEARCH BY IMPERIAL OIL LIMITED

(D. J. McEachern, Production Research, Calgary)

The *in situ* ice stress measurement programme around Imperial's artificial islands near the McKenzie Delta was continued using wide thin sensors extending through the ice sheet thickness. Detailed surveys were made of the rubble field generated around one island by ice movement and the location of the ice failure zone. Ice movement was monitored with respect to the seabed and the island and by an array of surveyed posts.

The crushing failure modes around artificial islands were duplicated in penetration tests both in a cold lab. and on the surface of a lake near Calgary. The test results served as input to a stochastic model developed to predict the most probable maximum force on an island.

Ice sheets 2-15 cm thick were pulled against a 7 m wide model island beach in Imperial's Ice Test Basin. The interaction was theoretically analysed to give criteria deciding whether the ice sheet piles up on the beach or rides up and over the island surface. The flexural strength of ice during break-up is a key determinant in this analysis and experiments to better define this, relating flexural strength to liquid water content of rotting ice, were performed.

BEAUFORT SEA PROJECT

(A. R. Milne, IOS)

The Beaufort Sea Project is an Arctic marine environmental assessment programme financed by the Federal Government and 18 companies of the Arctic Petroleum Operators Association. Field studies ended in September 1975 and were followed by intensive data analysis and report compilation for 40 studies.

A preliminary assessment based on these studies describes the likely environmental impact of an underwater oil well blowout at sites proposed for exploratory drilling in the southern Beaufort Sea in 1976. Detailed technical reports and six general 'overview' reports have been published.

FROZEN SEA RESEARCH GROUP
(E. L. Lewis, IOS)
The statistics of the ice cover in the Beaufort Sea as derived from two years of laser profilometer data have been investigated and references made to its potential for oil containment in the event of a spill.

Extensive assistance was extended to NORCOR in connection with their contracted field studies involving oil spilled under growing sea ice at Cape Parry, N.W.T.

A study of the possible climatic effects of any change in surface albedo of the sea ice due to oil contamination has been carried out.

Assessments of the environmental effects of mine tailings disposal into Arctic fiords has been attempted on Little Cornwallis Island and on the shores of Strathcona Sound.

Current measurements were made in d'Iberville Fiord, Ellesmere Island, in 1975 with a Christian Michelsen Institute ultrasonic instrument and a prototype telemetering current meter system. This system, with sensors affixed to the ice bottom and sea bed is to be deployed across one of the proposed inter-island gas pipeline crossings north of Parry Channel.

GROUNDED ICE RIDGES, SOMERSET ISLAND, N.W.T.
(R. B. Taylor, GSC)
Grounded ice ridges formed along the NW shores of capes in N. Somerset Island. Ridge height was generally less than 15 m but one near Cape Rennell was estimated at 30 m. Those built nearshore lasted 10-40 days, on the beach foreshore up to 60 days and those further inland existed for several years. The rate of destruction is primarily dependent on wave action. Grounded ridges along the north coast remained the whole season being protected by a wide band of sea ice. The large ridges east of Cape Anne built in 1973 (Ice, No. 50, 1976, p. 13) finally melted in late August 1976 leaving a beach topography with pits and mounds.

ICE ENGINEERING
(R. M. W. Frederking, DBR)
Laboratory measurements on the vertical ice loads developed on small diameter piles by a floating ice cover are being continued.

A pilot project to measure ice forces was carried out on a wharf at Strathcona Sound, Baffin Island. Observations on forces and ice conditions were made during the winter.

FAST ICE STUDIES IN WESTERN DAVIS STRAIT
(R. G. Barry, R. L. Weaver, INSTAAR, J. D. Jacobs, U. of Windsor)
This programme is concentrating on the analysis of 1973-75 field data on ice conditions around Broughton Island, microclimatic data and synoptic weather conditions.

ICE PUSH, LABRADOR
(W. P. Adams, CEG)
A story of ice-push on lakes in Central Labrador was undertaken in the break-up month, June.

AUFEIS
(B. J. Grey, D. K. MacKay, GD)
An extensive literature survey with special emphasis on material published in the 1970's was produced for the Working Group on Hydraulics of Ice-covered Rivers.

LABORATORY STUDIES

GLACIAL ABRASION
(W. H. Mathews, GEOL/UBC)
Experiments have been initiated on simulated glacial abrasion using a grindstone of ice plus crushed quartz turning slowly in a deep-freeze between stone plates.

MECHANICAL PROPERTIES OF ICE UNDER HYDROSTATIC PRESSURE
(S. J. Jones, GD)
Preliminary results at -12 C in the strain-rate range 10^{-6} to 10^{-2} s^{-1} show that the comprehensive strength of polycrystalline ice approximately doubles as the hydrostatic pressure increases to 30 MNn^{-2} and thereafter decreases. A creep jog has been built with which it is hoped to obtain results at lower strain-rates, and in particular to determine activation volumes for polycrystal deformation.

SINGLE CRYSTAL DEFORMATION CLOSE TO THE MELTING POINT
(S. J. Jones, GD)
Constant strain-rate tests on more than 100 different single crystals of ice between $-20°C$ and $-0.2°C$ show that the activation energy for deformation is constant in the temperature range at 0.83 eV (19 kcal. mol^{-1}). A report is in preparation.

