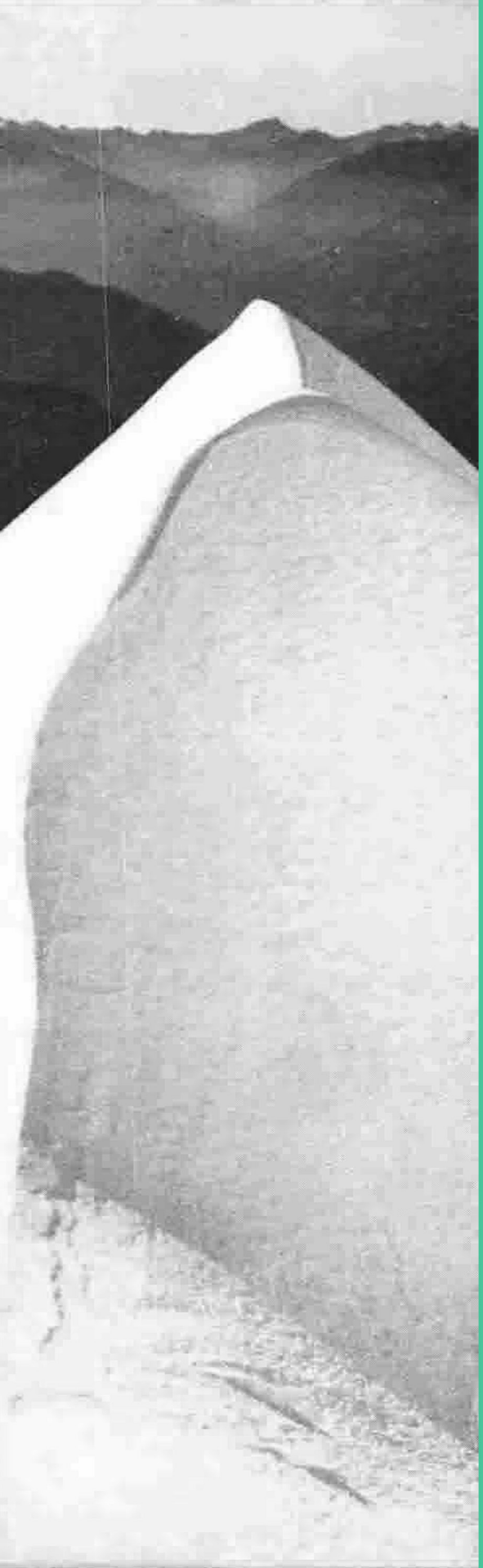

NUMBER 35 APRIL 1971

ICE

GLACIOLOGICAL SOCIETY

1971 ANNUAL GENERAL MEETING

This will be held in Moscow, U.S.S.R., on Tuesday 10 August, during the period of the IUGG XV General Assembly. After the Meeting there will be a party, with food and drinks. The cost of the party will be £3/7 roubles/ US $7.20. Visitors will be welcome.

Members and visitors who wish to attend are asked to send their money to the Secretary of the Glaciological Society, Cambridge CB2 1ER, England, **by post before 1 July** (cheques should be made payable to the Glaciological Society) or to pay in person upon registration in Moscow.

ICE

NEWS BULLETIN OF THE GLACIOLOGICAL SOCIETY

APRIL 1971 (published June 1971) NUMBER 35

CONTENTS

ANNUAL GENERAL MEETING 1971. This will be held in Moscow, USSR, on 10 August. Details will be circulated later.

1971 DUES. Have you paid?

THE SOCIETY'S ACTIVITIES. A new section in ICE draws together information about our meetings, the branches of the Society, the library, and the articles accepted for the Journal of Glaciology. (See pages 19-22 of this issue.) The names and addresses of new members of the Society will remain as a separate section at the end of each issue, for easy reference.

COVER PICTURE. La Sentinelle Rouge, eastern slope of Mont Blanc, with the Aosta Valley in the background. Photograph by André Roch, Davos, Switzerland.

FIELD WORK

CANADA

GLACIER RESEARCH

The Sub-Committee on Glaciers held one meeting in 1970, on 15 October in Ottawa. The Canadian National Committee for the I.H.D. organized a Workshop on Glaciers which was held in Vancouver on 24 and 25 September.

UNIVERSITY OF BRITISH COLUMBIA

W. H. Matthews continued his work of previous years, as a participant in the Berendon Glacier project with the Glaciology Subdivision group and in the maintenance and analysis of snow creep observations on Mount Seymour.

Previous thermal measurements on the Fox Glacier were continued by G. Clarke, D. J. Crossley and D. Classen. Deep ice temperature measurements indicate a zone of basal ice at the pressure melting located in the ablation area. The discovery of this temperate basal ice supports surge theories which invoke basal melting. The second experiment to measure in situ thermal conductivity of ice yielded ambiguous results.

R. Kuchera completed a 16 mm colour film titled 'Ablation Processes on the Athabasca Glacier, Jasper National Park, Alta'. Four years time-lapse photography field work up to 1970 is included in the film which has a running time of 18 minutes. Several processes are well-illustrated, including the formation of annual miniature moraines and actual ice movement and deformation.

UNIVERSITY OF TORONTO
(R. Rossiter and D. W. Strangway)

A means of depth-sounding highly resistive layers using electromagnetic interference fringes is currently being developed to probe the lunar subsurface from Apollo 17. In order to evaluate the technique and to test prototypes in a full-scale geological environment, two trips to the Athabasca Glacier, Alberta, were made during 1970. Frequencies from 1 to 24 MHz have been used. Results compare well with previous depth-soundings of the Athabasca Glacier using seismic and gravity measurements.

GLACIOLOGY SUBDIVISION, INLAND WATERS BRANCH, OTTAWA (O. H. Løken)

During the year two workshop seminars were arranged by the Subdivision, the first concerned projects within the Headwaters of the North Saskatchewan River, the second a discussion of hydrologic models to predict run-off in alpine areas. The first meeting was held in Ottawa in December 1969, attended by 29 persons, and the second, attended by about 20 persons, was held in Lake Louise, Alberta.

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

Field work was carried out on the following glaciers:

1. Per Ardua Glacier, Ellesmere Island (U. Embacher). Mass balance studies were continued.
2. White Glacier, Axel Heiberg Island (K. C. Arnold). Determination of mass balance from detailed surface elevation changes using terrestrial photogrammetry.
3. Barnes Ice Cap, Baffin Island
   a) S. J. Jones carried out ice thickness measurements with a SPRI 35 MHz radio-echo sounder, along a profile from the south shoulder ice divide to the north-east margin and on the South Dome.
   b) G. Holdsworth carried out a triangulation/trilateration from the divide to the north-east margin, tying into bedrock stations to the north-east. In addition the South Dome strain network was connected into the system.
   c) R. LeB. Hooke (University of Minnesota) undertook englacial measurements of the strain components in a 100 m tunnel and in two vertical boreholes penetrating the tunnel on the east margin of the south lobe of the ice cap.
4. Decade Glacier, Baffin Island (U. Embacher). Mass balance, run-off, ice deformation and meteorological measurements were carried out.

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

Mass and water balance measurements (A. D. Stanley, O. Mokievsky-Zubok, T. Bellaar-Spruyt) —Field programmes were continued at five glacier basins in a transect across the southern part of Alberta and British Columbia and on Berendon Glacier near Stewart, B.C. The winter accumulation was less than normal and the summer ablation was considerably greater than the average for the preceding years. The net loss at each glacier was more than 1 m water equivalent. Berendon Glacier in northern British Columbia had a positive net balance.

Summit Lake, south of Berendon Glacier, drained catastrophically beneath Salmon Glacier flooding the lower valley of the Salmon River. Prior to the discharge the water level was at 821 m elevation and throughout the draining the water level was monitored several times each day.

Maps (W. E. S. Henoch)—Large-scale maps of each glacier have been compiled and that of Peyto Glacier has been published complete with pictorial representation of landforms and a descriptive text. The project was co-ordinated by W. E. S. Henoch and assistance was given by the Department of Indian Affairs and Northern Development. During the summer photographs of main rock faces were taken as part of a project to depict shaded relief in the Peyto map.

Secular fluctuations of glaciers have been studied (W. E. S. Henoch) and wood samples obtained from above the present treeline. One of the samples has a C_{14} date of 2,790 ± 170 B.P. In co-operation with M. Parker, tree ring samples taken from the Peyto area are being analyzed to determine the relation of late wood density to climate controls near the glacier.

Energy balance of Peyto Glacier Basin (L. Derikx)—Thermohydrographs were located at five sites over the Peyto Glacier Basin and the energy balance over the ablation zone of Peyto Glacier was obtained from a micrometeorological station established on the ice.

Distribution of snow over the glacier was measured (G. Young, McGill University) to relate to computer derived models of snow depths.

Glacier melt contribution (H. Loijens)—Contributions of glacier melt to stream flow of the headwaters of the North Saskatchewan River are to be determined for simulated streamflow based on models that include the snow melt period and the main glacier run-off period. Snow accumulation was measured at 20 snow courses and the recession of the snowline was recorded photographically several times during the summer. Meteorological information was obtained at five stations covering a range up to 2,100 m. Samples of precipitation and streamwater were collected for tritium analysis.

Movement of water through a snowpack (P. Foehn)—This was investigated using a gamma transmission probe and dye in the accumulation zone of Peyto Glacier. The movements were compared with energy balance measurements from a meteorological station and radiation instruments.

Radio-echo sounding unit (R. H. Goodman, T. Beck)—The recording unit was redesigned after the field trials on the Wapta Icefield.

Moisture flux in a snowpack (L. Derikx, P. Foehn, R. Harlan)—A study of moisture flux and processes within a snowpack are to be started at an experimental plot in Mer Bleue near Ottawa. Instrumentation has been installed to record precipitation and snowfall (approximately 50 cm snowpack) and to measure energy fluxes across the air-snow and snow-soil boundaries. Within the snowpack water content will be obtained with a transmission gamma probe, free water with a capacitor developed by Howorka and Ambach, temperature profiles with thermistors at 5 cm intervals.

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

Work maps have been compiled for five major drainage basins in the Rocky Mountains stretching from the Waterton Lakes National Park to the Columbia Icefield. Measurements of the 1,616 glaciers identified in the Nelson River Basin will be made using a D-Mac pencil follower interfaced with a PDP-8/1 Computer. Measurement of 191 glaciers on Vancouver Island has been completed and the final Vancouver Island Glacier Inventory Report is in preparation. Index maps for the 1,411 glaciers of Devon Island have also been prepared.

From the Baffin and Bylot island indexes, a list of all tide-water glaciers has been prepared in connexion with a survey of calving glaciers. In 1971 this study will be extended to cover Ellesmere Island.

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

Dislocations in ice crystals (S. J. Jones)—Observations on prismatic dislocation loops in ice by X-ray topography were published. Preliminary results from topographs of Meighen Ice Cap were obtained.

Mechanical properties of impure ice (T. Nakamura)—Results of HCl-doped ice single crystals were published. H_2O_2-doped ice showed a softening effect at −26°C. Other impurities were attempted including HF, NH_3 and NaOH.

Glacier dynamics (D. Fisher)—The revised computation of the future behaviour of Berendon Glacier was completed. The predictions were little different from the earlier ones of Untersteiner and Nye.

Pollution in ice infested waters (R. O. Ramseier)—The oil spill at Deception Bay of 427 gallons of Arctic diesel and gasoline was studied in terms of prevention, containment, clean-up and disposal. Participation on the U.S. Coast Guard Arctic oil spill test programme gave the opportunity to investigate the behaviour of North Slope crude oil in a series of tests such as spreading on ice, water, under the ice, the use of absorbents and combustion of fresh and aged oil with and without the use of wicks. Laboratory tests studying evaporation and combustion of various types of oil as a function of temperature under various conditions are underway.

POLAR CONTINENTAL SHELF PROJECT, DEPARTMENT OF ENERGY, MINES AND RESOURCES, OTTAWA

(E. F. Roots)

Mass balance studies (W. S. B. Paterson, R. M. Koerner)—Mass balance measurements were continued on the Meighen Ice Cap and on the four small ice caps in western Melville Island. For Meighen Ice Cap, the winter balance for 1969-70, as measured at the end of April, was

10 cm water equivalent. The mass balance for 1968-69 was a gain of 6 cm w.e.; provisional figures indicate that the mass balance for 1969-70 was approximately zero. On Melville Island, the winter balances of the ice caps, as measured in early June, ranged from 17 to 22 cm w.e.; approximately 5 cm of this accumulated between 29 May and 6 June. The mass balances of the ice caps for 1968-69 ranged from +2 to +10 cm w.e. In 1969-70 each ice cap lost about 29 cm w.e., a loss which almost eliminated the amounts gained in the previous three years.

The 1961-1967 stake network on the north-west side of the Devon Island Ice Cap was found and reset, and the net balance at each stake measured. The mean net balance for the balance years 1966-67, 1967-68 and 1968-69 was −10.3 cm w.e. per year.

Glacier meteorology (B. Barge, D. Petzold)—The meteorological station network on Meighen Island was expanded during the summer of 1970. The new stations, combined with the original ones, permit analysis of the meteorological conditions along a north-south profile from the north coast across the land and over the ice cap. On Meighen Island, the summer of 1970 was cooler and wetter than 1968 and warmer than 1969.

The wind programme was expanded in 1970, in order to make a detailed study of the wind regime on Meighen Island. This programme is under the general supervision of Dr. S. Orvig, Department of Meteorology, McGill University.

Radio-echo sounding (W. S. B. Paterson, R. M. Koerner)—An SCR-718 radar altimeter, loaned by the Canadian Forces, was used for ground-based radio-echo sounding on the Meighen Ice Cap, the largest of the four ice caps on Melville Island, the Devon Island Ice Cap and the main ice cap north-west of Tanquary Fiord in Ellesmere Island.

The work on Meighen Ice Cap was carried out simultaneously with soundings by S. J. Jones (Inland Waters Branch) who used the equipment developed by the Scott Polar Research Institute. As expected, much of the ice cap was too shallow for effective sounding, but, where echoes were obtained, depths measured by the two equipments were in satisfactory agreement. However, some of these depths were greater than those previously determined by a gravity survey. Attempts to obtain reflections from layers within the ice, for possible correlation with horizons in the core from the deep borehole, were unsuccessful.

Much of the ice on Melville Island was also too shallow for effective sounding; elsewhere, the results confirmed those of the gravity survey of Spector (1966). On Devon and Ellesmere Islands, regions of some 50 km^2 in the highest parts of the ice caps were surveyed as possible sites for a deep borehole. Bottom reflections were obtained through up to 800 m of ice.

Other work (R. M. Koerner)—110 snow samples were collected from 43 locations in the Canadian Archipelago and the Arctic Ocean. The samples will be used to study the regional variation of O^{18} content and electrolytic conductivity in snow.

GEOLOGICAL SURVEY OF CANADA, DEPARTMENT OF ENERGY, MINES AND RESOURCES, OTTAWA

SOUTHERN ELLESMERE ISLAND, DEVON ISLAND, AND COBURG ISLAND: GLACIER FLUCTUATIONS (W. Blake, Jr.)

A study of glacial history in southern Ellesmere, Devon and Coburg islands, begun in 1967, was continued in 1970. As in 1967 and 1968, emphasis was placed on the collection of samples for radiocarbon dating so as to establish an absolute chronology of events for as long a time as possible. Also, as noted in previous reports, many glaciers are now at (or have recently retreated from) their maximum extent since general deglaciation over 8,000 years ago. Recession of the snout by calving is especially noticeable in the case of the largest tidal glacier at the head of South Cape Fiord, Ellesmere Island; its position was sketched by Glenister in 1955 during the course of the Geological Survey's "Operation Franklin", and it was photographed from the air in 1959, 1967, 1968 and 1970.

RICHARDS ISLAND, TUKTOYAKTUK PENINSULA, AND ESKIMO LAKES, DISTRICT OF MACKENZIE: LARGE GROUND ICE BODIES (V. Rampton)

During the course of stratigraphic investigations of Richards Island, Tuktoyaktuk Peninsula, and around Eskimo Lakes, observations were made re the presence of large ground ice bodies and the larger structures within the ice.

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

The Defence Research Board operated Tanquary Camp, northern Ellesmere Island, from mid-April until late June. Logistic support in the field was provided by chartered Otter aircraft and by motor toboggan.

Ice cap north-west of Tanquary Fiord—A camp was occupied at an elevation of about 1800 m above sea level on the extensive unnamed ice cap north-west of Tanquary Fiord. A pit was excavated to a depth of 7 m and a CRREL 3-in corer was used to extract a core from the bottom of the pit for a further 25 m. From stratigraphy and density measurements in the pit the mean annual accumulation is calculated as 140 mm H_2O for the period 1950-70. From density measurements in the core and by extrapolation, the firn at the bottom of the core with a density of .68 Mg m^{-3} is estimated to have originated from snow that fell about the year 1846. K. E.

West (Department of Physics, University of Alberta) collected about 240 samples of snow and firn at systematic depths in the walls of the pit and from the core for oxygen isotope analysis. Further samples were collected at various other altitudes on the ice cap.

Nansen Sound—A field party under H. Serson (Defence Research Board) made a preliminary investigation of the plug of multi-year fast ice that has blocked the mouth of Nansen Sound for at least the last 8 years. The plug is estimated to cover at least 1000 km^2, from a line joining Lands Lokk to Cape Stallworthy southward to a line running south-west from Emma Fiord. It appears to have a minimum thickness of 6 m, and could possibly be regarded as an incipient ice shelf.

SNOW AND ICE SECTION, DIVISION OF BUILDING RESEARCH, NATIONAL RESEARCH COUNCIL (L. W. Gold)

Deformation behaviour of ice—Studies were continued on the deformation behaviour of columnar-grained ice under a uniaxial compressive load applied at a constant rate of movement of the cross-head of the testing machine. Information was obtained on the stress dependence of the upper yield stress at −10°C for both laboratory grown ice and natural ice from the St. Lawrence River. A subpress has been designed for investigations of the deformation behaviour under biaxial compressive loads (plane strain condition).

Tubular type meters for measuring strains in ice covers have been constructed and tested in the laboratory. They have been found to have a good response to rapid changes in load. Flat pressure cells (Gloetzl cells) were also embedded in ice and tested in the laboratory. They were found to respond well to long term changes in load. It is planned to try both systems in the field during the winter of 1970/71.

Avalanches—Observations were made of the impact force developed by an avalanche on a 1 sq. in. surface. These observations indicated that the avalanche produces a series of pressure waves; the maximum observed was 228 kN/m^2 (33 psi).

A study has been carried out on the amount of snow moved by avalanches. The mass of a 10 year maximum avalanche was estimated for the Rogers Pass area from information on the terrain and annual snowfall using extreme value statistics.

McGILL UNIVERSITY, MONTREAL

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

A party of 12 continued field work on Axel Heiberg Island for the twelfth consecutive summer, from mid-April to the end of August 1970. Logistic support was again provided by the Polar Continental Shelf Project, Department of Energy, Mines and Resources, Ottawa.

Mass balance of the White and Baby glaciers—Mass balance observations were continued on both glaciers, and the network of some 120 stakes was maintained.

Energy and water balances and meso-climate (A. Ohmura)—The analysis of the 1969 observations collected at the 10 climatological stations spread over the approximately 150 km^2 area of the Baby, White and lower Thompson glaciers was completed and the results mapped by computer. The results of the meso-scale measurements of the temperature field and of the numerical solution of the diffusion equation suggest that about 50% of the heat advected onto the marginal areas of the McGill Ice Cap originates from the surrounding tundra. The condition of the tundra is therefore of prime importance for the glacier mass balance. As the climatological conditions of the tundra are often very different from one year to the next, these observations are being carried out for several years. During the field season, 23 April to 24 August 1970, the second phase of this programme was carried out.

Automatic weather stations (J. Whiting, J. Scott and K. Schroff)—In addition to the two Australian-made and the two Ott digital punch-tape automatic weather stations, two Plessey magnetic tape recording stations with 7 sensors and a catalytic propane generator were installed, tested and left for unattended winter operation. The experience to date with the Ott and the Plessey stations has been compiled.

Glacier movement (A. Iken)—The short-interval measurements (2-8 hours) at selected profiles on the White Glacier were continued for the third summer. In addition to the discharge of streams, the water pressure in moulins was measured with especially designed pressure gauges. At depths of 50-80 m cable length below the glacier surface the water pressure rose from atmospheric pressure up to over 2 bars additional pressure during the hours of high meltwater discharge. Similar pressure fluctuations were observed in an abandoned moulin 650 m down-glacier from the active moulins. In periods of exceptionally high water pressure the glacier velocity increased strongly. However, the time of maximum water pressure in the moulins did not always coincide with the time of maximum glacier movement at a profile 2 km downglacier.

Glacial history (T. Caflisch)—Based on the interesting results of the analysis of the 1969 sediment cores from the 60 ft deep Colour Lake (radiocarbon age of about 14,000 years for a sample from 140 cm sediment depth, sufficient pollen grains for palynological work) it was decided to continue this programme during the 1970 season. The main investigation was carried out on the 600 ft deep glacier-dammed Phantom Lake, where an attempt was made to raise sediment cores of 19 ft length as well as 7 ft

ones. Due to logistic and technical difficulties, only a limited amount of additional core material could be collected.

UNIVERSITY OF COLORADO, INSTITUTE OF ARCTIC AND ALPINE RESEARCH (J. T. Andrews and R. G. Barry)

A total of ten persons (graduate students, faculty and a research technician) engaged in a glaciological programme in east Baffin Island during the summer of 1970. The area selected lies between Quajon and Narpaing fiords at approximately latitude 67°35'N, 65°17'W. The overall objective is to model the palaeoclimate of the area at a time when large south-facing glaciers occupied south-facing corrie basins, whereas the situation today is that glacierization is confined to north-facing aspects.

The results so far can be summarized in the following manner:

1. Winter budget on the Boaz averaged 42 cm w.e. ± 6.
2. The summer was abnormally cold and snow occurred throughout the summer resulting in a positive summer balance of approximately 10 cm w.e. Run-off measurements from the glacier indicated that only about 5 cm w.e. was lost. Because of the low temperatures it is clear that the glacier was acting very much as a closed system. The snow pack was isothermal for less than two weeks.
3. A lichen growth rate curve has been established for east Baffin Island, and this is being used to study the neoglaciation of the Penny Ice Cap and mountain glaciers.
4. Of prime interest on the energy budget side is the relationship between the micro-meteorological conditions and synoptic scale events. Weathering studies indicate that the south-facing glaciers existed in late-glacial times and they are possibly older than 12,000 years. The equilibrium line was then at 825 m on these south-facing glaciers compared with 950 m today on north-facing glaciers.

F. Müller

FRANCE

GLACIER D'ARGENTIERE (Mont Blanc)

During work by Electricité de France (EDF) to channel and collect the vigorous streams of water beneath the glacier (S. A. Emosson), a splendid spot was discovered where a three-fold scientific research programme in glaciology, hydrology and morphology would be feasible. Since October 1966 a series of hydro-morpho-glaciologic investigations has been undertaken by the joint research groups of EDF REH Alpes Nord and the Grenoble Institut de Géographie Alpine (IGA). The two groups aimed at the full use of a 1000 m subglacial channel carved in the bedrock by a flowing glacier. Many openings give access to the cave.

In 1963 a comprehensive research programme was developed under the leadership of Robert Vivian (IGA). An extensive range of high quality equipment is installed outside and under the glacier. Qualified personnel control the instruments throughout the year, though access to the cave is possible only during winter time, when the water level is at a low ebb. Beneath 80+ m of ice and more than 2 km upstream of the glacier snout, this glaciological research centre represents in 1971 a unique example of a true subglacial laboratory.

External apparatus

(a) A metereological station was established on the left-hand side of the moraine, 1800 m from the ice front at an altitude of 2000 m. It includes one thermograph (automatic for one week), one hygrometer (automatic for one week), one rain-gauge, type DTG (automatic for 3 months), one anemometer, and one heliograph.

In the Chamonix Valley, Lognan's Meteo Control Equipment is set in the centre of well-distributed weather stations situated at different altitudes: Plan des Aiguilles (2308 m), Aiguille du Midi (3842 m), Village du Tour (1410 m), Glacier du Tour (2000 m).

(b) A water analysis unit (morphologic lab antenna of the IGA) is set in a prefabricated wooden hut at the entrance of the EDF tunnel (2060 m). In the near future this unit will be installed in the tunnel.

(c) Photographic instruments were set up in cavities several meters wide at a vantage point on the level of an upward projection of the bedrock, in the lee of the glacier flow. Pictures were taken every other day during the summer months. Glacier motion is imperceptible to the eye but the dynamic study of bergschrunds and séracs is aimed at measuring the speed of surface ice. In addition, during a three-month period in 1969 a 5-minute 16 mm film was made of Lognan's bergschrunds and their summer evolution. Future plans include the installation of a remote time-lag camera of the Hasselbad-Flotron type, as used at the Unteraargletscher.

(d) 15 stakes, spread from the head to the snout, were driven into the glacier at an altitude of 1600 m. The first ones were planted in 1956. Every September or October the EDF and IGA survey team takes new bearings and plots ten transverse profiles.

Apparatus in the subglacial laboratory (tunnel at 2130 m)

(a) A gauge-station operated and controlled by EDF experts: the OTTH's linigraph, automatic for one week, is coupled with a registering diagram unit operated by electricity. In the summer of 1971 IGA will complete the lab. facilities of the Hydrology Department Division.

(b) A pressure-gauge (Richards' type), in use since 1967, recording various amounts of pressure created in a waterpool behind Lognan's rock channel (see Comptes Rendus de l'Académie des Sciences, Jan. 1970).

(c) Four thermometer probes placed at different levels under the glacier (2 m) in order to measure the geothermic ebb and flow.

(d) Apparatus to melt ice (EDF) includes: a boiler, a thermostat to keep water at a fixed 40°C, and a sprinkler.

(e) A cavitometer (Vivian's and Rio's idea and Grenoble DTG EDF's production) which was invented to measure (i) the bottom velocity of the glacier, (ii) ice loosening as a function of hydraulic water flow, (iii) both the average room temperature of the subglacial cavity and the water temperature of the stream.

This instrument is made of two separate components: the first one consists of a receptacle placed in a cavity under the glacier, the second one, away from the snout, contains the measuring instruments placed well behind waterproof doors. The receptacle consists of an articulated 3 m-long arm. At one extremity is a dented 400 mm-diameter-wheel kept in constant contact with the glacier by a ballast of 70 kg. The wheel is calibrated on a 100Ω potentiometer adjunct to another articulated axle of 470Ω. This articulated axle sustains the probing line temperatures. On the shaft is an assembly-box connecting the wires of each potentiometer to a main wire cable, thus ensuring proper liaison with the recordings in the cavity. In spring 1971, of all the 20 available conductors, only six are being used to convey data collected by the potentiometers. All the potentiometers and the 2-thermometric probing lines are linked to a Philips recording apparatus (type PEB 72). If power failures occur, the recording apparatus is switched automatically to a 72-hour emergency power supply. Even at this early stage, first-hand data denote interesting trends. It is worth noting that this experiment has enabled us to have on file for the first time minute records of the "heart-beat" of an alpine glacier.

The velocity of the Argentière Glacier varies from mere traces for a period of a few days to 19-41 mm per hour (165-350 m per year) in less than half a day, thus keeping an average of 24 mm per hour or 200 m per year.

Chronometered speeds were measured upstream of an upward projection in the bedrock. Measurements taken under 80 m of ice show that the moving ice under the glacier has no significantly different speeds from the ones measured on the surface, both coming close to 150-200 m per year. Plotted temperatures of water are constant and always positive: + 1°C.

For further information write to: Robert Vivian, Institut de Géographie Alpine, Rue Maurice Gignoux, 38—Grenoble, France.

R. Vivian

ITALY

The 1970 glaciological survey took place as usual. 143 glaciers were observed: 39 in the Western Alps, 67 in the Central Alps, 36 in the Eastern Alps, and 1 in the Apennines.

There was a comparatively large amount of snow in the winter of 1969-1970, although not as much as during the same period of 1968-1969. The snow cover remained until well into the summer and only at the end of August was it possible to measure snout variations.

On the whole, Alpine glaciers are relatively stationary and there are as yet no signs of a definite phase of general advance. This stationary phase probably results from the average summer temperature, which is slightly lower than that of the last thirty years.

Summary	**1970**	**1969**
Retreating glaciers	74 (51%)	43%
Advancing glaciers	18 (13%)	22.4%
Uncertain, snow covered, stationary glaciers	51 (36%)	34%

M. Vanni

For detailed results, in the form given in reports from previous years (see ICE no. 32 p. 3-4), please write to Professor Vanni, Piazza Adriano 17, Torino, Italy.

NORWAY

SEDIMENT TRANSPORT STUDIES IN GLACIER STREAMS

Detailed sediment transport studies were started at selected glacier streams in 1967 to obtain information about the magnitudes and variations of sediment transport. The data obtained have an important bearing on the planning of future hydro-electric projects utilizing meltwater from glaciers and also on the scientific study of glacier erosion. The main effort of the studies was devoted to the transport of suspended material but some attention was also given to the accumulation of coarse material in river deltas. At one location an attempt was made to measure the bed-load transport by trapping the coarse material in a large steel net that was erected across the glacier stream.

To measure the sediment transport it was necessary to take several water samples every day throughout the entire ablation season. The water was collected in 1-litre plastic bottles and filtered in the field through a relatively dense filter paper. The papers were sent to the laboratory for ashing. Water discharge was calculated from automatic water level gauges or from frequent visual staff-gauge readings. The volume of sediment transport was computed from measured sediment concentration in the sample and the discharge at the sampling station. The water volume discharging at each sampling site was computed for every hour of the day. In cases where continuous water records were not available, the hourly values of water stage were generated by the computer through linear interpolation between existing observations. Hourly sediment concentrations were obtained similarly by linear interpolation between the known concentrations of collected samples. The amount of sediment transport for each hour was then computed by multiplication of water discharge and sediment concentration for that hour.

Direct measurement of bed-load transport

The river draining from Nigardsbreen transports considerable amounts of coarse materials in addition to suspended material. An attempt was made to measure directly the bed-load transport by means of a strong steel net erected across the river at a site where the river passes over exposed bed-rock. The fence was woven of 4 mm steel wires with a mesh size of 2 x 6 cm. It was 50 m wide and 2.5 m high, supported by a steel construction drilled into the bed-rock, held in position by heavy steel cables. The rate of agglomeration on the upstream side of the net was determined by daily surveys along fixed cross-sections. The levelling was performed at 180 points, covering an area of 720 m^2.

An unusually high flood broke the net at the end of June but at that time the net had collected about 400 metric tons of coarse material. During the same period, i.e. from May 24 to the end of June, about 1270 metric tons of suspended material were transported by the river. The ratio of bed-load to suspended load turned out to be approx. 1 : 3, based upon measurements during the above-mentioned period. Because the mesh size allowed certain fractions (sand and gravel) to pass the net, the said relation was therefore *at least* 1 : 3, probably much higher.

Results from suspended load studies in 1969

(i) **Nigardsbreen.** During the observation period (94 days) almost 14,000 metric tons of fine materials were transported from the glacier into the lake. During the same period about 3,400 tons were carried out of the lake, thus leaving 10,000 tons to be deposited on the lake bottom. The total water discharge was measured to 183 million m^3. The corresponding figures for 1968 were 4,400 tons of sediment into the lake and 14,000 tons out of the lake. A large delta is growing where the glacier stream enters the lake. Measurements of delta growth are repeated at 290 single points each year. Thus, the amount of bed-load can be indirectly measured, at least through a time period of several years. A preliminary calculation has shown that the bed-load transport possibly can make up as much as 50% of the total transport of material from Nigardsbreen (cf. the above-mentioned experiments for direct measurements by the "fence" project).

(ii) **Vesledalsbreen.** Sediment samples were collected at three sites: near the glacier front, at the entrance to the lake Vesledalsvatn which is situated 1 km downstream from the glacier and, finally, at the outlet of this lake. During the summer of 1969 the glacier produced 580 metric tons of fine material of which only 330 tons passed through the lake. Levelling at 90 single sounding points makes it possible to determine the delta growth, but to establish a reliable figure for the ratio between bed-load and suspended load it will be necessary to take measurements over a period of several years.

(iii) **Erdalsbreen.** This glacier is very similar to Vesledalsbreen. They are both outlet glaciers from the Jostedalsbreen ice cap, they are situated very close to each other and they are probably resting on the same gneissic rock complex. The main difference is the size: Erdalsbreen is about 11 km^2 and is thus three times as large as Vesledalsbreen, and it covers an altitudinal range 1800-870 m a.s.l. compared to 1560-1130 m a.s.l. for Vesledalsbreen. Erdalsbreen has several ice-falls but Vesledalsbreen has none. One can therefore expect a higher production of

sediment at Erdalsbreen. During the summer almost 15,000 metric tons of suspended material were transported by the stream at the glacier front. The total water discharge in the same period amounted to 44 million m^3. The maximum sediment concentration in the water was as high as 3290 mg/l. This glacier seems to produce more sediment per unit area than any of the other glaciers under observation.

(iv) **Austre Memurubre.** This glacier was originally selected as a representative for the numerous glaciers in Jotunheimen, a central part of the mountains in southern Norway. The glacier is surrounded by high mountains and rests partly on basic plutonic rocks and partly on morainic material of unknown thickness which has been exposed by glacier recession in the 20th century. These deposits are easily eroded by the great number of smaller streams issuing from the glacier front. Stream discharge measurements and sediment sampling must therefore be done 1.5 km downstream where all the streams collect in one single course. About 6900 metric tons of suspended material were carried by the river at the sampling site during the field period of 1969. The total water discharge was measured to 26 million m^3 during the same time. The sediment concentration varied between 11 and 337 mg/l. Not all the transported material originated from beneath the glacier. Erosion in the glacier deposits must have taken place, so it is assumed that only some 4,500 tons originated exclusively from the glacierized area.

(v) **Engabreen.** Sediment transport studies started in 1969 at this large outlet glacier from the Svartisen ice cap in northern Norway. The glacierized area is almost 40 km^2 and a lake is situated just below the glacier front at an altitude of 10 m a.s.l. In total, 8,600 tons of suspended material were carried into the lake whereas only 2,000 left the lake. The total water discharge amounted to 103 million m^3 and the sediment concentration was generally much lower than for other glaciers, only 20-350 mg/l. Bed load studies have not been started yet but future measurements on the delta will make it possible to calculate the coarse material carried by the river from the glacier to the lake.

Specific erosion

If the measured amounts of solid matters in the glacier streams were to be evenly distributed on the appropriate glacier surface, and, further, if this material is thought to be the result of erosion by the glacier, a figure called "specific erosion" could be calculated. (We assume, then, that the discharged amount of solid matter is a result of one year's erosion—an assumption which is valid only when a very long series of years is taken into account.) Such calculations were made for all the glaciers observed using both the figures from 1969 and similar results from earlier years. These calculations showed that Vesledalsbreen eroded some 0.1 mm/year, whereas Erdalsbreen eroded 0.5-0.9 mm/year. The other glaciers gave figures ranging within these two limits, although closer to the smallest figure. Definite conclusions concerning the rate of glacier erosion cannot be drawn yet, but it is hoped that similar measurements made through a series of years will encourage further discussion of this problem.

A complete report (68 p. with an extensive English summary) is published jointly by the Norwegian Water Resources and Electricity Board, P.O. Box 5091, Oslo, Norway, and the Department of Geography, University of Stockholm, P.O. Box 6801, Stockholm, Sweden.

G. Østrem

U.S.S.R.

(We are pleased to include the first comprehensive report we have received on Soviet glaciological investigations. As members will be interested to read about these activities, we are publishing the report at greater length than is our custom.)

In 1969, Soviet glaciological expeditions carried out investigations in the mountains of the Caucasus, Central Asia, Altay, Polar Urals, Trans-Baikalia, Novaya Zemlya, Khibini and also in Greenland and Antarctica.

The investigations were performed by the Institute of Geography of the Academy of Sciences of the USSR, the Section of Physical Geography and the Institute of Hydrogeology and Hydrophysics of Kazakhskaya SSR, by the Institute of Geography of the Academy of Sciences of Georgia, the Institute of Geology and Geophysics of the Academy of Sciences of Uzbekskaya SSR, the Tien-Shan physico-geographical station of the Kirgiz Academy of Sciences, by the Institute of Railway Transport of Novosibirsk, by the Pedagogical Institute of Chita, by the avalanche service of the mines "Apatit", by Central Asian, Kazakh and Trans-Caucasian research institutes of Hydrometeorology, by Moscow, Leningrad, Tomsk, and Karkov Universities and by the Uzbek, Kirkiz, Tadzhik and North Caucasian Hydrometeorological Services.

THE CAUCASUS

(1) The observations of 3 representative glacier basins-Murukh, Gergety (Institute of Geography, Academy of Sciences, USSR) and Dzhankaut (Moscow University)—were continued.

On the Murukh glacier the ablation and accumulation in the period of maximum snow storage were determined. The mass balance turned out to be anomalously negative. Through the firn layer 2 pits to the depth of 17 m were made. This was accompanied by laboratory measurements. At the contact of the firn and ice a water-bearing horizon was found. Observations on the variations of its level were carried out. The rate of sinking of the firn was measured during the course of 3 months and this made it possible to evaluate the properties of infiltration and recrystallization in the ice formation. The depth of penetration by melted snow and internal nourishment were determined in the spring, autumn and winter of 1969. In spring the temperature of the glaciers in the accumulation areas and the theodolite survey of the snouts of the glaciers were completed. The moraine transport contents were measured in different parts of the glacier. A structural survey of the glacier and sampling for ice crystal fabrics and pollen analyses were made. A bore-hole to the bed of the glacier was made by a thermal drill and this revealed some facts about the water pressure at the bed of the glacier. In the accumulation area of the glacier meteorological and heat balance investigations as well as albedo observations were carried out.

On the Gergety glacier (Central Caucasus) the mass balance appeared to be negative, just as on the Marukh glacier. The meteorological and heat balance observations at the firn line were carried out, and the types of nourishment noted. Results showed that the accumulation of firn and superimposed ice shared equally in the nourishment of the glacier. Sediment transport in meltwater streams was measured.

In addition, a snow survey of the Kelbashy glacier and a glaciogeomorphological interpretation of the snout of the Bezengy glacier (Central Caucasus) were again completed. With the aim of compiling a glacier inventory of the basins of the Kodory and Ingury rivers in Georgia, the firn areas of about 60 glaciers were investigated.

In the basins of Dzhankaut (Central Caucasus), meteorological and actinometric observations on the glacier and hydrometric observations in part of the basin were carried out from May to September. The ice and firn stratigraphy in the accumulation area of the glacier was studied and samples of the firn and ice for pollen analysis were taken.

A phototheodolite survey of the glaciers and of the whole basin was completed. The velocity of the glacier movement was determined at two profiles.

(2) Winter investigations of the seasonal snow cover in connexion with avalanche activity were carried out at the Moscow University Station in the El'brus area. This work consisted of observations of avalanches in the upper part of the Baksan river, a study of snow stratigraphy, and results of a wave impact caused by avalanches, and an analysis of the relation of weather conditions to avalanches. On the slopes of mount Cheget a number of experiments were carried out to determine the pressure of falling snow on engineering constructions, and to analyse the existing recommendations on their positioning and the theoretical optimum distance between such constructions.

(3) From June to September field work was carried out by Kharkov University Caucasus Expedition. The meteorological, hydrological and glaciological regimes of 3 glaciers in the Teberda and Baksan river basins were studied. Standard meteorological and actinometric observations, the temperature of the ice surface, ablation, velocity of glacier movement, levels of water temperature and meltwater discharge at the

snouts were measured. The expedition collected material on present and former glaciations in the Chegem and Baksan river basins.

(4) The Institute of Geography of the Academy of Sciences, Georgian SSR (Tbilisi), carried out glaciological, hydrological and meteorological observations on the Tbilisi glacier from July to September. The regime of ablation and the glacier run-off in the range of altitudes 2800-3400 m were studied, and a theodolite survey was made of the glacier snout. Four other glacier snouts in Svanetiya were resurveyed by phototheodolite, and this made it possible to determine the changes in the position of their tongues during the period 1967-69. In order to draw up a map of ablation the total ablation on the Tbilisi, Tviber and Seryy glaciers was determined.

(5) The Transcaucasian Hydrometeorological Institute (Tbilisi) continued observations of 12 glaciers on the southern slope of the Caucasus. They surveyed glacier velocities at permanent transverse profiles, total ablation, changes in the level of the ice surface (by levelling) and position of the tongues of the glaciers at the beginning and the end of the ablation season. The observations show an increase in the mass of the glaciers, which were first measured in 1960. The glaciers of the Caucasus are now slowly retreating at a maximum rate of 10-11 m a year. Some glaciers, however, are advancing.

(6) In the Kuban and Terek river basins the North Caucasian Hydrometeorological Service (Rostov-Don) continued observations. It was found that almost all these glaciers are slowly retreating (2-10 m a year) at the present time. In the period 1967-69 only one glacier advanced.

CENTRAL ASIA

(1) The Section of Physical Geography of the Academy of Sciences, Kazakhskaya SSR (Alma-Ata), continued observations from May to October of the variations of the glaciers in the Zailiyskiy Alatau (16 glaciers) and in the Dzhungarskiy Alatau (11 glaciers). These observations included the measurements of the levels of the glacier surfaces at fixed profiles, the velocity of glacier movement and deformation of its surface, ablation of the glacier tongues and firn basins, maximum accumulation of the snow cover and net balance in the accumulation area, precipitation, the run-off from the accumulation and ablation areas and the mass heat exchange between the glaciers and the air. The changes in the position of the ends of the glaciers and the heights of the firn line were determined. The hydrophysical processes in the firn basin (rate, depth of infiltration, humidity of the firn, its temperature, density and others) were investigated. A phototheodolite survey was made of some glaciers and meteorological, actinometric and gradient observations were carried out.

The accumulation season of 1968-69 produced more precipitation than normal and thus the ablation season began one month later than usual; the ablation was half the normal amount and in the Dzhungarskiy Alatau at the altitude of 3500 m it was almost non-existent. The line of the seasonal snow was lower than average (150-170 m) and on the central Tuyuksuskiy glacier it was as low as 3690-3720 m.

The ends of the glaciers reacted differently: some retreated, others remained stationary or advanced slightly. The mass balance of the glaciers in the Zailiyskiy Alatau in 1969 was very close to zero.

On the central Tuyuksuskiy glacier the investigations were carried out according to the IHD programme for which it is one of the representative glaciers. The work included observations of precipitation by a set of 9 precipitation gauges, heat balance observations in the ablation season in the firn basin, investigations of the snow cover and the run-off from the firn basin, measurements of glacier movement, hydrometric observations at the end of the glacier, two tachiometric surveys of the front of the glaciers and one phototheodolite survey.

(2) The investigations of the Kazakh Hydrometeorological Institute were devoted to the methods of forecasting glacial mudflows on the northern slope of the Zailiyskiy Alatau. The main observations were carried out in the region of the Tuyukskiy glaciers as well as in the Bol'shaya Almaatinka, Issyk, Talgar river basins.

(3) A glaciological expedition from the Central Asian Institute (Tashkent) continued its work for the IHD programme on the representative Abramov glacier in the Koksu river basin (southern slope of the Altay range). The main task in 1969 was to study the heat and mass balances of the glaciers and the regime of the run-off from them. In order to accomplish this task different observations were carried out: meteorological, actinometric, heat balance, hydrological and thermophysical. The velocity of glacier movement and the snow cover, accumulation and ablation, were measured. The tongue of the glacier was resurveyed by phototheodolite.

The velocity of glacier movement was measured once a month at 3 cross-sections at altitudes of 3700-3800 m and 3900 m above sea-level. Maximum velocity was 54 m a year at 3800 m altitude and the minimum was 15 m a year at the end of the tongue. A relation between glacier movement and temperature regime was found. Monthly observations (in the summer) of the natural pollution of the snow cover showed an increase by the end of the summer and its direct relation with the intensity of melting.

In 1969 the observations of the temperature regime of the body of the glacier in the central part of the tongue began in a borehole 26 m deep. To compile a map of ablation and accumulation snow surveys were made monthly. Maximum height of the snow cover, by the beginning of the ablation season (April), was from 1-4 m

on the tongue of the glacier to 6 m in the firn zone.

(4) The Tien-Shan Physico-Geographical Station of the Academy of Sciences, Kirgiz SSR (Pokrovka village), carried out investigations on the Karabatkak glacier (northern slope of the Terskey Alatau range) in July-September. Gradient and actinometric observations and measurements of ablation and run-off were made. After most of the glacier was free from the snow (beginning of July) a snow survey was made in the firn zone.

The survey revealed that in the lower part of this zone the entire body of ice was impregnated with meltwater and a layer of superimposed ice was formed. The melting in the upper part had not yet begun. The amount of snow storage varied from 53 to 104 gr/cm^2. The melting during summer 1969 was up to 181-248 gr/cm^2, that is 30 g/cm^2 higher than the mean value. The glaciological party of the expedition investigated the Karasay glacier in the central Tien-Shan where radar soundings were made. The velocity of the surface movement of the glacier was determined and the influence of the tributaries on the main glacier stream studied. A phototheodolite survey and meteorological observations were also carried out. It was found that the structure of the glacier was multilayered, with a more active upper layer (from 45-63 m). The total influence of the tributaries on the upper, more dynamic, layer of the ice of the main stream could be the cause of the catastrophic surges of some valley glaciers of the Tien-Shan.

(5) In the mountains of the Tien-Shan a snow survey party of the Hydrometeorological Service, Kirgiz SSR (Frunze), accomplished a number of observations. As a result of the snow resurvey (July-August) and surface levelling of 6 glaciers in the western Tien-Shan quantitative characteristics of the surface changes were obtained. As a result of aerial observations (September) of 29 glaciers, details of their configuration and relief were obtained.

(6) The Hydrometeorological Service of the Uzbekskaya SSR (Tashkent) continued observations of the position of 11 glacier snouts in the Pskem and Sokh river basins. Due to the abnormally snowy winter of 1968-1969 the snouts of some glaciers in the Pskem river basin remained snow covered. On the Autor glacier in the same basin, meteorological and actinometric observations were carried out. The discharge of the meltwater stream (including sediment transport) and the seasonal cover were measured.

(7) In the Amu-Darya basin (RGO glaciers with the tributaries Ravak, Medvezhiy, Fedchenko) the investigations were carried out by the glaciological laboratory of the Institute of Geology and Geophysics of the Academy of Sciences, Uzbekskaya SSR (Tashkent). From June to September phototheodolite surveys of the tongues of some glaciers were made. Water discharge was measured and the level and estimation of sediments carried by the stream were observed. Several meteorological observations including actinometry and aerology were carried out.

The glaciological observations included measurements of melting, lithogical analysis of the moraines, thermophysical measurements in the moraine cover of the ice-cored moraines, estimation of the infiltration processes within the snow-firn strata, measurement of the glacier movement at the tongue, and a snow survey in the upper zone of the glacier.

(8) The Institute of Geography of the Academy of Sciences (Moscow) continued their investigations into the glacierization of the Pamirs. The Pamir Expedition worked from July to October. The theme of the work was "Glacial pulsation and its paleogeographical effects". Many glaciers in the west, north and east of the Pamirs were observed. The observations of the movement and mass balance of the Medvezhiy glacier were continued. Glaciotectonics in relation to the peculiarities of surging glaciers were studied in order to discover what features would be of assistance in forecasting surges in these glaciers. The record of glacial activity during surges and between surges was found to specify palæographic constructions. Aerial and terrestrial surveys of the right tributary of the Lenin glacier (Zaalayskiy range), which advanced catastrophically in spring 1969, were carried out. The common morphological features of this glacier and of the Medvezhiy glacier during the period of its catastrophic surge in 1963 were revealed. The thickness of the tongue of the Medvezhiy glacier and the thickness of loose sediments in the periglacial zone of the Abdukagor valley were determined by graviometrical techniques. In the firn zone of the Lenin glacier heat and water balance measurements were made. Near the Muskol range meteorological observations were carried out, and in the Tanimis basin at an altitude of 5000 m the snow drift was observed.

(9) The Tadzhik-Pamirs Aeroglaciological Expedition carried out a number of researches from July to October in order to compile a glacier inventory of the Pamirs glaciers. The glaciers of the Obikhingou and Surkhob river basins were investigated. The basin of the Markansu river and lake Karakul in the East Pamirs were studied. For the second time stationary observations were made of the accumulation, ablation and structure of the firn thickness of 6 glaciers in the Obikhingou and Surkhob river basins at altitudes of 3900-4800 m above sea-level. About 550 glaciers in the basin of the Obikhingou river were investigated from the air.

THE ALTAY

Tomsk University continued observations on the representative glacier basin of the Aktru river.

Meteorological, actinometric and gradient observations, with ensuring calculations, were completed at 3 stations from 2500 up to 3150 m above sea-level. Hydrometric measurements at 7 stations, two of which were located very near to the glaciers, were made. The ablation was measured at the beginning of the season and after the snowfalls within the mentioned altitudes, and a snow survey was carried out. The velocity of ice movement at 5 transverse sections on the tongues of the Bol'shoy and Malyy Aktru glaciers was measured. The relationship between the energy and mass balance of the glaciers was established.

It was also established that the deep, closed basins of the Aktru type were very important in forming run-off. The rate of precipitation in such basins was 1000 mm a year and on the glaciers, judging by hydrological information, it was 1300-1500 mm. In 1969 an abnormally high air temperature in July was noted. At the station Nizhnyaya Aktru during the period of daily rains it was 11.0°C (2°C higher than normal).

Observations were also made in the western part of the Katun range and during 20 days on the northern slope of the highest peak of the Altay, Belukha mountain (Akkem glacier). At altitudes of 2000-3000 m an increase in snow accumulation was found. Because of the great amount of snow on the glaciers which did not have low altitude tongues, the bare ice was exposed only for 30-40 days.

TRANSBAIKALIA

The Pedagogical Institute of Chita conducted field investigations of the snow cover, avalanches, icings, river and lake ice at the permanent station on the Yablonovyy range and in the taiga zone of the Cherskiy range. On the outskirts of Chita the pingoes were surveyed by levelling and observations were made of the frozen flood water and lake ice, paying attention to their influence on relief and microclimate.

The winter work on the stratigraphy and evolution of the seasonal snow cover was made by the Laboratory on the Problems of Snow Avalanches, Moscow University. They made a graph of the evolution of the snow cover in winter 1968-1969. They also studied the temperature regime of the snow pack, the regime of the avalanche fans and winter snow-transport.

POLAR URALS

The Institute of Geography of the Academy of Sciences, USSR, continued observations according to the IHD programme in the representative basin of the Bol'shaya Khadata river and observations of the variations of the IGAN, Obruchev and Oleniy glaciers. In the basin of the Bol'shaya Khadata river the main items of water balance were measured: snow storage in the period of maximum accumulation, liquid and solid precipitations, ablation of snow, firn, ice, evaporation from different kinds of surfaces, the run-off in the whole basin and in its different parts, and mass balance of the glaciers. They also carried out meteorological and actinometric observations. The mass balance of the cirque glaciers IGAN and Obruchev and the wall-sided glacier Oleniy was determined. On these glaciers photogeodetic work was carried out together with measurements of the thickness of the ice by electrosounding. The study of the variations in the regime of the glaciers in this region was made. These observations were made with full application of all photogeodetic and glaciological data collected over several years.

10 maps of the Polar Urals glaciers are being compiled. Analysis of them will make it possible to characterize changes in these glaciers over 15 years and to find out if the IGAN and Obruchez glaciers were in fact representative.

KHIBINY

At the "Apatit" mines a quantitative method of forecasting avalanches with the help of a computer was developed. In view of this, on the Ukespor and Lovchorr plateau the powers of adhesion at the point of contact of the snow-drift layer and the under layer were measured. A snow survey of 30 avalanche centres on the outskirts of Kirovsk, more than 580 snow-transport observations on the Ukespor plateau and about 1000 on the Lovchorr plateau were made. The possibility of compacting snow fields was studied in order to prevent the danger of avalanches and to control some avalanche-forming processes. The dynamics of snow avalanches and anti-avalanche structures were studied. The value of the impact of dry avalanches at different altitudes and distribution of density of the avalanche stream and other values were obtained.

Some of these investigations of the impact on immobile obstacles were carried out in collaboration with the Laboratory on the Problems of Snow Avalanches, Moscow University. In addition, on the Lovchorr plateau the Novosibirsk Institute of Railway Engineering conducted a number of investigations. Their aim was to establish a relation between wind speed and the formation of snow microrelief.

NOVAYA ZEMLYA

In 1969 the Institute of Geography of the Academy of Sciences, USSR, sent a party to Russkaya Gavan', Novaya Zemlya, where they carried out investigations previously performed during the IGY. On the Shokal'skiy glacier they measured melting at the stakes, accumulation of the firn and snow in the nourishment zone of the glacier over the last 10 years. They studied the character of ice formation.

On the profile Bar'er Yablonskiy-station Ledorazdel'naya they measured the temperature of the ice down to 10 m depth. The geodetic work was carried out to determine the position

of the ends of the Shokal'skiy and Chayev glaciers. The sides and the moraines of these glaciers were investigated. The levels and the temperature of the water in them were measured. The correlation of the moraines with the sea terraces in the region of Russkava Gavan' was found. Organic material was collected for absolute determination of the age of the terrace and moraine and samples of sea-bed fauna were also collected. As a result of the investigations a material change in the regions and ice formation during the last decade was worked out.

ANTARCTICA

A French and Russian glaciological party took part in the 13th Soviet Antarctic expedition. The Russian team consisted of scientists from the Institute of Geography of the Academy of Sciences of the USSR. The investigations completed in 1968-1969 were a repetition of investigations made in 1964-1965. The deformation of the glacier surface by tellurometer measurements was obtained from the geodetic pentagons in the region of maximum glacier depth near the stations Vostok, Komsomol'skaya, and Vostok-1. These measurements made it possible to calculate the changes in the rate of external mass exchange, direction of the flow line and the strain rate tensors, fields of density, stress and changes in the mass.

A large profile of the bed of the ice sheet, over a distance of 1000 km (the measurements of the thickness of the ice were carried out by radar) was made. This made it possible to find new features in the relief of the bed and in a number of cases to decrease its absolute height by several hundred meters. The long firn and ice cores for isotope and chemical analyses were collected on the profile Mirny-Vostok to study the snow accumulation for the period 1964-1969.

GREENLAND

The Institute of Geography of the Academy of Sciences of the USSR took part in an expedition to Greenland. In western Greenland a number of observations of stage moraines of different ages were made. The dependence of the velocity of glacier retreat on its environment was investigated.

V. M. Kotlyakov

VLADIMIR KOTLYAKOV

Vladimir Mikhaylovich Kotlyakov was born in 1931. In 1954 he graduated from the Department of Physical Geography of Moscow University. The same year he began work on the problems of snow cover, working under Professor G. D. Rikhter in the Physical Department, Institute of Geography (Academy of Sciences, USSR).

In 1955 Kotlyakov passed his first winter with a small group of glaciologists on the north island of Novaya Zemlya, living for 8 months in a tent on a glacier, where he observed for the first time the processes of accumulation and ablation. A year later he took part in the Second Soviet Antarctic Expedition which included many glaciologists led by Professor P. A. Shumskiy.

There he headed a small group of physicists studying the problems of snow, and carried out laboratory research in a special cold laboratory at Mirny. Helped by aircraft and cross-country vehicles, the group investigated the snow cover of the coastal belt of Antarctica, of Drygalsky Island, and inland at the stations "Vostok-1" and "Komsomol'skaya".

When he returned from Antarctica in 1958 Kotlyakov worked for three years on Antarctic data. In 1960 four volumes of "Data of glaciological investigations (IGY)" were published. In 1961 he obtained his master's degree, on "The snow cover in Antarctica and its role in present day glaciation of the continent". The same year Kotlyakov's book of that title was published (translated and published in English in 1966), in which he detailed the processes of nourishment of the Antarctic ice sheet and its evolution.

In connexion with the International Geophysical Year a Glaciological Department was set up in the Institute of Geography under Professor G. A. Avsyuk, and Kotlyakov was appointed scientific secretary. At the same time a Soviet Committee of the IGY was organized and included a Glaciology Section; Professor G. A. Avsyuk was appointed chairman and Kotlyakov scientific secretary of this section. The Section, on the initiative of Kotlyakov, began to publish a series called "Chronicle, Discussions", the first glaciological journal in the Russian language. 17 issues have now been published, with Kotlyakov as the editor.

During the first half of the 1960s, Kotlyakov continued his field investigations, working 2 or 3 months out of every year with a small group of colleagues on the mass balance of the glaciers of Elbrus (Caucasus) and of the Zailiskiy Alatau (Tien-Shan).

As scientific secretary of the Section of Glaciology, Kotlyakov organized regular national symposia on glaciology. The first of these was held in Moscow in 1961; the second in Alma-Ata in 1962; the third on the lake Issyk-Kul in 1965; the fourth in the village of Terskol in the Caucasus, and the fifth will be held in Tashkent in 1972.

Kotlyakov spends a great deal of time on the popularization of glaciology and works on popular scientific magazines such as "Priroda" (Nature), "Zemlya i Vselennaya" (The Earth and Universe) and "Vokrug Sveta" (Round the World). In 1965 he published a booklet, "The mystery of glaciers", and in 1965 appeared his well-known book, "We live in the Ice Age". In this book he describes in simple language the objectives and achievements of modern glaciology.

Kotlyakov's exacting approach to scientific problems is well-known, and was exemplified in his doctoral thesis in 1967. In it he investigated the role of snow cover on glaciers and summarized all the known data about the nourishment of glaciers. In 1968 this work was published as a monograph called, "The snow cover of the earth and glaciers".

In 1967 Kotlyakov succeeded Professor Avsyuk as the head of the Glaciological Department of the Institute of Geography (Academy of Sciences, USSR) and in 1968 was appointed deputy chairman of the Glaciology Section of the Soviet Geophysical Committee. He took an active part in the work of the Commission of Snow and Ice (International Association of Scientific Hydrology), participating in glaciological training courses in Tarfala and in the XIV General Assembly of IUGG in Switzerland, and in the Glaciological Society's Symposium on the Hydrology of Glaciers in Cambridge. In 1970 he was assigned as a representative of the USSR on the Co-ordinating Council of the International Antarctic Glaciological Project.

In spite of the fact that Kotlyakov is very busy with administrative activities he continues his scientific researches and is a scientific editor of a number of publications. He also supervises several graduate students who work in the Caucasus and Central Asia.

In 1968 he headed the Pamirs Aeroglaciological Expedition of the Institute of Geography (Academy of Sciences, USSR) which investigated the glaciers in this little-known region of the USSR. The object of the expedition was to compile a catalogue of the glaciers and a comprehensive monograph on glaciation. The work necessitated the use of helicopters to get to the accumulation areas of these glaciers at a height of 4000-4500 m above sea level: this was done on Kotlyakov's initiative.

Kotlyakov is now busy with the preparations for the XV General Assembly of IUGG (Moscow, 1971) and was appointed a member of the Organizing Committee on behalf of the Department of Glaciology, and a Convener of the Symposium on "Interdisciplinary researches of snow and ice in mountain regions". He is continuing his own research and at the moment is writing a monograph, "Foundations of snow science".

Kotlyakov's wife is a neuropathologist who looks after the members of the Soviet national athletic team, and in summer months she often goes on her husband's expeditions as a doctor. Despite their very busy lives, the Kotlyakovs have found time to welcome to their home glaciologists from abroad as well as from different parts of the USSR.

ARCTIC ICE DYNAMICS JOINT EXPERIMENT (AIDJEX)

by W. F. Weeks

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

The idea for a multi-disciplinary project to study problems related to the movement of pack ice in the Arctic Ocean dates from the early occupation of ice island T-3 and the IGY drift of Pack Station Alpha. The increased interest in such a project since the mid-1960's can be seen in two documents prepared by the Glaciology Panel of the Committee on Polar Research of the U.S. National Academy of Sciences (1967, 1970). A preliminary description of such a project was completed by N. Untersteiner and K. Hunkins in July 1969. By November 1969, J. O. Fletcher was named project co-ordinator, the project approach and its timeliness were reviewed and endorsed by a group of specialists, and AIDJEX was underway.

The goals and operational outlines of AIDJEX have been well described by Untersteiner, Maykut and Thorndike (1970). "An understanding of the large-scale response of sea ice to its environment is needed for solving many important theoretical and practical problems, ranging from the interaction between ice cover and global circulation to the passage of ships in ice-covered seas. Observations from single stations are intrinsically inadequate for this purpose. It is therefore proposed to conduct measurements from an array of drifting stations in the Arctic Ocean. The proposed array consists of a central manned station surrounded by four unmanned stations forming a square 20 km on a side, and four manned stations forming a square 100 km on a side. Additional unmanned stations will be deployed outside the main array. A logistic headquarters based on a secure location (such as a nearby ice island) is required. Position, atmospheric pressure, and wind speed will be determined regularly at all stations. In addition, observations at the manned stations will include meteorological conditions, wind stress, water stress, and ice conditions. To determine the areas of open water, pressure ridges, melt ponds, and other features, surface observations will be supplemented by regular airborne surveys of the test area by means of photography, side-looking radar, laser profilometry, and infrared imagery. Under-ice topography must be obtained by submarine transits."

Data obtained on the AIDJEX project will help to provide answers to a number of important problems.

"1. They would provide the parameters relating air and water stresses to ice strain, necessary for further development of dynamic models of large-scale sea ice motion. Since forecasts of future ice conditions are based on forecasts of wind fields and their influence on ice movement, clarification of these relationships is fundamental to the improvement of such forecasts.
2. They would provide much of the information needed to evaluate the participation of sea ice in air-sea interaction and climatic change. An understanding of this interaction is necessary to assess the purported instability of the ice cover on the Arctic Ocean.
3. They would provide information on the general morphology of sea ice, its relation to past strain, and the mechanisms producing the morphological features.
4. They would enable us to relate ice strain and particularly the amount of open water to the heat balance and production of new ice.
5. They would provide environmental data useful in understanding primary production and other biological phenomena in the ocean under conditions different from today's, and in evaluating the possibility of damage to the arctic environment from expanded economic activity in the area.
6. They would greatly enhance our knowledge of the structure and dynamic behaviour of arctic water masses and the attendant features of sound propagation.
7. They would provide crucial information on the feasibility and desirability of large-scale artificial removal of sea ice."

Logistical support for such a program will include "medium or light aircraft for transport between the Base Station and satellite stations, and helicopters, particularly for summer flying and rescue. The manned stations will be occupied for extended periods during two years, with several weeks of intensified studies during selected periods in each season when large seasonal fluctuations in the ice and environment require synchronized observations at all stations."

It is planned to implement the full scale AIDJEX array in 1973. Needless to say the operation of the full array will be a difficult task both scientifically and logistically. To gain valuable experience on a variety of measurement

and analysis problems that must be surmounted for the full scale array to function successfully, smaller pilot programs are being operated during 1970, 71 and 72. The logistical portions of these pilot programs have been undertaken by the Polar Continental Shelf Project, Department of Energy, Mines and Resources, Ottawa.

The March 1970 pilot study was focused on problems related to the measurement of the water stress and was under the technical direction of L. K. Coachman and J. D. Smith of the University of Washington. The program was based from a main camp located on an ice floe roughly 240 miles north of Tuktoyaktuk, N.W.T. Measurements were made of the time-dependent velocity and Reynolds stress fields under a fairly smooth piece of ice. Mechanical current meters developed by Smith were placed by divers in orthogonal triplets at five locations down to 17.7 m beneath the ice. Because of difficulties with the electronic portion of the instrument package, it was only possible to obtain information over a four-day period. Fortunately during this period a storm passed and appreciable relative ice-water motion was observed. The divers also mapped the topography of the lower surface of the ice in the vicinity of the instrument mast. Studies were made of the mean flow within and beneath the boundary layer and of the coherence of the current field at 40 m depth. Several synoptic hydrographic casts were performed to study the approach of flow in the Arctic Ocean to geostrophic. MRA-2 tellurometers were used to measure small-scale strains in the ice near the camp. It was found that good readings were only possible up to distances of 2.6 miles. Gross deformation of a 10-20-30 mile triangle of stations could, however, be measured twice daily by positioning the stations with a Decca-Lambda system. Severe pressure ridging near camp caused considerable inconvenience during the study and resulted in some experiments being prematurely terminated. A detailed description of the 1970 pilot study can be found in AIDJEX Bulletin No. 4.

The 1971 pilot study will also occur during the month of March. This time the location will be roughly 300 to 350 miles north of Tuktoyaktuk where, it is hoped, pressure ridging will be less of an operational problem. The scope of the research program has been greatly expanded and now includes the participation of four main groups of investigators.

Coachman and Smith will again head the University of Washington water stress program (13 men). The 1971 project objectives are the same as the 1970 study and similar experiments will be attempted. Two satellite stations will again be used in conjunction with the main base camp. In addition a group of three men headed by K. Hunkins from the Lamont-Doherty Geological Laboratory of Columbia will also be involved in Ekman spiral and drag coefficient studies. Savonius rotor current meters will be used in determining the water stress by the Ekman spiral method. A hot-wire current meter is also being developed to measure water stress by the eddy flux method.

Eight investigators headed by J. Brown from the Navy Arctic Submarine Laboratory (ASL) will be studying the shear stress at the air-ice interface as well as the main energy components (sensible, latent, net radiant and conducted). Measurements will be made of temperature, wind speed and humidity from two 10 meter masts. An attempt will be made to extend these profiles to 1000 m using a tethered aerodynamic wing. The conducted heat flux will be determined from the thermal properties of the ice as specified by its temperature, composition, and density and its temperature profile. Heat flux meters will be emplaced in the ice. Several different types of radiometers will be utilized in measuring short wave, long wave, direct and diffuse components of radiation. The variations in the atmospheric turbidity coefficient will be investigated with a pyroheliometer equipped with a variety of filters. The ASL group will also attempt water stress measurements using both a hot film probe and a series of special thermoprobes oriented in the vector directions.

The ice mechanics and morphology portion of the pilot study will be carried out by a 7-man team, from the U.S. Army Cold Regions Research and Engineering Laboratory (A. Kovacs and W. Weeks) and the U.S. Geological Survey (W. Campbell). Overflights for this part of the program will be performed by a NASA Convair 990 (5 flights), a U.S. Coast Guard CI130 (2 to 3 flights) and a U.S. Navy NC-121K (3 flights). The instrumentation aboard the NASA aircraft includes standard aerial cameras, side-looking radar (SLAR), microwave instrumentation and a laser profilometer. The Coast Guard aircraft will carry standard aerial cameras and SLAR while the Navy aircraft will carry standard aerial cameras, an infrared scanner and a laser profilometer. Prior to the first overflight a triangular strain net will be laid out near the main AIDJEX camp (one station will be at the main camp while the other two stations will be at distances of 5 to 10 miles). The distances will be measured using MRA-3 tellurometers. The strain sites will be occupied during the remote sensing overflights and for 4 to 8 hour periods at two-day intervals during the intervening times. The NASA and Navy aircraft will then make low level passes along the legs of the strain net and a high level pass (10-12,000 m) for regional coverage. The Coast Guard aircraft will fly at roughly 3,000 m. The overflights will take place at fairly regular intervals between 8 and 26 March 1971. The sequential remote sensing coverage will serve as a valuable complement to the surface strain measurements. In particular, the

photography will provide a base for the identification of specific deformation features that can be correlated with observed strains.

Detailed ground observations will be made concerning the local ice deformation leading to the formation of ridges and hummocks. The surface and sub-surface geometry of ridges and hummock fields will also be studied by both drilling and sonar. An attempt will be made to document block size distributions, the degree of bonding above and below the water line, and the physical property profiles of the ice in both newly formed and old pressure ridges and hummocks. The variations in ice thickness along the strain lines will be established by drilling. Also a number of temperature and salinity profiles as well as microwave reflectivity measurements will be obtained on representative ice types in the general test area. The ratios of the anions in the salinity samples will be studied for possible strong departures from the ratios found in normal sea water.

The 1971 pilot study is very ambitious considering the time limitations and the technical and logistic problems that must be surmounted. It will be noted that some of the measurements, particularly water stress, are being attempted using several different approaches. An analysis of the test results should permit a selection of the best methods for use during the full AIDJEX program. It is hoped that the experience gained during these pilot studies will simplify both the scientific and logistic portion of the operation of the full AIDJEX array in 1973.

More detailed information about the AIDJEX program can be obtained from the references following this note or from J. O. Fletcher, Program Co-ordinator, AIDJEX, Division of Marine Resources, University of Washington, Seattle, Washington 98105, U.S.A.

References

National Research Council (Washington). Committee on Polar Research. Glaciology Panel. 1967. Glaciology in the Arctic. *American Geophysical Union. Transactions,* Vol. 48, No. 2, p. 759-67.

National Research Council (Washington). Committee on Polar Research. Glaciology Panel. 1970. Polar glaciology. (*In Polar research: a survey.* Washington, D.C., National Academy of Sciences, p. 73-102.)

University of Washington. Division of Marine Resources. *AIDJEX Bulletin (Arctic Ice Dynamics Joint Experiment).*

No. 1. Status report. 1970. v, 34 leaves.

No. 2. Theoretical discussion. 1970. iv, 70 leaves.

No. 3. Selected Soviet research. 1970. iv, 119 leaves.

No. 4. Water stress studies. 1971. iii, 55 leaves.

No. 5. 1971 pilot studies—remote sensing and ice morphology. 1971. iii, 58 leaves.

Seattle, Washington, University of Washington, Division of Marine Resources.

Untersteiner, N., *and others.* 1970. *Arctic Ice Dynamics Joint Experiment. Part 1: Scientific plan. By N. Untersteiner, G. A. Maykut and A. S. Thorndike.* Seattle, Washington, University of Washington, Division of Marine Resources, 44p.

GLACIOLOGICAL SOCIETY

MEETINGS

BRITAIN 1971

4 FEBRUARY, Reading University, Department of Geography—"Radio echo sounding in Antarctica" by S. Evans.

28 APRIL, London W.1., joint meeting with the Challenger Society—"The 'Manhattan' voyages and the development of Arctic shipping" by W. F. Weeks.

5 MAY, Aberdeen University, Department of Geography—"The Arctic Ice Dynamics Joint Experiment (AIDJEX)" by W. F. Weeks.

The Society's Annual Conference was held in Cambridge on 29 and 30 April, at the Scott Polar Research Institute, by kind permission of the Director. Members from several countries attended the sessions and the dinner, which was held on the evening of 29 April at the University Centre. The following talks were given. (Members who wish to know further details of any particular talk should write direct to the author.)

C. W. M. Swithinbank—
Arctic pack ice from below.

W. F. Weeks—
Pressure ridges.

R. H. Thomas—
Ice shelves and the flow law of ice.

P. Wadhams—
Remote sensing of waves in pack ice.

S. Evans—
Hot ice results.

J. F. Nye, R. Kyte, D. Threlfall—
Ultrasonic analogue for radio-echo interpretation.

C. H. Harrison—
Computer-generated radio-echo records.

A. Weidick—
Hypsithermal readvance of Greenland glaciers.

W. Dansgaard—
A pole to pole comparison of climatic events.

G. Østrem—
Use of computers in mass balance studies.

P. Calkin—
Glacio-geomorphic studies at the margin of the Antarctic ice sheet.

P. V. Hoobs—
A theory for the variation of ice crystal habits with temperature.

J. F. Nye, P. Watts, S. Mae—
The flow of ice at the melting point.

J. Weertman—
General theory of water flow at the base of a glacier.

G. de. Q. Robin, J. Weertman—
Surges solved?

J. G. Paren—
Liquid in ice: dielectric properties.

J. W. Glen, G. C. Camplin—
Electrical properties of HF-doped ice.

G. Østrem—
Definition of the term: "glaciation limit".

FUTURE MEETINGS

BRITAIN

16 JUNE 1971, at 5 p.m. at the Scientific Societies Lecture Theatre, 23 Savile Row, London W.1.—joint meeting with the Royal Meteorological Society:

"Ice in the atmosphere"

P. V. Hobbs—
Aspects of growth of ice crystals from the vapour phase.

D. A. Johnson—
The role of ice crystal droplet interaction in clouds.

J. Latham—
Electrical aspects of freezing.

J. G. Paren—
Impurities in deposited snow and their effects on electrical properties.

U.S.S.R.

10 AUGUST 1971, in Moscow—Annual General Meeting, followed by a party.

BRANCH NEWS

The Northeast North American Branch held a meeting at Burlington, Vermont, on 19 and 20 February 1971. The Branch was honoured to welcome the President of the Society, who spoke at the banquet. René Ramseier was elected President of the Branch, Lorne Gold the Vice President, and Austin Kovacs the Secretary. The proceedings were, as usual, much enlivened by the social festivities, although the weather was uncooperative and prevented the traditional experiments on the sliding friction of skis.

The following papers were read at the meeting.

C. S. L. Ommanney—
The Glacier Inventory of Canada.

W. O. Field—
Progress report on the compilation of inventory and variations data for coastal Alaska.

G. J. Young—
Glacier mass balance: a data-bank approach.

U. H. I. Embacher—
Aufeis as part of the groundwater system in a permafrost area located in the fiord region of Baffin Island.

A. D. Stanley—
Movement of the Steele Glacier, Yukon Territory.

S. J. Jones and D. A. Fisher—
The possible future behaviour of Berendon Glacier: a further study.

K. C. Arnold—
The photographic bas-relief effect: an unusual application to illustrate glacier movement.

A. V. Karpov—
Breakthrough in glacier studies.

O. H. Løken—
Recent developments of the research programme in the Glaciological Subdivision, Dept. of Fisheries and Forestry, Canada.

W. J. Campbell—
The 1971 AIDJEX Pilot Study.

W. E. S. Henoch—
Potential of tree ring analysis for glaciological and water resources research.

E. R. Pounder—
Ice drift in the Gulf of St. Lawrence.

M. P. Langleben—
The melting of sea ice.

G. Holdsworth—
Processes of calving into a proglacial lake.

P. W. Wagner—
Lake ice movements and ice ramparts.

R. Frederking—
In situ pressure and deformation measuring devices.
Confined compression testing.

L. W. Gold—
Recent work on the bearing capacity of ice and deformation behaviour of ice under 'constant rate of strain'.

W. F. Weeks, C. M. Keeler and W. Parrott—
Recent work on the wintertime cooling of rivers.

J. T. Hollin—
Progress in testing for ice-sheet surges.

C. W. Thomas—
Ice rafting of Alaskan trench plutonics.

THE LIBRARY

One of the privileges of membership of the Glaciological Society is access to the library. Few members, even those who live nearby, take advantage of this, so we hope that the following description may encourage the use of our library.

Under the care of Gerald Seligman, a valuable nucleus of classic works on glaciology was assembled during the formative years of the Society. In 1968, upon his retirement, the library was moved from Dr Seligman's home in Kent to the Society's office, which is housed in the Scott Polar Research Institute, Cambridge. It now forms a small but lively unit in the general activities of the secretariat: over 300 volumes are crammed into 30 ft. of shelving, another wall of shelves is occupied by periodicals and bound volumes of pamphlets, and a four-drawer filing cabinet is filled with folders containing reprints, leaflets, and booklets, filed in alphabetical order by author. In other rooms, there are a drawer of maps and more bookshelves holding Russian and Japanese publications and boxes of reports from official and non-official organizations mainly in Britain, the United States and Canada. There are also collections of expedition reports, bibliographies, and, of course, miscellanea.

The quantity may be small but the quality is high. Recent books cover every aspect of glaciology, for the beginner and for the expert, and include the ever increasing conference and symposium proceedings that are so expensive for individuals to buy, but are available for members to borrow. There are some excellent regional books on the shelves, such as B. Fristrup's *The Greenland ice cap,* A. Desio's *I ghiacciai del Gruppo Ortles-Cevedale* and R. Thoren's *Picture atlas of the Arctic.* Also into this group fall some of the older volumes, such as J. D. Forbes' *Norway and its glaciers visited in 1851* (published 1853) and the same author's *Travels through the Alps of Savoy and other parts of the Pennine Chain with observations on the phenomena of glaciers* (published 1843). There is A. von Ruthner's *Berg und Gletscher-Reisen in den österreichischen Hochalpen* (1864) and H. -B. De Saussure's *Voyages dans les Alpes* in nine volumes (1807). The oldest book of all is *An account of Switzerland written in the year 1714,* printed in the same year "for Jacob Tonson at Shakespear's Head, over-against Catherine-street in the Strand", but it is hardly glaciological in content, apart from a reference

to hoards of snow and ice. A particularly attractive possession is *Sive itinera per helvetiae alpinas regiones facta annis MDCCII-MDCCXI . . .* by J. J. Scheuchzerus, published in 1723, which is notable for the alarming and highly inaccurate illustrations of the fauna of Switzerland, such that would cause the humble ice worm to blush in shame. Unfortunately, there is only one volume (the first) from the set of four. These old books cannot, of course, be borrowed, but may be consulted in the office.

About a dozen periodicals are obtained in exchange for the *Journal of Glaciology.* These include *Arctic, Biuletyn Peryglacjalny, Bollettino del Comitato Glaciologico Italiano, Geografiska Annaler, Jökull, Antarctic Record, the Journal of the Japanese Society of Snow and Ice, Low Temperature Science,* and *Zeitschrift für Gletscherkunde und Glazialgeologie.* By the same token, the U.S. Army Cold Regions Research and Engineering Laboratory sends its reports to the Society.

Owing to limitations of space and finance, book purchases are restricted at the present time to those considered absolutely necessary. However, the Society is fortunate in receiving gifts of books and other publications from many author-members, and also from publishers for reviewing or listing in the *Journal of Glaciology* or here in *Ice.* In the past two or three years, the Secretary and her staff have led very busy lives, and we regret that these gifts have not always been acknowledged properly. On behalf of the Society, we now thank most sincerely all who have so generously presented books, reprints, reports, maps and photographs. At the end of this article are listed some of these gifts, recent and not so recent, which have escaped formal acknowledgement.

Our close association with the resources of the Scott Polar Research Institute library is of immense value, and it is satisfying when the Society is able, in return, to help that library in glaciological matters. Here, personal contacts with members is of great benefit, as up-to-date information or advice may usually be obtained verbally or by return of post. We would also like to help our members in the same way by putting them in touch with one another when this will be helpful, by seeking out information they require, by lending them books for short periods (members to pay two-way registered postage) or by providing them with xerox copies of anything in Cambridge (at 5p per sheet).

Suggestions are welcome. It is your library; please use it!

Ailsa Proudman
Librarian

ANDERSEN, B. G. Glacial geology of western Troms, north Norway. *Norges Geologiske Undersøkelse,* No. 256, 1968, 160 p.
[Moraine chronology study indicates six main glacial phases.]

BARNES, M. *ed. The mountain world 1966/67.* London, George Allen and Unwin; Chicago, Rand McNally, [c1968], [xii], 228 p.
[Ninth volume of the English language series. Original published by the Swiss Foundation for Alpine Research. Mountaineering feats in various regions of the world.]

BERGER, H. *Vorgänge und Formen der Nivation in den Alpen.* Klagenfurt, Verlag des Geschichtsvereines für Kärnten, 1967. 89 p., plates. (Buchreihe des Landesmuseums für Kärnten. Geleitet von G. Moro. Bd.17.)
[Investigation of nivation, based on several years' fieldwork in the eastern Alps.]

BIROT, P. *The cycle of erosion in different climates. Translated by C. I. Jackson and K. M. Clayton.* London, Batsford, 1968, 144p.
[Part 1: basic processes; Part 2: influence of different climates, including periglacial.]

BRATHAY EXPLORATION GROUP. *Handbook for expeditions; a planning guide.* n.p., Brathay Exploration Group in association with the Geographical Magazine, [c1971]. v, 138 p.
[Although written specifically to assist in planning of expeditions for young people, it is thought that much of the information should be of value for expeditions generally.]

CLARKE, G. K. C. Geophysical measurements on the Kaskawulsh and Hubbard glaciers, Yukon Territory. *Arctic Institute of North America. Technical Paper* No. 20, 1967, 36 p.
[Ice thickness determined by gravity and seismic measurements, summer 1963.]

CORNWELL, I. *Ice ages: their nature and effects.* London, John Baker, 1970. 180 p.
[Glacial advance and retreat, and effect on Earth's surface (including flora and fauna) and climate, examined in sequence of Lower, Middle and Upper Pleistocene periods and into postglacial times.]

CUSHING, E. J., *and* WRIGHT, H. E., *jr., eds. Quaternary paleoecology.* New Haven and London, Yale University Press, 1967. vii, 433 p. (Vol. 7 of the Proceedings of the VII Congress of the International Association for Quaternary Research. Sponsored by the National Academy of Sciences—National Research Council.)
[Group of papers concerned with one or more aspects of terrestrial ecology within the Quaternary period.]

DESIO, A. *I ghiacciai del gruppo Ortles-Cevedale (Alpi Centrali). [Vol. 1] Testo. [Vol. 2] Tavole.* Torino, Palazzo Carignano, 1967. 2 vols.
[Comprehensive well-illustrated descriptions of the glaciers of the Ortles mountains, Italy.]

DOUMANI, G. *ed. Antarctic bibliography. Vol. 1. Prepared at the Library of Congress and sponsored by the Office of Antarctic Programs, National Science Foundation, Washington, D.C.* Washington, D.C., Library of Congress, 1965. vii, 506 p.

EMBLETON, C., *and* KING, C. A. M. *Glacial and periglacial gemorphology.* London, Edward Arnold, [c1968]. xvi, 608 p.
[Landforms and processes of erosion and deposition.]

HEUBERGER, H. *Gletschergeschictliche Untersuchungen in den Zentralapen zwischen Sellrain- und Ötzal.* Innsbruck, Universitätsverlag Wagner, 1966. 126 p. (Wissenschaftliche Alpenvereinshefte, Heft 20. Gemeinsam herausgegeben von den Hauptausschüssen des Deutschen und des Österreichischen Alpenvereins.)
[Review of research on Austrian glaciers in central Alps.]

KOSACK, H. -P. *Die Polarforschung; ein Datenbuch uber die Natur-, Kultur-, Wirtschaftsverhaltnisse und die Erforschungsgeschichte der Polar regionen.*
Braunschweig, Friedr. Vieweg & Sohn, [c1967]. xv, 471 p.
[Factual data in tabular form, derived from recent published sources, relating to all aspects of the Arctic and Antarctic.]

OSBURN, W. H., *and* WRIGHT, H. E., *jr., eds. Arctic and alpine environments. Vol. 10. Proceedings VII Congress International Association for Quaternary Research, Boulder Denver, Colorado, August 14-September 19, 1965. Sponsored by U.S. National Academy of Science—National Research Council.* Bloomington and London, Indiana University Press, 1968. xi, 308 p.
[Papers on climatology and glaciology, ecology and geology.]

PORTER, S. C. Pleistocene geology of Anaktuvuk Pass, central Brooks Range, Alaska. *Arctic Institute of North America. Technical Paper* No. 18, 1966, 100 p.
[Advance and retreat of Itkillik glaciation northward through Anaktuvuk Pass and recent warming of climate in that region.]

SPENCER, A. M. Late Pre-Cambrian glaciation in Scotland. *Geological Society of London. Memoirs,* No. 6, 1971. vii, 98 p., plates, maps.
[Field study, explaining depositional processes, environment and history of the Port Askraig Tillite in the Dalradian succession.]

THORÉN, R. *Picture atlas of the Arctic.* Amsterdam, London, New York, Elsevier Publishing Co., 1969. xii, 449 p.
[Nature and resources of the Arctic Ocean and surrounding polar lands. Illustrated with over 300 air and ground photographs.]

TREMAINE, M. *ed. Arctic bibliography, prepared by the Arctic Institute of North America with support of government agencies in the United States and Canada. Vol. 14.* Montreal and London, McGill-Queen's University Press, 1969. xxxii, 1693 p.

TRICART, J. *Le modelé des régions périglaciaires.* Paris, Société d'Edition d'Enseignement Supérieur, 1967. 512 p. (Traité de Géomorphologie par J. Tricart et A. Cailleux. Tome 2.)
[Second edition, revised and expanded, first published in 1950.]

Quaternary Research, Vol. 1, No. 1, September 1970.
[Described by the Editor, A. L. Washburn, as "an interdisciplinary journal"; the editorial advisory board draws its members from 17 fields of scientific activity, including glaciology, geography and gemorphology, geophysics, atmospheric sciences, oceanography, and Quaternary geology.]

JOURNAL OF GLACIOLOGY

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

Articles—

W. F. Budd:
Stress variations with ice flow over undulations.

W. F. Budd and D. B. Carter:
An analysis of the relation between the surface and bedrock profiles of ice caps and ice sheets.

A. K. Chatterjee and H. H. G. Jellinek:
Calculation of grain-boundary thickness in polycrystalline ice or low salinity.

S. C. Colbeck and R. J. Evans:
Small-scale strain measurements on a glacier surface.

J. D. Cross:
The effect of impurities on the surface structure of evaporating ice.

E. Dorrer:
Movement of the Ward Hunt Ice Shelf, Ellesmere Island, N.W.T., Canada.

S. L. Hastenrath:
On the Pleistocene snow-line depression in the arid regions of the South American Andes.

F. Prodi and C. T. Nagamoto:
Chloride segregation along grain boundaries in ice.

C. J. Readings and J. T. Bartlett:
Interference phenomena in deformed single crystals of ice.

H. Rutishauser:
Observations on a surging glacier in East Greenland.

R. A. Souchez:
Ice-cored moraines in south-western Ellesmere Island, N.W.T., Canada.

Short notes—

D. C. Connell and J. M. C. Tombs:
The crystallization pressure of ice—a simple experiment.

W. L. Hamilton:
Oxygen-isotope measurements on 1,700 ± 300 year old Antarctic ice.

G. E. Weller and P. Schwerdtfeger:
New data on the thermal conductivity of natural snow.

MEETINGS

RADIOGLACIOLOGY MEETING

In May 1970 a Meeting on Radioglaciology was held at the Technical University of Denmark with an attendance from 12 countries. 22 papers were presented in sessions entitled: dielectric properties of ice, measurements on thick polar ice, measurements on temperate glaciers, and measurements on thin ice.

21 papers and abstracts, including two papers which were not presented at the meeting, have been published in the Proceedings: 180 typewritten pages. The Proceedings are available at a price of US $ 5 or d.Kr. 40 including postage for surface mail from the Laboratory of Electromagnetic Theory, Technical University of Denmark, DK—2800 Lyngby, Denmark.

WORKSHOP ON ACTION OF ICE ON STRUCTURES

About fifty representatives from oil companies, universities and various Canadian and U.S. Government agencies attended a Workshop on the Action of Ice on Structures at the Division of Building Research, National Research Council, Ottawa, 12-13 November 1970. The Workshop was sponsored by a Working Group of the Snow and Ice Subcommittee, NRC Associate Committee on Geotechnical Research. The purpose of the Workshop was to review the current state of knowledge and research activity concerning the forces ice can exert against structures.

The subject of ice pressures against structures if of great interest in the design of offshore facilities for the exploration and production of oil in the Beaufort Sea, Hudson Bay and Arctic Ocean. The potential recoverable oil reserves under Canada's Continental Shelf and in ice-infested waters is estimated to be several times the proven reserves for all of Canada. The cost of offshore drilling, production and transportation for offshore wells may be five times that for comparable operations on land. Forces imposed by ice on offshore structures, drilling barges, supply vessels and tankers, create a most formidable problem that must be overcome if oil reserves in ice-covered waters are to be exploited.

The Workshop gave particular attention to three aspects of the ice pressure problem. These were introduced in the Opening Session in a paper on the characteristics of ice covers and movement, presented by E. R. Pounder, McGill University; a second on the deformation and strength properties of ice by L. W. Gold, National Research Council of Canada; and a third on the interaction between ice and structures by B. Michel, Laval University. The participants then continued discussion of these three subjects in concurrent study sessions. Reports of these three groups and their recommendations were considered and discussed in the final session.

The study session on the movement of ice showed the need for information on the size, occurrence, movement and distribution of pressure ridges, icebergs and floes. It was recognized that severe pressure conditions would occur when the polar pack ice is driven against the shore fast ice, and attention should be given to the movement of the pack ice and the forces responsible for it. Reliable information on the movement of ice in areas where structures are being considered is absolutely necessary to establish if a safe design is economical.

The session on the properties of ice emphasized that additional information is required on the deformation and strength behaviour of all types of ice, particularly for the more complicated stress conditions that would occur adjacent to structures. This information would be useful not only for design, but also for the analytical models that are urgently required for engineering calculations, and for the design and interpretation of experiments on the interaction between ice and structures.

The session on the action of ice on structures revealed that there is practically no data available for the design of structures to be built in Arctic waters. Investigations are required both in the laboratory and the field to establish the design conditions. These studies will assist in setting up the theoretical models describing the effect on ice pressures of factors such as shape and ratio of width of structure to thickness of ice. Fully instrumented structures are needed to obtain reliable measurements of ice pressures under field conditions. As such installations are costly, maximum use of laboratory investigations and theoretical models should be made in design of such field studies and the interpretation of the results.

The Workshop provided an opportunity for much stimulating discussion and exchange of ideas. J. Hnatiuk of the Arctic Petroleum Operators Association closed the final session with a concise summary of the proceedings. It is planned to publish a record of the Workshop as a Technical Memorandum of the Associate Committee on Geotechnical Research. Copies will be available from the Secretary, Associate Committee on Geotechnical Research, National Research Council, Ottawa 7, Ontario. K1A OR7.

SOCIETE HYDROTECHNIQUE DE FRANCE

The Glaciological Section held its annual meeting in Grenoble, 4-5 March 1971. The following papers were read:

—. Obled—Possibilités de prévisions numériques du risque d'avalanches.
C. Péguy—Etude sur la variabilité des précipitations de semestre froid en Vanoise.
Bon Mardion, J. C. Chazeau, P. Perroud—Délenchement d'avalanches par explosif: le programme "dynamique".
C. J. Lorius—Les calottes polaires: des témoins de l'environment.
—. Rey—La neige en Chartreuse.
C. de la Casinière—Fonte de la neige et bilan thermique dans la Sierra de Guadarrama.
C. J. Lorius, Corompt, Sermay—Possibilités d'une sonde à neutrons pour l'étude des couches de neige.
W. Good—Un système automatique pour l' analyse des coupes minces.
—. Boutron, Echevin, C. J. Lorius—Eléments traces dans la neige de l'Antarctique.
F. Gillet—Reconnaisance glaciologique de la calotte Cook.
—. Reynaud—Mesures de vitesse de glaciers par photogrammétrie terrestre.
—. Grard—Essais d'un modèle explicatif des variations des glaciers par le climat.
R. Vivian—Variations récentes de la Mer de Glace et du Glacier d'Argentières.
A. Bezinge—Variations récentes des glaciers de Zermatt et d'Herins.
M. Vallon—Le "Callejon de Huaylas" et la Cordillera Blanca (Pérou).
P. Veyret—Les observations de phénomènes d' érosion et d'accumulation au glacier des Bossons.

FUTURE MEETINGS

COMMISSION OF SNOW AND ICE

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

IUGG XV GENERAL ASSEMBLEY, MOSCOW 1971

Symposium on interdisciplinary studies of snow and ice in mountain regions

9–13 August

SECOND CIRCULAR

I. SUBMISSION OF PAPERS

The first circular dealing with the submission of abstracts and papers was issued on 1 July 1970. Authors of papers and shorter contributions who have received notice of acceptance of their abstracts are reminded that three copies of their complete documents, prepared in accordance with the requirements given in the first circular and approved by national committees, should be sent to the Secretary of the Commission to arrive by 1 July 1971.

II. ORGANIZATION OF SESSIONS

The Symposium will be held from Monday 9 to Friday 13 August in the main building of Moscow University, 18th floor, room No N.1807. Morning sessions will run from 10.00 to 13.30 hours and afternoon sessions from 15.00 to 18.30 hours. A Chairman will be appointed for each session. His main tasks will be to maintain strict timing of the presentations and to organize lively discussion. Those intending to contribute to the discussion should inform the Chairman before the session commences and indicate the nature of their contribution.

Papers in category (a) will be allowed 20 minutes for presentation, and short contributions in category (b) will be allowed 10 minutes presentation. Discussion time for both categories is 10 minutes. At the end of each session a period of general discussion is planned. Contributors to the discussion should hand in a written summary to their contributions to the Secretary of the Commission during the Symposium, if they wish the discussion to be published.

III. PROGRAMME OF SESSIONS

* Letters following titles refer to full papers (a) or short contributions (b)

MONDAY 9 AUGUST, MORNING

Session 1 Climatology of glacier regions

Hattersley-Smith, Krouse and West: Oxygen isotope analysis in accumulation studies on an ice cap in Northern Ellesmere Island, N.W.T. (b)

Keeler: The character of the snow in the accumulation zone of Mount Logan, Yukon Territory, Canada. (b)

Glazyrin: The formation of an ablation moraine as a function of climatological environment. (b)

Vinogradov: Peculiarities of accumulation and ablation on the glaciers of Kamchatka volcanic regions. (b)

Benson, