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ICE

INTERNATIONAL GLACIOLOGICAL SOCIETY

SYMPOSIA

1974—Remote sensing in glaciology.

15-21 September, Cambridge, England.

(See page 24 of this issue of ICE.)

1976—Problems of applied glaciology.

September (dates to be decided),

Cambridge, England.

This Symposium is being held to celebrate the 40th anniversary of the founding of the Society.

Further information about the Symposia may be obtained from the Secretary of the Society, Cambridge CB2 1ER, England.

ICE
NEWS BULLETIN OF THE INTERNATIONAL GLACIOLOGICAL SOCIETY

1st ISSUE 1972 NUMBER 38

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CHANGES IN THE SOCIETY'S CONSTITUTION. The ballot held at the end of 1971 showed the following percentage votes in favour.

Rule 1 (name of the Society)—93%

Rule 2 (objects of the Society)—99%

Rule 3 (branches)—99%

Rule 8 (composition of the Council)—97%

Rule 9 (election of the Council)—96%

Rule 10 (appointments to Posts, etc.)—95%

Not all the other votes were against the changes—there were several abstentions. The changes have now been incorporated into the Constitution, which is printed at the back of the List of Members 1972.

COVER PICTURE. Vertical section of aufeis obtained at the terminus of the McCall Glacier, Alaska. Prepared by G. Wakahama. Photographed by Hokkaido Newspaper. Magnification . . . X4. The lower and middle part of the picture shows a fairly large single crystal, but the middle and upper part shows fine-grained and columnar structures.

This is the first time that ICE has had a full-colour cover. The reason? — To celebrate the Society's new name. *Ed.*

RECENT WORK

CANADA

Glacier Research

The Sub-Committee on Glaciers held one meeting in 1971, on 25 February in Ottawa. A motion was carried "That an international meeting on the topic 'The thermal regime of glaciers' be held early in 1974 under the sponsorship of the Sub-Committee on Glaciers."

University of British Columbia

R. E. Kucera, Department of Geology, has completed a 16 mm colour film devoted to the study of geological processes active at the terminus of the Athabasca Glacier, Columbia Icefields, Alberta. Entitled "What happens at the front of a glacier?", the film presents data collected over a period of more than four years using time-lapse and sequence cinematography. The film allows quantitative measurements of the rates of retreat, the changing dynamic conditions of the ice, the formation of morainal ridges, deltaic gravels, and the movement of ice. Frame rates were chosen so that particular geological events could be studied with the time element compressed as much as 2500 times. Significant footage shows:

1) that annual moraines result in part from the advance of ice during winter, later modified by mudflows and slides during the ablation season;
2) that parallel retreat of the ice front on the north side of the glacier is taking place on a 40° scarp cut by closely-spaced rills. Talus slopes associated with the rill system form at the base of the scarp;
3) that changes in the channel patterns of the streams on the delta at the front of the glacier are caused by minor erosion and deposition rather than variations in discharge;
4) extreme close-up of melt of ice crystals and downwasting of rocks on ice;
5) time-lapse of ice-crystals moving past field of view with migration of fluids past crystal boundaries;
6) by sequence photographs from selected camera stations that the ice near the terminus is moving at the rate of 5.7 cm/day and that the ice front advances 7 to 10 meters during the winter, but retreats 15 to 27 meters during the summer.

The film was recently awarded the best Science Research film in Canada at the Science Film Symposium held at Edmonton and has been selected to represent Canada at the International Science Congress in Kiev, U.S.S.R.

J. Hoffman, an M.Sc. candidate at the Department of Geophysics, is completing a theoretical analysis of glacier surging under the supervision of G. K. C. Clarke. The surge model starts from Weertman's simple theory for glacier sliding and uses geothermal heating and sliding friction to start the surge. The surge is stopped by the downward advection of cold ice which cools the bed and by disappearance of the water layer at the bed. When completed Hoffman's model should yield quantitative information about the periodicity of glacier surges and the effects of such variables as channel slope, bed roughness, and geothermal heat flux.

G. K. C. Clarke returned briefly to the Fox Glacier in August 1971 to remeasure deep ice temperatures in two holes completed in 1970. Temperature measurements performed in 1970 by Clarke, D. F. Classen and D. J. Crossley indicated that the Fox Glacier had a zone of basal temperature ice and that this "hot spot" probably controlled the glacier's surge behaviour. Because of the importance of these measurements to surge theories it was decided to remeasure the ice temperatures in 1971 to insure that the 1970 temperatures were indeed close to equilibrium and not erroneously high due to slow freezing of ice in the thermally drilled holes. The 1971 measurements were in good agreement with those taken in 1970 although the thickness of temperate ice is somewhat less than the 1970 measurements suggested.

In connexion with thermal drilling of non-temperate ice K. G. Neave and Clarke are studying improvements in thermal probe design and drilling procedures. The problems being considered are hole closure due to refreezing and probe stalling due to dirt layers.

Clarke, Crossley and Classen are completing a 16 mm colour film of the 1970 Fox Glacier expedition. The final version will have animations and a sound track and should be approximately 25 minutes long.

University of Calgary *(H. R. Krouse)*

Kenneth West is continuing isotope studies on glaciers with H. R. Krouse at the University of Calgary. Studies have been made in the St Elias Mountain Ranges, on Peyto Glacier, and on an icecap on Ellesmere Island. One of the interesting features of the St Elias Mountain Ranges study was the significant O^{18} depletions on the summit of Mt Logan because of high altitude. The isotopic composition was comparable to that for samples found at the South Pole. In the Ellesmere Island study, seasonal isotopic variations were well preserved. It was also demonstrated that lens and pipe formations were very localized phenomena since seasonal isotopic variations were still preserved nearby. Some discrepancies were found between isotopic years and stratigraphic years.

On the Peyto Glacier, the isotopic variations were very small in samples of ice below the firn line. A computer programme was used to contour the isotopic composition. As a result of this work, there appears to be some correlation between the convexities and concavities of the glacier's surface and the isotopic composition.

Currently, samples obtained this summer from the Devon Ice Cap drilling project of the Polar Continental Shelf Project, D.E.M.R. are being processed.

University of Toronto *(J. R. Rossiter, R. D. Watts and D. W. Strangway)*

Radio interferometry on the Athabasca Glacier: In order to acquire scientific baseline data for the Surface Electrical Properties Experiment planned for Apollo 17, tests using automated prototype hardware were made on the Athabasca Glacier during July and August 1971. The radio-frequency interferometry technique, using six frequencies from 1 to 32 MHz, gives a dielectric constant of 3.2 $\pm$ 0.3 and f.tanδ of 0.25 $\pm$ 0.05 MHz. Random scattering, presumably from crevasses, is much greater at the higher frequencies. Preliminary depth determinations are promising, and location of a diurnally varying water table is possible.

Inland Waters Branch, Environment Canada *(O. H. Loken)*

This report reviews the studies of the Glaciology Subdivision, those of the Water Survey of Canada and the radio echo sounding project. Some highlights of last year's activities are mentioned first:

The new Ice Science Laboratory, with 4 coldrooms, was opened in June 1971. It is located at 562 Booth Street, Ottawa.

The trend towards greater emphasis on the hydrologic aspects of snow and ice continued and the new Snow Hydrology Field Laboratory at Mer Bleue, outside Ottawa, was for the first time operating throughout the winter.

The possible early start of pipeline construction in the Mackenzie Valley led to increased activities in that area with particular emphasis on potential ice problems near river crossings.

A research scientist with background in chemical engineering joined the subdivision for work on the oil pollution problems in situations where oil interacts with snow and ice.

A study of the geographical distribution and of the rate of iceberg production in Arctic Canada was initiated, and an RC-10 Wild aerial camera was acquired for this research project. The camera was installed in the ice reconnaissance aircraft of the Polar Continental Shelf Project and it has assisted in many research projects requiring special air photography.

(a) ARCTIC SECTION (G. Holdsworth)

Field work was carried out on the following glaciers:

1) Per Ardua Glacier, Ellesmere island (U. Embacher). Mass balance measurements were made in April; work on this glacier will be temporarily discontinued.

2) Selected, small highland ice masses on Axel Heiberg Island (K. Arnold). These thin ice masses are assumed to be suitable for measuring volume changes with time. In this way, regional patterns of glacierization/deglacierization may be studied and some correlation with climatological data made. Thickness changes are measured by aerial photogrammetry.

3) Barnes Ice Cap, Baffin Island (G. Holdsworth).

a) A triangulation/trilateration network on the south dome area (extending from the dome summit to the NE margin) was completely resurveyed, so that the velocity and strain rate fields for the area can be computed. The past and current mass balance determinations for the same area will be compared with the current flow regime.

b) A study of calving processes into the proglacial Generator Lake was concluded. These results will be published shortly.

c) R. Le B. Hooke (University of Minnesota) resurveyed pole networks for marginal velocity and strain rate determinations. Further strain rate measurements and ice fabric analyses were made in a tunnel driven in from the ice margin. Two vertical boreholes were also relogged for deformation studies.

4) Decade Glacier, Baffin Island (U. Embacher). Mass balance and run-off measurements were carried out. The mode of formation of nearby aufeis occurrences were studied.

Iceberg production study (K. C. Arnold, G. Holdsworth). Aerial photographs (metric) were obtained of the calving glaciers on Devon and Ellesmere Islands. A reconnaissance was made of the SE coastline of Ellesmere Island and Leffert Glacier (78° 40′N; 75°E) was tentatively selected for a detailed study of calving from a floating ice tongue.

Remote weather stations (D. Terroux). An Ott automatic weather station was installed at the meteorological station at Resolute Bay so that automatically collected data can be compared with conventional observations.

Baffin Island climatology (S. Fogarasi). A detailed study of the 1968 summer weather pattern was completed.

(b) CORDILLERA SECTION (A. D. Stanley)

IHD mass balance studies (A. D. Stanley, O. Mokievsky-Zubok). Mass balance data, meteorological information and stream discharge, were obtained from six glaciers in the Canadian Cordillera (Berendon, Place, Sentinel, Woolsey, Peyto and Ram glaciers). Most information was obtained with long-term recorders and persons stationed continuously at Peyto Glacier in Alberta and Sentinel Glacier in British Columbia. On most glaciers the winter accumulation was greater than average for the past four years, but the ablation was small so that the snow line was lower than in previous years. In late August, Summit Lake drained beneath Salmon Glacier but there was no damage to the roadway along the Salmon River.

Hydrology of glacierized basins, Peyto Glacier (L. Derikx). Field work included very detailed heat balance measurements at a site on the glacier tongue. Horizontal wind speed was measured at 12 levels and wet bulb and dry bulb temperatures at 8 levels up to 8 m above the ice surface. Net allwave, incoming allwave, incoming shortwave and reflected shortwave radiation were measured about 2 m above the surface. The discharge from a small experimental site at the same location was recorded continuously. About 240 hours of complete heat balance data and 160 hours of discharge data were obtained between July 15 and September 15 during different weather conditions. The object of these investigations is to determine the latent and sensible heat transfer during highly different weather conditions.

Mass and energy transfer in a shallow snowpack, Mer Bleue, Ottawa (L. Derikx and P. Föhn). Data collected at the Snow Hydrology Field Laboratory at Ottawa during the winter 1970-1971 have been analyzed and a model developed for the vertical percolation of water through the snowpack. The heat balance of the winter snowpack showed some unexpected results.

Glacier meltwater contribution to streamflow in the North Saskatchewan headwaters (H. S. Loijens). Field work concentrated on the measurement of summer streamflow from seven highly glacierized sub-basins in the North Saskatchewan headwaters. The data will be used to verify the recent application of a glacier run-off simulation model (Derikx and Loijens) to all glacierized areas in the Mistaya River basin and to study the flow transformation characteristics of the Mistaya River from the head of the basin (Peyto Glacier) to the outlet gauging station. This river flow phase will essentially become part of a hydrologic model of an alpine watershed.

Fluctuations of glaciers in the Rocky Mountains (W. E. S. Henoch). Analysis of increment cores previously collected from tree trunks in the Peyto Glacier area continued and two papers on recent glacier changes were completed.

