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ICE

NEWS BULLETIN OF THE GLACIOLOGICAL SOCIETY

AUGUST 1970 NUMBER 33

CONTENTS

HONORARY MEMBERS. We are pleased to announce that the Council of the Glaciological Society has elected Dr W. O. Field and Dr R. F. Legget as Honorary Members. Dr Field has made great contributions to the science of glaciology and has been a staunch supporter of the Society throughout its period of re-organization and expansion. Dr Legget made important and successful efforts to promote the study of glaciology in Canada, especially in the late 1940s and early 1950s, and has always had the interests of the Society at heart.

Honorary Members, limited in numbers by the Society's Constitution, are: H. W:son Ahlmann, W. O. Field, R. Haefeli, R. F. Legget, Sir Raymond Priestley, M. de Quervain, Sir Charles Wright.

NEW BRANCH OF THE SOCIETY. At a meeting in May 1970, the Council approved the suggestion that there should be a branch of the Society established in France and invited Prof. L. Lliboutry to initiate its formation. Further news about the new branch will be given in the next issue of ICE.

We are very sorry to report the death of Professor N. N. Pal'gov on 2 June 1970. Prof. Pal'gov celebrated his 80th birthday on 10 December 1969, as reported in ICE No. 31, December 1969. He was an Academician of the Kazakhstan Academy of Sciences and had made many valuable contributions to glaciology, notably through his work in central Asia.

COVER PICTURE. Natural snow crystal observed at Syowa Station, Antarctica. Photograph taken by K. Kikuchi, Department of Geophysics, Hokkaido University, Sapporo, Japan.

FIELD WORK

AUSTRALIA

CASEY

During 1969 the first thermal core drillings were successfully carried out on the local Wilkes ice cap by R. Anderson and S. Little, with support from other expedition members. The first hole was sunk to 350 m depth near Cape Folger and most of the core was recovered. Measurements of temperature were successful to 300 m depth, but those of inclination and hole diameter encountered difficulties suggesting a need for instrumental improvements. A second hole was cored on the ice cap summit to a depth of 400 m with good core recovery and temperatures to 320 m depth. Unfortunately the drill then got stuck and was lost with most of the cable before further measurements could be made in the hole. A portion of the two cores and the temperature data are now being analysed in Melbourne. This work will benefit from the forthcoming visit of G. Wakahama, of the Institute of Low Temperature Science in Hokkaido University, as Melbourne University's Leverhulme Fellow for 1970.

MAWSON

Previous heat budget studies on the plateau and near the coast by G. Weller and J. Illingworth were extended during 1969 by I. Allison to the water and sea ice close to Mawson harbour. Despite numerous problems with the raft carrying the instrumental system a substantial set of data was obtained and is now being analysed in Melbourne.

AMERY ICE SHELF

A tellurometer re-survey of the 400 km movement and strain nets was carried out during the summer 1969/70 by M. Correy, the leader of the party which set up the nets during 1968 (cf. ICE no. 30, p. 2). In addition a new radio ice thickness sounder designed by I. Bird received its first tests and gave good echoes both for about 300 km of the ground traverse and during aircraft trials. The computer analysis of the survey results and the reduction of the echo soundings are nearing completion in Melbourne.

All this work has been carried out under the direction of W. Budd of the Antarctic Division, Department of Supply.

U. Radok

BELGIUM

The 1969 Belgian Antarctic Summer Expedition (in logistic collaboration with South Africa) had planned to continue and extend its 1969 airborne radio echo sounder survey in the neighbourhood of Sanae. An accident at the beginning of the season destroyed the DCH3 OTTER aircraft of the expedition and the programme could not be carried out.

As a substitute, a detailed topographic and morphological survey was made of the depressions in the ice shelf near the coast, where areas of thin (50 m) ice was found in contact with the 150 m thickness of the normal ice shelf.

In Belgium, interpretation of the 1969 survey continues (T. Van Autenboer, H. Decleir) and further geochemical studies of Antarctic snow and ice have been made at the University of Brussels (E. Picciotto).

T. Van Autenboer

CANADA

The Sub-Committee on Glaciers held two meetings in 1969 in Ottawa, one on 20 February and one on 30 October. The proceedings of the international Seminar on the "Causes and Mechanics of Glacier Surges", organized by the Sub-Committee and held at St. Hilaire, P.Q. in September 1968, were prepared for publication and appeared as a special issue of the Canadian Journal of Earth Sciences (Vol. 6, No. 4, Pt. 2). The results of the standard snow survey programmes carried out by various Federal and Provincial government agencies were again published by the Meteorological Branch of the Department of Transport, by the Meteorological Service of the Department of Natural Resources of Quebec and by the Water Resources Service of the Water Investigations Branch of British Columbia.

SNOW AND ICE HYDROLOGY

(a) The following **agencies** are among those which carried out hydrological studies during 1969: Department of Agriculture's Research Station at Swift Current, Saskatchewan; Northern Economic Development Branch of the Department of Indian Affairs and Northern Development; the Meteorological Service of the Department of Natural Resources of Quebec; the Forest Hydrology Section of the Canadian Department of Fisheries and Forestry at its Prairies regional laboratory in Calgary; the Department of Energy, Mines and Resources through a contract with the Shawinigan Engineering Company of Montreal, and through its Inland Waters Branch. The three projects currently underway in Alberta, and conducted by the Prairies regional laboratory mentioned above, are typical of these hydrological studies:

(i) **Influence of varying size openings in forest on accumulation and ablation**

Snow accumulates in small openings and along the edge of an abrupt forest-cleared area. It also tends to melt more slowly under a closed canopy and in small openings than in large openings. Qualitatively more snow accumulates in openings 1/2 H or greater in diameter (where H = tree height) then under the closed canopy. It ablates sooner from openings greater than 3—5 H-diameter, and later from 1/2 to 1 H openings. These observations can be used to specify timber management practices to influence water yield. However, their effects are predictable only in a general sense: specific results cannot be predicted because of lack of a common denominator between research projects and manageable areas.

For accumulation, this common denominator may be wind velocity during snow precipitation periods. For ablation, the common elements are likely wind velocity and solar radiation. A study to test these hypotheses has been started. This is an attempt to gain both statistically significant and physically relevant information. Ten treatments, consisting of nine openings 1/4 H to 6 H in diameter and one uncut control, will be repeated 10 times in a uniform stand of lodgepole pine located 30 miles northwest of Sundre, Alberta, on uniformly flat topography. All openings smaller than 1 H and one complete replica of the larger openings were completed prior to the 1969–70 snow season. The remainder will be completed during the summer of 1970.

(ii) **Snow distribution on Deer Creek**

Various researchers have reported a marked influence of elevation on snow accumulation. These data have originated from catchments with a change in vegetation type—also related to elevation. Deer Creek has no perceptible variation in vegetation with elevation. Is the water content of the accumulated snow pack influenced by elevation in this catchment? A snow course covering numerous aspects, slopes and the entire elevational range of the basin was established in 1968. This course was read monthly from December to April 1969. Preliminary analysis of the collected data shows no trends with respect to elevation; aspect or slope. Data collection will continue through the spring of 1970.

(iii) **Distribution of snow accumulation on Marmot Creek at maximum pack**

Hydrological research has been conducted on Marmot Creek for the past eight years to determine the effect of forest-cover manipulation on water yield, regime and quality. A major effect of logging on the hydrology of the area will be in the redistribution of snow and alteration of energy relations and hence snow melt.

In March 1969, at approximately the time of maximum snowpack, 1,210 points on a 1 x 10–chain grid were measured for snow depth and water equivalent. This will be repeated each spring for several years before and after treatment of one of the sub-basins on the watershed to determine changes in the snow accumulation pattern. Multiple regression and correlation analyses were carried out relating snow-water equivalent to each of the variables, elevation, slope, aspect and forest density. In the final model, with a multiple correlation coefficient of 0.418, the four independent variables contributing significantly to the regression were elevation^2, slope^3, forest density and the interaction of elevation and slope.

(b) Some **university departments** are also studying snow and ice hydrology. For example, at **McGill University** a team is working on multifactor analysis of variations in time and space of the snow cover in relation to physiographic and climatic parameters in different environments: high arctic (Axel Heiberg Island, NWT), sub-arctic (Schefferville, Québec) and St. Lawrence lowland (St. Hilaire, Québec).

At the **University of British Columbia**, the Faculty of Forestry has initiated a programme of hydrological research in an area of the Pacific Ranges just north of Vancouver, to study the physiographic and forest effects of snowfall, accumulation and melt and their relations to stream discharges. To date, six precipitation storage gauges have been installed over an elevational range of 800–3500 feet in two mountain valleys.

In the Department of Civil Engineering M. C. Quick is carrying out both a laboratory simulation and a programme of field measurements of snow-melt to be utilized in a river forecasting system.

The amount of snow deposited on a slope of Mount Seymour is being measured after each storm at 15 sites ranging from sea level to 4,000 feet, by B. B. Fitzharris of the Department of Geography.

EXPERIMENTAL STUDIES

(a) ICE SCIENCE SECTION, Glaciology Sub-Division, Department of Energy, Mines and Resources: S. J. Jones

Arrangements have been completed to transfer and augment the laboratory cold room facilities during the coming year. With the addition of two scientists to the Section, research on the effects of impurities now include studies of surface structures and the thermoelectric properties of ice.

(i) **Dislocation in ice crystals (S. J. Jones)** — An X-ray topographical technique—the Lang technique—is being used to look at the dislocations in ice crystals. A study of zone-refined ice has shown that it has a fairly low dislocation content, typically less than 10^3 cm^{-2}. Small angle boundaries are sometimes present.

(iii) **Mechanical properties of doped ice (T. Nakamura*)**—The effect of various impurities on the mechanical properties of ice single crystals is being investigated. It has been shown that at $-26°$ HC1 has a softening effect somewhat similar to HF. At higher temperatures the effect is less pronounced. *Postdoctoral Fellow on leave from the National Research Center for Disaster Prevention, Japan.

(iv) **Impurities in polycrystalline ice (S. J. Jones, G. Barnett)**—A project to investigate the effect of impurities on the mechanical properties of polycrystalline ice has started. Preliminary results at $-10°C$ show an observable softening effect of HF on the deformation of polycrystals.

(v) **Glacier dynamics (D. Fisher)**—Computations to predict the future behaviour of Berendon Glacier, B.C., have been started. The object is to repeat the calculations made by N. Untersteiner and J. F. Nye (Journal of Glaciology, Vol. 7, p. 205, 1968) using more accurate and more recent field data gathered by the Sub-division.

(vi) **Electron microscopy studies of ice surfaces (J. D. Cross)**—The surface of polycrystalline ice is studied by direct examination in a scanning electron microscope. Emphasis is placed on the effect of impurities on the surface structure. Preliminary results show that complex structure previously reported for pure ice is absent in impure specimens.

(vii) **Thermoelectric properties of ice crystals (J. D. Cross)**—The thermoelectric power of ice crystals will be measured using a vibrating capacitor technique with no electrodes in contact with the ice. It is hoped to overcome the difficulties due to contact potentials and to determine the thermoelectric power with an uncertainty of less than 10%.

(viii) **River and lake ice (R. Ramseier)**—Studies of the creep and growth mechanism of river and lake ice are carried out at Laval University under Professor B. Michel.

(b) SNOW & ICE SECTION, Division of Building Research, National Research Council: L. W. Gold

(i) **Deformataion behaviour of ice**—Studies were continued on the failure process in columnar-grained ice during compressive creep, and deformation under constant rate of strain conditions. It was observed that when the strain rate exceeded about 10^{-5} per min., yield and failure were always associated with the formation of internal cracks. Observations have been completed on the spatial distribution of cracks that develops during creep under a compressive load of 10 kg/sq cm or less. Studies have also been completed on the angular distribution of these cracks relative to the direction of the stress, and on the distribution in crack widths. Studies of the stress and temperature dependence of stress relaxation in ice were continued. Observations on the stress relaxation in ice single crystals at $-10°C$ were analyzed using a theory developed previously. It was found that plastic deformation in the single crystal is controlled by one of the following mechanisms: Peierls mechanism, dislocation intersection or non-conservative motion of jogs. This behaviour is similar to that observed earlier for polycrystalline ice. The observations indicate that dislocation climb cannot be the rate controlling mechanism. A series of compression tests were carried out at constant rate of strain on ice taken from the St. Lawrence River. The increase in the upper yield stress with increasing rate of strain was determined and found to be about the same for columnar-grained, snow and frazil ice. This conclusion is of some interest because if it is generally true it will greatly simplify calculations concerning the deformation and strength of ice covers.

(ii) **Avalanche research**—Observations are continuing on the characteristics of avalanches and their dependence on weather and characteristics of the avalanche site. Instrumentation has been set up for measuring the dynamic pressure of avalanches occurring in the Rogers Pass area of British Columbia.

(c) McGILL UNIVERSITY: J. J. Jones and F. Müller

Deformation of ice at high reductions and strain rates

Using the new Instron environmental chamber and compression frame, the stress and temperature dependence of the flow rate under extrusion conditions has been determined in the temperature range -1.7 to $-22.7°C$ and the strain rate range 10^{-2} to 1 sec^{-1}. The observed power law stress dependence was $\simeq 5$ and the activation energy of flow was 50 ± 3 kcal/mole. In experiments currently under way, the strain rate range is being extended to six orders of magnitude, and the temperature range to −40°C. A constant true strain rate die has been designed and tested. With the aid of transparent equipment, it is also intended to study in more detail the microstructural changes taking place during deformation and the mechanisms of crack formation and fragmentation. The possibility that dynamic recrystallization may be involved in the flow instabilities that lead to glacier surges is being investigated.

(d) LABORATOIRE DE MECANIQUE DES GLACES, Université Laval, Québec: B. Michel

The laboratory is continuing research on several projects, including:

formation and structure of river and lake ice; rheology of river and lake ice; analysis of the different textures of river and lake ice; thrust exerted by thermal expansion of ice.

GLACIER RESEARCH

(a) GLACIOLOGY SUB-DIVISION, Inland Waters Branch, Department of Energy, Mines and Resources: O. H. Løken.

(i) **ARCTIC SECTION (G. Holdsworth)**

Work was undertaken on the **Per Ardua Glacier**, Ellesmere Island by R. Rogerson; on the **White Glacier**, Axel Heiberg Island by K. C. Arnold, as a part of the overall Axel Heiberg Expedition under F. Müller, McGill University; on **Baffin Island** and the arctic archipelago; on the **Devon Island Ice Cap**, in collaboration with the Arctic Institute of North America, under the supervision of F. Müller; and on the following two projects:

Barnes Ice Cap, R-SIG-17, North 3 (O. H. Løken & G. Holdsworth)—Last year's mass balance was measured in May-June. Preliminary examination of the results show that all but the very lowest parts of the ice cap had a positive balance for the year 1967-68. Surface movement in three parts of the South Dome was measured for the third consecutive year. A radio-echo survey of ice depth had to be aborted due to equipment breakdown. G. Holdsworth did a reconnaissance study of the southern part of the ice cap in August in preparation for new studies on ice deformation and flow to start next year. Also in August, Dr. R. Hooke, University of Minnesota, completed a reconnaissance of the marginal zone for future studies of the processes responsible for the formation of shear moraines.

Decade Glacier, IWB-RB-North 2 (U. Embacher)—A party of two persons conducted mass balance measurements of the glacier and maintained meteorological instruments at the glacier and stage recorders at the meltwater stream and at Inugsuin River, from 26 June to 4 September. During the summer a study of aufeis formation at two locations included photographs of thin sections for grain size and shape determinations.

Specialised projects included the following: parametric model of the melt run-off for the Peyto Glacier (L. Derikx); contribution made to the North Saskatchewan River by glacier meltwater (H. Loijens); distribution of snow in the Mistaya Valley (G. J. Young); glacier maps—4 Arctic sheets completed (W. E. S. Henoch, joint project with the National Parks Branch of the Department of Indian Affairs and Northern Development).

(ii) **CORDILLERA SECTION (A. D. Stanley)**

Mass and water balance measurements (Stanley, Mokievsky-Zubok, Beck, Bellaar-Spruyt, Rogerson)—Field programmes were continued at the five glacier basins in a transect across the southern part of Alberta and British Columbia (Place, Sentinel, Woolsey, Peyto and Ram Glaciers) and on Berendon Glacier near Stewart in northern British Columbia. At each basin standard glaciological, hydrological and meteorological data were obtained from late May until early October. During the winter 1968-69, for most basins, the winter snowfall was about normal and average conditions prevailed over most of the summer.

Radio echo sounding unit (R. Goodman, D. Terroux)—In cooperation with the Water Science Subdivision a radio echo sounder was developed for use in temperate ice. The unit is a 5 kw, 623 MHz transmitter giving a 100 ns pulse from a directional antenna. The unit is mounted on two skidoos fastened in tandem, and has a radar navigation system to determine its location on the glacier. All data is digitized and recorded on a tape. A small computer averages the data on a sample and average basis so that the total data recording rate remains manageable. Field trials were made in the Wapta Icefield at Bow Glacier. The unit was run in a grid pattern over part of the glacier and data used to compile a computer drawn map.

(iii) **GLACIER INVENTORY SECTION (C. S. L. Ommanney)**

An index of all the glaciers on Baffin and Bylot islands has been completed and will be published in 24 maps at a scale of 1:500,000. The detailed inventory of this area will be undertaken once the inventories of glacierized areas mapped at a scale of 1:50,000 or better have been completed. During 1970 a start will be made on the inventory of the Cordillera. Many early photographs of glaciers in the Arctic and along the International Boundary are now on file and it is hoped that this file will be increased in 1970.

(b) GEOLOGICAL SURVEY OF CANADA, DEPARTMENT OF ENERGY, MINES AND RESOURCES

Tchaikazan and Friendly Glaciers, British Columbia (J. A. Heginbottom, M. L. Parker)—In July 1969 three days were spent in the upper Tchaikazan Valley collecting tree-ring specimens and examining recent alpine moraines of the Tchaikazan and Friendly Glaciers. These are two of a group of five glaciers in the Tchaikazan Valley which have advanced below upper timberline in the recent past, and are now retreating. The valley is tributary to the Taseko Lakes, on the east side of the Coast Ranges (N.T.S. Sheet 920-3). The objectives of this field work were (i) to evaluate the usefulness of the tree species in this area for dendrochronological studies, and (ii) to assign minimum dates to the moraines through annual ring counts.

Glacial history, Selkirk & Monashee Mountains, B.C. (R. A. Achard)—Field observations were made during two reconnaissance trips above timberline, one in the northern Selkirks, from Bachelor Pass to the Adamant Range, and one across the Jordan Range in the Monashee Mountains. The formation of moraine ridges and of other glacial deposits was observed on and around different ice tongues. In general, dead ice and dead ice layers in glacial deposits were seen to play a more important role than running water in the final structure of the deposits. During the last postglacial advance, which began 200 to 300 years ago and reached its maximum near the end of last century, most accumulation areas were apparently no more extensive than at present. Longitudinal profiles of lateral moraines built during this advance indicate that within the ablation zone the gradients of the glaciers were lower and the tongues much thicker than they are now in the glaciers further up-valley.

(c) UNIVERSITY OF BRITISH COLUMBIA

An assessment of the mass balance, both for the International Hydrological Decade and for forecasts of any advance which might interfere with mine operations, is the principal objective of a continuing study of the Berendon Glacier in the northern Coast Mountains of British Columbia.

Summit Lake, south of Berendon Glacier, and the catastrophic **release of the lake water under the Salmon Glacier** have been the subject of a continuing study by R. Gilbert, Department of Geography. Reports on escape of water under the Salmon Glacier were presented at the Glaciological Society's Symposium on the Hydrology of Glaciers, Cambridge, England by W. H. Mathews and D. Fisher, Glaciology Subdivision, Department of Energy, Mines and Resources.

Investigations on the slow **creep of the winter snow pack** on hill slopes and on the pressures exerted by the creeping snow against static obstacles within it have been continued by W. H. Mathews on Mount Seymour near Vancouver, and at five other sites in southern British Columbia. Variations with depth and with snow conditions in the maximum pressures exerted during the winter are the prime concern of this study.

Time-lapse 16 mm films, taken during the 1968 and 1969 seasons, showing the formation and modification of certain ablation features at the terminus of the **Athabasca Glacier,** Alberta, are presently being edited by R. E. Kucera.

Geophysical studies on the **Fox Glacier in the Icefield Ranges,** Yukon Territories, have been undertaken in 1968 and 1969 by D. J. Crossley, D. Classen and G. K. C. Clarke, Department of Geophysics. The Fox Glacier is of particular interest because it is believed to be a surging glacier in the late stages of quiescence. Interpretation of the 1968 gravity survey has been completed by D. J. Crossley. His map of the ice thickness shows the Fox Glacier to be strikingly shallow. The maximum ice thickness was found to be 88 m, which would explain the consistent failure of seismic reflection surveys on this glacier. The bulge in the accumulation area (which has been suggested as an accumulation feature) appears to be a bedrock high. This in no way precludes the possibility of a future surge. In June-August of 1969 D. Classen and G. K. C. Clarke obtained deep ice temperature measurements on the Fox Glacier. Holes were drilled using two types of thermal probe, and temperatures obtained by resistance measurements on thermistors. The depths of the three holes which penetrated to bedrock agreed excellently with Crossley's gravity interpretation. Preliminary surface temperatures were of the order of $-5°C$, and the basal temperatures were all colder than $-1.8°C$. A surge in the near future due to water lubrication at the glacier boundary is not indicated by these measurements. Theoretical studies of glacier surge mechanisms are being undertaken by D. Phelps and G. Clarke.

(d) ARCTIC INSTITUTE OF NORTH AMERICA AND AMERICAN GEOGRAPHICAL SOCIETY: THE ICEFIELD RANGES RESEARCH PROJECT (IRRP)

The scientific and organizational direction of the 9th field programme of IRRP with the main activity in the St. Elias Mountains and Kluane Lake area in the Yukon Territories was again in the hands of W. A. Wood and R. H. Ragle.

Fox Glacier (Tom Brewer, Boston University)—For the third consecutive year intensive studies were pursued on the Fox Glacier which is expected to surge in the foreseeable future. Ablation, and snow and ice density measurements were carried out between 20 June and 10 August to establish the 1969 mass balance.

The budget year ended during the last week in July compared to the first week in September of 1968: a paradoxcial situation, as the budget was strongly negative. A plane-table map of the Fox Glacier was prepared showing various small features on the most recent terminal moraine. This study indicated that no glacier motion has occurred in the lower part of the glacier since shortly after the moraines were formed, and that shear plane fillings pass untruncated from moraine to glacier.

A resurvey of the 68 marker poles placed in the Fox Glacier in 1967 and the 26 in the Hyena Glacier was completed by S. Collins by the end of July. In addition, two new reference stations were established for the Hyena Glacier survey.

Kaskawulsh Glacier (R. H. Ragle, AINA)—As in past summers synoptic weather was recorded and radioed to Kluane base station from where it was transmitted to Whitehorse. In mid-July a standard snow pit study was made to 4.5 m depth in the firn at Divide Camp (el. 2630 m). A depth-load curve derived from the density measurements places the snow masses of this area within the percolation facies but very close to the saturation line and the wetted facies. As in previous summers the firn temperatures throughout the annual accumulation layer hovered around the 0°C mark. In a 14.7 m core hole the temperature was −0.25°C. Samples of firn were collected for analysis of Ca, Na, Mg and K ions by atomic absorption method. In addition, samples of precipitation were collected during storms both at Divide Camp and at Kluane Base.

Steele Glacier (W. A. Wood, AINA)—In the latter half of July, at the request of the Surveys and Mapping Branch, Department of Energy, Mines and Resources, re-identification and marking of ground control stations was carried out in the Steele watershed by helicopter, to prepare for an aerial photo survey by Range Aerial Surveys, Calgary. Too much snow and continually changing weather prevented completion of this programme.

Rock Glacier (J. P. Johnson, Jr., Carleton University, Ottawa)—The research was initiated in 1965. This summer coring into the rock glacier on Sheep Mountain was initiated with a drilling crew from Arctic Diamond Drilling, Whitehorse. Drilling was difficult and progressed to a depth of about 19.5 m. The hole was cased and temperatures were read—probably before equilibrium was reached. Temperatures ranged from top to bottom from 3.3°C to 1.0°C. A movement survey of the 1966 stakes was also made, and preliminary data indicates that surface motion along the centre line amounts to about 1 m. The inclination of the bore hole will be measured.

(e) ARCTIC INSTITUTE OF NORTH AMERICA: DEVON ISLAND ICE CAP (R. Braithwaite)

The long-term glacier-climatology project on the Devon Ice Cap (operated by the Arctic Institute of North America in co-operation with the Glaciology Sub-Division of the Department of Energy, Mines and Resources and McGill University) was continued by a three-man team. A manual synoptic weather station was operated from 3 June to 15 August at the old ice cap station (el. 1320 m) on the north-west side of the ice cap. In addition, Stevenson screens with hygrothermograph recorders were installed at the old Plateau Station (el. 1800 m) near the summit of the ice cap and at the north-west margin of the ice cap (el. 820 m). A preliminary meso-scale study of the summer climatology of the ice cap will now be attempted. In June, traverses were made on the ice cap, and the winter accumulation was measured in 33 snow pits. The mean accumulation was 0.08 m, which is almost half that measured in the 1968 summer.

(f) UNIVERSITY OF NEW BRUNSWICK, DEPARTMENT OF SURVEYING (G. Konecney)

E. Dorrer compiled and analysed the results of the May 1968 **Ward Hunt Ice Shelf Survey.** Movement, deformation and change in elevation of the ice shelf was determined with respect to survey data gathered in 1964 and 1965. Atmospheric refraction above the ice surface was studied and ice stresses were estimated.

Ice movement survey data of the **Expédition Glaciologique Internationale au Groenland** were analysed using a new computer programme. Likewise, a further analysis of movement survey data from the Ross Ice Shelf expeditions 1962-63 and 1965-66 was made and submitted for publication by the German Geodetic Commission.

Radio echo soundings by the Scott Polar Research Institute on the Ross Ice Shelf in 1968 have been analysed for positional accuracy. These data are being combined with the movement survey results in order to determine precise iceflow and sub-surface melting.

In conjunction with the Juneau Icefield Research Program, G. Konecny conducted a survey of the **Atlin Rock Glacier** in northern British Columbia. Three movement profiles and four terrestrial photogrammetric baselines were established. A reconnaissance for the survey of several rock glaciers in the Dezadeash Valley in the Yukon Territories was carried out. E. Krakiwsky measured ten movement profiles across the following glaciers: **Lemon Creek, Ptarmigan, Taku, Herbert.** At the same time, three gravity survey profiles were run across the Lemon Creek and the Taku Glaciers.

(g) POLAR CONTINENTAL SHELF PROJECT, DEPARTMENT OF ENERGY, MINES AND RESOURCES, OTTAWA (E. F. Roots)

Melville Island (W. S. B. Paterson, F. P. Hunt)—Mass balance observations were continued on the four ice caps. The winter balance for 1968-69, as measured at the end of April, varied little from ice cap to ice cap. The average value was 14 cm water equivalent. This is close to the average value for the past six years. Net mass balance for the period 1966-68 ranged from a gain of 17 cm w.e. on the south ice cap to a gain of 26 cm on the north ice cap. (These figures cannot be divided into net balances for the separate years because, as previously reported, measurements made in 1968 were unreliable).

Meighen Island (W. S. B. Paterson, B. Barge)—The meso-scale meteorological study, begun in 1968, was continued. This programme will be continued for one more season. The data, and also data collected by K. C. Arnold during the summers of 1960, 1961 and 1962, will be used to make a meso-scale study of the glacier-climate relationship for the Meighen Ice Cap, using synoptic energy budget techniques. This work is being carried out by B. Barge under the general direction of Prof. S. Orvig, Department of Meteorology, McGill University.

Routine mass balance measurements, started in 1959, were continued. The winter balance for 1968-69, as measured in early May, was 14 cm water equivalent. This is slightly less than the ten-year average. The net mass balance of the ice cap for 1967-68 was a gain of 4.5 cm w.e. Preliminary figures indicate that the net balance for 1968-69 was a gain of 5 cm w.e. The diameter of the deep borehole, drilled in 1965, was remeasured, at depth intervals of 7.6 m, to determine the rate of closure.

(h) McGILL UNIVERSITY, MONTREAL

AXEL HEIBERG ISLAND, N.W.T. (F. Müller)

A party of 12 continued field work on Axel Heiberg Island for the eleventh consecutive summer from 23 April to 24 August.

Mass balance of the White and Baby Glaciers—The network of about 120 stakes on the two glaciers was maintained. Accumulation and ablation measurements were carried out three times on the White Glacier and eight times on the Baby Glacier. The 1968/69 winter snow cover was slightly less than average, while ablation amounted to considerably less than the ten-year mean value (the sunshine duration total for July was only 7 hours). The 1968/69 mass balance falls therefore slightly to the positive. The equilibrium line was at an elevation of about 780 m.

Energy balance and meso-climate (A. Ohmura)—Ten climatological stations were set up for the meso-climatic space relevant to the Baby, White and Thompson Glaciers, covering an area of about 150 km^2 and an elevation interval of about 1.5 km. The computer mapped temperature and radiation distribution is being related to physiographic and synoptic conditions. Evapotranspiration on tundra and precipitation were found to be homogeneous in horizontal direction but strongly differentiated in the vertical. The heat balance measurements carried out in previous years mainly over glacier surfaces were supplemented by measurements over the tundra of the surrounding bare land. Field data was collected for 4 months and a computational model designed to assess the amount of heat advected on to the glacier surfaces.

Automatic weather stations (J. Whiting and J. Scott)—The two Australian-made automatic weather stations continued to operate successfully for their fourth continuous year. Replacement of the electrolytic capacitors by special low temperature components and some improvements in the power supply resulted in 90% data recovery for both the six-sensor station at the equilibrium line of the White Glacier and the two-sensor station on bare land at the Base Camp. During the summer the latter station was moved to the accumulation area (1542 m a.s.l.), and the Ott digital punch tape station (prototype II) with eight sensors was established at the Base Camp. The two-sensor Ott station (prototype I) was set-up on the tongue of the White Glacier. These four long-term automatic recording stations cover the mesoclimatic space governing the mass balance of the Baby and White Glaciers. Laboratory and outdoor tests under Montreal winter conditions are in progress on a magnetic tape recording station.

Glacier movement (A. Iken)—During the second summer of detailed observations, short-interval measurements (2-6 hours) at selected profiles on the White and Thompson Glaciers were carried out simultaneously with measurements of stream discharge and water-table fluctuations in moulins. Prior to the onset of melt, no short-term velocity fluctuations greater than the error limits were observed, but during the melt-season changes in glacier surface velocity and in run-off quantities show a strong relationship.

Photogrammetric measurement of ice ablation (K. C. Arnold)—Field data for a methodological study of ice ablation were collected on the White Glacier. The change in surface elevation, resulting from loss due to melt and gain due to glacier flow, was measured with a Wild P-30 phototheodolite from nine base lines. Artificial and natural targets were employed. Preliminary analysis indicates that elevation changes of 10 cm can be detected up to a distance of 1000 m from the camera. Horizontal and vertical movement as well as ablation were measured on some 25 stakes in the area throughout the season.

Glacial history (T. Caflisch)—The limnology and sedimentology of two glacial lakes (Colour Lake, 80 ft deep; Phantom Lake, 600 ft deep) were continued. Temperature profiles were measured throughout the season and samples taken for chemical analysis. Bottom sediments were collected with a modified piston sampler using the lake ice as a working platform.

(i) DEFENCE RESEARCH BOARD, DEPARTMENT OF NATIONAL DEFENCE, OTTAWA (G. Hattersley-Smith)

Tanquary Camp on northern Ellesmere Island was operated from mid-April until mid-June. Logistic support was provided by Canadian Forces C-130 ("Hercules") aircraft from Ottawa to Alert, and by chartered DHC-3 ("Otter") aircraft.

Ward Hunt Ice Shelf—Measurements were made at 38 poles set in the ice rise on the north side of Ward Hunt Island and at 94 poles set in a 1 km-square grid on the ice shelf 5 km east of the island. These measurements showed a mean net deficit of 10 kgm^{-2} on the ice rise and of 110 kgm^{-2} on the ice shelf for the 1967-68 budget year. Seven holes were drilled in the Ward Hunt Ice Shelf and associated ice rises by J. B. Lyons and his two assistants from Dartmouth College, NH, USA, using a combination of mechanical and thermal methods. One of these holes penetrated the ice shelf where it was 47 m thick and apparently floating on salt water. The holes were drilled for the main purpose of obtaining accurate temperature profiles.

Gilman and Per Ardua Glaciers—During May routine mass balance measurements were made at poles set on the Gilman Glacier and adjoining ice cap, and on the Per Ardua Glacier.

F. Müller

DENMARK

THE 1969 RADIOGLACIOLOGICAL ACTIVITY OF THE TECHNICAL UNIVERSITY OF DENMARK

The second Greenland expedition of the Technical University was carried out in April-May 1969 and its purpose was to test a new radio sounding system developed at the university. The system operates at 60 MHz with pulses at 1.6 kW and pulse width variable in steps from 60 nsec to 1 μsec. The aerial was an antenna array of four dipoles mounted below the wings of a DC 4 aeroplane.

In all, 25 hours of flight were carried out over routes from about lat. 72°N to 60°N. Bedrock echoes were recorded almost all the time and echoes from layering in the ice were recorded over the greater part of the flight routes. The results may be summarized as follows. The maximum thickness recorded was 3200 metres. The minimum thickness observable was about 100 metres. Echoes from layering in the ice were detectable to depths of about 2500 metres in the central part of Greenland, with up to 20 layers being observed at some places. In a smaller area in mid-Greenland (the saddle around 68°N) bedrock echoes could not be detected because of large dielectric absorption in the ice. In another area (about 46°W, 68°N) bedrock echoes were masked by a multitude of echoes originating either from the ice surface or from rough layers in the ice. It is found that there is a good qualitative agreement between the measured signal strength and the calculated two-way dielectric absorption in the ice.

P. Gudmandsen

NEW ZEALAND

GLACIOLOGICAL STUDIES BY WATER AND SOIL DIVISION, MINISTRY OF WORKS

Seasonal Snow

Work has continued on the two courses in foothill areas, giving good yearly comparisons of snow cover duration, depths and densities.

Tasman Glacier

Balance measurements are continuing at seven points for obtaining specific balance measurements. No attempt has been made to obtain net balance figures in terms of volumes, because of the large areas that would have to be covered, (the glacier is 29 km in length by 3.5 km wide in the névé area). The following altitudes of the equilibrium line indicate the trend of recent balance variations:

Balance year	Altitude, Equilibrium line
1965	1730 m
1966	1970
1967	1820
1968	1690
1969	2200

Difficulties have again been experienced with losses of site marking stakes through overtopping and wind breakages. This season aluminium tubing is being used in place of the rigid P.V.C. piping previously used. Ablation stakes have been installed down to 1545 m altitude to allow the net specific budget curve to be extended to below the firn line.

Difficulties continue with end of season snow density measurements. Standard snow coring equipment will not penetrate the hard snow, which reaches densities of over 60 gm/cc, while pit studies have proved extremely arduous and have given unsatisfactory results.

I.H.D. Glacier Basin

A glacier basin has been selected and N.Z. Government approval has been given to follow an experimental programme of various balance studies. The glacier, the Ivory, is small, with an area of 2.7 km^2; it faces south, and lies to the west and windward of the New Zealand Southern Alps, S. Lat. 43° 8′, E Long. 170° 54′.

Snow measurements and elementary ice flow measurements have been carried out in the first season. Recently, most of the required structures have been installed, including a hut, automatic water level recorder and foundations for roofing this structure, and several meteorological instruments. It is intended to carry out continuous water balance, ice balance studies, and intermittent heat balance studies.

T. J. Chinn

WHAKAPAPANUI GLACIER, MT. RUAPEHU

Hydrological budget studies and glaciometeorological analyses were initiated in May 1968, and the 1970 research progress is associated with the continuation of measurements into the third successive budget year. The research is being undertaken by the Department of Geography at Massey University with financial assistance from the New Zealand University Grants Committee.

R. D. Thompson

ANTARCTICA

New Zealand Antarctic glaciology shifted into a new phase during the 1969-70 summer. With the near completion of the McMurdo Ice Shelf Project, a series of investigations was begun in the vicinity of the new Vanda Station in the Wright Valley, South Victoria Land.

In order to calculate the water budget of Lake Vanda, various measurements were undertaken. A timber and plywood weir was contructed across the Onyx River and continuous flow measurements were made between 5 December and 12 February. Lake water levels, water evaporation and ice ablation were also measured. At Vanda Station, a full meteorological programme is being carried out, and this data will be used in the lake budget calculations.

To supplement the glaciological work already carried out by the Institute of Polar Studies to the east on the Meserve and Bartley Glaciers, a glacier budget project was initiated in the Odin-Obelisk area. Based on a small hut (4300 ft a.s.l.) where regular meteorological observations were made, the survey team completed a general glaciological and geological reconnaissance of the region. Survey work was also carried out and used to make a map of the ridge and glacier system. A wide photographic coverage of the area was made, to help with geological and soil surveys and patterned ground investigations (comparable with those already made in the Wright Valley). Accumulation and ablation stakes were set out on the glaciers in the area.

During the measurements on the water level of Lake Vanda, it was discovered that, at certain times, a pattern of seiches developed within the lake itself. The magnitude of the seiches appears to correlate with the intensity of the wind in the valley, but further research will be required to confirm this.

Further elevation measurements on the McMurdo Ice Shelf completed this project, and the final reports and maps are now being prepared.

A. J. Heine

POLAND

In July and August 1968, a Polish Expedition (Polish Geographical Society) carried out investigations along the margin of S-Vatnajökull in the area of Skeidararjökull and Sidujökull. Nine scientists from several scientific institutions in Poland participated in the expedition.

In 1969, only field investigations on snow and rime frost in the Polish mountains were made, most systematically in the Karkonosze Range in the region of Mt. Szrenica by the Mountain Branch Observatory of the Meteorological and Climatological Department of Wroclaw University (leader A. Kosiba). These investigations, which have been continuous for many years, include fundamental physical parameters of snow cover and rime frost, radiation, and meteorological parameters, including also the foehn processes which are typical of these regions and which are very important in studies of water resources, especially in snow cover thickness and duration, melting and evaporation.

Interpretation of the following field work continued during 1969:

1. Glaciological and glaciometeorological investigations in SW Spitsbergen during Polish I.G.Y. and I.G.C. Spitsbergen Expeditions, 1957-1960.

2. Glaciological, glaciometeorological and periglacial investigations on the inland ice of West Greenland, in the region eastward of Arfersiorfik Fiord, Norde Ström Fiord and Sophiahavn, carried out during the 1937 Polish Expedition. (The delay in this work was caused by the loss of some expedition materials during the 1939-45 war.)
3. Glaciological and periglacial investigations in South Iceland along the margin of Vatnajökull in the region of Skeiderarjökull and Sidujökull, carried out by the 1968 Polish Expedition.

A. Kosiba

SWITZERLAND

Glaciological work in 1969 was carried out under the auspices of: Gletscherkommission der Schweizerischen Naturforschenden Gesellschaft (GK), Abteilung für Hydrologie und Glaziologie der Versuchsanstalt für Wasserbau und Erdbau an der Eidgenössischen Technischen Hochschule Zürich (VAWE), Eidgenössisches Institut für Schnee- und Lawinenforschung Weissfluhjoch-Davos (SLF), Abteilung "Low Level Counting" des Physikalischen Institutes der Universität Bern (LLC), Institut de Physique de l'Université de Neuchâtel (IPN) and Laboratorium für Festkörperphysik an der Eidgenössischen Technischen Hochschule Zürich (LFP).

ANNUAL SURVEY OF GLACIERS (GK & VAWE)

Accumulation and ablation were nearly balanced at all four glaciers where studies are carried out (Aletsch, Gries/Aegina, Limmern, Silvretta). Preliminary figures show that of 102 observed snouts 29 have advanced, 4 were stationary and 69 have retreated. Almost all of the advancing glaciers show true (dynamic) advances, since in the fall of 1969 almost none of the snouts were covered by old snow. The number of advancing glaciers has increased in the Valais and Bernese Oberland, while in the eastern part of the Swiss Alps only a few glaciers have continued to advance. (Kasser)

ALETSCHGLETSCHER (VAWE & GK)

Observations of the mass balance and the annual and seasonal velocities were continued. Methods of using AC current in wire markers for snow depth and the neutron probe for density have been refined and previous measurements were analyzed. (Föhn, Nobs)

JUNGFRAUJOCH ICE CAP (GK)

A high net accumulation of 2.0 m was observed, mainly due to the accumulation of wet snow in summer; in winter the dry snow is drifting away, and wind erosion in older layers may occur. (Haefeli)

STEINLIMMIGLETSCHER (GK)

A maximum longitudinal strain rate near the terminus of 8.7%/year was observed. The sliding velocity at the snout varied from 2.43 cm/day (14 Dec. 1968–6 July 1969) to 4.8 cm/day (6 July–17 Aug. 1969) and 3.9 cm/day (17 Aug.–3 Nov. 1969). The observed net ablation of 4.86 was approximately balanced by bed slip indicating a stationary terminus. (Haefeli)

GLACIOLOGICAL PROJECTS OF VAWE (Director Prof. G. Schnitter)

The consulting activity continued with little change from 1968 (ICE No. 30), but previously not reported investigations on the Grubengletsche above Saas Balen were carried out in relation to the catastrophic flood of 2 July 1968 caused by the sudden outbreak of an ice dammed lake or water pocket. In addition the following research projects were carried out: snow accumulation data of 50 stations were analyzed for their use in relation to long range run-off forecasts of the river Rhine; two lysimeters were installed for measuring the run-off from the snow cover. A statistical analysis of the correlation between meteorological factors and diurnal run-off of the Massa river (Aletsch) and Rosegbach (Roseggletscher) were carried out, and the influence of change of glacierized area on the summer run-off of the river Rhone at Porte du Scex were studied. A physical theory of steady state water circulation in channels in glaciers has been developed.

SNOW AND ICE STUDIES OF SLF

The remodelling of the laboratories at Weissfluhjoch has taken longer than expected, so that the experimental work could not be taken up again. Computer programmes for the processing of tomograph data have been established and tested. Hydrological investigations in the Dischma Valley were initiated at the beginning of 1969. Tritium content and $^{16}O/^{18}O$ ratios in the snow cover and in the run-off water have been compared for evaluating the retention of water during the melting period. (de Quervain)

GLACIOLOGICAL INVESTIGATIONS OF LLC

Preliminary tests for CO_2 extraction for ^{14}C-dating in a deep drill hole were carried out at Byrd

Station, Antarctica, in co-operation with USA-CRREL during the austral summer of 1968/69. The probe was lost in the operation because of power failure. New probes were built in the meantime and were tested in the following field season of 1969/70. Two different types of probes were used this time. With the dry-hole probe, limited to the depth of approximately 400 m, six total gas samples were collected for ^{14}C and ^{39}Ar datings at Berne. In addition the melt water was pumped to the surface for the extraction of ^{32}Si to be measured at the University of Copenhagen. The other CO_2 sampling probe is the deep-hole probe operating in deep fluid-filled bore holes, where the CO_2 has to be collected from the melt water using a strong basic ion exchange resin. Field tests were performed, but no sample collections were attempted. Successful ^{14}C datings were carried out, however, on CO_2 samples extracted from glacier ice on Storglaciären by Dr G. Denton of Yale University in 1966. The age of (140±330) years was found for a sample near the equilibrium line, and the oldest sample was dated at (2170±370) years at the terminus. The results seem consistent with the relatively slow motion of the glacier. (Oeschger, Stauffer)

BASIC STUDIES OF ICE

Proton channeling (IPN): The equipment was further developed, including the one necessary to grow ice crystals from the vapor phase. (Jaccard)

Electrical properties (LFP): Investigations of the dependence of electrical properties of pure and doped ice single crystals on hydrostatic pressure have been continued. Studies on zone refining of single crystals of pure ice are under way. (Gränicher)

SWISS PARTICIPATION IN THE INTERNATIONAL EXPEDITION TO GREENLAND (EGIG)

The 1968 field data of the nivological and rheological groups are being analyzed. (de Quervain, Haefeli, Federer, von Sury)

PERMANENT SERVICE ON THE FLUCTUATIONS OF GLACIERS (VAWE & GK)

Work on Volume 2, to be published in 1970, continued. (Kasser)

H. Röthlisberger

UNITED KINGDOM

BRITISH TRANS-ARCTIC EXPEDITION

Using the unique opportunity of a complete surface crossing of the Arctic Ocean via the North Pole, the British Trans-Arctic Expedition's glaciological programme was aimed at studying the change of surface topography on the Arctic Ocean in both space and time.

ICE TOPOGRAPHY

Ice thickness. Once the expedition had crossed the shear zone off the coast of Alaska and reached the pack ice, at least one measurement of ice thickness was taken each day, either with a CRREL hand-drill or by direct observation at floe edges in fractures. A total of 258 thicknesses was taken. While the expedition was camped on a floe between July 1968 and February 1969 the changing thickness of the floe was measured by hand drilling.

Change of topography with time. Twice during the summer a line of precise levels was made with a kern DKM1 theodolite along an old ridge and across a series of new ridges, to determine the effect of summer ablation on the surface profile of the ice-pack. The levelling was associated with photographs taken of the same ridges at weekly intervals. Ablation at the surface was measured daily at an ablatomoter consisting of two stakes frozen into the ice and joined by a taut cord used as a reference level. The overall thickness of the floe decreased by 45 cm during July and August.

During winter, the change in surface topography was recorded by daily reconnaissance of an area of 3-4 km radius from the winter hut. Width of new fractures, rate of ice growth in the fractures and ridging were all recorded.

Change of topography in space. A log of ice forms was kept throughout the journey. Between latitudes 75°N and 90°N along longitude 160°W a summary was drawn up at the end of each day. From 90°N to Spitsbergen records were kept of the estimated height of each pressure ridge crossed, its age (i.e. new, 1 year or old) and the thickness of the slabs forming the ridge. Most commonly, ridges are 200 cm or less in height and the slabs forming the ridge are 20-30 cm thick. Ridging of multi-year ice, although not common, was observed in several localities. The Beaufort Gyral contains fewer but more massive ridges than the Trans-Polar Stream but the latter contains more forms caused by divergent flow, i.e. polynyas and wide fractures on a regional rather than local scale. A large area of dirty ice containing sea-shells and driftwood was crossed at 86°N, 30°E.

METEOROLOGY

Micro-meteorology. A micro-meteorology programme was carried out in July and August 1968 and in the following months of December, January and February. Temperature, humidity and wind profiles were measured between the surface and 4m. Short-wave and total radiation and ice temperatures were also measured.

Snow accumulation. The snow which had accumulated on the ice was measured frequently in the period February to June 1968. Snow density was generally 0.29 and 0.31 g/cm^3 and the winter snow balance from 8-10 g/cm^2 on the floes.

PACK-ICE MOVEMENT

Throughout the expedition astrofixes were made to determine the party's geographic position. Azimuths were taken while the expedition was camped on a multi-year floe between July 1968 and February 1969 to measure floe rotation. The mean drift in July and August 1968 was NNE between 81°20′N and 84°00′N. By February, 1969 the floe's position was 85°49′N and 141°20′W after a long period of ENE drift. Change of the floe azimuth was usually less than 1° a day but reached several degrees a day over a 3-day period in December.

The Scientific work was sponsored by the Leverhulme Trust of Great Britain. The data will be studied by R. M. Koerner, presently working for the Polar Continental Shelf Project in Ottawa, Canada.

R. M. Koerner

U.S.A.

ICE SHEET DYNAMICS IN MARIE BYRD LAND

To test the several theories of ice sheet dynamics a three-season program was initiated during 1969-70, 50 km northeast of Byrd Station, by the Institute of Polar Studies, The Ohio State University. The principal theories being tested are (1) the regular ice flow theory of W. Budd and (2) the density imbalance theory of T. J. Hughes. Both theories predict the wavelength of the small-scale surface topography to be about 6 km as is found in the study area. Budd's theory ties the surface topography and strain rate field to the bedrock topography, whereas Hughes' theory has plumes of light, warm, ice rising like diapirs through the colder ice. Hughes' model is closely analogous to several models of convection in the earth's mantle.

The field area was selected to straddle the Byrd Station Strain Network, to have simple surface and bottom topographies and strain rates, and yet to be close to the Byrd Station bore hole. Field measurements include two surveys by trilateration with an AGA Model 6A Geodimeter and levelling with a Wild NA2 automatic level of a grid of stations spaced 500 m apart and covering an area of 12 by 4 km. The effect of variable snow accumulation and firn densification on the surface features will be obtained separately from pole height changes, shallow pit densities, and the direct measurement of vertical strain rates in the firn to 50 m at several locations. The seismic and gravity work of G. Dewart will be augmented to determine the bedrock topography in the study area.

I. M. Whillans

DECEPTION ISLAND, SOUTH SHETLAND ISLANDS

Heat and mass balance studies of a selected glacier basin and investigations of the effects of the recent volcanic eruptions on the glaciers of Deception Island were carried out during the 1968-69 and 1969-70 austral summers by expeditions from the Institute of Polar Studies (The Ohio State University). The selected glacier, which is on the west side of the island, is temperate (based on temperature measurements to 27 m depth) and the elevation of the equilibrium line is about 250 m. Mass balance was positive in each of the balance years 1968-69 and 1969-70; averaged over the glacier area it corresponded to about +0.10 m for each of the years. The volcanic eruptions in 1967 and 1969 took place 8 to 10 km from the selected glacier and did not significantly affect the heat and mass balances of the glacier. The 1969 eruption was subglacial, and opened a series of fissures, mostly 30 to 60 m deep, through the accumulation area of the glacier on the east side of the island. The mass balance history of this area from 1910 to the present was determined from the fissure walls. The mass balance history of the selected glacier back to about 1850 is now being determined in the laboratory from ice cores from the glacier.

O. Orheim

SUGGESTIONS FOR THE COLLECTION OF GLACIOLOGY DATA

by Richard P. Goldthwait

(Member of the Glaciology Panel of the U.S. Committee on Polar Research, National Academy of Science)

Purpose

Here are suggestions of the sorts of data which have proven useful and necessary in studies in the broad field of glaciology. Need for this list stems from the very interdiciplinary breadth of this new field involving as it does: geophysics, geochemistry, climatology, geology, hydrology, pedology, and oceanography. Scientists working on one speciality in an out-of-the-way place, near snow and ice, or on the imagery of remote polar areas, have the opportunity to collect much data of fundamental interest and need to many glaciologists. There is also the new student glaciologist who is concerned with a check list of facts ancillary to his own problem.

These data are sought by and stored in the World Data Centers for Glaciology. Indeed this list was generated in conjunction with World Data Center A in New York (W. O. Field in charge) through the efforts and suggestion of the Glaciology Panel of the Committee on Polar Research, U.S. National Academy of Science. Portions of the list were contributed by each of sixteen different glaciologists, specialists in that particular area:

A Snow: C. S. Benson
B Glacier meteorology: S. Orvig
C Glacier maps: F. Müller
D Variations in snow-ice limits: W. O. Field
E Avalanches: E. R. LaChapelle
F Physics-chemistry: B. Kamb
G & H Glacier teconics and geophysical profiling: C. R. Bentley
I Mass budgets: F. Müller
J Hydrology: M. F. Meier
K Lake-river ice: L. W. Gold
L Sea ice: N. Untersteiner
M Permafrost: T. L. Péwé
N Periglaciology: A. L. Washburn
O Polar soils: J. Brown
P Radiometric measurements: M. Stuiver
V Organizations: J. C. Reed

Items Q to U were considered essential to mention for completeness, because they are often essential to glaciology, but no detail is specified. This does not make the list complete or final for the serious research worker in such a fast growing field, but it does pinpoint the data which are commonly needed at this stage. International Hydrological Decade requirements, for example, do go further in detail, but few checklists or guides will have the full breadth of glaciology which this expresses. Some other available detailed guides are:

Østrem, G. and Stanley, A. (1969) Glacier mass balance measurements; a manual for field and office work. Canadian Dept. of Energy, Mines, and Resources, and Norwegian Water Resources and Electricity Board. 125 p. Available on request.

Technical papers in hydrology: a contribution to the International Hydrological Decade. UNESCO, IASH (cost $4.00)—

1. Perennial ice and snow masses. 1970, 59p.
2. Seasonal snow cover. 1970, 38p.
3. Variations of existing glaciers. 1969, 19p.
4. Antarctic glaciology in the International Hydrological Decade. 1969, 16p.
5. Combined heat, ice and water balances at selected glacier basins. 1970, 20p.

Data Centers

Not the least of the objectives of this presentation is to encourage all scientists to submit analyzed and summarized glaciological data promptly to a World Data Center. Since all three centers (A, New York, U.S.A.; B, Moscow, USSR; C, Cambridge, England) exchange all material with each other, submission of *three* copies of any study of snow and ice, or related features, to any one center will supply all three. By and large these materials will comprise:

(1) All *published* papers, reprints, books.
(2) Published maps (very important).
(3) Indexes of new data and especially photographs held on file by the investigator or his sponsor.

The subject, glaciology, is any study involving natural snow or ice and including those studies by artificial replica or by analogue. This broad view of glaciology has always been the accepted view of the Glaciological Society (Jour. Glaciol. vol. 1, no. 1, 1947, p. 3; and vol. 3, no. 29, 1961, p. 802). It will be easiest for future glaciological research if:

(1) all data are recorded in the metric system and given (at least parenthetically) in metric in published works.

(2) near-standard quarto (22 x 28 cm) or octavo (14 x 22 cm) page size is used. Records may be recorded on standard microfilm. Photos are best enlarged to 13 x 18 cm or 18 x 26 cm glossy format.

(3) simple arabic numbers and letters are used (printed by machine or hand) and in common English words if possible. In World Data Centers other languages are welcome.

Additionally each center is to some extent a national or regional collecting agency. These additional items are recorded in some sort of data retrieval system for the information of any who enquire:

(1) *Unpublished* reports and maps (progress, grant, or contract).

(2) Unpublished but processed and prepared tables, summaries, sections, annotated photographs if they have any possible lasting value.

(3) Microfilmed information or punched data cards of specific programs open to future extended or repeated study, *if not storable* with the investigator.

(4) Microfilm of glaciological theses, dissertations, or prepublication summaries.