ICE MECHANICS
(N. K. Sinha, DBR)
Studies on deformation and fracture of fresh water ice as a function of strain rate and the application of replicating and scanning electron micrography to examine the deformed microstructure have been carried out. Replications of the surface conditions of the ice for examination with the scanning electron microscope have been developed to a sophisticated level. The technique

has been used to observe the dislocation densities of freshly grown and deformed polycrystalline ice to reveal basal as well as non-basal dislocation lines in ice.

Much less work has been carried out on saline ice which has the added complication attributable to multiphase systems. A study underway is concerned with the formation and location of brine pockets. Detailed crystallographic analysis of first-year sea ice has been carried out by the application of microtoming, replicating and scanning electron micrography. The structure of growing sea ice depends upon the unstable growth conditions at the interface between the ice and water. Experimental techniques have been developed to examine the ice-water interface of growing sea ice.

THERMAL PROPERTIES OF ICE IN ITS VARIOUS FORMS

(G. P. Johari, GD)

The heat capacity and entropy of the vapour-deposited vitreous form of ice have been investigated. The results are available in *Nature*, 1976, Vol. 260, pp. 421-422. A theoretical and experimental investigation of the temperature and pressure variation of the infrared absoptivity in ice has been published in *Nature*, 1976, Vol. 263, pp. 672-673. Further investigations on the high-pressure forms of ice are planned.

ATTENUATION, PERMITTIVITY AND REFLECTIVITY OF ICE

(G. P. Johari, GD)

The results obtained for both polycrystalline and single-crystal ice are reported in the publications: *Journal of Glaciology*, 1975, Vol. 14, No. 71, pp. 293-303, and *Journal of Chemical Physics*, 1976, Vol. 64, No. 10, pp. 3998-4005.

THE ELECTRICAL BEHAVIOUR OF ICE ALONG AND PERPENDICULAR TO THE HEXAGONAL AXIS

(G. P. Johari, GD)

The results obtained on zone-refined single crystals of ice show no anistropy of orientation polarization and relaxation time within $\pm 2\%$. The data are available in the temperature range, 200-270 K and frequency range $0.2\text{-}2 \times 10^5$ Hz. A report is in preparation.

OPTICAL PROPERTIES OF ICE AND SNOW

(W. A. Adams, GD)

Light scattering using laser sources (conventional and Raman spectrosopic), refractive index studies at high pressures, and transmission spectrophotometry on ice samples have been continued in 1976.

OIL AND ICE RESEARCH

(E. C. Chen, CCIW)

Research on the interaction of oil and ice has continued. During 1976 the thermal effect of an oil layer under fresh-water ice was studied. An oil layer sandwiched between ice was found to affect the ice growing rate as well as the temperature profile across the ice.

FROST ACTION IN SOILS

(E. Penner, T. Ueda, DBR)

Laboratory studies have been undertaken to investigate the nature of "shutoff" pressures in frost susceptible soils to determine whether ice lens growth from externally supplied water can be independently controlled from *in situ* heave by the application of loads. Elaborate controls have been devised to obtain precise measurements of frost heave, water intake and water expulsion on a continuous basis.

MODEL STUDIES OF FOUNDATIONS IN FROZEN GROUND

(V. R. Parameswaren, DBR)

Adfreeze strengths between piles and artificially frozen soils in the laboratory were measured. These were 3 inches in diameter and 12 inches long, frozen into a 7.5 inch thick layer of a mixture of Ottawa fine sand and water (14%). The maximum load borne by the pile before failure of the pile-soil interface is measured as a function of the rate of pushing used in the Instron. The adfreeze strength is caluculated by dividing the maximum load by the surface area of the pile.

Comparative measurements show that the adfreeze strength decreases in the following order, B.C. fir, concrete, creosoted B.C. fir, unpainted steel and finally painted steel. Measurements were made at $-5\,^{\circ}C$ at crosshead speeds varying between 5×10^{-4} and 1×10^{-1} mm min^{-1}.

GROUND ICE AND PERMAFROST

SUB-CHANNEL PERMAFROST, CORNWALLIS ISLAND

(J. G. Cogley, GEOG/TU)

A programme of research on sub-channel permafrost regimes was started at Resolute Bay. Heat balance analyses suggest that permafrost should be absent beneath large, permanent streams in Arctic regions, but the extent of the moderating influence of smaller, intermittent snowmelt streams is less easy to predict. The aim of the project is to extend the theory and couple it with direct measurements of temperatures below actual channels. No results have been obtained as yet.

GEOTHERMAL STUDIES IN NORTHERN CANADA

(A. Judge, A. Taylor, J. Colyer, M. Burgess, P. P. Raj, Earth Physics Branch, Dept. Energy, Mines & Resources)

78 permafrost thickness determinations based on deep temperature measurements in northern drillholes have been published and 8 new determinations made in the Mackenzie Delta in 1976.

In general thickness is highly variable regionally, e.g. 65-600 m in the onshore Mackenzie Delta. Numerical models have been developed to determine the physical parameters of the surrounding formation (ice content, porosity, pore-water salinity and lithology). Gas hydrates are being investigated with current emphasis on prediction and detection. Combined seismic and thermal studies of the permafrost and hydrates beneath the offshore areas of the Beaufort Sea have continued to show a distribution pattern related closely to the combined water- and ice-cover history. To support the necessary drill studies a hydraulic jet drill has been developed with GSC. Shallow thermal studies of the near-surface regime continue in the Beaufort Sea and and were started in Arctic channels using mud temperature gradiometers originally developed to measure terrestrial heat flow through the ocean floor. Routine measurements of the thermal properties of frozen and unfrozen soils and rocks have been continued. It is hoped that universal models connecting thermal and other physical properties may be discovered.