(c) GLACIER INVENTORY SECTION (C. S. L. Ommanney)

Glacier Atlas of Canada maps are now available or in the final stages of compilation for 11,364 glaciers on Baffin and Bylot Islands, 1,835 glaciers on Devon Island, 1,616 glaciers in the Nelson River drainage basin and 219 glaciers on Vancouver Island. In the summer of 1971 indexing was extended to parts of Ellesmere Island and 3,097 glaciers in 46 basins were listed. Detailed mapping of the glaciers in the headwaters of the Columbia River system has started.

As part of the iceberg production study special attention was given to tide-water glaciers on Baffin Island, 3 on Bylot Island, 69 on Devon Island and 4 on Axel Heiberg Island.

(d) ICE SCIENCE SECTION (S. J. Jones)

During the summer the new laboratory at 562 Booth Street was opened. These facilities include four new cold rooms, a new Instron mechanical tester with low temperature chamber, an interference microscope and Hewlett-Packard data acquisition system.

X-Ray topography of dislocation (S. J. Jones and N. K. Gilra). Observations continued and a report will be prepared shortly.

Oil pollution studies (R. O. Ramseier, E. C. Chen). The study of oil/water/ice system currently involves: a) determination of the spreading coefficients of oils on ice surfaces; b) investigation into the effect of temperature on the stability of oil/water emulsions; c) aging of petroleum oils on ice surfaces; and d) vapour-liquid equilibrium of hydro-carbon oils/ice system. A study of the evaporation of Arctic diesel oil has been completed as a function of temperature. Work has begun on the spreading of oil under an ice cover. R. O. Ramseier participated in the U.S. Coast Guard Oil spill test in the Arctic Ocean.

Lake and river ice (R. O. Ramseier). Theoretical and experimental work has been completed on the behaviour of different types of fresh water ice in the ductile range. Work has begun on the large scale investigation of the laboratory findings.

(e) MACKENZIE VALLEY STUDIES (D. K. MacKay)

A series of new studies was initiated and some existing ones were accelerated in connexion with possible pipeline construction in the Mackenzie Valley. These studies include investigation of: freeze-up and break-up of river ice, ice-jamming, aufeis distribution, and associated groundwater flow, ground temperatures as a function of snowcover, regional hydrology, hydrometeorological conditions and dendrochronology. Of particular interest is a detailed study of a major storm that occurred in July 1970.

(f) RADIO ECHO SOUNDING (R. H. Goodman)
A greatly improved radio echo sounding apparatus was constructed and mounted on a Sure-go vehicle. The equipment underwent extensive field testing on Athabasca Glacier in the period May-November.

(g) WATER SURVEY OF CANADA (I. Reid)
Terrestrial photogrammetric surveys of the Saskatchewan and Athabasca glaciers were completed as part of a long term programme. The work on the Saskatchewan Glacier also included the second phase of a study of ice discharge which started two years ago.

Polar Continental Shelf Project *(E. F. Roots)*

MELVILLE ISLAND (W. S. B. Paterson, L. Lundgaard). In 1971, ablation on the four ice caps both began and ended unusually early. The amount of ablation in July was much greater than normal so that the mass balance for 1970-71, about -500 kg m^{-2}, represents the greatest annual loss since records started in 1963.

DEVON ISLAND (W. S. B. Paterson, R. M. Koerner). An attempt to drill through the ice cap, near its crest, failed when the drill became frozen in at a depth of 230 m or about three-quarters of the way through. The trouble is believed to have resulted from either failure of the pump or leakage of melt water from the tank in the drill. The drill cable was cut a short distance above the drill so that the borehole is free for measurements. Temperatures ranged from -23.2°C to -20.5°C; extrapolation indicates a temperature of -18°C at the base of the ice. The inclination and diameter of the hole were also measured at various depths.

Core recovery was virtually complete, though many cores were badly fractured. The firn-ice transition occurred at about 65 m. The ice at the bottom of the core is estimated to be about 2000 years old. The electrolytic conductivity of the melt water from the drill was measured. Values varied between 1.5 and 2.5 micro-Siemens. The melt water was then filtered and the filters brought to Ottawa for particle-size analysis of the filtrate. Each core was photographed in transmitted light and the stratigraphy described. The stratigraphy was very clear to a depth of 140 m when vertical fractures began to make parts of the core opaque. Below 170 m closely-spaced horizontal fractures obscured most of the stratigraphy; a brief examination of this ice through crossed polaroids showed a strong fabric with the pole of concentration normal to the surface. The cores are stored on the ice cap at present, but will be brought to Ottawa for detailed examination early in 1972.

Control studies were made in pits near the drill site of the variation of insoluble particle concentration and of electrolytic conductivity with depth. Thirty-two air-sampling runs of approximately 12 hours each were made to windward of the camp to determine the particulate fall-out rate for various weather situations. A snow survey was made in a 16 km^2 area round the drill site to study the local variability of snow accumulation.

P. J. Winter (Earth Physics Branch, Department of Energy, Mines and Resources) made repeated gravity loops between Resolute Bay and the drill site, using two geodetic gravimeters. It is hoped that repetition of these measurements (at the same point relative to bedrock) in a few years' time will determine whether the ice thickness there has changed.

Networks of stakes were set up around the borehole and along the flow line through it, for measurement of surface strain rates. Precise levelling was carried out over the lines, totalling about 55 km, where radio echo soundings were made in 1970. The relation between surface and bed topography can now be studied. Precise levelling profiles were also made across Sverdrup Glacier at 300 m a.s.l. and up the steep slope at the edge of the ice cap 13 km west of Sverdrup Glacier, for comparison with profiles first made in 1961 and 1962 respectively.

The mass balance of the north-west part of the ice cap for 1969-70 was measured; the value was $+39$ kg m^{-2}.

MEIGHEN ISLAND (B. Barge, D. Petzold). Meteorological observations were again carried out at the network of stations on Meighen Island. Warm June and July temperatures resulted in considerably more melt on the ice cap than has been experienced in the past few years. August was unusually cold. For 1970-71, the winter balance was 170 kg/m^{-2} which is close to the 10-year mean, whereas the mass balance of -500 kg m^{-2} was the greatest loss since 1961-62. Results of the continuing meso-scale energy-balance study point to considerable similarity between the energy balance regime of Meighen Ice Cap and that of the adjacent Arctic Ocean. This is particularly evident in the colder summers. The meteorological programme is under the general supervision of Dr. S. Orvig, Department of Meteorology, McGill University.

Geological Survey of Canada, Department of Energy, Mines and Resources, Ottawa

MELVILLE ISLAND, DISTRICT OF FRANKLIN, N.W.T.; OBSERVATIONS ON ICE (D. M. Barnett). A glaciological curiosity was observed during a reconnaissance flight over Drake Point in July 1970 and was examined at closer quarters during July 1971. The feature in question is an ice cone estimated to be 20-25 m high which was built around a gas well drilled for Panarctic Oils Ltd. and which blew out of control for several months. A combination of natural gas, water vapour and drilling mud was ejected in volcanic fashion to form the cone. The cone is slowly ablating but may last for several years if left untouched. The main object of the study on Melville Island was to examine terrain disturbance by man during oil exploration. It was predicted that the presence of ground ice would be highly significant in areas which had been disturbed. From preliminary examination of incomplete shallow drilling results (up to one metre) it appears that little massive ground ice occurs. Bands up to 5-10 cm thick were located, though infrequently. High-water contents were revealed when cores were thawed.

BEAUFORT SEA, EAST OF MACKENZIE BAY, SUBMARINE PINGO-LIKE FEATURES (J. M. Shearer). During the summer of 1970, hydrographic and marine geological surveys established the existence of submarine mounds possessing a relief very similar to the pingos on Tuktoyaktuk Peninsula. The mounds were found in water depths of 30 to 70 m, well within the surface exposed to subaerial conditions during the last glaciation. If this exposed area was similar in relief to the Tuktoyaktuk Peninsula, lakes where winter ice did not reach the bottom probably were present, and hence thermally insulated zones existed within the permafrost. It is thought that in addition to providing conditions favourable for subaerial pingo formation, this temperature regime would likewise favour submarine pingo formation. Because of the present rate of erosion at the shoreline, it is believed that these features are pingos in the genetic sense, but that they have formed in the submarine environment. During transgression of the sea, exchange of the fresh lake water with sea water would have taken place. Sea bottom temperatures in the area now range from −1 to −1.8°C, depending upon the salinity. If conditions were similar in the past, then the sub-sea temperature regime existing is believed to have been such that freezing of the freshwater saturated sediments in lake basins could occur, with subsequent migration and expulsion of porewater upon freezing, causing pingos to develop.

RICHARDS ISLAND, TUKTOYAKTUK PENINSULA, AND ESKIMO LAKES, DISTRICT OF MACKENZIE N.W.T.; LARGE GROUND ICE BODIES (V. Rampton). During the course of stratigraphic investigations of Richards Island, Tuktoyaktuk Peninsula, and around Eskimo Lakes, samples of ground ice were collected for isotopic analysis (in collaboration with J. R. MacKay, University of British Columbia). Gravity profiles were made to test the possibility of using a gravimeter to measure the thickness of unexposed ground ice bodies, and to determine if certain landforms are due to ground ice or the melting of ground ice.

Defence Research Board, Department of National Defence, Ottawa *G. Hattersley-Smith and H. V. Serson)*

NORTHERN ELLESMERE ISLAND. The Defence Research Board operated Tanquary camp from mid-April until the end of August. The following activities were supported from this base.

PER ARDUA GLACIER. Mass balance studies were continued on the Per Ardua Glacier for the ninth consecutive year by U. Embacher of the Glaciology Subdivision of the Inland Waters Branch. Permanent "igloo" shelters were established below the tongue and at the 800 m level.

NANSEN SOUND ICE PLUG. During April and May a survey was made of the 1500 km^{-2} plug of ice in the mouth of Nansen Sound; recovery of 1970 stations indicate the plug to be in equilibrium. At its northern edge where the thickness is 6 m the 1970 ablation was 400 m. Aerial photographs taken in August 1971 show piles of rock debris rafted on the ice and fragments of shelf ice located in the same position as shown on 1950 aerial photographs. Four solar radiation integrating stations were established and two 55 km lines of ablation stakes set out.

WARD HUNT ICE SHELF. In June, 125 stakes on the Ward Hunt Ice Shelf and ice rise were scaled for ablation. A tide gauge and seven current meters were installed at the southern edge of the ice shelf in Disraeli Fjord to measure the exchange of fresh Disraeli Fjord water and Arctic Ocean water under the shelf. Forty-five days of data were obtained from all instruments covering a complete tidal cycle.

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

DEFORMATION BEHAVIOUR OF ICE. Studies on the deformation behaviour of columnar-grained ice under uniaxial compression are being continued. The strain rate dependence of the upper yield stress at —10°C for laboratory grown ice and St. Lawrence river ice has been reported on by Gold and Krausz. Additional measurements of the stress-strain behaviour of ice have been completed and are being analyzed. A programme of confined compression testing (plane strain condition) of columnar-grained ice has been initiated and preliminary results on the upper yield stress at selected strain rates have been obtained.

A tubular strain transducer was developed and has since been used successfully in the field for measurement of strains in ice covers. Flat pressure cells (Gloetzl and Roscoe type) have been assessed and found to be most suitable for static pressure measurement. Both strain and pressure measurements will be made in the field during the winter of 1971-72.

AVALANCHES. Observations were continued in the Rogers Pass area of the Selkirk Range on the impact force developed by an avalanche. Several successful measurements were made during the 1970-71 winter with a pressure cell having a pressure measuring surface of 6.5 cm^2 in area.

Observations were also continued on the dependence of the amount of snow brought down by avalanches, and the frequency of avalanches, on terrain characteristics and snowfall.

McGill University, Montreal, Axel Heiberg Island, N.W.T. *(F.Muller)*

The work carried out during the 1971 field season was a continuation of the established programmes of synoptic and meso-scale meteorological observations, accumulation and ablation studies on the White and Baby glaciers, glacier movement studies on the White Glacier and further work with the several automatic weather stations. Winter snow accumulation was low, the onset of melt early and the glacier ablation season was effectively terminated at the beginning of August by heavy snowfalls.

The first five members of the field party arrived on Axel Heiberg Island on 9 May by Polar Continental Shelf Project Twin Otter from Resolute Bay. The remaining two members, the glacier movement team, arrived on 15 June. Final evacuation of the party was on 27 August.

METEOROLOGICAL AND CLIMATOLOGICAL PROGRAMME (R. Braithwaite and J. Curtis). This consisted of full 6-hourly synoptic observations, together with measurement of global short wave and net radiation throughout the summer at base camp. A station on Ermine Ridge was occupied for one week in June as part of the meso-scale study and data from 9 thermohygrographs in the expedition area were obtained throughout the summer.

It is intended that meso-meteorological temperature data from the expedition area will serve as input to a statistical model treating the area as a filter. Such a filter model has been developed for the Devon Island ice cap by the investigator and results suggest a promising line of development. Measured temperature data comprise the output signal of the meso-climatic filter whilst the input is the temperature in the free atmosphere computed by interpolation of upper air data from Arctic weather stations. Quadratic polynomial methods of interpolation have been used, but the amount of computation required for the planned application of the filter to a full eleven year run of meteorological data for Axel Heiberg Island suggests that the slightly more economical optimum interpolation technique should be used. A computer programme is being developed for this purpose.

MICRO- AND MESO-CLIMATOLOGY (A. Ohmura). The heat balance on the tundra, as measured between 23 April and 25 August 1970, was studied using two methods based on the conservation of heat energy. Bowen Ratio and latent heat measurement with a lysimeter-analysis of the data was completed for a discussion of the mass change of the snow cover and the growth of the active layer.

A two-dimensional time dependent model of heat diffusion was solved, using 1970 air temperature and precipitation data from ten stations on or around the Baby and White glaciers to study the transport of heat between the atmosphere and tundra, between the atmosphere and glacier surface, and in the atmosphere itself.

AUTOMATIC WEATHER STATIONS (K. Schroff and R. Zwicky). The performance of the 6 automatic weather stations left for the winter 1970/71 in the expedition area was analyzed. Throughout the summer most attention was paid to the alleviation of the technical problems encountered during the wintering operation, rather than to the collection of further data. All three types of stations used (OTT, Plessey and Rauchfuss) are now close to all-year-round reliable operation under Arctic conditions as encountered on Axel Heiberg Island.

MASS BALANCE OF THE WHITE AND BABY GLACIERS (Ch. Wuilloud). A network of 80 stakes on the White Glacier and 9 stakes on the Baby Glacier was maintained. Pit studies in the accumulation area and ablation readings on the stakes of the lower parts of the glaciers were made repeatedly during the season.

GLACIER MOVEMENT (A. Iken and J. Niemi). During the summer of 1971 water pressure in moulins and glacier surface velocity were measured at several locations in the ablation area of the White Glacier. Water pressure was measured in active and abandoned moulins with Bourdon or membrane gauges linked to electrical resistances. The greatest depth reached with a gauge in an abandoned moulin was approximately 180 m, corresponding to 213 m length of cable below the surface. In the later season diurnal variations in water pressure as large as 13 bar were observed in this moulin, into which no surface stream had flowed for several weeks. The glacier surface velocity in the area of the moulins reached the daily maximum at approximately the same time as the water pressure. At a profile 2 km downglacier from this site the velocity maxima were usually a few hours later. At a profile 2 km upglacier, near the equilibrium line, velocity fluctuations were very small, irregular and in no apparent relation to those at the other observation sites. The daily maximum velocity in the second half of the season was considerably smaller than in the beginning, while the water table in the moulins still rose occasionally almost to the glacier surface.

In continuation of yearly measurements since 1960, the surface lowering of the White Glacier was measured at 3 profiles, and the new position of the advancing Thompson Glacier snout was determined.

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

FOX GLACIER STUDIES (S. G. Collins). A nominal programme was carried out in 1971 on the Fox, Jackal, and Hyena glaciers, three small glaciers for which there is evidence of a history of surging. The three glaciers are neighbours within the Steele Valley watershed with as yet no apparent relationship linking their surging activity.

A network of surface markers was first set out on the Fox Glacier in 1967 and subsequently on the Hyena Glacier in 1969 to survey surface movement. Although markers also were drilled into the Jackal Glacier in 1967 and 1968, the glacier was in the last stages of surge, and therefore its surface was too extensively crevassed to allow placing markers in any meaningful network. Markers were placed only in order to compute the rate and direction of movement of its snout.

During the period from mid-July to mid-August 1971 surface markers were checked and extended where necessary on Fox and Hyena glaciers, and a complete survey was made of surface motion since 1970. Little change in rate of surface movement occurred on the Fox Glacier. Net balance was estimated to be slightly positive. A thickening in part of the upper region of the Hyena was measured but has not yet been computed for height nor extent. A single measurement of the snout of Jackal Glacier shows that it continues to slow down, and though still moving very slightly, it most probably is entering the quiescent phase of this type of glacier.

SEWARD GLACIER (M. G. Marcus). During the period of least stability near the end of July a pit was dug on the Seward Glacier at an elevation of nearly 1600 m to a depth of about 4.7 m. Mean firn density approached 0.5 g/cm^3 giving a water equivalent of about 2.3 m. This approximation of precipitation for 1970-1971 is higher for that elevation on the Seward Glacier than for any year previously measured.

University of Colorado, Institute of Arctic and Alpine Research *(J. T. Andrews and R. G. Barry)*

Research was continued by the University of Colorado faculty and graduate students in the area of Cumberland Peninsula, Baffin Island, N.W.T., Canada. The activities were supported by grants from the National Science Foundation and the U.S. Army Research Office.

GLACIAL CHRONOLOGY OF THE PENNY ICE CAP. Four parties of two were involved in investigations in the following area: 1) Maktak Fiord and the trough between Maktak and Narpaing fiords, 2) the fiord system centered on Nedlukseak Fiord, 3) Okoa Bay, and 4) raised marine cliffs consisting of interbedded tills and fossiliferous marine strata extending between Quajon and Narpaing fiords.

The relationship in terms of response of the Penny Ice Cap and the local ice caps and valley glaciers is one primary area of activity. A lichen curve has been developed for *Rhizocarpon geographicum* that allows dating back to approximately 7,000 BP. Results indicate that the early Wisconsin ice was the most extensive of the Wisconsin glaciations and that the late-Wisconsin ice only extended a limited distance down fiord.

MASS AND ENERGY BALANCE OF THE BOAS GLACIER. This was studied in 1970 and, in a more limited way, in 1971. The general characteristics of cirque basins with and without glaciers is being investigated and a total of approximately 500 cirque basins have been delimited on the Okoa and Cape Dyer map sheets. A computer programme has been developed by L. Williams, University of Colorado, which takes into account the topographic shadowing effect on slope receipts of global radiation for clear skies. Results indicate that there is a small but significant difference, on average, between the global radiation being received in present ice-free and ice-filled cirques. Using the same programme, attention is now being focussed on the magnitude of the Milankovitch variations. Indications are that they may be quite significant for this area.

After the very positive mass balance year of 1969-70, the 1970-71 balance year resulted in an average winter mass balance of approximately 35 cm w.e. Heavy melt was experienced during the summer and preliminary indications are that all the 1970-71 snow was ablated, but the majority of the 1969-70 accumulation was not affected.

AIR/SEA INTERACTIONS. In late May 1971 a programme of airborne measurements at elevations of 100–1000 feet was carried out in the Davis Strait east of Cape Dyer using a Queenair of the National Center for Atmospheric Research in Boulder (which is supported by the National Science Foundation). Instrumentation included a PRT-5 airborne infrared thermometer, Eppley Pyranometers, a Swissteco linear net radiometer and temperature and dew point sensors. Attention was focussed on variations in energy budget over sea and ice surfaces. Profile measurements were made during each flight over a micrometeorological station operated on the ice in Sunneshine Fiord. The primary aim of this programme is to investigate the applicability and resolution of satellite data for determining synoptic energy budgets in the eastern Arctic. From June–August 1971 a micrometeorological programme was operated on the fast ice and at a shore station on Broughton Island. In this area break-up is characterized by melt and puddling rather than primarily by mechanical action as in the Davis Strait. A climatological station, established near sea-level at Broughton, has been in continuous operation since 4 June 1971. Its purpose is to provide a basis for comparisons with the hill-top DEW-line stations which provide most of the meteorological data for the east Baffin region.

F. Müller

ICELAND

The research work of the Iceland Glaciological Society in 1971 was limited mainly to the annual expedition in June to study the changes in the Grímsvötn area and to the annual measurements of the longitudinal glacier variations. The Grimsvötn expedition, led this time by engineer Carl Eiríksson, could state that the water level in the Grímsvötn basin was about as high as before the two previous jökulhlaups, in September 1965 and January 1960, so that one could now expect jökulhlaup at any time, and certainly before a year has elapsed. The knowledge about the behaviour of Grímsvötn gained by the annual expeditions since 1953 has suddenly become of a great practical interest as the Icelandic government decided this year to build an autoroad over Skeidarársandur, thus completing the road system around the whole country. The 20 miles broad sandur is at present the only gap in the ring-road system and the reason why that gap has not been closed is the high cost of building a road and bridges that could withstand the great jökulhlaups from Grímsvötn (Grímsvatnahlaup or Skeidarárhlaup). Before 1938 these usually occurred at 9-12 year intervals, but since then at 4-6½ year intervals. The older floods had a maximum run-off of at least 40,000 m^3/sec; the recent ones have not exceeded 10,500 m^3/sec (about the discharge of the river Volga). It is now known that the total discharge of a Grímsvatnahlaup is a nearly linear function of the length of the time passing since the last hlaup occurred, and thus the total discharge at any given time of a jökulhlaup beginning can be approximately predicted. When the road is finished, in 1974, the 1100th anniversary of settlement in Iceland, it will be possible to drive from the capital to the most magnificent glacier district in Europe, the Öræfi-Breidamerkurjökull area, in less than six hours.

The results of the measurements of glacier variation in 1971 have not been published. In 1969 33 glaciers were measured, 9 of which (27%) were advancing.

Sigurdur Thorarinsson

P.S. While this was being written, the Grímsvatnahlaup, predicted last summer as due to occur within a year, is in full process. It started about 13 March, and will probably culminate tomorrow (24 March).

S.Th.

UNITED KINGDOM

British Antarctic Survey

Radio echo sounding

Dr Charles Swithinbank and Dr Michael Walford were based at Adelaide Island from 30 November 1971 to 5 March 1972. A Scott Polar Research Institute Mark 4 radio echo sounder was installed in the Survey's latest DHC-6 Twin Otter aircraft. It was the third season of BAS airborne sounding and the fourth BAS aircraft to be used for the work. A total of 61 hours was flown on sounding runs over Graham Land, Palmer Land, and Alexander Island. While ice shelf profiles were generally flown at heights of 600 m above terrain, many inland tracks were flown at a height of 10 m. Low flying yielded bottom reflections in several areas where reflections were unobtainable in previous seasons owing to heavy attenuation and also to surface scattering. Ice depths of up to 2000 m were recorded on the Palmer Land plateau. Special tracks were flown in support of surface gravity and magnetometer surveys made in previous seasons.

In addition to the airborne work a new experiment suggested by Professor J. F. Nye of the University of Bristol was carried out on the surface of Fleming Glacier. The purpose was to measure the velocity of flow of the glacier using a radio echo sounder mounted on a manhaul sledge. It was known from both theory and experiment that the signal strength in the tail of an echo returned from a glacier bed varies rapidly as the aerial is moved horizontally. Such a rapidly varying signal was mapped over a site a few metres across at 69°30'S, 66°16'W where the ice thickness was 1100 m. The same site was mapped again the following day. The two maps are similar but because of glacier movement they show a displacement which was measured to ± 5 cm or approximately one hundredth of a wavelength. Thus the velocity of the glacier at this point was found to be 35 ± 5 cm/day in direction 260° ± 10°. The experiment has exciting possibilities and further developments are being considered.

SWEDEN

Mass balance studies on Storglaciären

	1968	1969	1970	1971
End of accumulation season	21 May	20 May	24 May	20 May
Beginning of ablation season	3 June	4 June	26 May	31 May
End of ablation season	10 Sept.	23 Sept.	21 Sept.	20 Sept.
Total winter balance in m^3 of water	$3.93 \cdot 10^5$	$3.13 \cdot 10^5$	$3.08 \cdot 10^5$	$4.16 \cdot 10^5$
Total winter balance in g/cm^2	130	102	101	136
Total summer balance in m^3 of water	$4.25 \cdot 10^6$	$6.27 \cdot 10^6$	$7.78 \cdot 10^6$	$4.72 \cdot 10^6$
Total summer balance in g/cm^2	141	205	254	154
Net balance in m^3 of water	$-0.33 \cdot 10^6$	$-3.14 \cdot 10^6$	$-4.70 \cdot 10^6$	$-0.56 \cdot 10^6$
Net balance in g/cm^2	–11	–103	–153	–18
Height of equilibrium line	1480	1570	1610	1490

Average retreat of glacier fronts in metres

			67/68	68/69	69/70	70/71
Salajekna	67° 08′	16° 27′	11	——34——	——	5
Hyllglaciären	67° 41′	17° 21′	10*	——10*——	——	2
Årjep Ruotesjekna	67° 26′	17° 30′	13.5	——42——	——	10
Suottas-jekna	67° 27′	17° 39′	15	——53——	——	5
Vartas-jekna	67° 21′	17° 41′	1	——26——	——	1
Mikkajekna	67° 24′	17° 42′	12	——39——	——	12
Pårtejekna	67° 10′	17° 43′	——	——65——	——	7
Ruopsokjekna	67° 21′	17° 59′	10	——50——	——	1
Riukojietna	68° 05′	18° 05′			——30*——	——
Kårsajökeln	68° 22′	18° 21′			——50*——	——
Stuor-Räita glaciären	67° 58′	18° 23′	20	——10*——	——	20
Västra Påssus	68° 04′	18° 24′		17	——23——	——
Östra Påssus	68° 04′	18° 25′		14	——14——	——
Rabots glaciär	67° 55′	18° 27′	13	17	10*	15
Unna Räita glaciären	67° 59′	18° 27′	5*	——	——8*——	——
Kuototjåkka glaciären	68° 09′	18° 34′		——	——31*——	——
Isfallsglaciären	67° 55′	18° 35′	——7——	——	34	15
Storglaciären	67° 54′	18° 36′	5	9*	13	6

* Figures less reliable because of partly snow-covered fronts or obtained from aerial photographs.

Ice and water balances of the Tarfala catchment area

Total area 20.6 km^2, glacier area 6.3 km^2

All figures in million m^3

	1966-67	1967-68	1968-69	1969-70	1970-71
Winter balance*	21.5	12.9	9.8	10.9	13.0
Rain during abl. season†	10.0	5.2	5.5	8.1	8.5
Glacier deficit	1.4	0.7	6.8	9.8	1.1
Total input	33	19	22	29	23
Run-off	36.9	27.7	27.0	29.3	23.1
Evaporation	2	?	?	?	?
Total output	39	28+	27+	29+	23+

* The 1966-67 figure was estimated from the detailed knowledge about accumulation conditions on the glaciers. From 1968 all figures are based on 20-25 observations per km^2.

† Number of rain gauges: 10 (1967), 19 (1968), 24 (1969), 29 (1971).

V. Schytt

U.S.A.

Western United States

Field activities in the western United States are concentrated in the mountain ranges of Washington and Alaska. Particularly active in the region is the United States Geological Survey (USGS) which has glaciologists based in Tacoma, Washington; Sacramento, California; Anchorage, Alaska; and Fairbanks, Alaska. During 1971, glaciologists from the Geological Survey were engaged in a diverse program of field research which included studies of glacier flow, glacier-climate relationships, glacier hydrology, and streamflow icing. Other USGS work involved further analysis of data on microwave emission from snowpacks in preparation for an Earth Resources Technology Satellite experiment on snowline mapping (M. F. Meier), and the continued development of a numerical model of snow and ice hydrology for the North Cascade Range of Washington which is based on area-altitude, run-off, precipitation, and temperature data (W. V. Tangborn, L. A. Rasmussen). Also active in the field of glaciology is the University of Washington in Seattle. Researchers from this institution are engaged in a variety of field and laboratory programs aimed at certain aspects of ice mechanics, glacier flow, glacier mass balance, thermal structure in "temperate" glaciers, heat and mass balance of sea ice, and pack ice dynamics. The University of Washington also serves as the coordinating center for the developing Arctic Ice Dynamics Joint Experiment (AIDJEX) which has previously been described in *Ice* (No. 35). World Data Center A: Glaciology, directed by M. F. Meier, was established in Tacoma, Washington, in late 1971.

BLUE GLACIER, WASHINGTON

Since 1957, the University of Washington (UW) has maintained a field station located in the accumulation zone of the Blue Glacier on Mount Olympus. During much of the same period, the California Institute of Technology (CIT) has operated a summer field camp on the lower part of the glacier. Both groups were again active during the summer of 1971. Field work this year emphasized studies of ice structure at the base of the ice fall and the thermal regime of ice in the lower glacier.

From extensive mapping of surface features on the lower glacier and from observations taken within a tunnel cut to bedrock through the ice fall, there is substantial evidence that well developed foliation first appears at or near the base of the ice fall. To study the origin of foliation in the lower glacier, a joint program was undertaken by C. F. Raymond and E. R. LaChapelle (UW), in cooperation with B. Kamb (CIT). The technique employed was to take cores along a longitudinal line in a zone at the base of the ice fall. During the summer of 1971, two deep core holes were drilled. The first hole, located about 100 meters below the major break in slope at the base of the ice fall, penetrated through the complete depth of the glacier (92 meters); the second hole was located about one annual motion upstream of the first, and was drilled to a depth of 42 meters, approximately one half the thickness of the glacier at that point. Each core from these holes was slabbed, photographed, and examined with regard to: orientation of all visible planes and linear structures, textural relationships, and c-axis fabric. The first hole provides a detailed picture of variations in the structural pattern with depth, while comparison of observations from both holes makes it possible to study the evolution of structures in the upper half of the glacier thickness. Measurements of vertical strain rate in the coreholes were made by J. Rogers (UW). These data plus the extensive measurements of ice deformation made the previous summer in this zone provide the basis for relating the differences in structure observed at the two core sites to the strain experienced as the ice traverses the distance between them.

The Blue Glacier exists in a maritime climate which, by all criteria, should cause it to be temperate. However, cumulative experience with thermal drilling suggests that ice temperatures are somewhat below the pressure melting point, as evidenced by summer freezing in boreholes, and therefore the glacier is not temperate in terms of the classical definition. The discrepancy probably arises from the existence of impurities in the ice. However, temperate ice is a complex thermodynamic system in which the temperature is related not only to the bulk impurity content, but also to the state of stress and the characteristics of included liquid water. As a first step in documenting these relationships, W. Harrison (UW) calculated theoretical values of ice temperature versus depth from data on rates of borehole closure, and then measured ice temperature profiles directly, using thermistors accurate to 0.005°C, at two locations on the lower glacier. Measurements were made to a depth of 80 meters at the upper site, and to 190 meters at the lower site. Ice temperatures appear to be typically about 0.02°C colder than that of ice and pure liquid water in equilibrium. Preliminary studies of bulk ice chemistry were undertaken on selected core samples. But impurity content was examined in the field by electrical conductivity measurements, while liquid water content of the ice samples was studied by calorimetric techniques.

In addition to the structural and thermal studies, routine meteorological and mass balance measurements were continued, adding to the increasingly valuable record of the relationship between climate and glacier nourishment which has been gathered over the past fifteen years.

SOUTH CASCADE GLACIER, WASHINGTON

A research station is operated adjacent to the South Cascade Glacier on Sentinel Peak in the Cascade Mountains by the Tacoma Office of the U.S. Geological Survey (M. F. Meier). During 1971, field work at this site was concentrated on experiments related to the flow of water through snowpacks and glaciers. Several different methods of measuring the movement of meltwater were attempted with varying degrees of success. In May, two pits, 7 meters deep, were dug in the winter snowpack. Six ablation pans were then installed at different levels in the undisturbed snow of the pit walls, and connected by plastic pipes to devices which measured the flow rate from each pan. This experiment proved to be only a partial success as three of the ablation pans froze up shortly after burial, and an extraordinarily cold May and June kept ablation to a nearly imperceptible rate (W. V. Tangborn, R. M. Krimmel).

During June, July and August, Dr S. Colbeck of the U.S. Army Cold Regions Research and Engineering Laboratory (CRREL) and Miss G. Davidson of Dartmouth College performed a complementary experiment using long plastic sleeves filled with homogeneous snow. These devices performed well and the measured percolation waves will be used in an attempt to verify Colbeck's theory for the movement of water through snow.

Experiments to determine travel time, routes, and storage of meltwater within the glacier were continued. A fluorescent dye was released at various points on the glacier and the fluorescence of water samples discharged at the glacier terminus then measured. As a result of this work, a clearer picture of water transmission and storage within the glacier is beginning to emerge. A conductivity recorder was also installed at the terminus in August to measure changes in the natural conductivity of the outlet stream, and to record the travel time of artificial "salt waves" moving through the glacier; these "waves" were generated by injecting concentrated saline solutions at different positions on the glacier. Results from these tests are, as yet, inconclusive. Tritium dating of snow, firn, and ice horizons was continued. Attempts were also made to use tritium to identify, in the outflow at the terminus, the amount of meltwater or rainwater derived from different parts of the glacier (W. V. Tangborn, R. M. Krimmel, and others).

Ice and water balance measurements, together with a large amount of supporting climatological and hydrological data, were collected from the South Cascade Glacier as part of a program of the International Hydrological Decade. A time-lapse camera provided daily photographs of the glacier and drainage basin throughout most of the summer. It appears possible to relate accurately the photographs of snowline position to the measured mass balance of the glacier and drainage basin, suggesting a valuable remote sensing method to refine hydrological balance measurements (R. M. Krimmel).

Logistic support during the 1971 field season was again provided by a de Haviland Beaver floatplane. Rather than landing exclusively on the terminal lake as in previous years, the floatplane this year accomplished numerous successful landings on snow near the center of the glacier, performing as well as or better than most ski-equipped planes.

NISQUALLY GLACIER, WASHINGTON

An investigation of flow characteristics in the ablation zone of the Nisqually Glacier, Mount Rainier, Washington, has been conducted by S. Hodge (Geophysics Program, University of Washington), in cooperation with the U.S. Geological Survey and the National Park Service. The object of this study is to measure seasonal variations in ice velocity and surface elevation, and to obtain information which can be used to infer possible basal sliding mechanisms for this glacier.

A longitudinal line of 20 motion stakes and a transverse line of 7 stakes were continuously maintained for a two-year period on the lower half of the glacier. During this period, 59 surveys were made of the array. Survey frequency was dictated by weather and avalanche conditions and was therefore somewhat irregular, the minimum interval between surveys being 6 days and the maximum being 90 days; the average interval was about 12 days. A detailed longitudinal velocity profile was obtained during May 1971 with a line of 75 motion stakes, spaced about 35 meters apart. All positions and elevations were computed from theodolite fixes, taking into consideration stake tilt and the bending which occurred during the winter months. Preliminary analysis of the data indicates a pronounced seasonal velocity variation superimposed on a longer period variation, both of which appear to have a dependence on down-glacier distance.

In addition to the motion studies, measurements of accumulation or ablation were made at all stakes during each survey. Daily measurements of run-off were made at a stream gage located about one mile below the terminus of the glacier. An extensive gravity survey has been completed and efforts are now underway to establish a few borehole depths as a check on the gravity calculations. A time-lapse film of ice motion in the Nisqually ice fall has also been completed.

