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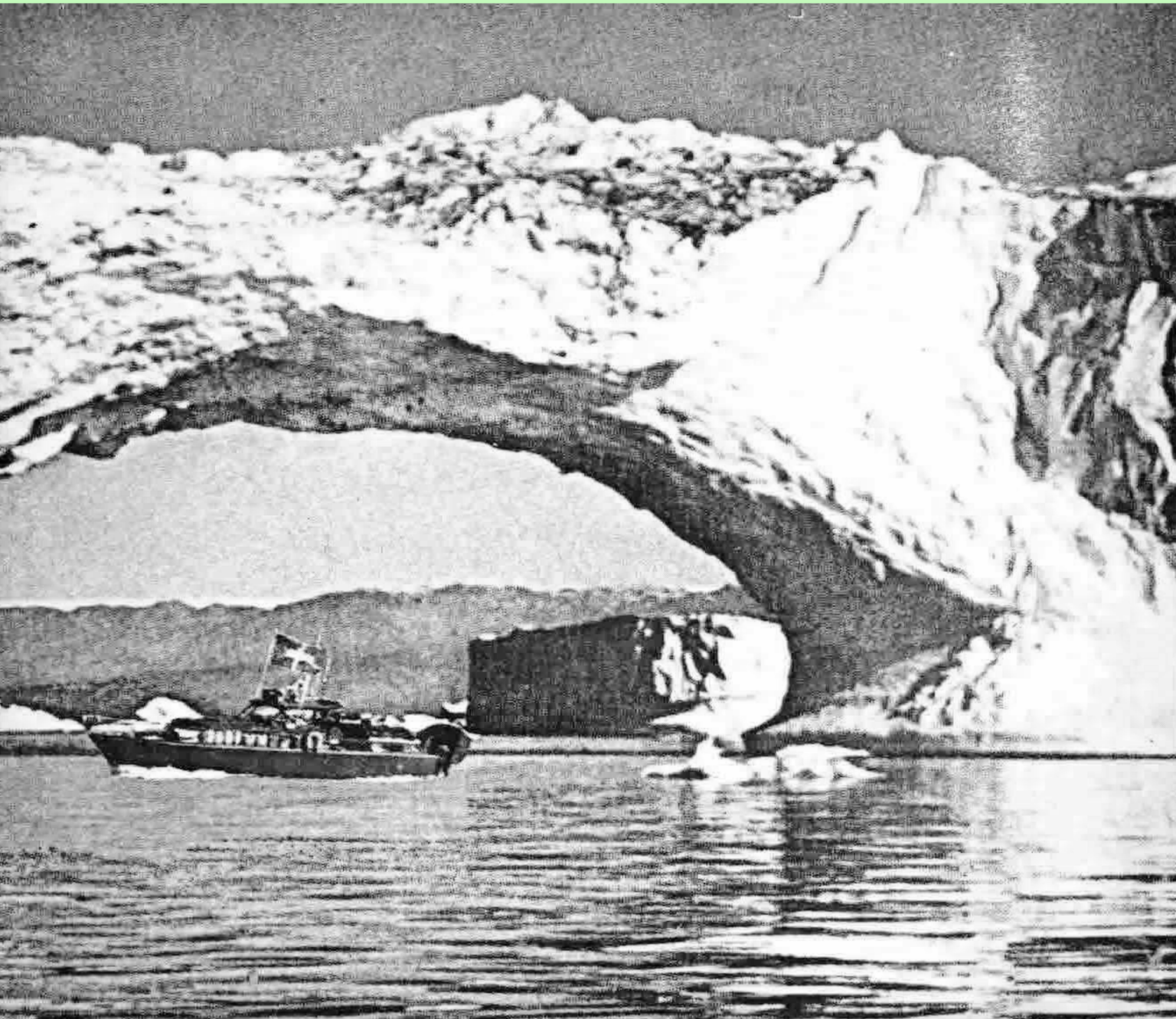

INTERNATIONAL GLACIOLOGICAL SOCIETY

MEETINGS 1974

15–21 September—Symposium on Remote Sensing in Glaciology, Cambridge, England.

19 September—Annual General Meeting, at 1800 h in the University Chemical Laboratories, Lensfield Road, Cambridge.
Annual Dinner, at 2000 h in Pembroke College, Cambridge.

BRANCH MEETINGS

26–30 August —Nordic Branch meeting in West Norway.

6–8 September—Western Alpine Branch meeting in Italy.

ICE

NEWS BULLETIN OF THE INTERNATIONAL GLACIOLOGICAL SOCIETY

1st ISSUE 1974 NUMBER 44

CONTENTS

DEATH OF HANS W:SON AHLMANN. Professor Ahlmann, Honorary Member of the Society, died on 10 March 1974 at the age of 84. He was head of the Geography Department, Stockholm University 1929-50, Swedish Ambassador to Norway 1950-56, and President of the International Geographical Union 1956-60. Between 1931 and 1938 he led expeditions to Spitsbergen and Iceland. He was the author of many articles, atlases and handbooks, and wrote the foreword of the first issue of the Journal of Glaciology. He was particularly known in glaciological circles for his work on the relationship of glaciers to climatic change. An obituary will be published in the Journal later this year.

1974 DUES. If you are one of the three hundred members who have not yet paid their dues, please would you do so without delay. The second issue of the Journal this year will not be mailed to members who have not paid.

COVER PICTURE. Mr Knud Lauritzen's "Bamsa Dan" in front of an iceberg in one of the inner Scoresbysund fiords, during a 1000-mile tour of geologist camps and old eskimo dwellings. The last eskimos on the north-east coast of Greenland were seen by English whalers on Clavering Island in 1827. Contributed by K. Lauritzen.

RECENT WORK

CANADA

Glacier Research

Defence Research Board *(H. Serson)*

(a) **ICE SHELF SURVEYS**

Between 7 and 8 May the accumulation networks on the Ward Hunt ice rise and ice shelf were measured and low level photographs of the boundaries of the ice shelves along the north coast of Ellesmere Island obtained.

(b) **INVESTIGATIONS RELATED TO CLIMATIC CHANGE**

On 9 May the accumulation network on the small ice cap near St. Patrick's Bay in northeast Ellesmere Island was measured and on 14 August low level aerial photography was obtained to indicate its present boundaries.

Glaciology Division, Department of the Environment *(O. H. Løken)*

(a) **ICE SCIENCE SECTION (S. J. Jones)**

Ottawa-based laboratory projects:

Mechanical properties of ice single crystals close to melting point (S. J. Jones and G. A. Barnett)

Single crystals of ice are being deformed above −10°C to determine the activation energy of deformation in this temperature range.

Mechanical properties of ice under hydrostatic pressure (V. R. Parameswaren)

Single-crystal and polycrystalline ice are being deformed at a constant strain rate with a super-imposed hydrostatic pressure of up to 1 k.bar, in the temperature range −30°C to the melting point.

Field work:

Radio depth-sounding (R. A. O'Neil and S. J. Jones)

Plans are being made to take a 620 MHz, a 440 MHz and a 35 MHz SPRI radio echo sounder to Barnes Ice Cap, Baffin Island in April 1974 to measure depths in an area of a postulated "surge" and to measure attenuation in the ice.

(b) **PERENNIAL SNOW AND ICE SECTION (C. S. L. Ommanney)**

Field work was carried out in the following areas:

Ice Island T-3, Arctic Ocean (G. Holdsworth)

A test was carried out, in the spring of 1973, of a laser interferometer to measure strain rates on the surface of the island. Wave motion and horizontal strains due to ice-pack pressure were monitored.

Mackenzie River and High Arctic Islands (K. C. Arnold)

Some 8,000 line miles of aerial photography were flown using a Wild RC-10 camera. The break-up of the Mackenzie River ice was observed. In addition, three of the ice caps being monitored for mass balance and several calving glaciers were rephotographed.

Decade Glacier, Baffin Island (A. D. Stanley)

The winter balance was measured in late June, but no measurements were taken in the summer.

Tweedsmuir Glacier, British Columbia (G. Holdsworth)

Field investigation of this new glacier surge started in October, 1973. Terrestrial stereo photographs were taken in mid-October and in early November; they will be repeated at intervals. Snout positions have been determined from a line of cairns. The glacier, advancing at a rate of about 2 m/day, has partially dammed the Alsek River and forced it into a new channel.

I.H.D. mass balance studies, Western Canada (A. D. Stanley, T. M. H. Beck, O. Mokievsky-Zubok and G. J. Young)

Measurements of winter and summer balances were continued on 6 glaciers in the Canadian Cordillera (Berendon, Place, Sentinel, Woolsey, Peyto and Ram). Stream discharge and meteorological data were obtained using long term recorders in all basins except that of the Berendon Glacier. Observers were stationed continuously at Sentinel and Peyto Glaciers. A study of the areal distribution of temperature, wind and relative humidity in the Peyto Glacier Basin was carried out by D. Foessel.

Peyto Glacier, Alberta (G. J. Young)

Preliminary field work was carried out to test a 'Digiray' portable radio-active snow gauge.

Glacier Inventory of Canada (C. S. L. Ommanney)

Glaciers in 8 basins of central Ellesmere Island have been identified and indexed. Included with this is the identification of calving glaciers. Key word listings have now been prepared for some 1000 articles containing references to Canadian glaciers and entered in the computer-based information file. Information on Canadian glaciers in the files of the Archives of the Canadian Rockies has been identified. The Arctic Institute of North America's inventory of the Canadian St. Elias glaciers, being carried out under contract, is nearing completion.

Cloudiness and global radiation at Inugsuin Fiord, Baffin Island (S. Fogarasi and M. Boakes)

Analysis of the influence of cloudiness on global radiation in Inugsuin Fiord has been completed. Indices for the depletion of global radiation by cloud types were obtained and the cloud and radiation characteristics of weather systems examined.

Precipitation and cloud patterns over the Cordillera glaciers (S. Fogarasi)

The summer 1971 patterns of daily total precipitation, as measured at 12 stations, have been classified and daily cloud patterns observed by the ESSA 8 satellite digitized. Precipitation and the related cloud patterns are being investigated to permit the estimation of precipitation amounts over small basins.

Data reduction system for glacier mass balance (G. J. Young)

Work has continued on a flexible computerized system for handling mass balance data to provide mapped and tabulated output. The individual stake readings are examined in order to identify those that are most meaningful and, in this way, reduce the amount of field work required without significant loss of accuracy in the final results.

(c) **SNOW AND ICE HYDROLOGY SECTION (A. L. Derikx)**

Hydrology of d'Iberville Basin, Ellesmere Island (A. L. Derikx)

The objective of this project is to determine the average monthly inflow of fresh water into d'Iberville Fiord. Office studies concentrated on components of the energy balance. S. Wilkinson completed the glacier inventory of the d'Iberville Fiord drainage basin, giving particular attention to the great number of ice-dammed lakes.

Icefield Ranges Research Project, American Geographical Society and Arctic Institute of North America *(R. H. Ragle)*

Kaskawulsh Glacier studies (A. D. Hyers)

Ablation and movement studies were continued on the 3 km-wide north-west lobe of the terminus. Ablation for 1973 was about 4.5 m of ice in debris-covered areas and at least 5.6 m where the surface was relatively free of debris. The circular, polygonal and striped patterns that are widespread in the debris-covered margins of the terminus were studied.