STUDIES BY THE GEOLOGICAL SURVEY OF CANADA

Detailed individual project reports on investigations by GSC scientists are published annually in the Report of Activities of the GSC. Summaries of only the most glaciologically relevant projects are given here.

AERIAL PHOTOGRAPHY

(K. C. Arnold, A. C. D. Terroux, GD)
The Polar Gas Pipeline route from Spence Bay to Baker Lake was photographed.

MACKENZIE VALLEY GEOTECHNICAL DATA

(D. E. Lawrence, D. A. Proudfoot, GSC)
Geotechnical data on over 12,000 boreholes is being assembled to assess permafrost and ground ice occurrence and distribution. Various methods of drilling and recovering samples in permafrost terrain are being reviewed to determine the relative merits of field and laboratory tests. Information on the boreholes being recorded includes stratigraphy with geotechnical and geological descriptions, test results, terrain and topographic description including active layer thickness.

REGIONAL OCCURRENCE OF PERMAFROST, MACKENZIE VALLEY

(J. A. Heginbottom, P. J. Kurfurst, J.S.O. Lau, GSC)
Extensive use was made of the geotechnical data from some 12,000 boreholes in the Mackenzie Valley and the Delta, compiled in the Mackenzie Valley Geotechnical Data Bank. Borehole logs and laboratory test records were evaluated and plotted for the genetic and engineering soil classes encountered in the area.

GROUND ICE IN NORTH-CENTRAL KEEWATIN, N.W.T.

(R. D. Thomas, A. S. Dyke, GSC)
Ice-rich frozen ground occurred at approximately 1 m depth in all deposits except for eskers where the ground was generally frozen at depths of 2 m, but did not contain visible ice. Some lakes adjacent to eskers had no surface outlet but drained through the esker forming aufeis. A shallow drilling programme by J. Veillette and M. Nixon in fine grained marine sediments did not generally encounter massive ice. Active layer temperature measurements were made by C. Tarnocai and D. Noakes.

SEASONAL GROUND TEMPERATURES ACROSS A BEACH, SOMERSET ISLAND, N.W.T.

(R. B. Taylor, GSC)
During 1975 and 1976 two 1 m long thermistor probes were installed above and below high tide level on N and E facing beaches of Cunningham Inlet. Ground temperatures at 10 cm intervals were measured daily from late June to early September. Detailed studies of the beach thermal regime were made over two complete tidal cycles and during a period when the beach was subject to storm waves. Frost table measurements were made with a hand auger.

ULTRASONIC TESTING OF FROZEN SOILS

(P. J. Kurfurst, GSC)
Ultrasonic wave velocities of frozen soil samples subjected to uniaxial stress were measured at temperatures from -10 to 0 C. Testing apparatus has been experimentally used to measure stress-strain relationships, porosity-ultrasonic velocity-shear strength relationships and the effects of stress cycles on soil samples of various temperatures.

ELECTROMAGNETIC SOUNDING OF ICE AND PERMAFROST

(D. W. Strangway, J. R. Rossiter, J. D. Redman, GEOL U. of Toronto)
Three experiments were conducted near Tuktoyaktuk in March 1976. Radio interferometry at 1-32 MHz at the Involuted Hill test site and on sea and lake ice, audio magnetotellurics (AMT) at 10 Hz-10 KHz at Involuted Hill and over the Beaufort Sea and *in situ* probe measurements of the dielectric constant and loss tangent in the surface 1 m of frozen soil at Involuted Hill. Results of all three experiments give the following consistent interpretations: (i) a very moist active layer, about 50 cm thick, with a conductivity-thickness product of <0.03 mhos on the surface in summer, (ii) the active layer freezes in winter and has electrical properties similar, but not identical, to the underlying material, (iii) the clay till permafrost near Involuted Hill has a dielectric constant of about 6-7, a loss tangent at 16 MHz of about 0.15 and thus a conductivity of about 10^{-4} mhos/m.

GROUND PROBING RADAR AND TIME-DOMAIN REFLECTOMETRY EXPERIMENTS IN PERMAFROST TERRAIN

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

Frozen soils exhibit low electrical loss at frequencies in the range 1 to 1000 MHz. This property permits the use of high frequency electromagnetic techniques to map, with high resolution, shallow geological structures. An extensive field programme to assess these techniques was carried out during the spring of 1976 at sites around Inuvik, Tuktoyaktuk, Normal Wells and Rae Point, N.W.T., and Dawson City, Yukon Territory. Conclusions to date are as follows: (1) Radar can be used to map lithology in coarse grained soils; interfaces at depths exceeding 30 m have been mapped. (2) Fine grained soils exhibit significantly higher electrical loss; in clay covered areas, penetration of radar signals was less than 3 m. (3) Ice thickness on fresh water lakes and rivers can be mapped quickly and routinely. (4) Water depths of shallow lakes and rivers can be mapped from an ice covered surface; river and lake bottoms have been mapped to depths of 7 m. (5) The electromagnetic wave velocities of frozen soil and ice are so similar that ice content cannot be inferred from velocity measurements alone.

PERMAFROST DISTRIBUTION AND RELATED ENVIRONMENTAL FACTORS

(R. J. E. Brown, DBR)

The observations on microclimate, surface energy exchange and ground temperatures at Thompson, Manitoba, located in the discontinuous permafrost zone, have been terminated. Detailed profiles of soil and ground ice conditions, and *in situ* thermal conductivity measurements of the mineral soil and peat are being carried out. Analysis of the terrain site data and report preparation is underway.

Ground temperature studies are continuing at the boundary between the discontinuous and continuous zones in northern Manitoba and Keewatin District and at various locations in the mountains in southern Alberta and British Columbia to investigate the characteristics of alpine permafrost.

GROUND THERMAL REGIME

(L. E. Goodrich, G. Johnston, DBR)

Instrumentation has been installed near Wrigley, N.W.T., to measure changes in the seasonal temperature pattern and thermal properties in permafrost resulting from the construction of a road embankment in a section of the Mackenzie Highway. Ground temperatures are being recorded by a data logger powered with a thermoelectric generator. Ground thermal conductivity measurements are determined from buried conductivity probes. Moisture pattern changes will be followed with the neutron moisture meter.

The insulated road study near Inuvik, N.W.T., is being continued.

PERMAFROST ENGINEERING

(G. H. Johnston, DBR)

Extremely variable permafrost conditions were encountered at a bridge site on the Dempster Highway in the northern Yukon. Ground temperature cables were installed during investigation of the site in 1974 to provide information for the design of the bridge foundations. Additional cables were placed on and adjacent to the steel piles when the abutments were constructed in September, 1976, to evaluate freezeback of the piles. Ground temperature and movement (if any) observations will be continued to assess changes in the ground thermal regime and the long-term performance of the bridge foundations.

STRENGTH OF FROZEN GROUND

(T. H. W. Baker, DBR)

The effects of various end restraint conditions on compressing cylindrical ice and frozen soil specimens have been analyzed using the finite element approach. A report describing the results is under preparation. In addition, a method of designing a platen for testing such specimens has been made and construction of the platen is underway.

A laboratory investigation of the effects of four different specimen/platen arrangements was completed using specimens of artificially frozen Ottawa fine sand. The tests were carried out at a medium strain rate of 0.07% min^{-1} and with different length/diameter ratios.

A series of *in situ* penetrometer tests was carried out in the seasonally frozen clay.

A new triaxial cell has been designed to allow for more accurate indirect measurements of sample volume change.

C. Simon L. Ommanney

CARL BENSON

Both his appearance and his name reveal Carl Benson's Swedish ancestry. He was born in 1927 in the state of Minnesota, an area with a tradition of Scandinavian immigration, and educated in local schools. At the age of 18 he was called up for military service and served for one year in the U.S. Navy. In 1946 he went to the University of Minnesota, reading geology, mathematics and physics, and gained his Bachelor's degree in 1950. The summer of that year he worked with the U.S. Geological Survey as a Geological Field Assistant with a Naval Oil Unit on the Arctic slope of Alaska—his first taste of a state that was later to become his home.

For the academic year 1950-51 he worked as a Research Assistant at the University of Minnesota and then joined the Snow, Ice and Permafrost Research Establishment (SIPRE) as a Physicist. During the period 1952-56, Carl became closely involved in glaciological field work, concentrating on snow cover problems and meteorological studies at the Central Sierra Snow Laboratory on Donner Summit in California, and then on joint U.S.-Canadian projects in Labrador, Hudson Bay area and Greenland. The Chief Scientist at SIPRE during this period was Henri Bader, who was one of the initiators of the snow and firn studies undertaken in northern Greenland by these expeditions. Carl was in charge of the glaciological research in 1952 and 1953, and expedition leader and glaciologist in 1954 and 1955. He was particularly concerned with the properties and structure of the snow and firn of the ice sheet, using data obtained from cores and pits. His major contribution was on the stratigraphy of the ice sheet, which still stands to-day as a classic in glaciological research.

His research efforts gained him a Master's degree in geology and geophysics at the University of Minnesota in 1956, and he then moved to the California Institute of Technology in Pasadena as a Graduate Assistant in the Division of Geological Sciences. Under the Chairmanship of Robert P. Sharp, this Division was gaining worldwide recognition for the high quality of the research completed by its glaciological Ph.D. students—and Carl contributed to this reputation.

After obtaining his Ph.D. in 1960, he took up a post in the Geophysical Institute of the University of Alaska in Fairbanks. He moved rapidly through the posts of Assistant Professor of Geophysical Research (1960-61), Associate Research Geophysicist (1961-62), Associate Professor of Geophysics and Geology (1962-69), to that of full Professor of Geophysics and Geology (1969 to the present), serving as Chairman of the Geology Department 1969-72. The 1968-69 academic year was spent on sabbatical leave at the Scott Polar Research Institute, Cambridge, U.K.

Moving rapidly is, in fact, a characteristic of Carl Benson—both in intellectual terms and in physical ones. Of boundless energy and enthusiasm, and occasional refreshing naïvety, he gets involved wholeheartedly in whatever he is doing, oblivious to the passage of time. Professionally, he has always worked on a great variety of projects in any one period. He drives himself hard, and expects the same of those who work with him.

He takes an intense interest in local community and environmental affairs and has a strong social conscience, stemming in part from a puritanical streak in his character. It was soon after he and his family had established themselves in Fairbanks that he became interested in an ever-worsening environmental problem: low temperature air pollution ("ice fog"), noticeably exceeding the well-known pollution of the Los Angeles area. The careful research undertaken by Carl and his colleagues resulted in several definitive reports that were of interest not only to meteorologists but to local government and Federal agencies.

Visitors to the Benson home have become accustomed to the activities of their host—who is liable to absent himself for an hour or so in order to measure ice formation on a small turbulent stream nearby, or, in summertime, to be late arriving home after an excursion on the Tanana river to catch a salmon for the dinner party. His wife, Ruth—also Scandinavian in ancestry, but a nurse by training—represents Alaskan nurses on the American Nurses Association and has been elected to office on the Board. She now has her own working trips away from home, a nice compensation after years of cheerfully coping with the extreme cold and the darkness of central Alaskan winters with three lively children, while Carl was on expeditions to the Antarctic or to the Arctic slope.

These expeditions aroused his interest in making comparisons between the two polar regions, and to-day one of his prime interests is a study of the glacier facies parameters on a global scale, with special reference to comparing selected glaciers of Alaska with the Greenland and Antarctic ice sheets. Much of his field work is concerned with glacier-volcano reactions on Mt. Wrangell and the thermal regime of the McCall glacier on the Brooks Range, northern Alaska. The great changes wrought in Alaska by the developments in the oil industry have affected Carl in two ways. Its effects on the permafrost have been studied by ground observations and by analysis of aircraft and satellite observations; while its effects on the local community life and environment have given him much cause for concern and action through pressure groups.

It is not surprising that after seventeen years in Fairbanks, a city not renowned for a high proportion of long-stayers, the Bensons should be well known. A shopping excursion through the main streets will take far longer than planned, because he always has time to talk with people; and departing guests run the risk of missing their plane at the airport because he takes them into the meteorological tower to check the weather conditions and gets involved in technical discussions. On the rare occasions when the Bensons leave Fairbanks for "outside", they are welcomed by friends and colleagues for their warmheartedness and their refreshing outlook on life as much as for Carl's professional expertise.

INTERNATIONAL GLACIOLOGICAL SOCIETY

CONSTITUTION CHANGES

290 members replied by the deadline date to the circular about changes to the Constitution proposed by the Council. The result of the ballot, held in accordance with Rule 17 of the Constitution, was as follows:

Rule 4: to increase the number of Honorary Members from 10 to 12—98.28% approval.

Rules 4, 5, etc: to use the word "payment" instead of "subscription"—99.66% approval.

Rules 6, 9, etc: to change the title "Secretary" to "Secretary General"—93.45% approval.

These changes came into effect on 6 April 1977. The revised Constitution will be printed at the back of the new List of Members, which will be mailed to members in July.

SYMPOSIA 1977, 1978, 1979 & 1980

1977 12-16 September, Cambridge, England
The Society is organizing a Symposium on "Physics and chemistry of ice" The Papers Committee has selected about 50 papers for presentation and has invited six people to give special papers. The proceedings will be published in the *Journal of Glaciology* in 1978. The Third Circular, containing the programme, will be sent to those who register by mail for the Symposium.

1978 15-19 August, Ottawa, Canada
A Symposium on "Glacier beds: ice-rock interface" will be organized by the Sub-Committee on Glaciers of the National Research Council of Canada's Associate Committee of Hydrology. Information concerning it may be obtained from C. S. L. Ommanney, Glaciology Division, Fisheries and Environment Canada, Ottawa, Ontario K1A 0E7, Canada. The proceedings will be published by the Society in the *Journal of Glaciology*.

1978 21-25 August, Ottawa, Canada
The Society is organizing a Symposium on "Dynamics of large ice masses". A group of members in Ottawa is handling the local arrangements, with the assistance of Carleton University, while the work of the Papers Committee will be handled by the Society's Headquarters in Cambridge. The proceedings will be published in the *Journal of Glaciology*. Post-Symposium tours are planned, and a special trans-Atlantic fare will be offered for those who are willing to form a group travelling from and returning to London. The Second Circular will be published in July and mailed to all members and to those who have already expressed interest in the Symposium.

1979 12-17 August, Fort Collins, Colorado, USA
The Rocky Mountain Forest and Range Experiment Station, of the US Department of Agriculture's Forest Service, will organize a Symposium on "Snow in motion: avalanches and blowing snow ' The Society will co-sponsor the Symposium and will publish the proceedings in the *Journal of Glaciology*. The First Circular will be available at the end of 1977 and will be published in ICE.

1980 25-30 August, Geilo, Norway
The Society is planning a Symposium on "Processes of glacial erosion and sedimentation". Co-sponsors will be Norsk Polarinstitutt and the Department of Geography, University of Oslo. A local committee is being formed, to handle arrangements in Norway, including post-Symposium tours, while the work of the Papers Committee will be handled by the Society's Headquarters in Cambridge. The proceedings will be published in the *Journal of Glaciology*.

BRANCH NEWS

NORTH EAST NORTH AMERICAN BRANCH

On 11 February 1977 Society members and interested non-members assembled in Montreal for the biennial meeting of the NENA Branch. Following an icebreaker, generously hosted by the McGill Centre for Northern Studies and Research, the technical presentations were given in the Macdonald Physics Building. John Elson's paper on a Montreal glacieret provided the delightful balance of scholarship and levity one has come to expect at such meetings. Other papers ranged from reports on work in press to problems encountered just prior to the meeting.

A resounding victory was recorded by Canada in the 3rd Can-Am Ski Race, possibly due to the non-participation of any U.S. skiers. At the traditional banquet, held in the McGill Faculty Club, the state of the Society was discussed, Bob Thomas offered to host the next meeting in Orono and Phil Langleben was thanked for hosting the Montreal meeting and putting together such an interesting programme.

The new officers of the NENA Branch are:

President: M. P. Langleben
Vice-President: R. H. Thomas
Treasurer: A. Kovacs

The following technical papers were presented at the meeting:

Ice core programme on Mount Logan, Yukon Territory (G. Holdsworth).