MOUNT RAINIER, WASHINGTON

An analysis of long-term records of run-off, precipitation, and glacier fluctuations is being made by D. Richardson (USGS, Tacoma) in an attempt to relate these records to recent, more detailed, data. At present, streamflow is monitored during most of the year by gages located a short distance below the Emmons and Nisqually glaciers. Although no unusual events were observed at either of these glaciers during 1971, an outburst flood occurred at the South Tahoma Glacier on 10 August which exceeded in magnitude the destructive outburst of 31 August 1967.

Annual thickness profiles taken on the Nisqually Glacier indicate continued thickening near the firn line, thinning and slight recession near the terminus, and little change between the two. In contrast, the Carbon Glacier on the north side of Mount Rainier has shown a net advance from 1967 to 1971 (D. Richardson, J. Dugwyler).

MACLURE GLACIER, CALIFORNIA

Ice and water balance measurements were continued by G. Balding and W. Hotchkiss (USGS, Sacramento) at this small glacier in the Sierra Nevada Mountains, as part of an International Hydrological Decade program.

GULKANA AND WOLVERINE GLACIERS, ALASKA

Studies on these glaciers are part of a contribution by the U.S. Geological Survey to the International Hydrological Decade which includes similar studies on the Maclure and South Cascade glaciers. Field work in 1971 was conducted by L. R. Mayo (USGS, Fairbanks) and C. Zenone (USGS, Anchorage), and was directed mainly toward proper measurements of ice and water balances, but with sufficient meteorological data to permit crude heat balance computations at a later date.

An extremely high flood, caused by an unusually warm rain extending to the higher altitudes of Gulkana Glacier, occurred in the spring and washed away the Gulkana Creek gaging station. On Wolverine Glacier, a very dense snowpack was found in the spring—so dense that meltwater was observed to flow over the top of the snow. The result was that the transmission time for meltwater to reach the terminus was greatly increased and no diurnal fluctuation in discharge occurred throughout the ablation season.

MALASPINA GLACIER, ALASKA

The huge Malaspina piedmont glacier displays on its surface a regular but enigmatic pattern of medial moraines. Although these have been mapped in detail by A. Post (USGS, Tacoma), the mechanism which forms the large, periodic bends in the moraines is still poorly understood. The bends are initiated where the lower Seward outlet glacier feeds the piedmont lobe of Malaspina Glacier. During 1971 two camps were established by glaciologists from the Tacoma office of the USGS near the Seward Glacier throat, one at the south-east extremity of Samovar Hills (R. M. and R. L. Krimmel) and the other at the south-west extremity of the Hitchcock Hills (A. Post and D. Richardson). These camps were maintained for a period of two weeks (31 July to 13 August). A helicopter was used for about two days at the beginning and end of the period, for access into and out of the area, and for work on the glacier itself.

The objects in order of priority were to: (1) obtain surface velocity measurements by sequential position measurements of several points on the lower outlet and upper lobe areas of the glacier, (2) take gravity readings at these points to determine ice depths, (3) run gravity profiles from the camps to the margin of the Malaspina Glacier, and (4) locate R. P. Sharp's camp of 1948-52 for movement and ablation information.

The helicopter was used to set out 7 velocity stations on the Seward outlet and another 7 on the Malaspina lobe; the stations were then located by triangulation and gravity readings taken. After the velocity stations were established the helicopter was used to gather approximately another 20 gravity readings on various parts of the lobe. Due to orientation problems and an unusually high snow cover, the search for Sharp's camp was short and unsuccessful. For the remainder of the period the velocity stations were routinely surveyed at 0800, 1400, and 2000 daily, weather permitting. Many secondary observations regarding ablation, marginal velocities, lateral moraines, and ice dammed lakes were undertaken between surveys.

The sighting of a marker set out two years previously on the Seward Glacier throat showed the average two-year velocity to be about 6.3 m/day; the average over the same path during the two-week survey was about 4.2 m/day. Preliminary gravity data indicate that the bed along a profile south of Samovar Hills is below sea level within about 7 kilometers of the south margin, and the bed within the throat is well above sea level.

AERIAL PHOTOGRAPHY OF NORTH AMERICAN GLACIERS

Aerial surveys of glaciers in western North America are conducted annually by the U.S. Geological Survey. During July, a photographic reconnaissance of glaciers in the Alaska Range was made by L. Mayo (USGS, Fairbanks). Extensive photography of glaciers in the Cascade Range of Washington (north of Mount Rainier), the Coast Mountains of British Columbia, and major portions of the Coast, St. Elias, Chugach, Kenai, Aleutian, and Alaska ranges in Alaska was completed in late August and early September by A. Post (USGS, Tacoma).

In general, it was a year of little change for most glaciers in this extensive area. A small glacier tributary to Peters Glacier in the Alaska Range was noted to be surging; surges of the Tokositna Glacier (Alaska Range) and the Fisher Glacier (Icefield Range, Yukon Territory) showed small gains over 1970 positions. Changes in tidal glaciers followed previous trends with recession observed in the Dawes, South Sawyer, Plateau, Muir, and Guyot glaciers. The most notable advances occurred in the Johns Hopkins Glacier (Glacier Bay) and the Hubbard Glacier (Yakutat Bay). The latter created excitement in the spring and early summer when its advance closed the entrance of Russell Fjord to 150 meters; however, observations by Geological Survey glaciologists in August and September indicated no further gains; in fact, slight recession was noted along some portions of the 10-kilometer terminus.

TANQUARY FJORD, ELLESMERE ISLAND

With assistance from the Arctic Institute of North America and generous cooperation from the Defence Research Board of Canada, a field experiment to measure light extinction in sea ice was conducted at Tanquary Fjord by investigators (R. Roulet, E. Vervoort, and D. Bell) from the Department of Atmospheric Sciences, University of Washington. The primary objects of the investigation were to measure light levels beneath the ice pack, in both ponded and unponded areas, and to obtain data on the wavelength dependence of light scattering in sea ice. These data will be used in an attempt to achieve an understanding of apparent inconsistencies in the relationship between the heat and mass balances of pack ice in the Arctic Basin. The field work took place during May 1971, coinciding with the first half of the melt season.

The basic instruments used for the observations were two highly directional, narrow-band spectrophotometers developed by R. Roulet. One of these devices was mounted at the surface to monitor incident short-wave radiation, while a miniaturized version was used to simultaneously record penetrating short-wave radiation in the water beneath the ice. The smaller spectrophotometer was lowered into the ocean through a SIPRE corehole, and then moved approximately 3 meters from the hole with a specially designed underwater positioning system. Observations were made under snow-covered ice, melt ponds, and a variety of bare ice types. In addition, several profiles of light intensity were obtained in the upper 30 cm of the ice cover. Supplementary information on albedo, salinity and density was also gathered. Preliminary inspection of data taken under 2 m ice indicates substantial differences in light penetration which appear to be directly related to surface characteristics. Complementary laboratory experiments to determine the scattering function for various types of ice are now in progress.

G. Maykut

Mesoscale Strain and Ice Morphology

As part of the 1971 AIDJEX Pilot Study, the deformation of a strain triangle ($\sim$ 6 x 8 x 11 km) located on 2 m thick first year ice in the Beaufort Sea was observed over a two-week period in March 1971. Significant strain events ($\sim$1.5%) occurred during short ($\sim$ 6 h) time periods. The long term (one day or more) divergence rate varied between .04 to .08 x 10^{-3} h^{-1}. Short term divergence rates showed values as high as .29 x 10^{-3} h^{-1}. The observed shearing motion indicated that the floes to the east were moving to the south relative to the floes to the west. This agrees with the shear pattern that might be expected considering the location of the station in the Pacific Gyre. Studies of fracture (lead and crack) orientations in the vicinity of the strain triangle indicate reasonable correlations with the orientation of the strain rate ellipse. A qualitative relation is also suggested between the fracture density and the long term divergence rate. Correlations were also observed between the divergence of the wind field as computed from the surface pressure field and the ice divergence.

Studies were also completed on the correlation between the elevation of both the snow and the ice surface of a multi-year floe. In addition, relations between snow and ice surface roughness and ice thickness as well as the bottom topography were examined. Profiles were also prepared (by drilling and side-looking sonar) of a large multi-year pressure ridge. The ridge sail extended 4 m above sea level and the ridge keel 13 m below. The cross sections of the ridge keel were roughly semi-circular suggesting a high form drag coefficient ($\sim$ 1.0) for flow normal to the axis of the ridges.

Work is also continuing on the analysis of the distribution of pressure ridging in time and space. A theoretical distribution function for ridge heights and keel depths has been derived from fundamental assumptions about the randomness of the ridges. In addition it has been shown that the distribution function for ridge spacings (distances between ridges) can also be predicted from the assumption of spatially random distribution. The suggested distribution functions are, in form, negative exponentials of the ridge depth (or height) squared and the ridge spacing respectively. Extremely good fits have been achieved to extensive data collected by visual observations, aerial photogrammetry, and laser and sonar profiles of the top and bottom surfaces of the ice respectively.

CRREL staff members working in this general problem area are Ackley, Hartwell, Hibler, Kovacs, Mock and Weeks. Other cooperating organizations are the AIDJEX Project, NASA, NAVOCEANO and the U.S. Geological Survey.

W. F. Weeks

Meltwater percolation through homogeneous snow

Miss Gail Davidson of Dartmouth College and Dr Sam Colbeck of CRREL made studies of water percolation through snow on the South Cascade Glacier. The specific purpose of these studies was to separate the effects of inhomogeneous snow structures from the effects of the physical processes of percolation. Thus the experiments used long columns of repacked snow which were set into the glacier surface. Water entered the columns by melting at the surface and meltwater waves passing various depths were observed at the bottoms of the columns. Much further insight into the physics of percolation was gained from the analysis of this data. In particular, the relationship between permeability to the water phase and water saturation was found. With this relationship now available, more accurate predictions of the movement of liquid water through snow can be made.

S. C. Colbeck

HONORARY MEMBERS OF THE INTERNATIONAL GLACIOLOGICAL SOCIETY

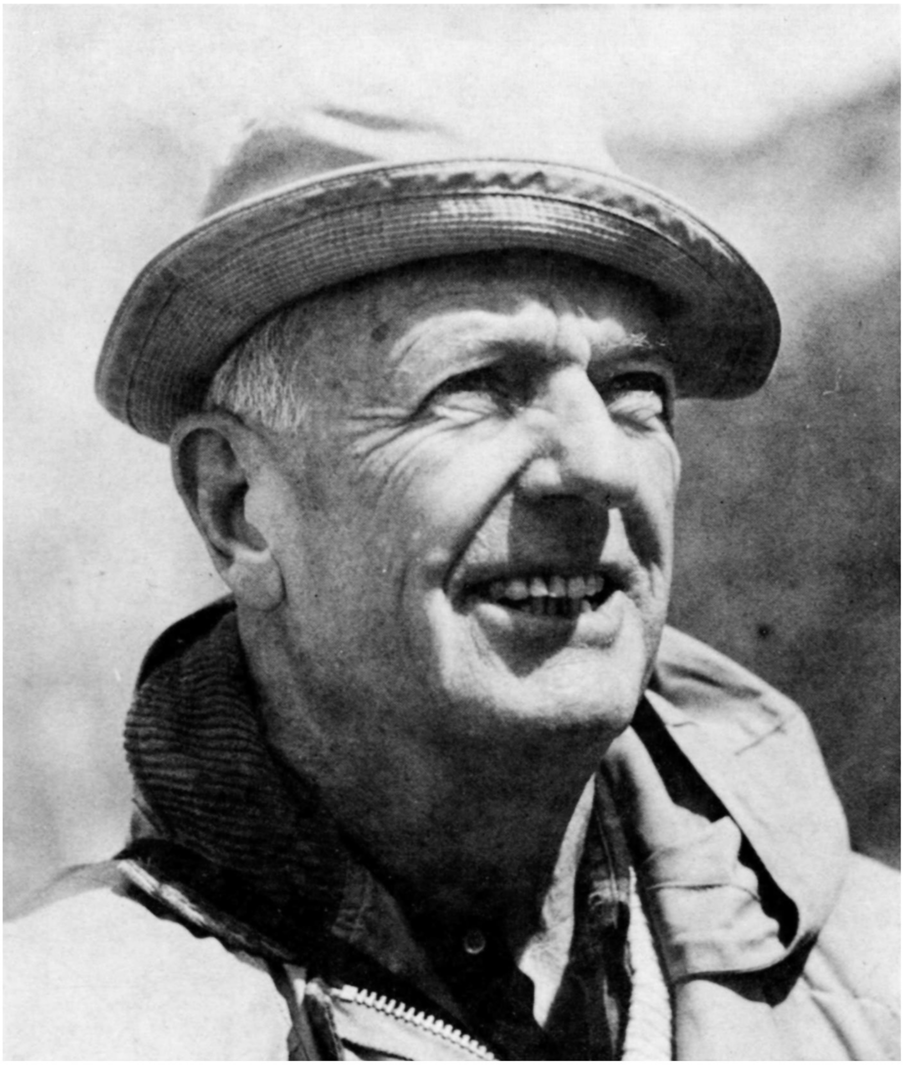
HANS W:SON AHLMANN

Hans Ahlmann, born in Sweden in 1889, was educated at Stockholm and Uppsala Universities. He taught in both universities after graduating, and in 1929 was appointed Professor and Director of Stockholm University Geography Department. Between 1931 and 1938 he led various expeditions to Nordaustlandet, Spitsbergen and Vatnajökull. Results of the investigations in Nordaustlandet were published in *Geografiska Annaler* during the period 1933-42. The results of his work since 1918 on glaciers and their relationship to climatic fluctuation were published by the Royal Geographical Society in London, as RGS Research Series, No. 1.

It was mostly Hans' enthusiasm and initiative that resulted in the creation of the Norwegian-British-Swedish Antarctic Expedition of 1949-52. He was Chairman of the Swedish Organizing Committee and was responsible for the type of glaciological programme that the Expedition carried out.

From 1950-56 Ahlmann was Swedish Ambassador to Norway, but he still continued his publication of glaciological articles. From 1956-60 he was President of the International Geographical Union, and First Vice-President 1960-64. Since his retirement in 1956 he has been very active as a writer in *Svenska Dagbladet* and author of various atlases and geographical handbooks.

He has had long connexions with this Society: the foreword of the first issue of the Journal of Glaciology, January 1947, was written by him. He was made an Honorary Member in 1962.



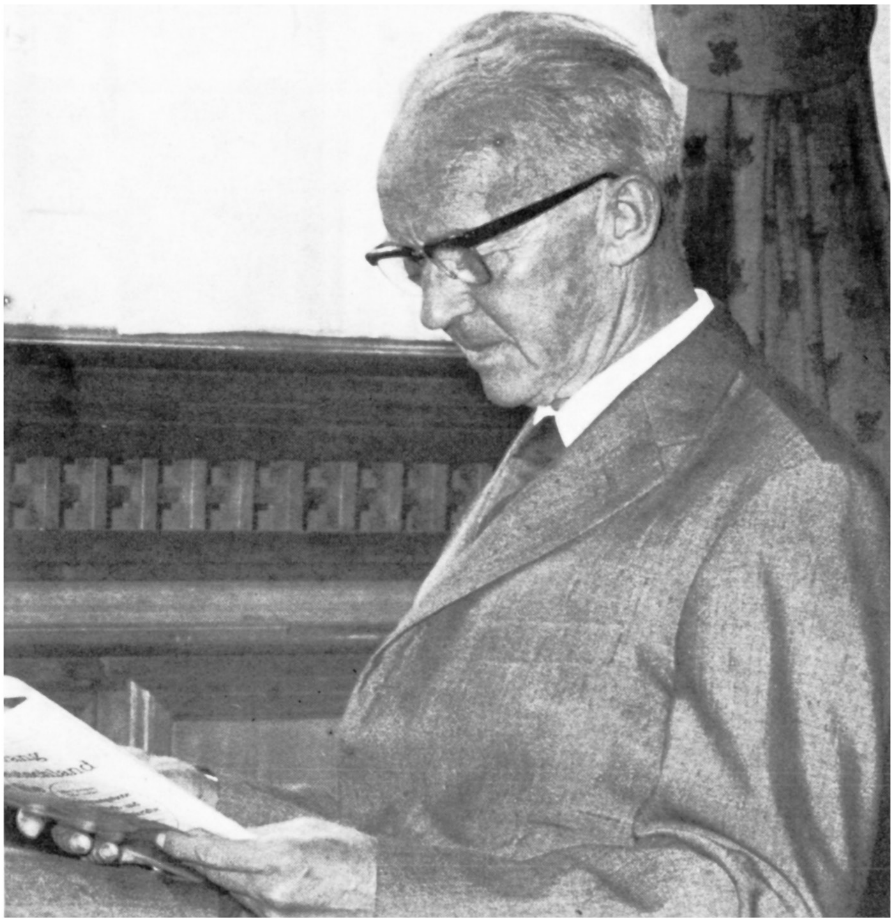
WILLIAM O. FIELD

Bill Field, born in New York in 1904, took his degrees in geology at Harvard University. In 1926 he began his studies of glacier variations in south-east Alaska. He joined the staff of the American Geographical Society in 1940, but his work was interrupted by service in the photographic branch of the US Army Signal Corps. In 1947 he became the head of the AGS Department of Exploration and Field Research, specializing in polar regions studies and various aspects of glaciology.

Many glaciologists consider Bill to be the integrator and catalyst of North American glaciology. For more than 40 years, studies of glacier variations have been meticulously documented, and the photographs make a unique record of the movements of over 200 glaciers, mostly along the outer slope of the coastal mountains. His contribution in unravelling the story of North American glaciers is rivalled only by his work on committees and panels. The success of the Glaciology Panel of the Committee on Polar Research (US National Academy of Sciences) stems in no small part from his many years of chairmanship, which showed his ability to mediate, organize, and quietly direct the discussions of busy and strong-minded scientists.

He was Vice-President of the Commission of Snow and Ice 1960-63 and of the Glaciological Society 1962-64. He has been a staunch supporter of the Society throughout its period of reorganization and expansion and was made an Honorary Member in 1970.

ROBERT HAEFELI

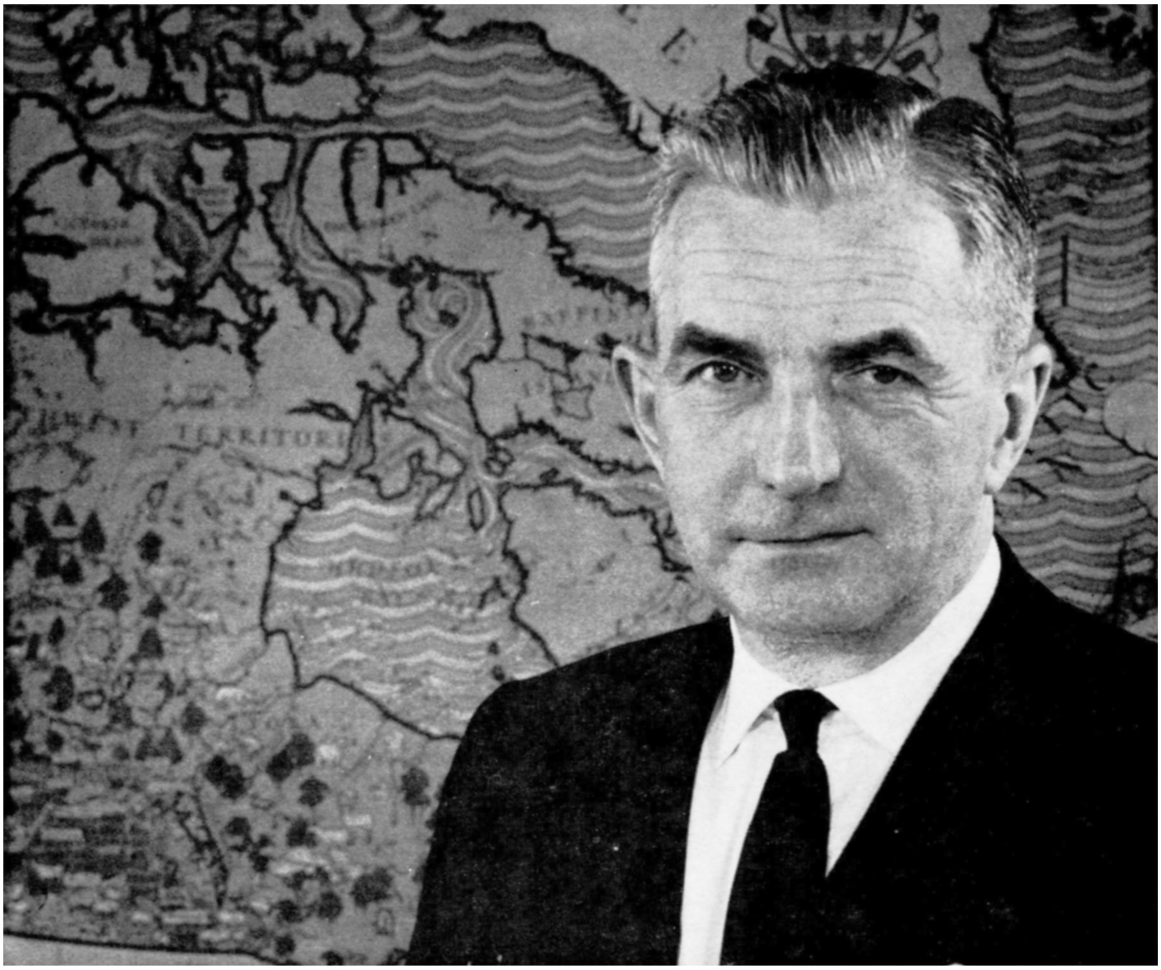


Born in Lucerne in 1898, Robert Haefeli was brought up to regard ski-ing and mountaineering as the natural form of recreation. He trained as a civil engineer in Zürich and worked in Germany, France, Spain and Switzerland. In 1933 he became head of the first Swiss laboratory on soil mechanics, in Zürich, and in 1935 was appointed head of the Eidg. Institut für Schnee- und Lawinenforschung, which had been founded a few years previously at the Weissfluhjoch above Davos. Here his experience in soil mechanics was successfully applied to the problems of snow. In 1942 he moved back to Zürich, as professor of soil mechanics, snow mechanics and avalanche protection at ETH.

From snow studies, Robert moved on to glaciers and in 1939 began his famous series of investigations on the Aletschgletscher. Other studies followed, and led to his work on the problems of large ice sheets. He was closely associated with the work of the Expédition Glaciologique Internationale au Groenland and was its President 1956-57.

He has also been active in the work of the Commission of Snow and Ice, and was its President 1954-57. For many years he was also President of the Gletscherkommission der Schweiz. In his retirement from full-time academic life, he is still very active in consultant work.

It was in recognition of his distinguished applications of engineering principles to glaciology that he was made an Honorary Member of the Glaciological Society upon his 70th birthday in 1968.



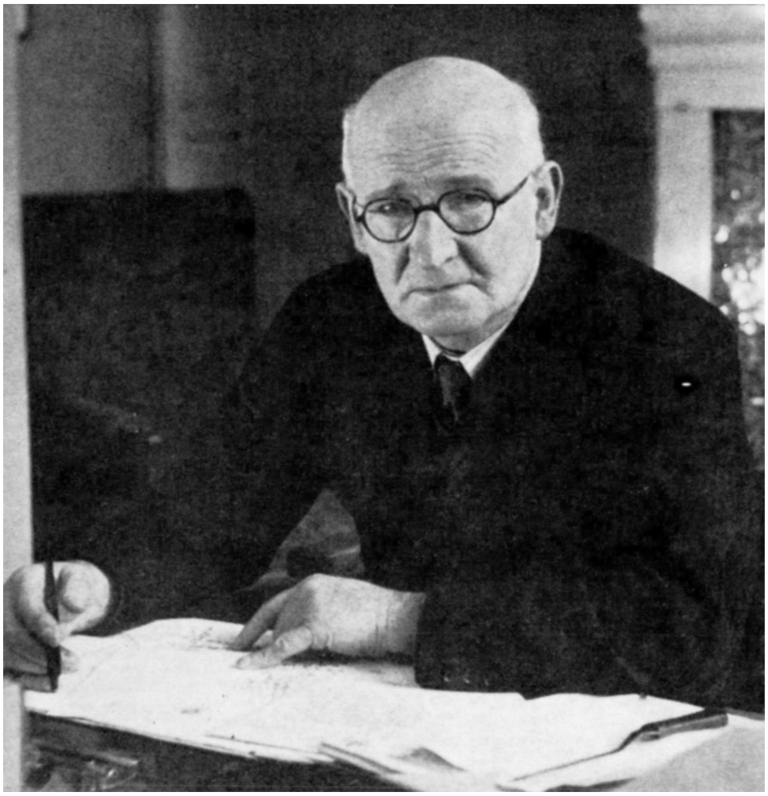
ROBERT F. LEGGET

Of Scottish parentage, Robert Legget was born in Liverpool and received his engineering training at Liverpool University, from which he graduated in 1925. After spending some years with a firm of consulting engineers in London, working mainly on water power and harbour installations in Scotland and England, he went to Canada in 1929, to work for the Power Corporation of Canada as Resident Engineer on what is still the largest Canadian fully automatic water power project, and later for the Canadian Sheet Piling Company. In 1936 he joined the staff of the Civil Engineering Department of Queen's University, and then moved to the University of Toronto in 1938, where he stayed until 1947. During this period he was consulted about several special foundation and soil problems, for mines, power plants, and subway projects. In 1947 he was invited to start the new Division of Building Research of the National Research Council in Ottawa, remaining there as Director until his retirement in 1969.

The need for glaciological research in Canada was recognised by Bob Legget's establishment in 1948 of the Snow and Ice Section of the Division. He invited Marcel de Quervain to work in the Division for a year on snow conditions in Canada, and in 1950 appointed Lorne Gold to undertake research on snow and ice. This was the first full-time appointment in these subjects in Canada and marked the establishment of what has proved to be a highly successful group.

The very active growth of glaciological research in Canada undoubtedly stemmed from Dr Legget's foresight and direction. It was in recognition of this work that he was made an Honorary Member of the Society in 1970.

SIR RAYMOND PRIESTLEY



Born in Gloucestershire in 1886, Raymond Priestley was educated at Bristol, Sydney and Cambridge Universities, where he specialized in geology. He joined Shackleton's *Nimrod* Expedition to the Antarctic 1907-09, and Scott's *Terra Nova* Expedition 1910-13. After service in the army 1914-19, he spent a few years writing scientific reports on his Antarctic work, notably one with Charles Wright on the glaciology of the *Terra Nova* Expedition. In 1923 he was made a Fellow of Clare College, Cambridge, where he stayed until 1935, serving as Secretary General of the Faculties in the final year.

The years 1935-38 he spent in the Southern Hemisphere, as Vice-Chancellor of Melbourne University. He then returned to Britain to take up his appointment as Principal and Vice-Chancellor of Birmingham University, staying there until his retirement from regular work in 1952. He was knighted in 1949.

After his retirement, Sir Raymond was in great demand for service in various capacities, including Presidency of the British Association for the Advancement of Science (1956) and of the Royal Geographical Society (1961-63). In the 1956-57 season, he accompanied Prince Philip, Duke of Edinburgh, in the Royal Yacht *Britannia* on a tour of the Falklands Islands Dependencies and Gough Island, while in 1958 he went to Antarctica again as guest of the Americans in "Deep Freeze *IV*".

His links with the polar world are many, for his two sisters married fellow Antarctic scientists Charles Wright and Griffith Taylor, and he was instrumental in founding, with Frank Debenham, the Scott Polar Research Institute in Cambridge. In 1959 he was made an Honorary Member of the Society.

MARCEL DE QUERVAIN

Marcel was born in Zürich in 1915, son of the geophysicist Alfred de Quervain, famous for his early crossing of Greenland. At the age of 7, Marcel earned his first money as a glaciologist, working with his brother in measuring the Grindelwaldgletscher. He was educated in Zürich, gaining a Diploma in Physics at ETH in 1940 and a Doctor's degree in 1944, for his X-ray studies of ferro-electrical materials.

He had begun work at the Eidg. Institut für Schnee-und Lawinenforschung in Davos in 1943 investigating the metamorphism and the visco-elastic and thermal properties of snow, and the evaporation and run-off from the snow cover. In 1948 and 1949 he worked in North America, partly at the newly formed US Army Snow, Ice and Permafrost Establishment (now CRREL) but mainly at the National Research Council of Canada, at the invitation of Dr Legget.

In 1950 he returned to Davos as Director of the Institute. Many glaciological problems are studied at the Institute, but special emphasis has been laid on the practical problems of avalanche protection. The daily avalanche warning system during the danger period of the year is the envy of other alpine countries. In addition to his work at the Institute, Marcel has given courses on atmospheric physics, nivology and avalanche protection at ETH in Zürich and is a member of many commissions and committees in Switzerland.

Internationally, he has served as Vice-President of the International Association of Scientific Hydrology (until August 1971), and he worked from 1959 with the Expédition Glaciologique Internationale au Groenland as head of the "Glaciology Inlandsis" group, studying the stratification and structure of the névé. He has long been associated with the Society and was made an Honorary Member in 1953; at the moment he is one of three Vice-Presidents.

SIR CHARLES WRIGHT

Charles Wright was born in Toronto in 1887 and was educated at Upper Canada College and the University of Toronto, and at Gonville and Caius College, Cambridge. Between 1908 and 1910 he did research in physics at the Cavendish Laboratory in Cambridge, and then took part in the British Antarctic Expedition 1910-13, with R. F. Scott as leader. He was one of the party that went in search of the South Pole Party, and it was he who spotted the tent, almost completely covered by snow.

After service in the Royal Engineers 1914-18, he worked in the Admiralty Department of Scientific Research and Experiment for ten years, and was then appointed Superintendent of the Admiralty Research Laboratory. He was promoted from that position in 1934 to be Director of Scientific Research Admiralty, a post he held until 1946. In 1946 he became the first Chief of the Royal Naval Scientific Service, and was knighted.

Sir Charles returned to North America in 1947 to continue his own research. He was Director of the Scripps Institution of Oceanography until his retirement in 1955, and then moved to Canada as a contractor for the Defence Research Board of Canada, working mainly from their Pacific Naval Laboratory. During part of this period, he was on loan to Stanford University to take part in a joint Stanford-PNR study of very low frequency radio waves. This involved a return to the Antarctic, to work at Byrd Station and to visit again Scott's huts at Cape Evans. From 1964-68 he was a lecturer in geophysics at the University of British Columbia.

He is best known to glaciologists for his report, written jointly with Raymond Priestley and published in 1922, on the glaciological work of the *Terra Nova* Expedition. He was made an Honorary Member of the Glaciological Society in 1968.

INTERNATIONAL GLACIOLOGICAL SOCIETY

MEETINGS

The following talks were given in Cambridge, England at the Society's 1972 Annual Conference, 20–21 April. Further details may be obtained from the authors—see 1972 List of Members for their addresses.

F. Müller — The glaciology and climatology of the North Water Project.

W. F. Weeks — Statistical aspects of sea ice ridge distributions.

B. Lyle Hansen — A progress report on an engineering study of core drilling problems in Greenland and Antarctica.

W. Dansgaard — New oxygen isotope profiles along ice cores from Little America, Antarctica, and Dye 3, Greenland.

M. Walford — Recent field work for the British Antarctic Survey.

O. Orheim — The Deception Island mass balance record and inter-hemispheric climatic correlations.

D. Sugden & B. S. John — C_{14} dates and recent glacier readvances in the sub-Antarctic.

G. Golubev — Internal feeding of glaciers.

R. Vivian — Problems of sub-glacial erosion.

A. Iken — Water pressure variations in moulins and diural fluctuations of the surface velocity of the White Glacier, Axel Heiberg Island, Canadian Arctic Archipelago.

A. Flotron — Short-term variations in the movement of the Unteraargletscher.

G. S. Boulton — Observations of sub-glacial till deposition.

J. G. Paren — Report on European discussion meeting on physics of ice.

R. Ferguson — Some observations on supraglacial streams.

W. B. Whalley — The advance of the Feegletscher north tongue.

N. R. Page — A radiocarbon chronology for East Anglia.

Visiting Lecturer

Dr. G. Golubev, Faculty of Geography, Moscow State University, spent three weeks in Britain recently as a guest of the Society. In addition to the lecture on "Internal feeding of glaciers" which he gave at the Society's Annual Conference in Cambridge, 20–21 April, he lectured on "Problems of the hydrology of glaciers" at the following places:

Aberdeen University
(Geography Department)

Newcastle University
(Geography Department)

Birmingham University
(Civil Engineering Department)

Cambridge University
(Scott Polar Research Institute)

He also visited Bristol and London, before returning to Moscow on 12 May.

FUTURE MEETINGS

1973

The Society's 1973 Annual Conference will be held 2, 3 & 4 May, at the Scott Polar Research Institute, Cambridge, England (by kind permission of the Director). Part of the Conference will be devoted to discussion of sea ice research, and the remaining time will be available as usual for informal talks on recent research into any aspect of glaciology.

1974

The Society will hold a Symposium on **"Remote sensing in glaciology," 15-21 September 1974,** in Cambridge, England. The Symposium will be concerned with the application of remote sensing by radiation to the measurement of glaciological parameters. It will include discussion of topics such as:

radio echo sounding,
active and passive microwave,
infra-red techniques,
and laser profilometry —

of glaciers, ice sheets, snow, sea ice, ground ice. The Symposium will **not** be concerned with conventional photographic techniques. The First Circular will be issued later in 1972.

1976

The Society will hold a Symposium on **"Problems of applied glaciology"**, some time in **September 1976,** in Cambridge, England. Details of the topics to be discussed will be announced in 1973. The Symposium will celebrate the 40th anniversary of the founding of the Society, originally named the Association for the Study of Snow and Ice.

BRANCH NEWS

Nordic Branch

We are pleased to announce the formation of a Nordic Branch of the Society, for members resident in Denmark, Finland, Iceland, Norway and Sweden. At a meeting held on 19 April 1972, the Council of the Society approved the statutes of the branch.

It is hoped that the inaugural meeting will be held in Stockholm in September 1972.

French Branch

The first scientific meeting of the French Branch will be held in Chamonix in the second fortnight of October 1972. The meeting will last three days, and the programme will include visits to nearby glaciers, lectures, a business meeting to elect the officers for 1973, and a banquet. Further details will be announced later.

There are now four branches of the Society: British, French, Nordic and Northeast North American. Discussions about the formation of three more branches are in progress.

JOURNAL OF GLACIOLOGY

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

Articles —

J. F. Nye, R. G. Kyte and D. C. Threlfall:
Proposal for measuring the movement of a large ice sheet by observing radio echoes.

W. D. Hibler and L. A. LeSchack:
Power spectrum analysis of undersea and surface sea ice profiles.

S. C. Colbeck:
A theory of water percolation in snow.

K. Itagaki and T. M. Tobin:
Mass transfer along an ice surface observed by a groove relaxation technique.

R. LeB. Hooke, B. B. Dahlin and M. M. Kauper:
Creep of ice containing dispersed fine sand.

G. Gudmundson and G. Sigbjarnarson:
Analysis of glacier run-off and meteorological observations.

T. Búason:
Equation of isotope fractionation between ice and water in melting snow column with continuous rain and percolation.

B. R. Barkstrom:
Some effects of multiple scattering on the distribution of solar radiation in snow and ice.

M. P. Langleben:
The decay of an annual cover of sea ice.

F. W. Smith:
Elastic stresses in layered snow packs.

W. A. Murray and R. List:
Freezing of water drops freely suspended in a vertical wind tunnel.

FUTURE MEETINGS

SYMPOSIA ON THE ROLE OF SNOW AND ICE IN HYDROLOGY

(Banff, Canada, 6–20 September 1972)

All correspondence regarding the Symposia, including registration forms and pre-payment for tours, should be addressed to:

Dr I. C. Brown, Chairman, Organizing Committee, International Symposia on the Role of Snow and Ice in Hydrology, c/o Inland Waters Directorate, Environment Canada, Ottawa K1A OE7, Ontario, CANADA.

Symposia on properties and processes (convened by UNESCO)

Unesco Session —1—

6 SEPTEMBER, MORNING
Physics and chemistry of snowfall and snow distribution
(Theme speaker—T. L. Richards, Department of Environment, Canada)
Theme paper will cover (i) factors influencing the distribution, water content, intensity, and chemistry of falling snow, and (ii) local variations in snowcover characteristics. The emphasis in this paper will be on physics rather than chemistry.

Unesco Session —2—

6 SEPTEMBER, AFTERNOON
Conditioning, ripening and melting of snowcover
(a) Energy exchange at air-snow interface
(Theme speaker—H. Kraus, Meteorologisches Institut der Universität München, F.R.G.). Theme paper will review the classical methods of micrometeorological energy balance studies over ice and snow surfaces. The paper will then deal with the variations in time and space of the various parameters, leading to a discussion of theoretical and practical aspects of mesoscale energy exchange studies.

7 SEPTEMBER, MORNING
(b) Heat and mass flux through snowcover; metamorphism and changes in physical properties
(Theme speaker—M. de Quervain, Institut für Schnee-und Lawinenforschung, Switzerland)
Theme paper will review the basic theory of heat and mass flux through the snowcover and the attendant changes in physical properties. The paper will also deal with recent findings about snowpack metamorphism and its influence on the run-off regime.

Unesco Session —3—

7 SEPTEMBER, AFTERNOON
Ground conditioning and water movement
(Theme speaker—G. A. Alekseyev, U.S.S.R. National IHD Committee)
Theme paper will be concerned with expressing changes in the physical properties of the soil caused by ground conditioning processes as they affect heat and moisture movement. The paper will also discuss how the amount of snowmelt entering the ground in infiltration is governed by the ability of the soil to transmit water under frozen or partially frozen conditions.

Unesco Session —4—

8 SEPTEMBER, MORNING
Properties and processes of glaciers
(Theme speaker—M. F. Meier, U.S. Geological Survey, U.S.A.)
Theme paper will concentrate on those aspects relevant to hydrologists. A review of the state of the art of mass balance measurements and computations for glaciers will be made along with a discussion of the complex relationship between mass balance and climate. Also discussed will be the dynamic response of glaciers to mass balance.

Unesco Session —5—

8 SEPTEMBER, AFTERNOON
Properties and processes of river and lake ice
(Theme speaker—B. Michel, Laval University, Canada)
Theme paper will deal with the various mechanisms of formation of river and lake ice, the effect of ice cover, and the various mechanisms of break-up as they influence the hydrology.

Symposium on measurement and forecasting (convened by WMO)

WMO Session —1—

9 SEPTEMBER, MORNING
Measurement in space and time
(Theme speaker—E. L. Peck, National Oceanic and Atmospheric Administration, U.S.A.)
Theme paper will briefly review methods of measuring snowcover, snowmelt and related meteorological parameters, and streamflow under winter conditions. Attention will be given to the development of airborne sensors and satellite methods.

WMO Session —2—

11 SEPTEMBER, MORNING
Forecasting run-off
(a) The forecast problem, theoretical
(Theme speaker—E. G. Popov, Hydrometeorological Research Centre, Moscow, U.S.S.R.)
(Theme speaker—E. A. Anderson, National Oceanic and Atmospheric Administration, U.S.A.)
Theme papers will review the snow and ice variables that influence run-off; the problems of measurement, of extrapolation in space and time, of the evaluation and interaction of relevant physical characteristics of drainage basins. Also examined will be the potential for utilizing mathematical methods for simulating basin outflow hydrographs resulting from basin characteristics and inputs thereto.

11 SEPTEMBER, AFTERNOON
(b) Operational practices
(Theme speaker—M. C. Quick, University of British Columbia, Canada)
Theme paper will describe on a world-wide basis regional operational practices in streamflow forecasting where snowmelt is the dominant contribution to run-off. It will also discuss briefly the requirement for special purpose forecasts associated with the small snow-fed watersheds.
(c) New techniques
In a Panel Discussion, the topic will be entertained with questions and contributions from participants.

WMO Session —3—

12 SEPTEMBER, MORNING
Measurement and forecasting specific to glaciers
(Theme speaker—G. Østrem, Norwegian Water Resources and Electricity Board, Norway)
Theme paper will review and evaluate the various forecasting techniques so far tried for glacier run-off. The paper will also touch on the problem of modelling, and forecasting the area and mass changes of glaciers.

WMO Session —4—

12 SEPTEMBER, AFTERNOON
Measurement and forecasting specific to river and lake ice
(Theme speaker—G. B. Ginzburg, Hydrometeorological Research Centre, U.S.S.R.)
Theme paper will review the practical measurements required for forecasting of river and lake ice and relate these to the requirements for greater understanding of both meteorological variables and structural conditions within a water body.

WMO Session —5—

13 SEPTEMBER, MORNING AND AFTERNOON
Modification of snowfall, snowcover and ice cover
In a Panel Discussion, the topic will be entertained with questions and contributions from participants. Papers have been solicited on the following suggested topics:
- Modification of snow accumulation by cloud seeding.
- Snow fences for influencing snow accumulation.
- Modification of snow accumulation by forestry practices.
- Modification of snowcover by other techniques.
- Thermal modification of ice cover.
- Modification of ice cover by dusting.
- Modification of ice cover by other methods, e.g. man-made structures, icebreakers, etc.
- Effect of modification of sea ice on climate and snow hydrology of arctic land areas.

14 SEPTEMBER
Start of technical study tours.

GLACIOLOGICAL DIARY

1972

30 June-15 July
Field Course in glaciology and glacier hydrology, Peyto Glacier, Banff National Park. Dr G. Østrem, Carleton University, Ottawa, Ontario, Canada.)

10-17 August
International Geographical Union, 22nd Congress, Montreal, Canada. (Secretariat, 22nd International Geographical Congress, P.O. Box 1972, Ottawa, Canada.)

14-18 August
Symposium on the Physics and chemistry of ice. Royal Society of Canada. (M. K. Ward, National Research Council of Canada, Montreal Road, Ottawa 7, Canada.)

21-30 August
International Geological Congress, 24th Session, Montreal, Canada. (Secretary-General, 24th International Geological Congress, 601 Booth Street, Ottawa 4, Canada.)

6-20 September
Symposia on the Role of snow and ice in hydrology. 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.)

26-29 September
Symposium on Ice and its action on hydraulic structures, I.A.H.R. Leningrad, USSR. (Mr B. P. Lebedev, committee for USSR participation in international power conferences, Sovmek, 11 Gorky Street, Moscow K-9, USSR.)

2-6 October
Symposium on the Remote sensing of the environment, University of Michigan. (Univ. of Michigan Extension Service, Conference Dept., Ann Arbor, MI 48104, USA.)

18-25 October
Radiocarbon Conference, Royal Society of New Zealand. (Mr G. W. Markham, Royal Society of New Zealand, P.O. Box 196, Wellington, New Zealand.)

1973

2-4 May
Annual Conference of International Glaciological Society, Cambridge, England. (Part of the Conference will be devoted to discussion of sea ice research.) (Mrs H. Richardson, Secretary, IGS, Cambridge CB2 1ER, England.)

16-28 July
Conference on Permafrost, USSR Academy of Sciences, Yakutsk. (Institut Merzlotovedeniya, Yakutsk, USSR.)

2-10 December
International Union for Quaternary Research, congress, New Zealand. (Dr Jane M. Soons, Secretary-General, Dept. of Geography, Univ. of Canterbury, Christchurch, New Zealand.)

1974

April
Symposium on Snow mechanics, Grindelwald, Switzerland. (Int. Commission on Snow & Ice, IAHS, Dr F. Müller, Secretary, Geog. Inst. der ETH, Sonneggstrasse 5, Zürich 8006, Switzerland.) (It is intended that the meeting will deal with the basic physics of this subject.)

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

1976

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

NEW MEMBERS

Barbour, Dr George B., Department of Geology, University of Cincinnati, Cincinnati, OH 45321, USA.

Beltramino, Dr J. C., 9 Wilton Crescent, London SW1, England.

Bridges, Miss Serena, 50 Croham Park Avenue, South Croydon, Surrey CR2 7HL, England.

Bryan, M. Leonard, Institute of Science and Technology, Willow Run Laboratories, The University of Michigan, P.O. Box 618, Ann Arbor, MI 48107, USA.

Campbell, D. S., Supt. — Mining engineering technical services, Iron Ore Company of Canada, P.O. Box 600, Sept-Iles, P.Q., Canada.

Camplin, G. C., Department of Physics, University of Birmingham, P.O. Box 363, Birmingham B15 2TT, England.

Endo, Yasoichi, Institute of Low Temperature Science, Hokkaido University, Sapporo, Japan.

Ehlers, Jürgen, D-2104 Hamburg 92, Cuxhavenerstrasse 204, Germany.

Flatau, Susan E., Rt 3 Box 36, Frazee, MN 56544, USA.

Fletcher, Dr N. H., Department of Physics, University of New England, Armidale, N.S.W. 2351, Australia.

Forslind, Dr E., The Royal Institute of Technology, 100 44 Stockholm 70, Sweden.

Fournier d'Albe, Dr. E. M., Department of Environmental Sciences, UNESCO, Place de Fontenoy, 75 Paris 7e, France.

Gibbard, P. H., Sub-Department of Quaternary Research, Botany School, Downing Street, Cambridge CB2 3EA, England.

Gloag, T. J., H. H. Wills Physics Laboratory, Royal Fort, University of Bristol, Bristol BS8 1TL, England.

Golubev, Dr G., Faculty of Geography, Moscow State University, Moscow B 234, USSR.

Harrison, William D., Geophysical Institute, University of Alaska, College, AK 99701, USA.

Hedström, Hans, Department of Physical Geography, Box 6801, S-11386 Stockholm, Sweden.

Hilbertz, Dr Wolf H., School of Architecture, University of Texas, Austin, TX 78712, USA.

Homer, D. R., 56 Bannister Street, Cradley Heath, Warley, Worcs., England.

Howell, M. J., 40 Lawrenny Street, Neyland, Milford Haven, Pembrokeshire, Wales.

Johnson, C. Branning, Entry 26 No. 15-L Graduate Circle, University Park, PA 16802, USA.

Makarevich, Dr K. G., Geography Section, Academy of Sciences, Kazakhskaya SSR, Kalinina 69-a, Alma Ata 2, USSR.

Miller, Gifford H. INSTAAR, PSRB No. 1., University of Colorado, Boulder, CO 80302, USA.

Mizuno, Miss Yukiko, Institute of Low Temperature Science, Hokkaido University, Sapporo, Japan.

Pike, K. G., University of Aberdeen, Department of Geography, St. Mary's High Street, Old Aberdeen, AB9 2UF, Scotland.

Reynolds, J. M., "Magnolia Cottage," Whitstable Road, Blean, Nr. Canterbury, Kent, England.

Rose, Gary D., 111 Davisville Avenue, Apt. 915, Toronto, Ontario, Canada.

Sandahl, Miss Ingrid, Amanuensv 4/116, S-10405 Stockholm, Sweden.

Trummel, John E., Box 165, Yorkville, IL 60560, USA.

Tsurikov, Dr Vladimir L., Oceanographical Commission, Block 2, 44 Vavilov Street, Moscow V-333, USSR.

Tvede, Arve M., Brekontoret, Hydrologisk Avd., Boks 5091, Majorstua, Oslo 3, Norway.

Woldenburg, J. M., Testlab Division of G.D.I. Inc., Box 66310, Chicago, IL 60666, USA.

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