Polar Continental Shelf Project, Department of Energy, Mines and Resources *(G. D. Hobson)*

Devon Island ice cap (W. S. B. Paterson and R. M. Koerner)

Another borehole, 299 m deep, was drilled to bedrock some 25 m from the hole drilled in 1972 and a complete core was recovered. P. Bucher and W. Bernhard of the Institute of Physics, University of Bern, extracted gas from the ice for radio-carbon dating. This was done at four depths, at each of which between 3 and 6 tonnes of ice were melted in the borehole. One 1000 kg surface snow sample and four 200-500 kg combined core and drill melt-tank water samples were chemically prepared in the field for dating by Si^{32} at the University of Copenhagen.

The drill melt-tank water was filtered down to 5μm for pollen studies by the Geological Survey of Canada. As a control for this work several 30 kg snow samples were melted and filtered to allow measurement of the seasonal variation of pollen fall-out onto the ice cap in the vicinity of the drill site.

Several samples of snow representing the August 1972—June 1973 period and ice samples from 4 m depth were collected along a traverse of the north-west side of the ice cap; these will be analysed for oxygen isotope ratios and electrolytic conductivity. Two sets of snow samples were collected in carefully precleaned tubes from two pits near the drill site for chemical analysis at the Centre National de la Recherche Scientifique, Grenoble, France.

Inclination, diameter, vertical strain rate, and temperature were measured in the 1971 and 1972 bore-holes and surface strain networks were remeasured. The 1971-72 mass balance of the North-west side of the ice cap was found to be + 102 kg $m^{-2}y^{-1}$.

Several analyses are in progress, on cores collected during the past three seasons and on near-surface samples from various parts of the ice cap, by groups in Canada, Denmark, France and Switzerland.

Scott Polar Research Institute, Cambridge, England *(G. de Q. Robin)*

Radio-echo studies on Devon Island ice cap

Investigations were centred on the Polar Continental Shelf Project's borehole site near the summit of the ice cap. Logistic facilities were provided by the PCSP, with assistance for transport from the Defence Research Board. The SPRI team consisted of G. de Q. Robin, C. A. Clayton, C. S. Doake, M. R. Gorman and G. K. A. Oswald. Systematic radio echo sounding was carried out over the eastern section of the PCSP stake network,

and additional lines run 50 km to the west and 20 km to the north.

Seven lines of one km length selected from the above surveys for their uniform ice thickness were studied in detail by taking calibrated A-scope photographs of echo returns at 1 m intervals along the line. The results are being analysed to check applicability of standard radio theory to bedrock echoes, to see if differing areas of bedrock show differing character in their returns and to give accurate figures of absorption losses in ice from field data.

Comparative studies of bottom fading at 60 MHz and 440 MHz were also made along a carefully positioned 300 m line. More detailed fading studies were made, mainly at 60 MHz, over an area of 8 by 2 m to determine the movement of ice in relation to the fading pattern. The 440 MHz equipment with a phase sensitive receiver was also used to make accurate measurements of the velocity of radio waves in ice. An interferometric technique was used with a receiver on the surface while a special borehole antennae was lowered to 200 m depth in the PCSP borehole.

University of British Columbia, Department of Geophysics and Astronomy *(G. K. C. Clarke)* and Department of Geological Sciences *(W. H. Mathews)*

(a) **SURGING GLACIERS AND OTHER STUDIES (G. K. C. Clarke)**

Studies of Trapridge and Steele Glaciers, two surge-type glaciers in the Icefield Ranges of Yukon Territory, were continued in 1973. Equilibrium ice temperatures measured at six of the 1972 deep drilling sites on Trapridge Glacier indicate that much of the glacier bed is at the pressure melting point. Near the snout, ice is frozen to the bed so that a thermal dam prevents the escape of basal meltwater. A similar feature has been identified on the nearby Rusty Glacier and is believed to control its surge behaviour. These results suggest a thermally-regulated water-film instability mechanism. The ice temperature and gradient near the bed control the formation of a basal water film. The thermal dam near the snout allows a thick water film to build up during the initial stages of the surge advance and accounts for the large sliding velocities associated with a surge.

G. T. Jarvis and Clarke have completed a theoretical study of the thermal effects of partially water-filled crevasses on cold glaciers. The work was motivated by anomalous ice temperature measurements recorded in a 114 m hole in Steele Glacier. Contrary to expectation, ice temperatures decreased with depth, reaching a minimum of approximately −7.0°C at 114 m. This reversal of the normal tendency of temperature to increase with depth is probably a consequence of the 1965-66 surge of Steele Glacier which opened deep crevasses and allowed meltwater to penetrate to great depths within the glacier. The theoretical results agree extremely well with observation and give strong support to this hypothesis. Five additional deep holes were drilled at three widely-spaced sites on Steele Glacier and instrumented with thermistors to permit future temperature measurements.

Clarke has completed a study of the effects of basal water on glacier sliding. Both Nye's linear sliding theory and Kamb's non-linear theory give relationships between the sliding velocity and the roughness statistics of the glacier bed. If a water film is present part of the glacier loses contact with the bedrock and the bed roughness is accordingly reduced. By deriving the modified bed statistics a simple approximation to the drowning effects of basal water and the resulting increase in sliding velocity can be calculated. The 10- to 100-fold increases in flow rate associated with glacier surges can be accounted for in this manner.

The thermal instability surge mechanism developed by J. W. Hoffmann and Clarke is being refined by Clarke to allow a more realistic treatment of obstacle drowning and basal water flow.

B. Narod with Clarke and R. H. Goodman are constructing a back-portable 840 MHz radar sounder for use on valley glaciers. Field experiments in 1972 using a 620 MHz apparatus indicate that scattering losses should not significantly limit the performance. The system will be closely related in concept to the 620 MHz sounder developed by Goodman but will sacrifice on-line signal processing and position location capabilities in favour of portability. The new system may be capable of measuring the roughness spectrum of the glacier bed as well as ice thickness.

(b) **Berendon Glacier studies** (W. H. Mathews)

These studies, which are aimed at forecasting changes in the terminus, were continued in conjunction with A. D. Stanley of the Glaciology Division, Department of the Environment.

University of Calgary, Department of Physics *(H. R. Krouse, H. M. Brown, R. Hislop)*

Stable isotope studies

Over the past year, snow pits on Peyto Glacier and nearby sites were density- and δO^{18} -profiled every one to two months.

Storm events could be isotopically identified over a wide area. These identifications were still possible in pits studied in the early summer, despite the fact that the density profiles had become uniform.

Some 300 samples from a wide area around Mt. Wood, in the St. Elias Mountains, were collected in the late spring of 1973 for isotopic analyses. It is hoped that they will be related to previous studies at other locations in the St. Elias region to elucidate the meteorological system.

University of Colorado, Institute of Arctic and Alpine Research *(J. T. Andrews, R. G. Barry, A. Dyke, G. H. Miller, J. J. Jacobs, R. Weaver)*

(a) **GLACIAL CHRONOLOGY IN BAFFIN ISLAND (J. T. Andrews, G. H. Miller, A. Dyke)**

The glacial chronology of the Penny Ice Cap and nearby local glaciers and ice fields was investigated by three two-man parties working in Pangnirtung Pass, the Padle/Kingnait trough, and along the southern and western margin of the Penny Ice Cap. This work was performed in part as a resource inventory programme for the new Baffin Island National Park. Lichenometric studies on outlet glaciers in Pangnirtung Pass and near Tundra Lake indicate that the glaciers reached their Neoglacial maximum extent about the turn of the century. In Pangnirtung Pass older moraines lie immediately on the distal side of the Neoglacial moraines. Buried organic layers onlapping these older sets of moraines are currently being C^{14} dated. The general impression from the survey was that the Penny Ice Cap was not greatly larger during late Wisconsin time. The conclusion that Padle Fiord/June River were botanical refugiums is reinforced by the geological evidence.

(b) **"BOAS" GLACIER, NORTHERN CUMBERLAND PENINSULA, BAFFIN ISLAND (J.D. Jacobs and R. Weaver)**

The mean snow depth on "Boas" Glacier on 10 June 1973 was 1.2 m $\pm$0.16 m. Average snow density was 0.279 $\pm$0.5 g/cm^3 giving a specific winter balance of 0.32 m water equivalent. A brief visit in late August showed an approximate surface lowering of 1.48 m. Estimated specific net summer loss is $-$0.42 m of water giving an approximate 1972-73 net specific balance of $-$0.10 m. This may be compared with balances of $+$0.39 m and $-$0.20 m for 1969-70 and 1970-71, respectively. Both the mass balance for 1971-72 and the overall balance for 1971-73 were strongly positive.

University of Minnesota, Department of Geology and Geophysics *(R. Le B. Hooke)*

Barnes Ice Cap, Baffin Island

During the 1973 field season, a party of four spent several weeks on the ice cap. In a study of the near-surface temperature distribution, six boreholes were completed and cased to depths of about 30 m and a seventh hole to 20 m. Good temperature profiles were obtained in all the holes. A detailed analysis of the structures developed in a deformed wedge of superimposed ice was begun in an 8 m vertical shaft previously excavated near the ice margin. Shear zones, a few centimeters wide and cutting across primary ice banding, were found to characterize this ice wedge. Fabric and texture studies on dirty ice and ice from the shear zones were made using thin sections.

Studies of deformation processes in dirty ice and of the temperature distribution and flow throughout a polar glacier are currently in progress.

University of Ottawa, Department of Geography *(P. G. Johnson, A. B. Ross)*

Ice-cored moraines

During 1973 work continued at the terminus of Donjek Glacier and on a small unnamed glacier at the head of Metalline Creek in the St. Elias Mountains, Yukon Territory. Measurement of the microclimatic and geotechnical parameters affecting the processes of formation, mass movement and degradation continued in the Donjek valley. Indications are of complex interrelationships of processes involved in all aspects of the problem. Study is being extended to look at the initial constraints of the nature and distribution of the glacier load.

Snow and ice other than glaciers

Defence Research Board *(M. Dunbar, H. Serson)*

(a) **ICE DRIFT STUDIES (M. Dunbar)**

A study of the drift of ice in Robeson Channel was initiated in 1971 using a shore-based radar and transponder stations on the ice. In 1973 activity was mainly concentrated on developing data processing methods and processing the large amount of ice drift, current, and wind data collected in 1972. A small field programme in August was devoted to testing a technique for measuring the drift of inshore floes with a television camera, by superimposing one image on a videotaped one taken a little earlier.

As part of the same study three winter flights were made the whole length of Nares Strait in Canadian Forces Argus aircraft to monitor the winter ice regime including that of the North Water in Smith Sound. This was the third year of a continuing programme.

(b) **REMOTE SENSING OF ICE (M. Dunbar)**

Two of the above-mentioned Argus flights were equipped with a sideways-looking airborne radar (SLAR). The second one, on 8 March, also included a laser profiler, infrared line-scanner and Vinten 70 mm vertical camera. Imagery from the first three was obtained, not only in Nares Strait (from Thule to the Lincoln Sea) but also from Alert to the north pole and thence down the 4°E meridian to the ice edge. Some interesting data on ridge height and frequency and on prevailing lead orientation were obtained and are now being interpreted.

(c) **SEA ICE SURVEYS (H. Serson)**

In view of the possibility of using stationary multi-year ice plugs as platforms for conducting oceanographic measurements throughout the year, a station was established at the north end of Sverdrup Channel (between Axel Heiberg and Meighen Islands) from which current profiles were obtained from meters deployed through the ice on probes. During the recording period 9-18 May, traverses were conducted across and along Sverdrup Channel to obtain sea ice thickness, salinity and entrapped detritus profiles.