Crystal size in ice and climatic change (R. M. Koerner).

Dendroglaciology as an aid in determining alpine glaciation chronology: an evaluation (H. W. Posamentier).

A reconciliation of the temperature and isotope profiles for Devon Island Ice Cap (W. S. B. Paterson and G. K. C. Clarke).

Detritus content and ablation of the Trafalgar Road glacieret (J. A. Elson).

Etching and replicating ice surfaces (N. K. Sinha).

Computer routing of unsaturated flow through snow (W. B. Tucker).

Mechanics of wet snow (S. Colbeck).

Deformation of single crystals of ice close to the melting point (S. J. Jones).

Electrical properties of ice (G. Johari).

Some results of North Water Project (F. Müller).

Interesting radar profiling of sub-surface features (A. Kovacs).

Interaction and transmission of solar radiation (400-720 nm) through ice covered lakes (W. A. Adams).

Ice biota in three locations: Gulf of St. Lawrence, West Hudson Bay, Robeson Channel (M. J. Dunbar and Judy Acreman).

Borehole flow measurements in the Devon Island Ice Cap (W. S. B. Paterson).

Glaciological investigation of the Peruvian Quelccaya Ice Cap (L. G. Thompson).

Creep instability in glaciers and ice sheets (G. K. C. Clarke, U. Nitsan and W. S. B. Paterson).

A catastrophic model of rock glacier flow (P. G. Johnson and M. Maxwell).

Recent and future work on the Ross Ice Shelf Project (R. H. Thomas).

Small terrain features around the Rusty Glacier's terminus, Y.T. (T. Brewer).

Cirques as parameters of upland erosion surfaces (A. N. Genes).

Preliminary results of water drag coefficient at AIDJEX Caribou (M. P. Langleben).

An hypothesis of till erosion (I. M. Whillans).

C. Simon L. Ommanney

WESTERN ALPINE BRANCH

Members of the Branch spent a magnificent three days in the Bernina Massif on 24, 25 and 26 September 1976. In spite of capricious weather, heavy clouds alternating with brilliant sunshine, everyone enjoyed the scenery and the warmth of welcome from the local hotel and people. There were many opportunities for walking in the Massif to see the spectacular glaciers, and for joining in discussions led by local experts on the variations of these glaciers. A wine party given by the Pontresina Mountain Guides Company was much appreciated after strenuous efforts in the mountains.

The Annual General Assembly of the Branch was held one evening and the Annual Banquet held at lunchtime on the last day of the meeting. After the gastronomic repast that has become such a well-known feature of the Branch's life, members settled down to listen to talks and to watch films about the glaciers of the region.

The new officers of the Western Alpine Branch are:

President: A. Roch

Vice-President: J. Y. Bernard

Secretary: G. Bocquet

Treasurer: F. Valla

JOURNAL OF GLACIOLOGY

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

J. A. Clark:
An inverse problem in glacial geology: the reconstruction of glacier thinning in Glacier Bay, Alaska, between A.D. 1910 and 1960 from relative sea-level data.

I. M. Whillans:
The equation of continuity and its application to the ice sheet near "Byrd" station, Antarctica.

T. C. Grenfe'l and G. A. Maykut:
The optical properties of ice and snow in the Arctic Basin.

M. J. Hambrey:
Structures in ice cliffs at the snouts of three Swiss glaciers.

N. Eyles and R. J. Rogerson:
Artificially induced thermokarst in active glacier ice: an example from north-west British Columbia, Canada.

J. Jouzel, L. Merlivat and M. Pouchet:
Deuterium, tritium and ß activity in a snow core taken on the summit of Mont Blanc (French Alps): Determination of the accumulation rate.

D. Jenssen:
A three-dimensional polar ice sheet model.

D. S. Munro and J. A. Davies:
An experimental study of the glacier boundary layer over melting ice.

D. F. Classen:
Temperature profiles for the Barnes Ice Cap surge zone.

R. Frederking:
Plain-strain compressive strength of columnar-grained and granular snow ice.

V. K. Raina, M. K. Kaul and S. Singh:
Mass budget studies of the Gara Glacier, India.

Short note

S. J. Bolsenga:
Preliminary observations on the daily variation of ice albedo.

FUTURE MEETINGS (of other organizations)

ELECTRONICS AND AVALANCHES

4-8 April 1978, Graz, Austria

A meeting on "Electronics and avalanches" will be held during the Vanni Eigenmann Symposium in Graz, Austria, from 4-8 April 1978. The organizers are the Institute of Electronics, Technical University of Graz (Head: o.Prof.Dipl.-Ing. Dr W. Fritzsche) and the Fondation Internationale Vanni Eigenmann, Milano, Italy.

The provisional programme is as follows:

4 & 5 April	Electronics for measurements of snow and ice and for the search of avalanche victims. Special lectures and short reports especially for electronic engineers, physicists, etc.
6 April	Short reports on available results of the special lectures the days before, and papers on applications for avalanche forecast, rescue, avalanche release, blasting, rocking, etc. Present non-electric methods.
7 April	The programme of 6 April is continued. Demonstrations without snow (at Graz).
8 April	Demonstrations with snow.

There will be invited lectures, 15 minute papers and 5 minute short reports, with discussion.

Further information may be obtained from: Institute of Electronics, Technical University of Graz, Inffeldgasse 12, A-8010 Graz, Austria.

SNOW AND AVALANCHES

12-14 April 1978, Grenoble, France

This meeting is organized by the Association Nationale pour l'Etude de la Neige et des Avalanches and is subsequent to that which took place in St. Vincent-d'Aoste, 26 February 1975. The programme includes all the questions concerning snow and avalanches. Therefore papers will have to deal with recent work on the one hand and with applications on the other hand. Topics may include: physical and mechanical properties of snow, statistics and ways of forecasting risk of avalanches, dynamics of avalanches, avalanche control, active and passive defence, legislation, rescue, observing the depth and condition of snow, snow and forests.

Summaries must not exceed 150 words and must be submitted before 1 September 1977, in French or in any other language chosen by the author. A second notice will contain instructions concerning the presentation of communications. Communications will be published in their final form after the meeting.

The working language will be French. Lecturers will be allowed to speak in any language but there will not be any simultaneous translation.

The entry fee is 300 F per person. It gives the right to a summary before the meeting and to a copy of communications after the meeting.

In October 1977 a second notice will be sent to those who have indicated interest in the meeting by writing to the organizers: A.N.E.N.A., 46 avenue Félix-Viallet, 38000 Grenoble, France.

GLACIOLOGICAL DIARY

1977

16–24 August
International Union for Quaternary Research, 10th Congress, Birmingham, England. Sponsored by the Royal Society. (Dr J. W. Jardine, Dept. of Geology, University of Glasgow, Glasgow G12 8QQ, U.K.)

22–27 August
3rd Symposium on Antarctic Geology and Geophysics, Madison, Wisconsin, USA. Sponsored by Scientific Committee on Antarctic Research, Int. Union of Geological Sciences, & Inter-Union Commission on Geodynamics. Organized by US National Research Council (Polar Research Board of U.S. National Committee for SCAR). (Dr C. Craddock, Dept. of Geology and Geophysics, University of Wisconsin, Madison, WI 53706, USA.)

4–9 September
Symposium on Sea ice — processes and models, Seattle, Washington, USA. Joint AIDJEX and ICSI symposium. (M. Mellor, Secretary ICSI, CRREL, Hanover, NH 03755, USA.)

6–9 September
Symposium on Dynamics of temperate glaciers and related problems, Munich, Germany. European Geophysical Society. (L. Lliboutry, Laboratoire de Glaciologie, 2 rue Très-Cloîtres, 38031 Grenoble cedex, France.)

11–16 September
Symposium on Physics and chemistry of ice, Cambridge, England. International Glaciological Society. (Mrs H. Richardson, Sec. Gen., International Glaciological Society, Cambridge CB2 1ER, England.)

21–27 September
Conference on Atmospheric aerosols, condensation and ice nuclei, Galway, Ireland. International Commission on Cloud Physics and Commission on Atmospheric Chemistry and Global Pollution (both of Int. Ass. of Met. and Atmos. Physics). (A. F. Roddy, Department of Physics, University College, Galway, Ireland.)

26–30 September
POAC-77 — Conference on Port and ocean engineering under Arctic conditions. (G. R. Peters, Chairman, POAC-77 Organizing Committee, Faculty of Engineering and Applied Science, Memorial University of Newfoundland, St. John's, Newfoundland, Canada.)

1978

8–10 March
Symposium on Ground freezing. Bochum, Germany. Ruhr — University Bochum. (Dr H. L. Jessberger, Soil Mechanics Division, Civil Engineering, Ruhr-University Bochum, P.O. Box 102148, D 4630 Bochum 1, Germany.)
April
Meeting about snow and avalanches, Grenoble, France. Association Nationale pour l'Etude de la Neige et des Avalanches. (ANENA, 46 avenue Félix-Viallet, 38000 Grenoble, France.) (See p. 17 of this issue of ICE.)

4–8 April
Symposium on Electronics and avalanches. Graz, Austria. (Dr W. Fritsche, Institute of Electronics, Technical University of Graz, Inffeldgasse 12, A 8010 Graz, Austria.) (See p. 16 of this issue of ICE.)

16–18 May
Symposium on Snow removal and ice control research. Hanover, NH, USA. Transportation Research Board; CRREL; US Department of Transportation. (A. Clary, Transportation Research Board, 2101 Constitution Avenue NW, Washington, DC 20418, USA.)

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.)

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 0E7, Canada.)

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

1979

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.) (See p. 14 of this issue of ICE.)

1980

25–30 August
Symposium on Processes of glacial erosion and sedimentation. Geilo, Norway. International Glaciological Society. (Mrs. H. Richardson, Secretary General, Cambridge CB2 1ER, England.) (See page 14 of this issue of ICE.)

REVIEWS

G. N. Golubev. **Gidrologiya lednikov** [Hydrology of glaciers]. Leningrad, Gidrometeoizdat, 1976 247 p. 1.90 roubles.

This is a very useful textbook of glacier hydrology, probably the best that can be found in any language. Golubev is an enthusiast who has a broad grasp of this rapidly developing branch of glaciology. Although for the purposes of illustration he draws extensively from his own researches on Lednik Dzhankuat in the Caucasus, very many other studies are reported in the context of particular hydrological characteristics. There are 99 references to foreign literature out of a total of 252 listed at the end of the work. While there are no photographs, 62 text figures and 23 tables are used to illustrate empirical relationships on named glaciers. After treating separately the water regimes of the accumulation

area, the glacier surface in the ablation area, the ice body itself, and the bed of the glacier, the author discusses components of the water balance, of whole glaciers and of drainage basins containing glaciers, and the analysis of run-off. The treatment is clear and for the most part uncontroversial. Although the emphasis is on practical problems of measurement and prediction, there is a generally happy balance between hydrological theory and observed relationships from particular glaciers. While the book is intended for professional glaciologists, hydrologists, geophysicists, climatologists, and physical geographers, it is also well worth using as a comprehensive textbook for advanced students.

Charles Swithinbank

H. Preusser. **The landscapes of Iceland: types and regions.** Dr W. Junk b.v., The Hague, 1976. 363 pp.

The purpose of this work, originally prepared as a doctoral thesis for the University of Saarland, Germany, is to provide a typological and regional classification of Iceland, and to describe the various landscape types and regions which make up this subarctic island of 103,600 km^2. The author uses the term "landscape" in the classic Germanic tradition of Hettner and Schmithüsen to imply the "personality" of a part of the geosphere that is of geographically relevant size and comprehensible as a unit when considered in all its aspects. All three "realms of existence—inorganic, organic and spiritual", therefore, are considered. And as the author points out, while there is a prevailing tendency to regard the greater part of the island as a "natural landscape", such a viewpoint risks overlooking the fact that the original natural balance of vegetation has been greatly disturbed during the 1,000-year period since the first settlers colonized the island during the latter part of the ninth century A.D. Thus the book is a "geography" of Iceland in the very special sense of being an analysis, description and classification of the landscape types, and so contains much information about the history of human occupance, and the human and economic geography of the twentieth century. Nevertheless, by far the largest proportion of the book deals with general geology, vulcanism, glacial geology, geomorphology, and glaciology, so that this review is appropriate for ICE.

The work has been compiled on the basis of three major scientific tours of the island, extensive air photograph interpretation, and a truly massive review of the literature which pleasantly surprised this reviewer for its thoroughness. The basic regional landscape classification, using three orders of landscape regions, was compiled in map form at a scale of 1:250,000. This map was reduced to approximately 1:1,500,000 for publication and is bound into the back of the book. It should be noted, however, that the reader needs a full set of the Icelandic 1:250,000 or, better, the 1:1,000,000 topographic maps at hand if he is to appreciate fully the detailed regional description. Since many readers will not have these map series readily available, it is unfortunate that a second map, showing place names, roads, and rivers, was not also bound into the book.

The work is divided into three sections. The first section is a survey of the "elementary facts of landscape structures" and deals with geology, glaciation during the last glacial period, late-glacial and post-glacial isostasy and eustasy, hydrothermal phenomena, climate, periglacial landforms, flora, fauna, deflation, cultural landscapes, agriculture, fishing, regional differentiation in the pattern of settlement, and communications. This covers 103 pages of well written, highly condensed, and comprehensive text that alone forms a veritable geography of Iceland. For this reviewer the discussions on the Tertiary Basalt Formation, tectonic activity, glaciation, periglacial landforms, and deflation were especially rewarding, each forming a well-balanced review of the voluminous research that is scattered through the scientific literature in many languages. The second section, 40 pages long, deals with the major landscape types, broken down into such familiar categories as: vegetated lowland, sandar, fjord landscape, tundra plateaux, highlands, young volcanic landscape, and glaciers. Understandably, these subsections receive varying degrees of detailed treatment, with nearly half the space going to the very complicated topic of the young volcanic landscape. The subsection on glaciers is, unfortunately, brief and rather disappointing, and the paragraph on "jökulhlaup" contains no reference to Glen or Röthlisberger.

Pages 145 to 327 constitute the third and longest section of the book. It involves a region-by-region, subregion-by-subregion description of the island. Frankly, it makes for extremely tedious reading. Whereas this reviewer could read sections one and two with enjoyment at a single sitting, section three emerges at best as an encyclopaedic reference to Icelandic landscapes; at worst, the reader who happens to be familiar with his own special corners of this magnificent and fascinating island may well be very disappointed. For instance, the personality of Vatnajökull cannot receive adequate attention in less than 8 pages; Europe's largest and perhaps most complicated volcano, Öraefajökull, receives less than three pages under subsection 23.3—"Öraefi and the Öraefajökull Mountains",

and the subsection's magnificent Morsardalur is barely mentioned, while the new national park, centred on Skaftafell, is omitted entirely. Similar thoughts come to mind when reading the subsections on the Snaefellsjökull peninsula, the western fjords, and the north-central coastal area. It is safe to presume that those familiar with other "regions" will experience similar reactions. In practice, this means that the original objective of describing and classifying the landscape types of Iceland may well be far from attainment. Nevertheless, this rather severe level of criticism must be tempered with the statement that the short-coming apparent to this reviewer is perhaps mainly the obvious and practical shortage of space—given three times the number of pages, a more effective catalogue of the regional landscapes of Iceland would likely have been produced. Total absence of photographs, of this abnormally scenic island, while presumably also the dictate of cost, has further deprived the landscape geographer of a vital medium. Twenty eight pages of references complete the work, and form a bibliography of considerable value.

In conclusion, the **Landscapes of Iceland** will undoubtedly form a basic, required reference for any person planning a scientific sojourn in Iceland, and this reviewer considers that the author and publisher have performed for him an important personal service, which certainly many others will feel. The book should also form an excellent starting point for testing the author's regional classification and for providing a more detailed and better justified series of papers, on the individual landscape regions of an island justly renowned for its majestic scenery, intriguingly active geologic and climatic processes, and courageous and hospitable people with the longest tradition of democracy in the Western World.

Jack D. Ives

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Edited by G. S. Hope, J. A. Peterson, U. Radok & I. Allison

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I C E

Editor: Hilda Richardson

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