These materials are of most use to the new investigator, or investigator who seeks a new example, if they are received *right* after analysis. Duplicating studies and poorly oriented effort can be avoided if materials are submitted at once, well before publication, to the national-regional archive. The author-donor's right to first use and published copyright is scrupulously respected.

These data centers can be of great value to you, the scientist, if they have up-to-date lists, retrieval systems, files of a particular glacier or polar area, or the kind of data which will just solve or exemplify the theoretical or empirical relation you are seeking. Hopefully, all submitted materials can be made open to all; in any case published materials of the World Data Center are open by international agreement.

Check list of subjects

The subjects collected by Data Centers and by the national archive are listed below by experts in each field. Any available material containing one or more of these studies is urgently desired.

A. SEASONAL SNOW COVER

1. Dates: a. first snowfall of season
   b. first snowfall lasting through winter (days duration snow cover)
   c. final disappearance of snow cover
2. Depth: a. number of samplings in measure
   b. occurrences of "trace"—how entered?
   c. variation with topography
3. Storm: direction of prevailing storm movement; variability
4. Surface features: drifts, sastrugi, melt crusts, melt channels
5. Snow pack: pit wall description, date, just after time of maximal accumulation
   a. time profiles of layers
   b. deposited snow crystal types
   c. secondary melt crusts and glands (ice)
6. Temperature profile: especially top and bottom of pack (in pit?)
7. Density: a. each snow layer, giving method
   b. calculate water equivalent
8. Soil beneath: a. frozen? depth frozen layer
   b. dried out? depth dry layer

B. GLACIER METEOROLOGY

1. Radiation: over glacier surface *and* over terrain nearby
   a. solar, incident and reflected
   b. infrared, incident and emitted
2. Profiles: over glacier *and* over surrounding surface
   a. wind velocity
   b. temperature
   c. humidity
3. Turbulence: best recorded on magnetic or punched tape
   a. wind, fast response
   b. temperature
   c. humidity
4. Temperature: surface and subsurface
5. Cloud conditions: sky cover and density, accurate
6. Particulate matter in atmosphere over glacier: dust, smog, ice crystals, fog droplets, etc.

C. GLACIER MAPS

1. Printed maps of glaciers
   a. distribution of glaciers, small scale
   b. contour maps, large scale — with date and means of survey
   c. glaciological (drainage) maps, large scale
2. Unprinted, manuscript, plots—Ozalid, Xerox, Thermofax
3. Orthophoto maps—glaciers, snow banks

4. Location maps
   a. ice thickness profiles—with method of determination (seismic, gravity, echo, radar)
   b. mass budget—accumulation, ablation, motion stations, met. stations

D. VARIATIONS IN EXISTING AND HISTORICAL LIMITS OF SNOW AND ICE

1. Dated observations of transient snow line: by traverse, airplane, airphotos, spacecraft
   a. map position or photograph
   b. altitude (m) and orientation
2. Accumulation limit observations: date, map position, slope, and method used
   a. snow line—maximum, seasonal
   b. firn limit—exposed edge old snow
   c. equilibrium line
3. Measurements of glacier variation: rates by year, decade, or century from:
   a. change in position of the terminus, by survey or by dated moraine
   b. change in area of the glacier or ratio of change to total area of glacier
   c. change in altitude of the ice surface, profiles, with or without terminal position change
   d. changes in volume of the glacier, from data above, and extrapolation to a regional basis

E. SNOW AND ICE AVALANCHES

1. General occurrence: publications on scientific-technical aspects
   a. mountain weather, precipitation intensity, snow crystal types, and storm patterns
   b. formation, snow conditions, snow density
   c. behavior, velocity, friction, cushioning, impact
   d. prediction
   e. control
2. Specific avalanches and avalanche areas
   a. preceding conditions — especially precipitation intensity, snow density, crystal types
   b. time profiles and structural features of cover
   c. fracture line profiles
   d. record of occurrence—photographs, movies
   e. destruction—accidents, rescue
   f. maps — detailed, showing size, location, date or frequency

F. PHYSICS AND CHEMISTRY OF SNOW AND ICE

1. Mechanical properties: described by careful laboratory tests, or field recording, summary and analysis
   a. density: porosity, permeability; firn-ice transformation
   b. acoustic properties
   c. elasticity: compressibility
   d. creep properties: viscoelasticity
   e. strength, hardness, ram hardness, cleavage, fracture
2. Energy properties: measured by tests
   a. electrical
   b. radiative and optical properties; spectra (IR, Raman), thermoluminescence
   c. temperature properties: conductivity, thermal expansion
   d. thermodynamic properties; lattice vibrations, vapor pressure
3. Structural properties
   a. crystal structure: defect, subgrain
   b. crystallization: nucleation, crystal habit, epitaxy
   c. surface characteristics: etching, melt figures, vapor figures, regelation, sintering
   d. petrography: granularity, tecture, fabric
   e. macroscopic structure: primary-secondary, planar-linear
4. Composition
   a. isotopic composition ($^{18}O/^{16}O$, D/H)
   b. gas content: composition, distribution, pressure
   c. salt content: composition, distribution
   d. particulate matter, especially organic
   e. trace element content (e.g. Pb)

G. GLACIER TECTONICS: FIELD MEASUREMENTS

1. horizontal movement and strain rates
2. drill hole deformation
3. bed slip
4. surges

H. GEOPHYSICAL PROFILING

1. Stations occupied, list
   a. locations — map coordinates
   b. precise surface elevation: method and types of corrections applied
   c. specific geophysical instruments used (e.g. "LaCoste & Romberg" 5; *not* "gravimeter")
   d. geophysical anomaly maps
   e. geodetic maps

2. Gravity observations, table
    a. observed values
    b. computed free air anomalies
    c. computed Bouger anomalies with assumptions made and densities used.

3. Seismic data tabulated, each station
    a. vertical reflection times
    b. reflection record reproduction, one per station
    c. refraction velocity vs distance and depth
    d. wide angle reflection times and "distances".

4. Electromagnetic sounding
    a. profiles of vertical reflection times.
    b. tabulated echo times at seismic reflection stations.

5. Magnetic observation: plotted profile of total or component magnetic field

6. Electrical resistivity profiles
    a. type of configuration
    b. apparent resistivity curves

7. Drill hole logging.
    a. identification of drill hole
    b. type of measurement
    c. tabulated parameter values vs. depth

I. GLACIER MASS BALANCES

1. Map(s) of each glacier showing precise area of
    a. accumulation, in water equivalent (cm)
    b. ablation, ditto
    c. mass balance

2. Specific mass balance parameters (Jour. Glaciology v. 4, n. 33, 1962, p. 252-261) need to be given, together with *probable error,*
    a. for the whole glacier: mean (gross) accumulation, mean (gross) ablation, mean balance (m)
    b. glacier area (m^2)
    c. total gross accumulation and ablation and balance (m^3)
    d. height of equilibrium line and depth of glacier
    e. for the accumulation area only: mean net accumulation (m) area (m^2) and total net accumulation (m^3)
    f. for the ablation area only: mean net ablation (m) area (m^2) and total net ablation (m^3)

3. Graphs of
    a. accumulation, ablation, mass balance, area distribution as a function of altitude
    b. accumulation, ablation, mass balance as a function of time

4. Apparent values, if the more significant values above are not available, clearly identified:
    a. apparent accumulation
    b. apparent ablation

J. GLACIER HYDROLOGY

1. Inventories of glaciers: including all perennial ice, following Commission of Snow & Ice, IASH, proposal
    a. area of permanent snow and/or ice (m^2), with accuracy indication
    b. depth (m) and volume (m^3), with probable error

2. Discharge measurements: water from glaciers or melting snow, indicating instrumentation used
    a. daily discharge curves (graph) or table, with accuracy
    b. seasonal discharge graph or table, with limits or error
    c. map of catchment area or calculation with topographic character if possible
    d. rating curves, if possible

3. Energy budget and runoff: studies relating meteorology to discharge
    a. correlations discharge to climate, including satellite data
    b. correlations discharge to regional snowline trends
    c. estimation and forecast of yield, methods

4. Ablation process and meltwater routing
    a. maps and tracing of glacier water routes, with method
    b. hydrostatic conditions, diagrams, time graphs for englacial waters, water tables in ice
    c. snow and ice melt process

K. LAKE AND RIVER ICE

1. Location and area
    a. surface area (m^2), length and width of water body
    b. depth, average and maximum (m) and slope (m/m) if moving

2. Freeze-up
   a. date of first seasonal ice: sheltered areas vs continuous cover
   b. sheet ice (%)
   c. consolidation of floes (%) or conglomerations of frazil
   d. anchor ice, and any supercooling of water
3. Characteristics of cover
   a. date and location of observation(s)
   b. thickness (cm): clear ice, white ice, floe or frazil
   c. average snow depth on ice; portion of ice area snow-free (%)
   d. estimated average maximum for each parameter above
4. Break-up
   a. date of active melt nearshore
   b. date central area free: broken by wind or flow
   c. ice jams: date, how formed, average thickness (m) change in water level (m)

L. SEA ICE

1. Position of sea margins: map, shape, area (km^2)
   a. positions of drifting stations, buoys, radar targets
2. Transects of ice-covered seas
   a. photographs, airphotos, satellite photography
   b. counts of leads, pressure ridges
   c. thickness, average, frequency distributions
3. Climatological data: additional to standards obs deposited e.g. at Ashville, N.C., U.S.A.
   a. radiation observations: visible, infrared, albedo
   b. wind: profile, gustiness
   c. snow cover: depth, density
   d. temperature-humidity profile, if more elaborate than synoptic code
   e. profiles in the boundary layer, and computations or measurements of turbulent fluxes
4. Ice data
   a. ice temperature: surface, and at stated depths (°C)
   b. ablation or accretion rates, measure (cm)
   c. puddling, dates onset and freeze-over
   d. salinity of ice, natural and artificial desalination
   e. water just under ice: stated depth (m), temperature, current, salinity, supercooling
   f. field observations on physical properties and composition
5. Laboratory experiments: data on physical, chemical, and petrologic properties

M. PERMAFROST

1. Distribution, specific location
   a. area, maps, airphotos, satellite photos
   b. classification of permafrost
   c. depth, vertical distribution, where known
2. Properties, with specified depth
   a. composition, ice content (%)
   b. chemical content
   c. temperature gradient, profile
   d. seismic and electrical properties
3. Formation, with radiometric dating if possible
   a. climatic trends, records
   b. vegetation influence, paleoecological evidence
   c. ground-ice morphology
4. Degradation—photographic, map, or descriptive records of
   a. thaw lake: distribution, migration
   b. disturbance: man-made, river erosion, slope movement
5. Materials, soil
   a. sampling methods
   b. photogrammetry, ground patterns, comparative studies over decades

N. PERIGLACIAL PROCESSES

1. Weathering information
   a. physical processes
   b. chemical processes
   c. climatic record associated
2. Erosion
   a. rates: eolian, fluvial, mass-wasting
   b. morphology: forms
3. Solifluction and frost creep
   a. rates of movement, with slope angle, vertical velocity profile
   b. conditions: thermal regime, material and grain size, moisture content
   c. special weather conditions associated with unusual rates
4. Patterned ground studies—quantitative and three dimensional
   a. rates of growth, with thermal cycle, moisture content, energy studies
   b. mechanics of growth, with slope angle, material and grain size, moisture content and transfer
   c. movement vectors

O. POLAR SOILS

1. Distribution — by map, airphoto, satellite photo
   a. classification and description
   b. areas, maps (all scales)

2. Properties: quantitative counts and percents, with sampling method
   a. physical: moisture content, consistency, standard Soils Manual properties
   b. chemical: mineralogy, key elements (Ca, Mg, Si, C)
   c. thermal and electric: depth profiles
   d. thaw zone: seasonal changes in each of the above

3. Genetic processes
   a. rate of soil formation
   b. types of weathering
   c. evaluation of climate, parent composition, time and slope

P. RADIOMETRIC MEASUREMENTS

1. Location—with date and collector's name for reference
   a. area and precise spot (lat. and long.)
   b. depth and stratigraphic position
   c. substance used for analysis

2. Reported dates — with identifying material above
   a. laboratory and number of isotope (^{14}C, ^{3}H, ^{32}Si)
   b. date in years B.P. (before A.D. 1950) and B.C. date
   c. standard error, based upon number of ^{14}C counts
   d. standard half life used and corrections made

3. Isotopic ratios — with identifying description (1)
   a. ratio used ($^{18}O/^{16}O$)
   b. chemical procedure and standard selected
   c. estimated error

Q. GEODETIC DATA AND PHOTOGRAMMETRY

e.g. satellite services, triangulation systems

R. DATA OF UNUSUAL SIGNIFICANCE

e.g. jökulhlaup

S. DRILL SITES AND CORE STORAGE

exact locations, availability

T. EQUIPMENT AND TECHNIQUES

e.g. self-operating multi-month weather stations; weather stations; ice drills

U. STANDARDIZATION OF MEASUREMENTS

V. ORGANIZATIONS AND FACILITIES

1. Universities (domestic and foreign)
   a. departments — subject, chairman, address
   b. institutes or centers — title, director, address
   c. occasional workshops, seminars, courses—title, number, supervisor, address
   d. data needed in each of the above: number of researchers, special fields of interest, publications, laboratory facilities available

2. Non university organizations and Institutes (domestic and foreign) (i.e. American Geographical Society, Arctic Institute of North America)
   a. similar information to d. above

3. Field facilities (domestic and foreign): besides name and location
   a. organizational tie (i.e. Inuvik Laboratory, Department of Northern Affairs and National Resources, Canada or Arctic Research Laboratory, University of Alaska)
   b. facilities and services available
   c. administration

SIGURDUR THORARINSSON

Sigurður Thorarinsson was born in 1912 (though many might guess 1922 from his appearance and behaviour) and is known to the readers of ICE as the Icelandic glaciologist. Other scientists know him as a famous vulcanologist and yet others as an expert on the cultural development of Iceland over the last 1000 years since the Viking settlement. In fact, Sigurður is one of those rare polyhistors with a considerable knowledge of the human as well as of the natural sciences.

His academic studies began with a year in Copenhagen, but he moved to Stockholm in 1932 where he became one of the top students of Hans Ahlmann, Gerard De Geer and Lennart von Post. He also made himself known as a devoted member of Ahlmann's "post-seminar", where the intellectual and cultural contributions and the gay or sad songs of Iceland, Scandinavia and many other countries meant more than glacier mass balance, varve chronology and pollen analysis.

He had his first experience of large scale field research as a participant in the glaciological expedition to Vatnajökull in 1936, led by Ahlmann and Eythórsson, and it was at this time that he first used volcanic ash for dating purposes. The eruption of the "Grimsvötn" volcano beneath the western part of the ice cap had spread an ash layer over the whole of Vatnajökull between 30 March and 8 April 1937 and this formed an excellent key horizon for stratification studies.

During the years to come Ice and Fire became the two main ingredients in Sigurður Thorarinsson's research and publications. He continued Ahlmann's work on Vatnajökull and his article on "Present glacier shrinkage and eustatic changes of sea-level" (1940) has been quoted regularly in text books and articles.

However, his interest in volcanic ash and airborne volcanic material absorbed more and more of his time. He realized that the ash layers spread over large parts of Iceland offer unique reference horizons, and he started a large scale mapping programme of all the distinct ash-falls of Hekla, Katla, Askja, Grimsvötn, Öraefajökull and others. From the old archives he obtained information about disastrous ash falls back to about 1000 A.D., and after years of work he had all the prominent ash layers dated: thus Icelandic "tephrochronology" was developed. Tephrochronology gave him a tool for further studies of cultural development, climatic change, history of vegetation, soil erosion by dry winds from the highlands, and, of course, for glaciological studies. His dissertation, "Tefrokronologiska studier på Island", was published in *Geografiska Annaler* (1944).

The Hekla eruption in 1947 offered magnificent research projects—important papers were published, a beautiful and dramatic film was produced, but one of his close friends was killed by a falling block of lava. The birth of the new island, Surtsey, was no less dramatic, and Sigurður was one of the first ashore—it is a wonder that he is alive to tell the story. In spring 1970 he was busy again with an active volcano, when Hekla erupted for the first time in 23 years. In recognition of his contributions to Iceland's cultural and natural history Sigurður Thorarinsson was awarded the Vega Medal of the Swedish Society for Anthropology and Geography in April 1970.

However, Thorarinsson would not be Sigurður to so many people if he was a scientist only. Though he is a professor of geography and geology, much of his time is spent on liaison with earth scientists of other countries. He works as a scientific adviser to numerous expeditions, as a scientific guide, unpaid travel agent and general factotum. Even NASA has found that their astronauts need excursions with Sigurður Thorarinsson in the lava and ash desert west of Vatnajökull. He ran the joint meeting of the Glaciological Society and the Icelandic Glaciological Society in June 1970 in a very efficient and pleasant way. Participants from eleven countries had a rewarding and exciting week in the field, and it seemed to them that Sigurður had laid on a special display of Hekla pyrotechnics, which threatened to turn several leading glaciologists into enthusiastic vulcanologists. Their evenings were enlivened with songs from all eleven countries; it was Sigurður who knew every song—sometimes more verses than anyone else. This would not be surprising to another Icelander, for he is well known for his singing and for the songs he has written. What other glaciologist could claim to have had some songs in his country's Top Ten list?

If we were in the position of being head of a rich international scientific foundation, we would relieve Sigurður of his duties as a university teacher, we would give him a secretariat for dealing with his international contacts and we would command him to do research only. He has less than 10 years to retirement, and he is the only man (and there will probably never be another) who can deal with three of Iceland's unique characteristics: the volcanoes, the glaciers, the ancient hand-written sagas, parish registers, and other Latin documents. It is remarkable, and a measure of his unfailing generosity, that with these constant demands on his time he should have achieved so much in the scientific field.

ANNUAL GENERAL MEETING 1970

MINUTES OF THE ANNUAL GENERAL MEETING OF THE GLACIOLOGICAL SOCIETY, 7 MAY 1970 AT THE UNIVERSITY CENTRE, CAMBRIDGE, ENGLAND

The President, Dr V. Schytt, was in the Chair.

1. The Minutes of the 1969 Annual General Meeting, published in ICE No. 31, December 1969, were approved, and signed by the Chairman.

2. The President gave his report for 1969-70.

When we last met for an Annual General Meeting, last September, it was during a symposium which marked one of the high points in the history of our Society. 110 of our members and 30 other interested glaciologists discussed the hydrology of glaciers—problems of vital importance to the world's population. Because of the devoted work of the organizing committee, of the Secretary and her helpers and because of the eminent guidance by my predecessor as President, Professor John Nye, the Symposium became a great success and it was an appropriate setting for presentation of the Seligman Crystal to John Nye.

The tour of Scotland and the tour of Norway measured up to the same high standards as the Symposium, being as well planned and conducted, and favoured, as they were, by glorious weather—not to forget that any group of glaciologists travelling together are likely to have a pleasant time.

After a good meeting comes a long period of very hard work for our editors. I think we all agree that the by far most important branch of our Society's various activities is the publication of our Journal, and this year our editors, John Glen, Ray Adie, Doris Johnson and Charles Swithinbank, have accepted the editing of the Symposium proceedings in addition to their responsibility for the Journal. How they manage to carry this heavy burden is beyond my comprehension, but what I do understand is that all members and particularly all the Council members feel a sincere gratitude to the editors. Anything that can be done to ease their work will be given the highest priority by the Council.

Dr Glen, the senior editor, attended the first conference of EDITERRA: European Association of Earth Science Editors, in Belgium last December. The aim of this organization is to work toward conformity of style, terminology, referencing, &c among European earth science editors, and I am sure that no journal was better represented than ours. In fact, I believe our Journal is so perfectly edited that it can stand as a pattern for any earth science publication.

We are anxious to get as good an international coverage as possible and the proportion of non-British members has increased from 60% in 1962, when we became the Glaciological Society, to 75% in 1970. This is very encouraging. We are also trying to establish, and keep, good contacts with other societies interested in snow and ice. Mrs Richardson and Professor Nye both attended the annual meeting of the glaciological section of the Société Hydrotechnique de France about two months ago, and both read their papers in French.

The preparations for the joint meeting with the Icelandic Glaciological Society are proceeding very well. A group of twenty-five glaciologists from North America, Australia and Europe will visit Iceland from the 18th to the 26th June, and spend most of the time in the field with their Icelandic colleagues.

Interest in the Society is growing in several countries and there is a possibility that new branches will be formed in the near future. The Council looks upon such branches as very effective means for promoting the science of glaciology and for making our Society more truly international.

The total membership has risen from 822 in May 1969 to 863 today. 91 new members have joined in the past year, compared with 72 in the previous year. The number of Library subscribers has risen slightly over the past year, and now stands at 598. The total circulation of the Journal of Glaciology, if we include the copies we distribute in exchange for other publications, is now 1500.

The Treasurer's report which will be read to you shows that the Society's finances are sound—but we are not rich, and we will have to continue the drive for increased membership. This is the last report during Terence Armstrong's period as Treasurer and I would like to express the Society's thanks and great appreciation for his long and devoted service in a period marked by rapid growth in the activities of the Society.

You will have noticed that the A.G.M. has been expanded to cover two days this year. This is to provide more time for hearing reports on current research. It has been evident during the last few years that there is a need for this type of meeting, and we are trying to meet this need in as informal a way as possible.

3. The Acting Treasurer, Dr J. A. Heap, introduced the accounts for 1969 by recalling the expectation of the Treasurer, Dr T. E. Armstrong, that the income and expenditure of the Society would be in balance for the 1969-70 financial year. The Society had, in the event, made a surplus of £473. He reported, however, that because of an auditing error, £960 of income for the year 1969-70 had appeared as income in the accounts for 1968-69. Taking this into account the true surplus for 1968-69 was £723 (£1,683 less £960) and the surplus for 1969 was £1,433 (£473 plus £960). £918 had been used during the year for reprinting back numbers of the *Journal of Glaciology* and of *Ice*. This represented an investment for the Society since back numbers sell at a price higher than the printing costs.

He ended his report on a cautionary note by observing that printing costs for the *Journal of Glaciology* and *Ice* had risen during 1969 and would probably rise considerably in the coming years, and that the editorial and secretarial functions of the Secretary were now stretched to the limit. To meet rising printing costs and to provide additional help for the Editors and the Secretary would require the Society to do all that it could to increase its membership.

4. Election of auditors for the 1970 accounts. Dr C. W. M. Swithinbank proposed and Dr R. J. Adie seconded that Messrs. Peters, Elworthy and Moore, of Cambridge, be elected auditors for the 1970 accounts. This was carried unanimously. The Meeting also approved the Council's wish that the auditors draw up detailed accounts of the 1969 Symposium for presentation at the 1971 Annual General Meeting.

5. Elections to the Council 1970-73.
After circulation to all members of the Society of the Council's list of nominees, no further nominations had been received. The following people were elected unanimously:

Vice-President	J. W. Glen
Treasurer	J. A. Heap
Elective Members	L. Gold
	R. P. Goldthwait
	C. A. M. King
	H. Röthlisberger

6. Appointments to Posts and Committees.
Under Rule 10 of the Constitution, the Council of the Society had made the following appointments, subject to the approval of the Annual General Meeting:

Special Post of Founder: Gerald Seligman.

Awards Committee (for Seligman Crystal and Honorary Membership): H. C. Hoinkes, M. F. Meier, J. F. Nye, the President (ex-officio), the Secretary of the Society as Secretary.

Library Committee: J. W. Glen, B. B. Roberts, the Treasurer (ex-officio), the Secretary of the Society as Secretary.

Research and Education Fund Committee: Sir Vivian Fuchs, J. F. Nye, H. Röthlisberger, A. L. Washburn, the President (ex-officio), the Treasurer (ex-officio), the Secretary of the Society as Secretary.

The appointments were confirmed unanimously.

MEETINGS

THE GLACIOLOGICAL SOCIETY ANNUAL CONFERENCE, 1970

The conference was held at the Scott Polar Research Institute, Cambridge, England, on 7 and 8 May. The papers read were as follows:

- J. G. Paren—Impurities in glacier ice and their effects on electrical behaviour.
- R. W. Myatt—Nuclear magnetic resonance studies into the nature of liquid water in ice.
- C. W. M. Swithinbank—Icebergs and satellites.
- M. de Quervain—Snow and avalanches in winter 1969/70 in the central Alps.
- G. Hattersley-Smith—Recent work in Ellesmere Island.
- D. Drewry—SPRI/NSF radio echo-sounding in the Antarctic—a report on the 1969/70 season.
- V. Schytt—An attempt at a combined study of the ice and water balance for a partly glacierized drainage basin.
- H. H. Lamb—Climatic variation and its causes—an up-to-date assessment.
- H. Röthlisberger — Applied glaciology in Switzerland.
- R. H. Thomas—Bottom melting and particle paths in the Brunt Ice Shelf.
- E. R. Pounder—Ice movement in the Gulf of St. Lawrence.
- E. R. LaChapelle—Core drill development on the Blue Glacier.
- G. de Q. Robin—Further thoughts on glacier surges.

The Society's Annual Dinner was held in the University Centre at 7.45 p.m., 7 May.

THE GLACIOLOGICAL SOCIETY

BRITAIN

5 MAY 1970, Bristol University Geography Department — "Some thoughts on glacial abrasion" by H. Röthlisberger.

13 MAY 1970, Aberdeen University Geography Department — "Applied glaciology in Switzerland" by H. Röthlisberger.

SOCIETE HYDROTECHNIQUE DE FRANCE

The Glaciological Section held its annual meeting in Paris, 17-18 March 1970. The following papers were given:

A. Bezinge—Le lac glaciaire du Gorner.

Mme. Gaudet—Les crues des rivières glaciaires.

J. F. Nye—Récent travail théorique sur le glissement des glaciers.

H. Richardson—Compte-rendu du Symposium de la Glaciological Society sur l'Hydrologie des Glaciers (Cambridge, Sept. 1970).

P. Kasser—Les variations des glaciers suisses en 1968/1969.

R. Vivian—Le recul récent des glaciers français.

R. Vivian—La glaciation himalayenne au niveau de l'Himalaya Népalais (Dhaulagiri-Annapurna, Everest).

M. Tonini—La mesure de la hauteur et de l'équivalent en eau d'une couche de neige.

M. Meyer—L'équipment de la nouvelle station nivo-météorologique du Col de Porte.

M. Plas — Le Bulletin climatologique du Cedonigla.

P. Guillot—Les échanges d'énergie entre la neige et l'atmosphère; projet d'un modèle mathématique et application de celui-ci auz mesures du Col de Porte.

A. Poncet—Rénovation des eaux urbaines usées et recharge des réserves phréatiques, par irrigation forestière fertilisante.

ENGINEERING GLACIOLOGY, USSR

The All-Union Conference on Engineering Glaciology, in which 37 institutes and laboratories were represented, was held from 6–9 April 1970 in Novosibirsk. 43 papers and reports were presented. The Conference confirmed the main trends and direction of research in engineering glaciology.

Problems of engineering glaciology

G. K. Tushinskiy—Physico-geographical aspects of engineering glaciology.

A. K. Dyunin—Engineering glaciology as an engineering and physical science.

K. M. Korzhavin—Problems of ice engineering.

A. U. Arsentiev et al—Engineering glaciology and mining.

D. M. Melnik—Engineering glaciology on railway transport.

G. V. Byalobzheskiy—Engineering glaciology and highway in winter conditions.

N. T. Makarychev—Engineering glaciology and afforestation.

V. A. Cholov—Problems of engineering glaciology in energetics.

Investigations on snow and ice

A. M. Elmesov and B. A. Anfilofiev—Field and laboratory investigations of the physical and mechanical properties of snow cover.

V. U. Fedotov—Engineering research into the formation of antarctic ice.

I. P. Butyagin—Strength properties of freshwater ice and ice cover.

N. V. Glukhova—New methods of investigation of the physical and mechanical properties of ice.

Avalanches and problems of investigations

Yu. D. Moskalyov—Some problems of avalanche dynamics in relation to engineering calculations.

A. M. Elmesov and I. I. Cherheulidze—Possible deceleration of avalanche velocity.

D. I. Tebuyev et al—Method of determining snow avalanche and air-borne wave dynamic parameters.

A. G. Goff — Avalanche control structures in Chuliki.

B. I. Novikov—Avalanches in the Carpathians: some results of investigations.

G. G. Charitiniv — Prediction of new snow avalanches during snow fall.

FUTURE MEETINGS

THIRD INTERNATIONAL CONGRESS ON CRYSTAL GROWTH (ICCG—3)

The Third International Congress on Crystal Growth will be held in Marseille, France, from 5 to 9 July 1971. Its aim is to bring together scholars of different disciplines who are interested in fundamental or applied problems of phase transformations or growth of crystals, new techniques of monocrystal production, and industrial crystallization.

In view of the large number of participants at the previous congresses (Boston 1966 and Birmingham 1968), two or three sessions will be running concurrently. There will also be a film show on new results and methods. An exhibition of scientific material and of monocrystal production will go on throughout the Congress. Any original work on the growth of crystals or the transformation of phases may be brought within the scope of the Congress on receiving the approval of the programme committee, but the principal themes will be as follows:

1. Theory (thermodynamics and kinetics of nucleation, forms of stability and of growth, interfacial kinetics, transport phenomena, morphologic stability, etc.).

2. Characterization of crystals in relation to their manner of growth.

3. Basic experimental research sub-divided as follows:
   - a) growth in vapour stage;
   - b) growth in molten stage;
   - c) growth in aqueous solution;
   - d) growth under high pressure or in high temperatures;
   - e) transformation in solid state and recrystallization;
   - f) crystallization of high polymers and biological crystals.

4. New methods and techniques of crystal growth.

5. Industrial crystallization (production of polycrystalline products and control of their physicochemical properties).

For all information please write to: Sec. Gen. ICCG-3, Laboratoire des Mécanismes de la Croissance Cristalline, Faculté des Sciences de Marseille, Saint-Jérôme, 13—Marseille 13e, France.

INTERNATIONAL UNION OF GEODESY AND GEOPHYSICS (IUGG), MOSCOW 1971

XV GENERAL ASSEMBLY, MOSCOW, USSR

28 July—14 August 1971

(a) Symposium on Energy Fluxes Over Polar Surfaces

During the XV Assembly of IUGG, to be held in Moscow in 1971, there will be a Symposium on Energy Fluxes over Polar Surfaces (snow, glacier, and land surfaces, and polar water surfaces). The Symposium will be sponsored by the International Association of Meteorology and Atmospheric Physics of IUGG, and the responsibility for the programme has been delegated to the International Commission on Polar Meteorology of the IAMAP. The dates for the Symposium are 3–5 August 1971.

A Programme Committee will examine contributions submitted for inclusion in the Symposium. For this purpose, informal abstracts, not exceeding three pages and written in English or French, should be submitted in six copies **before 31 October 1970.**

Please send submissions to Professor S. Orvig, Secretary, ICPM, Department of Meteorology, McGill University, Montreal 110, P.Q. Canada.

(b) Symposium on Air-Sea Interaction

The Symposium will be held in Moscow on 6 and 9 August. The latter date is reserved for papers dealing with air-sea interaction in the presence of floating ice. The Symposium is organised by IAMAP and co-sponsored by IASH, IAPSO and SCOR. Anyone interested in this meeting should write to the Convener (Prof H. Charnock, Dept. of Oceanography, The University, Southampton, Hants., England) for details.

(c) Symposium on Interdisciplinary Studies of Snow and Ice in Mountain Regions

COMMISSION OF SNOW AND ICE

INTERNATIONAL ASSOCIATION OF SCIENTIFIC HYDROLOGY (INTERNATIONAL UNION OF GEODESY AND GEOPHYSICS)

First Circular

A first general circular about the fifteenth General Assembly of the Union has been issued already and is available from your National Committee. During the Assembly the Commission of Snow and Ice is responsible for organizing a Symposium on "Interdisciplinary studies of snow and ice in mountain regions", which is co-sponsored by the Association of Meteorology and Atmospheric Physics. The Convener is Dr V. M. Kotlyakov of the Glaciology Department, Institute of Geography, Academy of Sciences USSR, Moscow. The Symposium will take place from 9 to 13 August 1971. This first circular deals with the submission of papers for presentation at the Symposium and for subsequent publication.

Immediately following the Symposium there will be an excursion to the Caucasus lasting 10 days.

PAPERS

There will be two categories of papers: (a) regular papers, (b) shorter contributions.

The papers and shorter contributions must deal with snow and ice in mountainous regions and with studies involving more than one scientific discipline. Papers may deal with the following subjects.

1. Meteorology and climatology of the snow and glacier environment in mountains.
2. Heat balance of snow and glacier cover in mountains.
3. The role of snow avalanches in the nourishment of glaciers and snow fields and as an element in the mass balance.
4. Processes of accumulation and ablation of glaciers.
5. Glacier mass balances and their variation in time and space.
6. Specific and regional mass balances of glaciers and mountain-glacier environments.
7. The formation and possible artificial regulation of glacier run-off.

(i) Submission of summaries

Those who would like to contribute in either category should first submit a summary of their proposed paper in English or French to their National Committee. This summary should not exceed two pages of typescript but should contain sufficient detail to enable referees to judge the scientific content and originality. The summaries must be submitted on paper of international standard size A4 (210 x 294 mm), be typewritten on one side of the paper only, with a 30 mm margin on the left hand side, and with 1½ type spaces between lines of type. The typescript must be suitable for photographic copying, i.e. the paper should be white, and the type uniformly black. Use a new ribbon and preferably an electric typewriter. The name and mailing address of the senior author and the category (a) or (b) proposed for the paper should be given in the top right hand corner of the first page of typescript.

The National Committees should send five copies of the summaries after appropriate selection to the Secretary of the Commission not later than 1 December 1970.

(ii) Selection of papers

Each summary will be assessed by an international group of referees for scientific merit, originality and relevance to the theme of the Symposium. The referees will select a limited number of papers and shorter contributions for presentation and discussion at the Symposium. It is hoped to notify authors of invited papers and shorter contributions by 1 March 1971.

(iii) Printing and distribution of summaries

Accepted summaries will be printed in Moscow and distributed to authors and participants in June 1971.

(iv) **Submission of final papers and short contributions for publication**

The proceedings of the Symposium will be published by the International Association of Scientific Hydrology. Papers presented at the Symposium will be considered for publication in these proceedings provided they have not been submitted for publication elsewhere. The maximum length for papers in category (a) is 5000 words or the equivalent length including any illustrations, and in category (b) is 1500 words or equivalent.

Papers should be typewritten on one side of the paper only with wide margins and double spacing, and be in either English or French. An abstract not exceeding 200 words should be provided in both languages. References should be given in the style used in the *Journal of Glaciology* and be listed separately. Illustrations and tables should be numbered consecutively in the text, and a list of illustrations and their captions should be included with the typescript. Algebraic symbols should be clearly written by hand. Numerical data should be given in SI units or units approved internationally for use with SI. Other units, if used, should be accompanied by SI equivalents. Algebraic symbols for physical quantities should follow the recommendations of the Commission for Symbols, Units and Nomenclature of the International Union of Pure and Applied Physics.

Line drawings should be clear with strong black lines and with professional lettering of sufficient size to be legible when reduced for block making. The lettering on diagrams must be consistent with the text and follow the units and symbols mentioned above. The original drawings should be sent as well as two copies. Photographs should be glossy prints with a minimum dimension of at least 110 mm.

Three copies of papers and shorter contributions approved by national committees should be sent to the Secretary of the Commission to arrive by 1 July 1971.

The papers will be refereed before being accepted for publication.

LETTER OF INTENT

Anyone intending to: (a) attend the Symposium, (b) submit a paper to the Symposium, (c) take part in the Caucasus excursion, should write immediately to the Secretary of the Commission stating their intention (a), (b) and (c).

W. H. Ward, Secretary,
Commission of Snow & Ice,
147 Rickmansworth Road, Watford,
Hertfordshire, England.

Dr V. M. Kotlyakov, Convenor. 1 July 1970

22nd INTERNATIONAL GEOGRAPHICAL CONGRESS, CANADA 1972

10—17 AUGUST

The 22nd Congress will be held in Montreal, Canada from August 10 to 17, 1972. The programme for the following week will include the presentation of technical papers, special panels and lectures, a series of workshops, films, an exhibition of maps, atlases, books and photographs, and local and regional excursions. Most of the Commissions plan to meet at host universities across Canada prior to the Montreal meetings. A broad programme of symposia and field tours will take place before and after the main Congress, extending from coast to coast and from the United States border to the Canadian Arctic.

Details of the Sections, Symposia, Commission meetings and Field Tours are listed in the First Circular. Provisional registration for the Congress should be made by 15 September 1970. The deadline for technical papers will be 1 September 1971. Separate copies of the First Circular and the application form may be obtained on request from the Executive Secretary, 22nd International Geographical Congress, P.O. Box 1972, Ottawa, Canada. Provisional registrants will be placed on the mailing list for the Second Circular to be issued in November 1970. Arrangements for booking hotel accommodation in Montreal will be announced in the Second Circular. Approximately 2500 beds in university residences in Montreal will be available at modest prices.

The following events are of special interest to glaciologists.

SECTIONS AND THEMES (Montreal, 10—17 August 1972)

Section I—Geomorphology
Themes include: erosion processes, with particular reference to dynamics.

Section II—(a) climatology (b) hydrology, glaciology
These themes aim at a balance between the conventional approach to the heat and water balance of the earth's surface and climatic change, and the applied aspects of climatology and hydrology. They include: heat and moisture balance of the whole earth, including new instrumentation; climatic models and climatic variations; heat and moisture balance of the Arctic and Sub-Arctic.

Section XIII—Remote sensing, data processing and cartographic data presentation
This Section solicits papers on surveys by remote sensing techniques (including conventional interpretation), on the processing of data obtained by these or other methods, how to classify them statistically, describe them and present them in graphical form, and on possibilities and problems related to the cartographical display of data. The themes include: recent advances in remote sensing techniques (the use and application of more advanced techniques of remote sensing, such as radar mapping, etc.); geographical significance of remote sensing from space; automation in remote sensing.

SYMPOSIA, COMMISSION MEETINGS AND FIELD TOURS

An extensive programme is being arranged for the periods before and after the main Congress in Montreal. Some arrangements are still tentative. Costs shown are provisional and unless otherwise stated include accommodation, meals, maps, guides and transport during the excursion. The cost of travel to and from the centre is not included. Accommodation at moderate rates in university residences will be arranged whenever possible. Final details will be published in the Second Circular.

BEFORE THE MAIN CONGRESS IN MONTREAL

SYMPOSIA

Sa 8 Mass Wasting in Arctic Mountains
(Symposium and field excursion)
Study and examination of the glaciology and geomorphology of a high mountain environment in north-west Canada. High mountain physiological studies. Mass balance studies.

Yukon Territory/July 25–August 8/$900 (side trip to Dawson $60 extra). Prof. J. P. Johnson, Dept of Geography, Carleton University, Ottawa, Ontario.

COMMISSION MEETINGS

Ca 1 Geographical data sensing and processing
Montreal and Ottawa/August 1–14/30–40 people. Mr. R. F. Tomlinson, 226 O'Connor St., Ottawa 4, Ontario.

Ca 2 High altitude geoecology
Study of three-dimensional arrangement (horizontal and vertical zonations) of climate, soils landforms, glaciers, vegetation, animal life and full ecosystems and landscape types in the Rocky Mountains of Alberta.

Edmonton, Pincher Creek, Banff, Columbia Icefields, Alberta/July 31–August 8/30 people/$175. Prof. D. A. Gill, Dept. of Geography, University of Alberta, Edmonton, Alberta.

Ca 6 Present-day geomorphological processes
Vancouver to Calgary/July 31–August 8/50 people/$150. Prof. O. Slaymaker, Dept. of Geography, University of British Columbia, Vancouver, B.C.

Ca 8 International Hydrological Decade
Human adaptation to and modification of hydrologic cycles.

Victoria, Vernon, Revelstoke, Mica Damsite, Banff, Edmonton/August 1–8/30 people. Prof. W. R. D. Sewell, Dept. of Geography, University of Victoria, Victoria, B.C.

FIELD TOURS

Ea 1 The Canadian north-west
A cross-section of the varied physical and cultural nature of the Canadian north-west, ranging across the Precambrian Shield, the Interior and Arctic Plains and the Cordillera from the subarctic to the Arctic. Charter aircraft transport includes visit to Eskimo community (Sachs Harbour) and over Icefield Ranges (St. Elias Mountains), weather permitting.

Edmonton, Fort McMurray, Yellowknife, Inuvik, Dawson, Whitehorse/July 31–August 8/48 people/$500. Prof. W. C. Wonders, Dept. of Geography, University of Alberta, Edmonton, Alberta.

Ea 2 Arctic Archipelago I
Interdisciplinary approach to an environmental study of the High Arctic; uplift in Resolute Bay area, Cornwallis Island; excursions in research study area on Axel Heiberg Island (White Glacier mass energy and water balance; Thompson Glacier push moraine: Wolf Mountain physiography; periglacial phenomena; erosion and accumulation effects of glacier-dammed lakes; morphology of Expedition Fiord; biogeographical patterns); visit to Tanquary Fiord and Eureka weather station on Ellesmere Island, Queen Elizabeth Islands.
August 1–9/18 people/$850. Prof. F. Müller, Dept. of Geography, McGill University, Montreal, P.Q.

Ea 3 Ice retreat and marine transgression features in eastern Canada
Montreal, Sherbrooke, Rivière-du-Loup, Quebec, St.-Gabriel, Ottawa, Pembroke, Mt-Laurier/August 1–9/40–50 people/$200. Prof. Joyce Macpherson, Dept. of Geography, Memorial University, St. John's, Newfoundland.

Ea 4 Southern mountains, British Columbia and Alberta
Landforms, climate, vegetation and landscape change of the southern mountain systems of British Columbia and Alberta.
Vancouver, Merritt, Vernon, Revelstoke, Nelson, Fernie, Calgary/August 2–7/50 people/$150. Prof. J. Crowley, Prof. L. D. Kordes, Dept. of Geography, University of Calgary, Calgary, Alberta.

Ea 5 Geomorphology of southern Alberta
Study of the sequence of late glacial events and the post glacial landscape evolution in southern Alberta. Relationship in age between the Laurentide and Cordilleran ice advances. Two unglaciated areas (only ones in southern Canada).
Southern Alberta/July 25–August 1/35–75 people/$170–190. Prof. S. A. Harris, Dept. of Geography, University of Calgary, Calgary, Alberta.

AFTER THE MAIN CONGRESS IN MONTREAL

SYMPOSIA

Sp 1 Glaciers of the Rocky Mountains
Glaciers, glacier hydrology, glacial morphology and snow avalanches.
Calgary, Banff, Peyto Glacier, Mistaya Valley, Athabasca Glacier, Rogers Pass, Revelstoke/August 30–September 6/30 people/$200. Prof. F. Müller, Dept. of Geography, McGill University, Montreal, P.Q.

FIELD TOURS

Ep 4 North-western Quebec and north-eastern Ontario
Geomorphology and glacial history; settlement patterns; natural resources.
Montreal, Val d'Or, Amos, La Sarre, Noranda, Rouyn, Kirkland Lake, Matheson, Iroquois Falls, Cochrane, Moosonee, New Liskeard/August 17–28/82 people/$200. Prof. H. Morrissette, Départment de géographie, Université d'Ottawa, Ottawa, Ontario. Prof. W. G. Dean, Dept. of Geography, University of Toronto, Toronto, Ontario.

Ep 13 Arctic Archipelago II
Physical environment of the Canadian Arctic Archipelago/August 17–25/20 people/$750. Prof. S. B. McCann, Dept. of Geography, McMaster University, Hamilton, Ontario.

24th INTERNATIONAL GEOLOGICAL CONGRESS, CANADA 1972
21—30 AUGUST

The 24th Session of the Congress will be held in Montreal, Canada from August 21 to 30, 1972. Headquarters will be in Hotel Bonaventure. The sessions will be held here and in several nearby hotels, connected by underground passageways, and at McGill University (about a 10 minute walk). The First Circular was published at the end of 1969. The Session will follow the main congress meetings of the 22nd International Geographical Congress in Montreal, 10–17 August. Only those who reply to the First Circular will automatically receive the Second and later Circulars. If you are considering attendance, please write without delay to: Secretary-General, 24th International Geological Congress, 601 Booth Street, Ottawa 4, Ontario, Canada.

Preparation of Papers
Two copies of a typewritten abstract (maximum 300 words) of each paper offered for publication by the Congress must be received by the Secretary-General, 601 Booth Street, Ottawa 4, Ontario, before 1 August, 1971. Two copies of the complete text of a paper should be submitted, in English or French, to the Secretary-General before 1 October, 1971. The papers will be published before the Congress. Authors are therefore requested to forward their papers at the earliest date possible. No exceptions from the proposed deadlines can be made. Further details about the preparation of papers are given in the First Circular. The following events are of special interest to glaciologists.

SECTIONS

Section 11—Hydrology
The interaction between geologic and hydrologic parameters. Papers synthesising important new developments in hydrogeology and integrating the geological framework with current hydrologic knowledge.

Section 12—Quaternary geology
(a) Late Quaternary time scale. Review of the geological sub-division and stratigraphic nomenclature applied to the last 100,000 years.

(b) Deformational structures in Quaternary deposits. The distinction and interpretation of structures imposed by glaciation, frost action, mass wasting, diagenesis, compaction, crustal movement and other processes, with implications on the recognition of stress history and the reconstruction of past events.

(c) Practical applications of Quaternary geology. Organized jointly with Sections 10 and 13 (Engineering Geology).

EXCURSIONS

(A=Excursions before the technical sessions—i.e. before 21 August.
C=Excursions after the technical sessions—i.e. after 30 August.)

A 02, C 02 Quaternary geology of the southern Canadian Cordillera

The Quaternary deposits of the Olympia interglacial (18,000 to 50,000 years before present) and the Fraser glaciation (the last 11,000 to 18,000 years before present) will be examined as well as recent deposits and sedimentary processes. The pattern of ice retreat and history of glacial lake development will be studied in the Interior Plateau area. The relationship between alpine and continental glaciation will be investigated in the Bow River Valley between Banff and Calgary.

Transport will be by bus. Short walking tours only will be involved.

Leaders: R. J. Fulton, R. A. Achard
Route: Victoria, Vancouver, Revelstoke, Banff, Calgary. 80 people/11 days/900 miles (1,450 km)/$290.

A 11, C 11 Quaternary geology and geomorphology, southern and central Yukon

The glacial succession from the oldest, most extensive glaciation (pre-Illinoian) to the modern glaciers of the St. Elias Range will be examined. A considerable difference in glacial landforms and soils occurs with differences in the age of deposits. Other glacial features include permafrost and periglacial features, open and closed system pingos, patterned ground, ground ice, thermokarst topography, etc. The geomorphic history of the Klondike district will be discussed.

Transport will be by bus. Short walking tours. 40 people/12 days/2,600 miles (4,150 km)/ $525 (included, the cost of return air fare from Edmonton to Whitehorse).

Leaders: O. L. Hughes, V. Rampton.
Route: Edmonton, Whitehorse, Haines Junction, Mayo Landing, Sixty Mile Road, Whitehorse, Edmonton.

A 22, C 22 Quaternary geology and geomorphology from Winnipeg to the Rocky Mountains

Three broad aspects of Quaternary geology will be emphasized: areas affected by continental glaciation only; areas of interaction between continental and mountain glaciation; and areas of mountain glaciation only.

Transport will be by bus.

Leaders: N. W. Rutter, E. A. Christiansen.
Route: Winnipeg, Dauphin, Regina, Lethbridge, Cranbrook, Banff, Calgary. 80 people/ 13 days/1,400 miles (2,230 km)/ $340.

A 30 Pleistocene geology and geomorphology, Mackenzie and Keewatin Districts, N.W.T.

Pingos, ice wedges, erosion and foundation engineering in permafrost, glacial and interglacial chronology and stratigraphy, post-glacial pollen stratigraphy, oriented lakes, thermokarst forms, patterned ground and coastal erosion will be discussed. The second part of the excursion will deal with glacial land forms and the pattern of deglaciation in the Barren grounds. The glacial lake features in Thelon Valley and Great Slave Lake basin and the recent sea-level change at Churchill will be studied.

Transport will be by charter aircraft.

Leaders: J. G. Gyles, J. Ross MacKay.
Route: Edmonton, Inuvik, Tuktoyaktuk, Banks Island, Cambridge Bay, Churchill, Winnipeg. 35 people/9 days/3,360 miles (5,380 km)/$650.

A 61, C 61 Quaternary geology, geomorphology and hydrogeology of the Maritime Provinces

Evidence of sea-level rise following the maximum of the last glaciation, and the influence of the rise on the pattern of deglaciation developed in the Atlantic provinces will be examined. The popular concept of overriding Laurentide ice versus radially flowing Appalachian ice will be discussed in terms of ice-flow features, moraines, crag-and-tail features, stiae, glaciofluvial deposits and the distribution of erratics. Numerous points of archeological, historial and scenic interest will be visited and a day will be spent at the Bedford Oceanographic Institute.

Transportation will be by bus.

Leaders: V. K. Prest, J. F. Jones, R. H. MacNeill, D. R. Grant.

Route: Halifax, Wolfville, Truro, Moncton, Saint John, Fredericton, Charlottetown, Cape Breton, Halifax. 35 people/11 days/1,260 miles (2,020 km)/$290.

A 66 (a, b) Geology of the Arctic Islands

The excursion will study examples of the stratigraphy, structure and geomorphology of the northernmost geological province of Canada. Important deposits or camps for the development of mineral resources will be visited, as well as an Arctic geophysical observatory and a glaciological research station. (66a and 66b are alternate routes, depending on the weather).

Leader: E. F. Roots.

Route: Edmonton, Yellowknife, Cambridge Bay, Resolute, Eureka, Ward Hunt Island, Axel Heiberg Island, Mould Bay, Tuktoyaktuk, Edmonton.

Transportation will be by charter aircraft.

36 people/11 days/ approximately 5,000 miles (approx. 8,000 km)/$1,000.

GLACIOLOGICAL DIARY

1970

7–10 September

Iceland IAHR, Reykjavík, Iceland. (Mr S. Freysteinsson, Chairman of the Organizing Committee, IAHR Ice Symposium 1970, Verkfraedistofa, Sigurdur Thoroddsen Sf, Armula 4, Reykjavík, Iceland.)

14–25 September

"The Ocean World", joint oceanographic conference, Tokyo, Japan. (Prof. K. Yoshida, Secretary, Japanese Organizing Committee for IAPSO, Science Council of Japan, Ueno Park, Tokyo 110, Japan.)

11–13 November

Geological Society of America, annual meeting, Milwaukee. (Symposium on Antarctica is planned.) (GSA headquarters, Box 1719, Boulder, Colo. 80302, U.S.A.)

1971

5–9 July

International Conference on Crystal Growth, Marseille, France. (Secretariat ICCG-3, Faculté des Sciences, Marseille St. Jérôme, 13-Marseille-13e, France.) (See p. 25 of this issue of ICE.)

28 July–14 August

XVth General Assembly of IUGG, Moscow, USSR. Joint symposia planned:

(a) Energy fluxes over polar surfaces. Organized by Commission on Polar Meteorology of IAMAP. (Prof. S. Orvig, Department of Meteorology, McGill University, Montreal 2, P.Q., Canada.) (See p. 25 of this issue of ICE.)

(b) Air-sea interactions with floating ice. Organized by IAMAP. (Convener Prof. H. Charnock, Dept. of Oceanography, The University, Southampton, England.) (See p. 25 of this issue of ICE.)

(c) Interdisciplinary studies of snow and ice in mountain regions. Organized by CSI, local convener V. Kotlyakov, Moscow. (Dr W. H. Ward, 147 Rickmansworth Road, Watford, Herts., England.) (See p. 26 of this issue of ICE.)

18–27 August

Pacific Science Association, congress, Canberra, Australia. (Geography Chairman: Akira Watanabe, Dept. of Geography, Ochanomizu Univ., Bunkyo-ku, Tokyo, Japan. Meteorology Chairman: J. F. Gabites, Director, Met. Service, P.O. Box 722 Wellington, New Zealand. Solid Earth Sciences Chairman: W. H. Mathews, Dept. of Geography, Univ. of British Columbia, Vancouver 8, B.C., Canada.)

1972

10–17 August

International Geographical Union, 22nd Congress, Montreal, Canada. (Secretariat, 22nd International Geographical Congress, P.O. Box 1972, Ottawa, Canada.) (See p. 27 of this issue of ICE.)

21–30 August

International Geological Congress, 24th Session, Montreal, Canada. (Secretary-General, 24th International Geological Congress, 601 Booth Street, Ottawa 4, Canada.) (See p. 29 of this issue of ICE.)

7–14 September
International Symposium on snow and ice, hydrology and forecasting. Banff, School of Fine Arts, Banff, Alberta, Canada. (Dr I. C. Brown, Secretary, Canadian National Committee for IHD, No. 8 Building, Carling Avenue, Ottawa 1, Canada.)

1973

(date not fixed)
International Union for Quaternary Research, congress, New Zealand. (Dr E. A. Francis, Dept. of Geology, Univ. of Newcastle upon Tyne, Newcastle upon Tyne, England.)

1975

(date not fixed)
International Union of Geodesy and Geophysics, general assembly, France. (Prof. G. D. Garland, Geophysics Lab., Univ. of Toronto, Toronto 5, Canada.)

NEW MEMBERS

Carter, Miss S., 12 Arlington Avenue, Goring-by-Sea, Sussex, England.

Collins, D. N., Emmanuel College, Cambridge CB2 3AP, England.

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Yoshida, Dr Y., Department of Geography, Hiroshima University, Hiroshima, Japan.

THE GLACIOLOGICAL SOCIETY

c/o Scott Polar Research Institute, Lensfield Road, Cambridge, England

President: Dr V. Schytt

Secretary: Mrs. H. Richardson

DETAILS OF MEMBERSHIP

Membership is open to all who have scientific, practical or general interest in any aspect of snow and ice study. Members receive the Journal of Glaciology free. Forms for enrolment can be obtained from the Secretary. No proposer or seconder is required. Annual subscription rates are as follows:

Private members—	Sterling:	£3 0s. 0d.
	U.S. dollars:	$8.00
Junior members (under 25)	Sterling:	£1 0s. 0d.
	U.S. dollars:	$3.00
Institutions, libraries—	Sterling:	£6 0s. 0d.
	U.S. dollars:	$16.00

(The dollar rates include Bank conversion charges)

Further details may be found in the Journal of Glaciology, published in February, June and October

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ICE

Editor: Mrs. H. Richardson

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