Frozen Sea Research Group, Department of the Environment *(E. L. Lewis)*

(a) **RUN-OFF STUDIES**

An extensive study of the run-off into d'Iberville Fiord, a tributary of Greely Fiord in Northern Ellesmere Island, has been carried out in conjunction with our oceanographic programme on Arctic fiord flushing. About half the total annual flow from snow-fed streams enters the sea within one week. Our study of glacial run-off in the same context continues.

(b) **FREEZING POINT OF SEA WATER**

Completion of the work on the freezing point of sea water under pressure led to a value of 7.59×10^{-3} deg/bar, that may be applied to freezing/melting studies on the Antarctic ice shelves and elsewhere. At atmospheric pressure our values give a freezing point for $35°/_{00}$ sea water 0.01 deg lower than that commonly accepted.

Geological Survey of Canada

(a) **GEOLOGICAL REVIEW OF GEOTECHNICAL DATA, MACKENZIE VALLEY (D. E. Lawrence)**

This is a co-operative project of the Department of Indian and Northern Affairs and the Geological Survey of Canada which attempts to assess the distribution of surficial materials, permafrost and ground ice in the Mackenzie Valley. The project is computer based; the detailed stratigraphy (ice and materials) as well as other related parameters —vegetation, temperature, hydrology, location, etc., of over 7000 boreholes have been recorded. The information in the data bank will be used principally in the geological-geotechnical assessment of the design, the soils investigations methods, and the environmental implications of the Mackenzie Highway. The highway will extend from the northern border of Alberta to Inuvik, N.W.T., through the Mackenzie Valley, a distance of approximately 1000 miles. Much of the highway will be built on permafrost soils, some of which have high ice contents which will cause unique construction problems. Melting of the ice in these soils may also cause unique environmental problems.

(b) **EFFECT OF ROAD CONSTRUCTION ON PERMAFROST (R. M. Isaacs and P. J. Kurfurst)**

A study is being made of the effects of construction of an unpaved road (the Canol Road) on the underlying permafrost. The road is situated near Norman Wells in the Mackenzie Valley, Northwest Territories and was constructed in the early 1940's. At the end of World War II it was abandoned. Drilling operations have shown that a thaw bulb may exist beneath the road within the permafrost and may be deeper than 36 m. Soils with high percentages of ice near the surface may be considerably warmed by the increase in mean annual ground surface temperature caused by the road building, but may still be frozen at this time because so much of the heat has been absorbed in the phase change to water. Attempts to predict mathematically the rate of thaw are not entirely satisfactory as it appears that heat transfer by convection of water into permafrost may be occurring as well as heat transfer by conduction.

(c) **STUDIES OF THE PERMAFROST ACTIVE LAYER, INUVIK, N.W.T. (J. A. Heginbottom)**

In the Inuvik area, investigations of the structure of the permafrost active layer and of the effects of ground surface disturbance on the active layer have been underway for several years. In 1973 holes were drilled with a split-barrel sampler driven by a drop

hammer to provide background information on soil and ground ice conditions.

One group of holes provided some interesting information concerning the effects of surface disturbance on ground ice content. Holes drilled in undisturbed terrain all penetrated massive ground ice or icy soil (here defined as more than 50% visible ice in the core) at depths between 20 and 200 cm. The layers of massive ice included lenses containing less than 10% soil material, and ranging from 20 to 65 cm in thickness. Of the holes bored in adjacent disturbed areas, subjected to bulldozing in August 1968, only one hole penetrated any massive ice or icy soil in the top 120 cm. This was in the form of two 10 mm thick lenses at 104 and 113 cm. Significant quantities of ice or icy soil were not encountered above depths of 120 to 220 cm.

Surface disturbances such as bulldozing appear to lead to the disappearance of excess ice in the upper metre of ground and a significant decrease in the second metre. In the third metre there is an increase relative to undisturbed areas, while below 3 m conditions are probably unaltered.

(d) **GRAVITY PROFILES ACROSS ICE-CORED TOPOGRAPHY (V. N. Rampton, Geological Survey of Canada and R. I. Walcott, Earth Physics Branch, Department of Energy, Mines and Resources)**

During the spring of 1973 a drilling programme was carried out on an 'involuted hill' in Tuktoyaktuk region, N.W.T. The hill was found to be ice-cored and samples were taken for analysis of dissolved solids in the ice and for oxygen isotopes. The hill has become a focus for testing and refining geophysical techniques of detecting ground ice. Joint investigators to date have been V. N. Rampton (Terrain Sciences Division, GSC), J. R. Mackay (Department of Geography, University of British Columbia), J. A. Hunter and W. J. Scott (Resource Geophysics and Geochemistry Division, GSC).

(e) **NEARSHORE ICE AND SEA ICE, SOMERSET ISLAND, N.W.T. (R. B. Taylor)**

Research on coastal characteristics and processes in the Arctic Archipelago included examination of the nearshore ice (e.g. ice-foot and anchor ice) and monitoring the break-up and freeze-up sequence of the adjacent sea ice. The nature and extent of features created by the movement of sea ice was also documented at the study site on the northern coast of Somerset Island. The most common and distinctive of these features were ice scourings in the nearshore zone and ice push mounds and ice "pitting" on the modern beach. Similar investigations are planned for 1974 on Prince of Wales and Bathurst Islands.

(f) **ICE OBSERVATIONS IN AN ARCTIC COASTAL ZONE, MELVILLE AND BYAM MARTIN ISLANDS, N.W.T. (P. McLaren)**

As part of a coastal geology project along the east coast of Melville Island and west coast of Byam Martin Island, the role of ice was examined. Frost table profiles were measured in conjunction with an extensive network of beach profiles, and a quantitative approach was taken to determine the distribution of frozen ground. In coarse, poorly sorted sediments, the frost table was shallow (30-50 cm), but it became considerably deeper in silts and clays (>150 cm). Study of the effects of nearshore ice on the coast revealed areas more prone to ice activity than others and demonstrated that ice push may be an important mechanism in providing sediment to a prograding beach sequence.

(g) **DRAKE POINT ICE CONE, MELVILLE ISLAND, N.W.T. (D. M. Barnett)**

The Drake Point ice cone, built around a gas well on Sabine Peninsula, Melville Island, N.W.T. was visited several times during the summer of 1973. Ablation continues and had removed the northern half of the cone by late August. The southern half had an estimated height of 9 $\pm$ 1 m. The northern rim of the cone was always lower and early operational requirements had led to blasting of a narrow cut in this part of the rim.

(h) **OBSERVATIONS ON GROUND ICE, ELLESMERE ISLAND, N.W.T. (D. A. Hodgson)**

Investigations of surficial materials on the Fosheim Peninsula, central Ellesmere Island, were continued. A modified Winkie diamond drill and a powered SIPRE-type corer were used to core a total of 130 holes to depths between 1 and 8 m; lithology, including visible ice, was described, and samples were retained for determination of (thawed) water content.

Average ice contents of 25 to 75% were commonly encountered in the upper few metres of clay to sand size unconsolidated deposits (active layer ca. 45 cm thick). A number of cores were recovered from ice wedges (dimensions up to 8 m deep, 4 m wide), and from thinly covered massive ice bodies.

(i) **GEOPHYSICAL INVESTIGATIONS OF GROUND ICE, TUKTOYAKTUK PENINSULA, N.W.T. (J. A. Hunter and W. J. Scott)**

Shallow refraction seismic and DC electrical techniques have successfully mapped the presence of massive ice lenses at depth in frozen unconsolidated silts and sands of Quaternary age. Ground and airborne electromagnetic techniques are presently being tested in the permafrost environment. A

pulsed radar method has been applied to mapping of fine-scale near-surface structure in ice-rich zones. The results of these tests are presently under study.

Glaciology Division, Department of the Environment *(O. H. Løken)*

(a) **ARCTIC HYDROLOGY SECTION (D. K. MacKay)**

Hydrologic studies relevant to various aspects of northern pipeline development continued under the auspices of the Environmental-Social Program, Northern Pipelines. Sixteen reports were published under the title "Hydrologic Aspects of Northern Pipeline Development".

(b) **FLOATING ICE SECTION (R. O. Ramseier)**

Field work was carried out in the following areas:

Extension of winter navigation—St. Lawrence Seaway (R. O. Ramseier, D. F. Dickins, R. J. Weaver)

Ice growth was measured at more than 50 stations along a 190 km section of the river, and the results correlated with meteorological data, water temperatures and remote sensing imagery. Related studies included an ice bubbler trial, the first field tests of an ice thickness radar unit, experimental use of strain gauges mounted in ice sheets and a shipboard sonar unit for profiling the underwater shape of ice ridges.

(BESEX) Bering Sea experiment (R. O. Ramseier)

In a joint project with NASA, United States Coast Guard, and the USSR, detailed data on the physical properties of sea ice were collected for correlation with airborne remote sensing records.

Ottawa based laboratory projects:

Radar unit (G. Lanteigne)

Evaluation of an FM radar unit operating in the X-band is continuing using a large tank to grow saline and fresh ice sheets. Accuracy is ± 0.01 m for ice thickness between 0.14 and 0.4 m.

Dielectric behaviour of sea ice (M. Vant, Carleton University)

A study is in progress of the dielectric behaviour of fresh water and sea ice at microwave frequencies.

Remote sensing and ice distribution (R. O. Ramseier)

Interpretation of airborne radiometer and infrared imagery is being applied to mapping ice distribution in the St. Lawrence River and the Canadian Arctic.

Plate tests (D. F. Dickins)

Small scale, thin, plate tests have been evaluated as a meaningful measurement of the tensile strength properties of ice sheets.

Oil pollution in ice covered rivers (B. Keevil)

Cold room studies are being conducted on the behaviour of oil under an ice cover.

(c) **ICE SCIENCE SECTION (S. J. Jones)**

Dielectric properties of D_2O ice (G. P. Johari)

The dielectric properties of polycrystalline D_2O ice are being determined in the temperature range 77-275K, and in the frequency range 10^{-4} – 10^5Hz. Thermally stimulated depolarization currents are also being observed.

Oil and ice research (E. C. Chen)

The kinetics and mechanism of oil spreading on an ice surface as a function of temperature, oil type and surface properties are being investigated. Also, changes in the physical properties of oil due to aging are being studied.

National Research Council, Geotechnical Section of Division of Building Research *(L. Gold)*

(a) **ICE MECHANICS**

An investigation of the strain rate and temperature dependence of Young's modulus for columnar-grain and granular ice showed that Young's modulus undergoes a change over the same range of strain that is associated with the ductile to brittle transition (10^{-3} to 10^{-8} s^{-1}). This dependence must be taken into consideration in calculations of ice pressures and the bearing capacity of ice covers. The need for further laboratory work will be determined after completion of the analysis of the present work.

Additional measurements were made of the strength of ice subject to plane strain compression. These observations showed that the almost doubling of the strength is due to a change in the mode of failure. Further work is to be done on improving the performance of the plane strain apparatus, and on the plane strain behaviour of the various ice types. The results of this investigation are relevant to current attempts to establish design methods for estimating ice pressures on structures.

(b) **ICE ENGINEERING**

Two winters of observations of the vertical force that can be developed on a small-diameter pile have provided useful information on the time and stress dependence of the creep of the pile relative to the ice. The study has been seriously hampered by poor ice conditions. A more flexible and practical loading arrangement for field use, based on the observed inter-action between a pile and an ice cover, has now been devised and should be ready for use in the 1973-74 winter.

Measurement of in situ stresses have been made with tubular and plate type load cells in an ice cover subject to a known load. Results of the investigation were encouraging, and indicate that the flat cells in particular may provide a practical means for measuring in situ stresses.

A laboratory study was carried out on the edge loading of plates, made of columnar-grained ice, with a rectangular indentor. The study indicates that the indentation load is a function of the width of the indentor, but not of the thickness of the plate. This is in contrast to field observations, which show that the indentation load depends on the ratio of the width of the indentor to the thickness of the ice cover, and indicates that an effect is present that must be given attention in the development of modelling techniques for the ice pressure problem.

(c) **AVALANCHES**

Observations on avalanche impact pressures and avalanche speeds were continued at Rogers Pass, Equations for predicting avalanche speeds and the impact pressure on a small surface were developed from the observed values.

Observations were continued on the mass of avalanches at Rogers Pass, Mount Copeland, and Kootenay Pass, and the variation with elevation of the snow on the ground at 16 sites in Southern British Columbia. These observations must be continued for another three years to obtain information sufficient for the prediction of 30-year maximum avalanches and snow loads.

Observations on the snow cover and weather will be undertaken at Lake Louise and Banff with the purpose of improving avalanche hazard forecasting techniques in the Rocky Mountain area.

The investigation into the use of pre-planted explosives for releasing avalanches, carried out in co-operation with the Defence Research Establishment, Suffield, is essentially complete. DRES developed a technique for exploding the charges using a radio activated mechanism. The technique can now be considered for routine application.

(d) **SNOW MELTING SYSTEMS**

Observations are being made of the performance of an imbedded snow melting facility on the grounds of the NRC at Ottawa. These observations are providing values for the surface heat transfer coefficients required for the design of snow melting systems for sidewalks and roadways.

(e) **PERMAFROST DISTRIBUTION**

Investigations are continuing in the three study areas of the permafrost region: discontinuous-continuous zone boundary, Arctic islands, Western Cordillera. Regular ground temperature observations are being taken to determine the thermal characteristics of the permafrost.

Thermocouples and thermistor cables were installed at Churchill, Manitoba, and on Melville Peninsula in the fall of 1973. Similar installations will be placed at several locations in Keewatin District, including Eskimo Point, N.W.T. and Baker Lake, N.W.T.

In the Cordillera, a helicopter reconnaissance of the relation between snow-free areas and alpine permafrost will be carried out in the spring of 1974 in co-operation with the Department of Geography, University of British Columbia.

Preparations are underway to investigate alpine permafrost occurrences near Banff in co-operation with the Department of Geology, University of Calgary.

(f) **PERMAFROST ENVIRONMENT STUDIES**

Regular observations on microclimate, surface energy exchange and ground temperatures, and their analysis, are continuing at a Permafrost Terrain Site at Thompson, Manitoba.

(g) **GROUND THERMAL REGIME**

Calibration work on the cylindrical probe developed for measuring thermal conductivity of frozen and thawed soils under field conditions was completed.

Work is currently in progress on measuring the thermal conductivity of several permafrost soils that may be used in the construction of the Mackenzie Highway.

A comprehensive one-dimensional numerical model for predicting ground temperatures has been developed. A scheme for calculating thermal diffusivity from ground temperature observations is being evaluated, and programmes were developed for automatic machine plotting of ground temperature and other measurements. Comparisons are being made of predicted and measured depths of frost penetration under pavements at the NRC test site.

(h) **FROST HEAVE FORCES**

Observations are being made of the uplift forces exerted on 9 steel piles during freezing of frost susceptible soil at a site near Thompson, Manitoba. Measurements made during the winter of 1972/73 included frost heaving forces, daily temperatures and weekly elevation surveys of the ground surfaces, tops of the piles and reaction frames. The forces developed exceeded the capacity of the gauges installed and new gauges have been made up for the winter of 1973/74.

It has been found that the uplift forces under the more severe climate conditions at Thompson, Manitoba, are appreciably greater than those observed in a similar study at Ottawa, Ontario.

Polar Continental Shelf Project *(G. D. Hobson)*

Sea ice reconnaissance (D. Lindsay)

The systematic airborne sea ice reconnaissance surveys conducted by the Polar Continental Shelf Project from March through October 1973 marked the thirteenth consecutive year for this programme. Observations for 1973 were made in the channels of the Canadian Arctic Archipelago between Alert and Tuktoyaktuk eight times during the season. The majority of the surveys were concentrated in Parry Channel and in the Queen Elizabeth Islands.

Good weather throughout the season permitted excellent coverage and approximately 450 hours of flying time were used to collect information. Break-up in 1973 came earlier than usual and by mid-September only Sverdrup Channel remained unbroken. Also, the extent of open water in 1973 was much greater than usual. During the latter part of August the eastern half of Viscount Melville Sound, normally seven-tenths ice-covered, and the southern part of Norwegian Bay, normally four-tenths covered at that time, were ice-free.

One small ice island was located in the Arctic Ocean along the western coast of Prince Patrick Island. Many small ice island fragments, the remains of T-1, were spread out in the southern part of McClintock Channel.

University of British Columbia, Department of Geography *(J. R. Mackay, O. Slaymaker)*

Ground ice and snowmelt studies

O. Slaymaker and students have carried out studies in Manning Park and in Miller Creek basin, B.C. during the snowmelt period 1972 and 1973. Data on snowmelt amounts and chemical quality have been determined from sampling within and below the snowpack and from rhodamine-dye injection and fluorometric laboratory analysis. A. Gell is undertaking a study of the ice fabrics of massive ice, ice wedge ice, pingo ice, and other varieties which occur in the Tuktoyaktuk area, N.W.T. J. R. Mackay is continuing his study on the effect of snow on ice wedge cracking at Garry Island N.W.T., and on the origin of massive ground ice in permafrost.

University of Colorado, Institute of Arctic and Alpine Research *(R. G. Barry, J. D. Jacobs* and *R. Weaver)*

Sea ice

Surface energy budgets of fast ice at Broughton Island (67.5°N, 64°W), N.W.T. were studied from late May 1973, continuing through January 1974. The programme included micrometeorological measurements on the fast ice and surveys of ice thickness, extent of puddling, etc. Climatological observations at Broughton Village were continued.

The frequency of synoptic weather patterns favourable to ablation and break-up was substantially greater during the 1973 summer than in 1972. The residual second-year ice had a significant role in retarding break-up and removal in 1973. Meteorological satellite data (NOAA-2 and ERTS-1) are being analyzed to obtain regional extrapolations of synoptic surface energy budgets and ice movements.

Université Laval, Ice Mechanics Laboratory *(B. Michel)*

(a) **RIVER REGIME AT BREAK-UP**

Even if the processes of break-up are rather well described in the literature there is little numerical data on maximum water levels and erosion action corresponding to various characteristics of jams.

This question is studied with a scale model in the hydraulic laboratory where the solid ice cover is simulated with an artificial material having, to scale, the mechanical properties of ice. The first phase of the project deals with the characteristic of dynamic jams when the ice is unstable and moving. An extensive programme is foreseen for this research.

(b) **RHEOLOGICAL BEHAVIOUR OF FRESH WATER ICE**

The laboratory is pursuing its long-term studies on the mechanical properties of river and lake ice. This year the programme deals with data processing of small sample behaviour in the ductile range. A general rheological model for various modes of deformation of ice is being tried.

(c) **IMPACT OF ICE ON PIERS**

Model ice having the properties of real ice in the brittle range is used at a scale of 1/50 to study modes of failure, form effects and contact co-efficients for piles of different geometries.

McGill University, Ice Research Project *(E. R. Pounder)*

Sea ice

The year 1973 was an unfortunate one for the field work of the Ice Research Project. Two planned field expeditions had to be cancelled because of adverse weather conditions.

Work has continued during the year on the improvement and recalibration of the equipment for these two field projects, which it is hoped will be carried out in late winter and early spring of 1974.

UNITED KINGDOM

NORWAY

Four people (three aged seventeen) comprised the team of the British Hardangerjøkulen Glacier Expedition 1973 and undertook a survey of the region at the end of July into August. The team organised everything themselves and had taken three years over it. They had the scientific support of the Scott Polar Research Institute, the British Natural History Museum, Norsk Polarinstitutt, and the Norwegian Water Resources and Electricity Board (NVE).

An uncharted glacier was discovered and studied as closely as was possible in the time available and was photographed to record the interesting features. This glacier gave an unprecedented opportunity to examine the structure of the ice and the forces affecting the flow. The features had not been distorted by the effects of time as had the main ice-area of the Hardangerjøkulen. This new glacier appears to be a relatively new accumulation of ice and is totally separate from the main ice field (about 6 km distant); it lies at a lower altitude, between 1150 m and 1220 m compared with 1300 m and 1680 m for the main ice field.

The glacier is situated between the Vesle Ishaug and Ishaug-redet and faces due north. The ice was about 800 m by 70 m in horizontal dimensions and the ice thickness varied from 0.003 m to 10 m. The ice was very clean and supra-, en- and sub-glacial streams were evident; near the firn area of the glacier a lake had formed feeding en-glacial rivers flowing north and south. The lake was fed by a sub-glacial stream entering from the west from another arm of the glacier which was the highest point of the ice. Shear planes were found and examined and were extremely good examples of this type of feature. An impressive shear ice-wall had developed along 50% of the glacier ranging in height from 3 m to 7 m. Several 'V' and 'A' shaped crevasses were found on the western side caused by the ice slewing as it progressed down the slope of the mountain.

Several rock/ice boundaries were examined and were found to have considerable growths of lichens on them. These are thought to be: Rhizocarpon geographicum, Lecidea sp., (probably L.subsorediza Lynge), U.cf.torrefacta and several unidentified species. The presence of these growths is useful in dating the glacier. It can now be inferred that the new glacier is about 35 years old.

As well as carrying out observations on the new glacier, a brief survey was made on glacial features and deposits on the Hardanger plateau. It was during this work that a large Bronze Age religious centre was discovered yielding information in the form of runic inscriptions on local rocks, and also boulder-marked causeways leading to a peat bog, possibly a sacrificial area.

This trip also served very well as a reconnaissance for a series of scientific expeditions, which, it is hoped, will be of a more detailed and quantitative nature and also on a larger scale. It is hoped that these expeditions will be completed by 1978. Further very suitable areas of glaciological and geological interest were selected as survey regions.

Other topics studied during this past expedition were geology, meteorology, archaeology and biology.

More detailed information can be obtained from the expedition reports: enquiries to J. R. Reynolds, Casa Laeta, 123 Burdon Lane, Belmont, near Sutton, Surrey, England SM2 7DB.

John M. Reynolds

U.S.A.

SOUTH CASCADE GLACIER, WASHINGTON

A research station is operated adjacent to the South Cascade Glacier on Sentinel Park in the Cascade Mountains by the U.S. Geological Survey, Water Resources Division, Tacoma, Washington under the direction of Dr M. F. Meier. The main emphasis during 1973 continued to be water circulation through and storage within the glacier. Mass and water balance data were also collected as part of the continuing International Hydrological Decade Program. The maximum snow accumulation on the glacier occurred in early May and amounted to 2.6 meters water equivalent at the main index station, approximately one-half the 1972 accumulation. Because of a relatively cool summer in 1973, the glacier experienced only a moderately negative mass balance for the year.

Development and testing of instrumentation to record directly the flux of water through the snowpack was continued. The most difficult problem is the freezing of the system during periods of low input. Rhodamine dye was used to attempt to measure particle travel time of water in the horizontal direction in snow and ice. Also, various pump tests in the firn were undertaken to determine permeability.

The major new effort on the South Cascade during the summer was a hot point drilling program. Ten holes up to 220 meters in depth were drilled through the glacier to determine depths and basal drainage patterns. An additional 5 holes were drilled near the equilibrium line to monitor water pressure within the glacier: of the 5 holes, all in the range of 200-220 m deep, 3 connected with a basal water system. The level of water was recorded in one or more of the holes from July until mid-November, at which time deformation of the hole resulted in closure.

SNOW AND ICE HYDROLOGY OF THE NORTH CASCADES, WASHINGTON

A simple hydrologic model to predict summer run-off of streams originating in mountain snowpacks using standard precipitation and discharge observations from valley stations has been developed by L. A. Rasmussen and W. V. Tangborn (U.S. Geological Survey, Water Resources Division, Tacoma, Washington). The model encompasses some 36 drainage basins in the North Cascade Range, an area of extensive irrigation and hydroelectric development. Historical records, covering the past 40-50 years, were obtained from 30 lowland weather stations in the area. Analysis of the data revealed that, by selecting an appropriate set of stations for a particular basin, it was possible to correlate annual precipitation at these stations with run-off from the basin to better than 0.9. Thus it appears that, for the North Cascades at least, local precipitation measurements can be reliably related to basin-wide precipitation. The model utilizes the precipitation relationships established for each drainage basin, together with winter streamflow measurements, to estimate total water storage. The model also uses short-term predictions of spring run-off to correct the initial storage calculations and to improve the total summer run-off forecast accuracy. The distribution of potential summer run-off with altitude is calculated on the basis of the total predicted run-off from each basin and the highly variable area-altitude distributions of the individual drainages.

While the model at this stage is still relatively crude, it is intended to be only a first step toward developing a more realistic, time-dependent model which emphasizes the physical processes occurring within the snowpack and minimizes the amount of needed statistical inference.

BLUE GLACIER, WASHINGTON

The University of Washington field station on the Blue Glacier of Mount Olympus was occupied continuously in 1973 from early July through early September (E. LaChapelle, B. Hartline, F. Hartline). Normal climate and glacier mass budget observations were maintained as in past seasons, extending to the sixteenth consecutive year the documentation of annual accumulation, ablation, and mass balance of this glacier. Although 1973 was a year of abnormally low snow accumulation in Washington, the situation had surprisingly little effect on the Blue Glacier. The calculated specific net mass balance at the end of the ablation season in mid-October was +0.1 meters water equivalent. This unexpected positive mass balance can be attributed to two factors: (i) about normal summer ice ablation on the lower part of the glacier and (ii) a greater snow accumulation on the upper glacier than might have been expected from the general 1973 snow patterns in the Cascade and Olympic Mountains. Much of the snow in the accumulation zone (2000–2600 m) was apparently deposited during an unusually warm and wet fall in which rainfall was widespread below 2000 meters. Thus, the glacier was in approximate equilibrium during the 1972/1973 period. Although there has been no change in the terminus position, the thickening taking place in the ice near the terminus continued in 1973; during the last two years this thickening has amounted to 15–20 m.

An investigation was also made of the gas contained in the coarse bubbly ice on the lower glacier, near the sites where high accuracy ice temperature measurements were made in previous years. In situ bubble pressure, void volume, and the amount of gas (reduced to atmospheric pressure) were determined. Bubble pressures in the near surface ice were typically on the order of three atmospheres. Preliminary comparison of the pressure data with the surface temperature data suggests that bubble pressure may be the primary factor in determining ice temperature at this location.

VARIEGATED GLACIER, ALASKA

A comprehensive program to define cyclic changes in the state of a surge-type glacier is being conducted by C. F. Raymond (University of Washington) and W. D. Harrison (University of Alaska). The glacier chosen for this study was the Variegated Glacier, located at the head of Yakutat Bay, Alaska. Personnel from the U.S. Geological Survey (A. Post, S. M. Hodge, and R. M. Krimmel) and the California Institute of Technology (B. Kamb) also participated in the 1973 field season. The initial year of the program was devoted to gathering essential geophysical data needed for a general understanding of the present dynamic state of the glacier. Work included general mapping, establishment of a survey station net, location of roughly one hundred stakes for determinations of velocity and surface elevation change, ten transverse gravity profiles, near surface temperature observations, and mass balance measurements.

The Variegated Glacier is about 20 km long and has an average surface slope of 5 degrees. Over most of its length, it flows in a narrow valley and has an average width of approximately 850 m; average depth is about 250 m. Most cross sections were found to have a small half-width to depth ratio (1.4–1.5) and small hydraulic shape factors (0.49–0.53). Surface velocity averaged over the summer ranged from 0 to 25 cm/day, with 10–15 cm/day being typical of the central reach of the glacier. These flow velocities appear to be compatible with the current geometry and a flow that is predominantly due to internal deformation. The balance flux at the equilibrium line was estimated to be about 6 times larger than the actual ice discharge of

$5.5 \cdot 10^6$ m^3/year, as determined from the surface velocity averaged over the width and cross sectional area.

Field work for the summer of 1974 will be directed toward refining knowledge of the bed geometry and continued monitoring of the surface elevation and motion.

BLACK RAPIDS GLACIER, ALASKA

Studies of the Black Rapids Glacier were continued by personnel from the U.S. Geological Survey (M. F. Meier, S. M. Hodge, L. R. Mayo, A. Post, and D. Trabant), assisted by investigators from the University of Alaska (W. D. Harrison and C. S. Benson) and the University of Washington (C. F. Raymond). The 1973 field season was devoted to establishing a triangulation net; 16 survey points were established using theodolites and a laser distance ranger on bedrock adjacent to this 50 km long surge-type glacier. About 20 stakes were placed along a longitudinal profile to measure velocity, balance, and dynamic surface level changes. Gravity profiles were run along two key transverse sections, ice foliation was mapped over a small area, additional markers to allow rough velocity measurements from the glacier were installed, and temperature profiles were determined at several points. Plans are to continue to monitor the geometric changes of the glacier through the anticipated surge, sometime in the 1980's.

GULKANA AND WOLVERINE GLACIERS, ALASKA

Mass and water balance data were again collected on the Gulkana and Wolverine Glaciers by the U.S. Geological Survey, Tacoma, as part of a contribution to the International Hydrological Decade (IHD). In addition, markers were installed on the Gulkana which will allow velocity measurements to be made throughout the year. A longitudinal altitude profile was also run on the Gulkana.

TIDAL GLACIER STUDIES

In May 1973, personnel from the U.S. Geological Survey, Tacoma (A. Post and L. R. Mayo) joined a research group headed by J. J. Kelley from the Institute of Marine Sciences, University of Alaska, aboard the research vessel ACONA conducting studies near tidal glaciers. A radio-controlled boat was successfully navigated to the ice cliffs at Columbia and Barry Glaciers, and bottom profiles were obtained which disclose that these glaciers normally terminate on submarine moraine shoals. Water depth soundings taken inside the large embayment recently formed on the western side of Columbia Glacier indicated that these shoals are sharp crested and that tidal glaciers such as the Columbia occupy deep water channels which extend far below sea level. Hence, the present situation for the Columbia Glacier is becoming increasingly unstable as the embayment enlarges and more of the glacier terminus is subject to increased iceberg discharge. Should the embayment continue to enlarge, the glacier may fail to maintain its position on the terminal shoal and catastrophic retreat could result. Should this take place, a minimum retreat of about 13 km to the first major narrowing of the valley would probably result; a maximum retreat of nearly 40 km would be possible if, as seems probable, below sea level depths extend to near the head of the east branch of the glacier.

In cooperation with the U.S. National Park Service, Glacier Bay National Monument, A. Post (U.S. Geological Survey, Tacoma) also obtained depth soundings in front of Lituya and North Crillon Glaciers during June 1973. As expected, both glaciers were found to terminate in relatively shallow water. The most interesting finding was that the debris from the 1958 rockslide avalanche which stripped off the terminus of Lituya Glacier and fell into Gilbert Inlet, did not stop in the inlet but, instead, passed over and around an intervening ridge and came to rest as a remarkably level fill in the deeper parts of Lituya Bay. The computed volume of the filling of the bay which has taken place in recent decades far exceeds the estimated volume of the slide and provides important data on the amount of outwash released by tidal glaciers.

McCALL GLACIER, ALASKA

Glacio-meteorological studies on the McCall Glacier were continued for the fifth consecutive year by investigators from the University of Alaska (G. D. Wendler, C. S. Benson, C. B. Fahl, W. D. Harrison, N. Ishikawa, and D. C. Trabant). The glacier is located in the eastern part of the Romanzof Mountains of the Brooks Range and is the only arctic glacier being studied in the United States at the present time.

As in each of the past four years, the annual mass balance was strongly negative, −326 mm water equivalent for the 1972-73 hydrological year as compared to −160 mm in 1971 and −253 mm in 1970. Such large negative mass balances are particularly striking in an arctic glacier where the annual precipitation is less than 0.55 metres water equivalent. During the summer an experiment was conducted to compare direct observations of ice melt with those inferred from heat balance calculations and from measurements of discharge. A small controlled run-off site was selected and intensive observations carried out for an eleven day period. Although daily values did not always compare well, for the entire eleven day period the amount of ice melt calculated from run-off and from heat balance, respectively, gave values 3.5% and 1.2% higher than the direct ablation measurements. This agreement suggests that it may be possible to extend such calculations to the whole glacier with some prospect of success. Work is presently underway to attempt this.

Simultaneous heat balance measurements over ice, snow, and moraine were made for an eleven

day period during the summer melt season. It was found that the radiation balance of the ice and moraine were almost exactly the same, since the smaller absorption of short-wave radiation by the ice was compensated for by a less negative long-wave balance. Because the surface temperature of the snow was similar to the ice, the higher snow albedo resulted in a radiation balance which was 40% smaller than the bare ice and moraine. Whereas, the moraine lost about half of its energy to the air in the form of sensible heat, the ice and snow gained 43% and 37% of their energy, respectively, from sensible heat input. About 90% of the net energy input to the ice went into melting, while, for the snow, about 60% went into melting and 40% to evaporation.

Studies of snow stratigraphy were continued during the summer of 1972 and spring of 1973 in the upper cirque. In cooperation with scientists from the Institute of Low Temperature Science, University of Hokkaido (D. Kuroiwa, G. Wakahama, and others), pits were excavated in the snow, firn, and ice of the lower, middle, and upper cirques. The continuity of stratigraphy was established in the upper cirque, and the percolation of water in the firn investigated. The studies included detailed temperature measurements and description of the complex ice masses which form by the refreezing of percolating melt water in the firn. Fracture patterns and foliation in the lower end of the glacier were mapped in some detail.

AERIAL PHOTOGRAPHY OF NORTH AMERICAN GLACIERS

Aerial surveys of glaciers in western North America are conducted annually by A. Post of the U.S. Geological Survey Office in Tacoma, Washington. During 1973 photographic reconnaissance was limited to glaciers in the Mount Rainier area of Washington, and to tidal and surging glaciers in Alaska and British Columbia. New surges in progress were noted in unnamed glaciers at the head of Bow Creek and Sheep Creek, Wrangell Mountains, Alaska. The large Tweedsmuir Glacier in the Icefield Ranges of northern British Columbia was also beginning a surge which has been anticipated for several years. It was predicted, after the September 1973 observations, that the surge would cause the Tweedsmuir Glacier to advance sufficiently to close off the main channel of the Alsek River. G. Holdsworth (Glaciology Division, Environment, Canada) reports that by early November 1973 the river had been forced into a higher, marginal channel. Fairly severe flooding in the lower Alsek River valley next spring or summer may result if the marginal channel is also closed.

A surge suspected to be beginning in 1972 in Russell Glacier, Wrangell Mountains, Alaska, has been confirmed. Although this glacier does not appear to be subject to surges of large magnitude, the 1973 ice flow was moving quite rapidly into the upper Skolai Lake basin and the folded medial moraines in the vicinity of Skolai Pass were being deformed. These deformations are also visible in satellite images obtained over the past year.

Hubbard tidal glacier made no appreciable gains in 1973, and the passage into Russell Fiord was much wider during the summer than it had been in the spring of 1972. This reduced activity appears to confirm a sketchily documented record of periodic changes in flow velocity of the glacier noted in recent years. The glacier near its eastern margin moved approximately 6,400 m between 1963 and 1966, while between 1966 and 1969 the flow was only about 2,240 m. The flow rates were again rapid between 1969 and 1972, resulting in the advance which nearly closed off the channel between the glacier and Osier Island. If the periodic flow velocity changes noted over the past decade are continued, the next wave of increased activity should reach the terminal area around 1976, and an advance sufficient to close the channel north of Osier Island sometime between 1976 and 1980 seems probable. Should this happen, Russell Fiord will presumably cease to be tidal, since the channel between Osier Island and Gilbert Point is both narrow and shallow.

Recent retreat of Columbia tidal glacier, situated in Prince William Sound, may be reaching a position of instability; a large embayment formed in the western side of the tidal cliff has failed to close in recent winters and has enlarged each year. The first recorded catastrophic dumping of a large glacier dammed lake situated in the second large embayment on the western side of the glacier in 1972 may have augmented the retreat.

THERMAL REGIMES OF ALASKAN GLACIERS

W. D. Harrison and D. C. Trabant (University of Alaska), in cooperation with L. R. Mayo (U.S. Geological Survey), recently have begun a program to determine the thermal regimes of representative Alaskan glaciers, in particular, they hope to provide a basis for understanding the relationships between the thermal regime, climate, thickness, and activity on an individual glacier. Near-surface measurements in the Alaska Range indicate that both the Gulkana and Black Rapids Glaciers are quite warm. Both can probably be classified as temperate, except for fairly thin areas in their ablation zones. If the Black Rapids, a surging glacier, is indeed temperate, it is unlikely that its surges are triggered by a temperature instability associated with alternation between freezing and melting conditions at the bed. In contrast, temperature measurements on the McCall Glacier indicate that it is freezing throughout most, and perhaps all, of its thickness. The near-surface temperatures were

observed to be highest at the highest elevations, an effect which depends upon the permeability of the ice to downward percolating meltwater.

ALASKAN GLACIERS AND CLIMATE

A synoptic climatology study by C. B. Fahl (University of Alaska) has revealed a number of interesting relationships between Alaskan glaciers and large-scale weather patterns. Three glaciers were investigated as part of this study: the McCall Glacier in the Brooks Range, the Gulkana Glacier in the Alaska Range, and the Wolverine Glacier in the Kenai Mountains of the Coastal Range. Mass balance measurements from these glaciers were taken to be representative of conditions throughout each of the associated mountain ranges. It was found that a strong Aleutian low pressure area generally favoured glacial growth in both the Alaska and Coastal Ranges, while favoring glacial decay in the Brooks Range. Conversely, a weak Aleutian low (implying a strong Pacific high) favored glacial growth in the Brooks Range and glacial decay in the Alaska and Coastal Ranges. Overall, however, conditions in the recent past (1900-1970) have been unfavorable for glaciation in all three of these mountain ranges.

REMOTE SENSING OF SNOW AND ICE

Data from the Earth Resources Technology Satellite (ERTS) relevant to a variety of large-scale glaciological problems are now being examined by numerous investigators. At the Tacoma office of the U.S. Geological Survey, M. F. Meier and others are studying passive microwave emission from snow in an attempt to develop a free water gauge using microwave absorption. In addition, ERTS satellite coverage from an area including a 600 km wide swathe from Washington to the Kenai Peninsula in Alaska has been evaluated for other glaciological data. Electronic and photographic enhancements of images revealed subtle slope changes in large glaciers which relate to bedrock topography and flow lines. Data on snowlines, ice velocities, surges, terminus changes, and ice discharge from tidal glaciers are being analyzed.

At the University of Alaska, three programs using ERTS imagery are underway. G. D. Wendler, R. F. Carlson and D. L. Kane are analyzing sequential ERTS photography in an attempt to develop more reliable forecasting methods for the spring breakup of ice in major Alaskan rivers. Work is being concentrated on detecting the areal extent of the two significant events in the break-up progression—initiation of melt and elimination of the snow cover. C. S. Benson and L. H. Shapiro are examining the feasibility of monitoring the interaction between volcanic heat and the snow and ice cover at the summit of Mount Wrangell volcano using ERTS data. Preliminary results from data acquired during the fall of 1972 and spring of 1973 look promising. In addition, the applicability of satellite data to the problem of determining the mass balance of glaciers flowing out of the Wrangell Mountains, and of the entire Wrangell ice sheet, is also being investigated. At this stage, it seems likely that it will be possible to assign at least a positive or negative value to the mass balance of individual glaciers, based upon relationships between snow, firn, and glacier ice visible at the end of the yearly melt season. The third and most ambitious effort is to determine regional variations in seasonal snow cover from ERTS data, and to correlate these variations with climatic parameters, orographic effects, and synoptic weather patterns (C. B. Holmgren, C. S. Benson and G. E. Weller). Satellite observations are vital to such a project because: (i) Alaska is divided by mountain ranges into several main climatic zones, with the arctic tundra climate in the far north sharply separated by the Brooks Range from the extreme continental climate of the interior, the transition climate in western Alaska, and the extreme maritime climate south of the Coastal Ranges, and (ii) the density of the ground-based observing network is too low to permit interpolation between stations. Preliminary analysis of the data indicates that the areal extent of the snow cover can be reliably determined in areas without dense vegetation, but that the concept of a regional snow line loses any meaning during the spring melt when the snow distribution is only weakly related to elevation in most parts of Alaska. From the large-scale patterns of wind-drifted snow, it was possible to obtain a clear picture of low-level wind patterns over widespread complex topographic features. In some instances, particularly on the Arctic tundra, it was also possible to trace the influence of individual storms. Ground-truth data obtained in support of this project included measurements of snow depth and areal extent, together with measurements of temperature, density, and hardness profiles from selected regions. These observations were conducted at frequent intervals in central Alaska, the North Slope, the Alaska Range, and the Chugach Mountains. Aircraft observations were also taken between Fairbanks and Anchorage, and between Fairbanks and Barrow.

ICE FORMATION IN ARCTIC STREAMS

Since 1963 investigators from the University of Alaska (C. S. Benson, T. E. Osterkamp, R. E. Gilfilian, T. Ohtake) have been studying the complex winter history of arctic and sub-arctic streams. The primary research site has been Goldstone Creek, a sub-arctic stream a few miles north of Fairbanks, Alaska. Ice formation in such streams causes a variety of serious problems which are of increasing concern as the arctic regions undergo development. Solutions to many of these problems require additional information

on the initial formation, subsequent development, and eventual break-up of this ice cover. Specific questions being considered by the University of Alaska group include: (i) amount and duration of supercooling in turbulent streams, (ii) concentration and growth rate of frazil ice crystals, (iii) type and concentration of nuclei in frazil ice crystals, (iv) nucleation processes in turbulent streams, (v) growth and effects of anchor ice, and (vi) melting and erosion of the ice cover during break-up.

Recent work has been concentrated on the physical processes involved during supercooling and initial freezing. In the Fairbanks area, October is generally the most active month of freezing, with several periods of underwater ice production. The freezing point for the stream water was determined to be -0.012 ± 0.003°C. The stream supercooled only at night when the air temperature was near −10°C; maximum observed supercooling was 0.040°C below the freezing point of the stream water. Frazil ice crystals in the form of discs, hexagonal stars, and platelets were observed to form when the stream supercooled. Shortly afterwards, anchor ice was observed, forming without any apparent sign of frazil adhering to the stream bottom. However, anchor ice was also observed on and within the stream bottom when no frazil crystals were present anywhere within the water column. Airborne ice crystal nuclei were initially detected above the stream when the air temperature reached −8°C and their appearance correlated with the time of formation of frazil ice crystals in the water. These airborne ice crystals are taken to be a possible source of nuclei for the frazil ice crystals.

The formation of anchor ice was observed to result in marked changes in the hydrology of the stream. During underwater ice production, stream discharge decreased by more than 30 per cent and the average stream velocity decreased by as much as 50 per cent. The growth of anchor ice generally caused the stream level to increase during the night and following morning until solar noon when the level rapidly decreased due to removal of anchor ice from the bottom. This was most likely the result of absorption of short-wave radiation in the water and at the bottom. Using the stream heat balance equation, it is possible to calculate growth rates for anchor ice, typically 0.6 g sec^{-1} per square meter of stream surface at an air temperature of −15°C. It was also found that the specific conductance of the stream water was directly related to the amount of ice produced by the stream. An equation was derived to calculate the underwater ice production on the basis of measured changes in the specific conductance of the water. These results substantially agreed with the calculations made with the heat balance equation.

SEASONAL SNOW COVER, PRUDHOE BAY, ALASKA

As part of a contribution to the IBP Tundra Biome Project, investigators from the University of Alaska (C. S. Benson, R. S. Timmer, B. E. Holmgren, and D. C. Trabant) established a network of 176 snow sampling sites in the Prudhoe Bay area. The water equivalent of the snow pack, the dust content, and the specific electrical conductance of the meltwater was determined at each site. The average snow depth was 32 cm, based on an average of 871 values from four traverses of the study area. The average snow density was 0.34 gm cm^{-3}, indicating a water equivalent of about 11 cm for snow on the tundra. Aerial photographs were also taken during May and June to record the evolution of snow melt on the tundra.

The effects of airborne sediment (dust, sand, etc.) on the snow was very pronounced. The primary influence was from sand dunes located along the west bank of the Sagavanirktok River, but dust derived from roads also had a noticeable effect on local snow melt. Airborne radiation traverses showed a gradual increase in albedo downwind from roads and a much more abrupt increase upwind from roads.

COASTAL SEA ICE, ALASKA

Two projects are underway at the University of Alaska which are aimed at an improved understanding of the behavior of the coastal sea ice which infests the coasts of northern and western Alaska. The goals of the first program are: (i) to define the types and distribution of ice present in the coastal zone and (ii) to determine the physical and mechanical properties of this ice (T. E. Osterkamp, R. D. Seifert). Of particular interest is the brackish ice which forms where large rivers and streams empty into the sea. The properties of the brackish ice can be expected to be quite different from those of the surrounding sea ice. The first stage of this study was to obtain ice cores from near-shore ice between Barrow and Prudhoe Bay; a total of 60 cores have now been taken. The crystallographic structure and salinity of these ice cores were used to identify ice types. Optical absorption coefficients were also measured in eight core holes. Substantial amounts of brackish ice were encountered in Harrison Bay. Core analysis showed that the brackish ice was usually underlain by sea ice, resulting in a layered structure. This layering appears to be the result of the annual flow cycle of the Colville River, the primary fresh water source in the area. Because the Colville River has its drainage basin entirely in an area of continuous permafrost, there is a winter cessation of flow which generally begins sometime between November and January. A map of the extent of the brackish ice in Harrison Bay has been constructed from the core data.

A second program, which is still in the early stages of development, is concerned primarily with the dynamics of coastal sea ice (T. E. Osterkamp, and others). An integral part of this program is the determination of the stress distribution in near-shore ice. During the past year, the development of stress transducers and associated instrumentation has been completed, and several stress-monitoring stations established in the shore-fast ice near Barrow. These transducers have been monitored continuously and the data is presently being analyzed. Complementing the stress program, a radar system was used to observe the movement of ice in the vicinity of the shore-fast ice zone. This information will be used in conjunction with the stress data to develop a model of sea ice dynamics near shore.

G. Maykut

EDWARD LACHAPELLE

Many of the glaciologists of the Pacific Northwest of the USA are artistic, but Ed LaChapelle outranks them all—and, indeed, may well be the most artistic member of this Society. Born in Tacoma in May 1926, and educated locally, he was attracted to scientific studies relating to the magnificent surroundings. He specialized in physics at the University of Puget Sound, from where he graduated in 1949. Soon afterwards he spent one year studying avalanche problems in Davos, Switzerland, at the world-famous Institute for Snow and Avalanche Research. In 1951, he returned to the Northwest and soon became involved in a glaciology research project sponsored by the American Geographical Society, on the Juneau Ice Field in south-east Alaska. The project involved much of his time in the summer of 1952 and he was leader 1954-56. The summer of 1953 was spent working on the Greenland Ice Cap. Also in 1952 he had joined the U.S. Forest Service as an avalanche hazard forecaster and began a job that has occupied him every winter up to the present time, in the mountains of Utah. In 1957 he became involved in the University of Washington's Blue Glacier Project, on which he still works today, and which occupies him every summer. He was Senior Scientist of the Project 1957-67, and was appointed Associate Professor of the University's Geophysics Program in 1968 and Professor of Geophysics in 1973. In 1967 he was awarded a Doctorate by the University of Puget Sound, and in 1972 he was elected a Vice-President of the International Glaciological Society.

It was in 1952 that Ed built a portable camera to photograph snow crystals for a snow compaction study on the Juneau Ice Field. He used it also in Greenland for studies of smooth ice areas, and made many records of the shape and size of particles found in glacier snow and firn. It was not until 1956 that he began to photograph snow crystals during the winter storms in

Utah, recording the weather and avalanche conditions at the same time. By 1960 these records made possible a formal study of the relationship between snow crystals and avalanche formation, a study that became part of the regular programme of the Alta Avalanche Study Center. His 1952 camera had proved its worth in showing the important part that snow crystal forms play in avalanche formation.

Further studies were made, with additional photographic equipment and an improved cold laboratory, and the results published. The vast number of crystal photographs formed a collection the value of which was only fully realised when Ed became involved in training programmes for snow rangers of the U.S. Forest Service. He found the pictures invaluable in teaching the meaning of the different types of crystal and their evolution, and in 1969 brought some of them together in a small book designed to show rangers what crystals were really like: "Field Guide to Snow Crystals".

His careful and patient work with the camera has given pleasure and knowledge to many people and has brought understanding of the part played by snow crystals in the evolution of features and hazards. Ed's contribution to glaciology does not stop there: his winter work has produced analyses of snow conditions and avalanches; and his summer work on the Blue Glacier, in collaboration with many well-known glaciologists, has included studies of glacier mass balance, mass and energy exchange, ablation, the effects of glacier movement, glacier sliding over bedrock, ice flow, and stress-generated ice crystallization features. He has turned his attention to the development of field equipment and to the assessment of mass balance by aerial photography, where he has worked in close collaboration with Austin Post, well known for his superb photographs of glaciers in the Western Cordillera and Alaska.

Ed's leisure activities reflect the artistry that is revealed in much of his work; he delights in classical music and poetry, while his creations in the visual arts are handsome and sensitive. His wife, Dolores, writes religious books for children, and his son has inherited his father's love of art and is a promising sculptor. His friends know that he appreciates good food and wine, while many of them have been drawn into helping with his glacier projects. But even those launched in a ski-plane over the ice fall of the Blue Glacier have no regrets for the involvement.

INTERNATIONAL GLACIOLOGICAL SOCIETY

SYMPOSIUM ON REMOTE SENSING IN GLACIOLOGY

15 - 21 September 1974, Cambridge, England

Fourteen Theme Papers will be presented at the Symposium, in addition to 28 papers accepted by the Papers Committee from those submitted for consideration. There will also be two half-sessions devoted to short reports of recent work, completed since the deadline for submission of the other papers.

A report on the Symposium will be published in ICE later this year and the Proceedings will appear as Volume 15 of the Journal of Glaciology in 1975. There will thus be two volumes of the Journal in 1975: Volume 14 (Numbers 70, 71 and 72) and Volume 15 (Number 73), the special Symposium Volume. Members should note that they will actually receive the numbers out of numerical order during the year, as we hope to mail the Symposium Volume in the middle of the year, before Volume 14 has been completed by the appearance of the October/November issue (Number 72). Members of the Society will receive Volume 15 free.

Further information may be obtained from the Secretary.

BRANCH NEWS

BRITISH BRANCH

A one-day meeting of the British Branch was held in the University of Birmingham on 26 March 1974. This was the first meeting of this kind held by the Branch, and its aim was to provide an opportunity for glaciological researchers in the British Isles to give progress reports on their work and to discuss their problems together.

25 members and friends registered for the meeting, and a few more local members and members of the University attended some or all of the sessions. The following papers were presented:

C. S. M. Doake & C. W. M. Swithinbank:
Glacier surface velocity by radio echo sounding.

C. W. M. Swithinbank:
Progress report on the GAP project (Glaciology of the Antarctic Peninsula).

J. G. Paren & G. C. Camplin:
Computer analysis of the defect concentrations and mobility in HF-doped ice.

D. W. Limbert:
Meteorological observations as an indicator of rates of snow accumulation and ablation.

D. J. Goodman & M. F. Ashby:
A deformation map for ice.

D. R. Homer:
Creep of ice monocrystals.

E. M. Morris:
The flow of ice over a series of obstacles by regelation.

M. Paul:
Subglacial deformation during flute formation.

I. Smalley:
Glacial action and the formation of quick-clay deposits.

D. A. Peel:
The organic chemistry of Antarctic snow.

The Branch also held a short business meeting to discuss its own future. Up to now the Officers of the Branch have consisted of those members of I.G.S. Council who reside in the British Isles, and there have been no Branch Statutes. The Branch meeting felt that this situation should now be changed, and considered draft statutes along the lines suggested by Council and adopted by other Branches. These statutes were approved by the Council of the Society at a meeting in Switzerland in April.

The Branch will therefore be holding a meeting under the new Statutes in 1975, possibly in connexion with a meeting of the I.G.S. if one is held in Britain, and at that meeting the first officers under the new statutes will be elected. Members of the Branch will be sent notice of this meeting nearer the time.

NORDIC BRANCH

Arrangements are proceeding well for the third annual meeting of the Branch, to be held in Western Norway 25-31 August 1974. A report and pictures will be published later this year. Further information may be obtained from Olav Orheim, Norsk Polarinstitutt, Oslo.

WESTERN ALPINE BRANCH

The third annual meeting of the branch will take place in Courmayeur, Italy, 6-8 September 1974. A report and pictures will be published later this year. Further information may be obtained from F. Valla, c/o C.T., G.R.E.F., Nivologie, B.P. 114, 38402 Saint-Martin-d'Hères, France.

JOURNAL OF GLACIOLOGY

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

Steven M. Hodge:
Variations in the sliding of a temperate glacier.

L. Lliboutry:
Multivariate statistical analysis of glacier balances.

M. A. Paul & H. Evans:
Observations on the internal structure and origin of some flutes in glacio-fluvial sediments, Blomstrandbreen, north-west Spitzbergen.

S. C. Colbeck:
A study of glacier flow for an open-pit mine: an exercise in applied glaciology.

Parker E. Calkin:
Subglacial geomorphology surrounding the ice-free valleys of southern Victoria Land, Antarctica.

C. C. Langway, Jr., M. Herron & J. H. Cragin:
Chemical profile of the Ross Ice Shelf at Little America V, Antartica.

L. Stephen Wolfe & David P. Hoult:
Effects of oil under sea ice.

S. A. Bari & J. Hallett:
Nucleation and growth of bubbles at an ice-water interface.

Charles Harris:
Autumn, winter and spring soil temperatures in Okstindan, Norway.

FUTURE MEETINGS (of other organizations)

CONFERENCE ON THE PROPERTIES OF WATER AND STEAM

France, 23 - 27 September 1974

The Eight International Conference on the Properties of Water and Steam will be held in the South of France, at Giens (near Hyeres, Var, 83) from the 23-27 September 1974.

The Conference will deal with all the properties of light and heavy water or their mixtures in all their physical states, their experimental determination, their correlations and formulations. One special session on some selected topics on the behaviour of dilute solutions will be included. General presentation of experimental methods and of theoretical developments regarding the properties of polar fluids are planned.

Further information may be obtained from Dr S. Beitler, Dept of Mechanical Engineering, the Ohio State University 206W. 18th Avenue, Columbus, Ohio 43210, USA.

SYMPOSIUM ON THE THERMAL REGIME OF GLACIERS AND ICE SHEETS

An International Symposium on the Thermal Regime of Glaciers and Ice Sheets will be held at Simon Fraser University, Burnaby, British Columbia, Canada from 8-10 April 1975. The symposium, initiated by the present NRC Canada Sub-committee on Glaciers, is sponsored by Simon Fraser University. Burnaby is adjacent to Vancouver; the University is eight miles (13 km) from Vancouver centre.

Organizing Committee

G. K. C. Clarke, Geophysics Department, University of British Columbia; S. J. Jones, Inland Waters Branch, Department of Environment, Ottawa; W. H. Mathews, Department of Geology, University of British Columbia; W. S. B. Paterson, Polar Continental Shelf Project, Department of Energy, Mines & Resources, Ottawa; R. B. Sagar, Department of Geography, Simon Fraser University; B. G. Wilson, Academic Vice-President, Simon Fraser University.

Topics

Among the topics that will be discussed are: temperature distributions in polar ice sheets and reconciliations of deep temperature measurements with past surface temperatures deduced from oxygen isotope profiles; possible effects of dumping radioactive waste; possible convection in the Antarctic Ice Sheet; factors determining temperatures in subpolar glaciers; thermal instabilities as a cause of glacier surges; temperatures in "temperate" glaciers; techniques of temperature measurement. There will be review papers on selected topics by invited speakers.

Papers

Those who would like to contribute to the Symposium are requested to submit the title of their proposed paper by 31 August 1974 and an extended summary (two or three pages) by 15 January 1975 to:

R. B. Sagar, Glaciology Symposium, c/o Department of Geography, Simon Fraser University, Burnaby, B.C. V5A 1S6, Canada.

Titles and summaries should be in English or French. The summaries will be mailed to all participants before the symposium. It is proposed that papers and discussions will be published.

Accommodation

Accommodation will be available in student residences at a cost of roughly $20 per day, including meals, or, if preferred, in nearby hotels.

Second Circular

A second circular with details regarding the programme, submission of final papers, registration fees and prices of accommodation, along with a reservation form, will be distributed in September 1974.

SYMPOSIUM ON ISOTOPES AND IMPURITIES IN SNOW AND ICE

Grenoble, France, 28 - 30 August 1975

Symposium on Isotopes and impurities in snow and ice will be held in Grenoble, France, from 28-30 August 1975. It will be under the joint sponsorship of the International Association of Hydrological Sciences (IAHS) and the International Association of Meteorological and Atmospheric Physics (IAMAP) and will be organized by the International Commission of Snow and Ice, during the 16th General Assembly of the International Union of Geodesy and Geophysics (IUGG).

TOPICS

The Symposium will be concerned with the basic problems of measurement and interpretation of isotopes and impurities in snow and ice before and after deposition. The influences of weather, space and time will be discussed. Papers on salinity in sea ice are specifically excluded. The detailed topics envisaged are:

Determination (in snow and ice) of

- ratios of isotopes in the water molecule ($H^2/_{H^1}$, $H^3/_{H}$, O^{18}/O^{16})
- contents of dissolved and particulate matter (elements and compounds of marine, continental and extra-terrestrial origin, elements and compounds connected with pollution of the earth)
- radioactivity in dissolved and particulate matter (Si^{32}, Cl^{36}, Mn^{53}, Sr^{90}, Pb^{210}, etc.)
- gas content and composition in ice (N_2, O_2, Ar, CO_2, CH_4, . . .)
- radioactivity of trapped gases (Ar^{39}, C^{14}, etc.)

Special attention will be given to new techniques and new possibilities with existing techniques.

Interpretation of the results in terms of

- present climatic conditions and history of climatic conditions (temperature, accumulation rates, atmospheric circulation patterns, aerosols, etc.)
- assessing properties and processes in snow and ice (origin and age of ice (ice flow), smoothing of seasonal O^{18} variations (movement of matter in firn), variation of gas composition and content of dissolved and particulate matter on temperate glaciers (water flow through temperate glaciers), etc.)
- history of other terrestrial and cosmic events (volcanic ashes, pollutants, cosmic radiation, cosmic dust, etc.)

PAPERS

In order to provide ample time for discussion the number of papers will be limited to 30. In addition, there may be 3 or 4 invited review papers.

Tentative titles, extended abstracts and final papers should be submitted to the ICSI Secretariat according to the following deadlines:

31 August 1974: Declaration of interest in the symposium and submission of tentative titles including a brief note on contents (see enclosed form)

15 January 1975: Submission of extended abstracts, maximum 300 words, in 4 copies

15 June 1975: Submission of final papers in 4 copies (1 original and 3 copies), maximum 3500 words including summaries and figures.

The papers must be written either in English or French, with abstracts in both languages. The extended abstracts will be screened by the Papers Committee and results will be communicated to authors in due time. The final papers will be mimeographed and distributed at the beginning of the symposium.

EXCURSIONS

It is hoped to organize a one-day excursion on Sunday 31 August 1975 and a several-day post-Assembly tour in the French Alps.

FURTHER INFORMATION

A second circular with a tentative programme will be issued in November 1974. Recipients of the second circular will automatically receive the third circular.

All correspondence concerning the papers (but not regarding registration) should be addressed to: Dr F. Müller, Secretary ICSI, IUGG Symposium on Isotopes and Impurities in Snow and Ice, Geographical Institute, Swiss Federal Institute of Technology (ETH), Sonneggstrasse 5, CH-8006 Zürich, Switzerland.

GLACIOLOGICAL DIARY

1974

28-30 August
Symposium on Ice core drilling, University of Nebraska-Lincoln, USA. (Dr Robert H. Rutford, Director, Ross Ice Shelf Project, University of Nebraska-Lincoln, 135 Bancroft Hall, Lincoln, NB 68508, USA.)

25-31 August
Nordic Branch, International Glaciological Society. Annual meeting, West Norway. (Dr O. Orheim, Rolfstangveien 12, Postboks 158, 1330 Oslo Lufthavn, Norway.)

6-8 September
Western Alpine Branch, International Glaciological Society. Annual meeting, Courmayeur, Italy. (Dr F. Valla, CT. GREF Nirologie, BP 114, St. Martin d'Hères, France.)

9-12 September
Celebration of Tercentenary of Scientific Hydrology and Symposia to mark end of I.H.D.; Effects of man on the interface of the hydrological cycle with the physical environment. Flash floods—measurement and warning, (Director, Division of Hydrology Unesco, 7 place de Fonternoy, 75700 Paris, France.)

15-21 September
Symposium on Remote sensing in glaciology, Cambridge, England. International Glaciological Society. (Mrs. H. Richardson, Secretary, Cambridge CB2 1ER, England.)

23-27 September
Conference on Properties of water and steam, Giens, France. (Dr. S. Beitler, Dept. of Mechanical Engineering, Ohio State University, 206 W 18th Avenue, Columbus, Ohio 43210, USA.)

1975

8-10 April
Symposium on the thermal regime of glaciers and ice caps. National Research Council of Canada, Simon Fraser University, Vancouver, Canada. (Dr R. B. Sagar, Dept. of Geography, Simon Fraser University, Burnaby, B.C., Canada.) (See p. 21 of this issue of ICE.)

18-20 August
International Symposium on the Geochemistry of Natural Waters, Burlington, Ontario, Canada. Sponsors: Working Group on Geochemistry and Cosmochemistry, the International Association of Hydrological Sciences and Canada Centre for Inland Waters. (Mary E. Thompson, Chairman, Canada Centre for Inland Waters, Burlington, Ontario, Canada.)

18-21 August
International Association of Hydraulic Research Committee on Ice Problems and US Army Cold Regions Research and Engineering Laboratory—Symposium to include ice management and engineering as related to extended season navigation of inland waterways, ice jam control, and effects of sea ice on marine structures.

25 August–6 September
XVI General Assembly of the International Union of Geodesy and Geophysics, Grenoble, France. (C.N.F.G.G., 136bis, rue de Grenelle, 75700 Paris, France.)
Symposium on Isotopes and Impurities in Snow and Ice, International Commission of Snow and Ice, Grenoble, France, during the 1975 General Assembly of IUGG. (Dr Fritz Müller, Secretary ICSI, Geog. Inst. der ETH, Sonneggstrasse 5, Zurich 8006, Switzerland.) (See p. 22 of this issue of ICE.)

12-17 December
The Second World Congress on Water Resources, New Delhi, India. (C. V. J. Varma, Secretary Indian National Committee for International Water Resources Association, Central Board of Irrigation and Power, Kasturba Gandhi Marg, New Delhi-110001, India.)

1976

Autumn
International workshop on dynamics of glacier fluctuations and surges, sponsored by ICSI organized by and held in USSR.

15-25 August
The 25th International Geological Congress, Sydney, Australia. (Secretary-General, 25th International Geological Congress, P.O. Box 1892, Canberra City, ACT 2601, Australia.)

August
23rd International Geographical Congress, Moscow, USSR. (V. Annenkov Institute of Geography, Academy of Sciences USSR, Staromonetny 29, Moscow 109017, USSR.)

September
Symposium on Problems of applied glaciology, Cambridge, England. (International Glaciological Society, Mrs. H. Richardson, Secretary, Cambridge CB2 1ER, England.)

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INTERNATIONAL GLACIOLOGICAL SOCIETY

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. No proposer or seconder is required. Annual payments 1974:

Private members	Sterling: £5.00
Junior members	Sterling: £2.00 (under 25)
Institutions, libraries	Sterling: £10.00

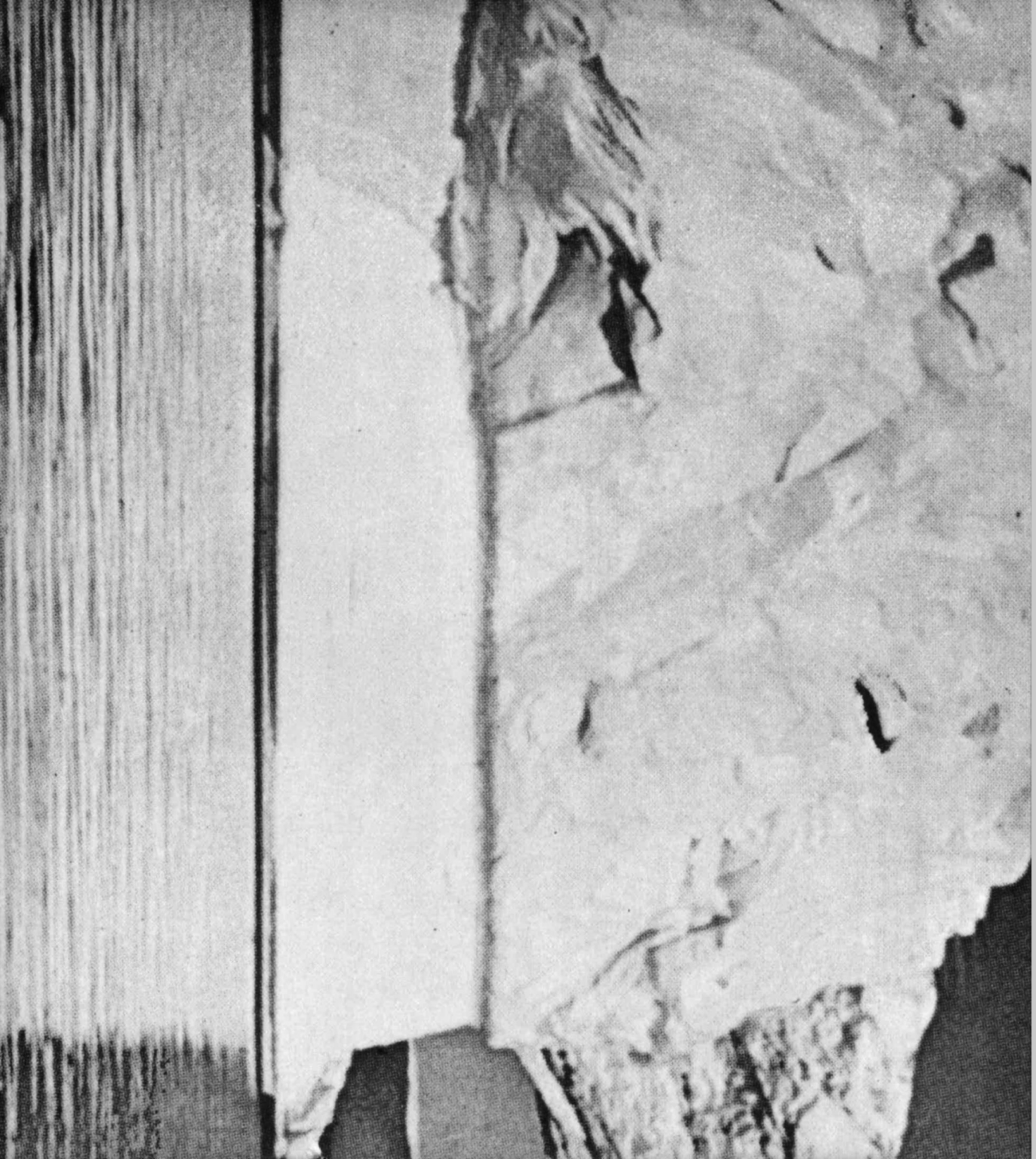
Note—Payments from countries other than Britain should be calculated at the exchange rate in force at the time of payment. If you pay by bank draft, rather than by personal cheque, please ensure that sufficient money is included to cover the bank charges of £0.50p per cheque. Thank you.

I C E

Editor: Mrs 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, Cambridge CB2 1ER, England.

Annual cost for libraries, &c, and for individuals who are not members of the Society: Sterling £1.50.



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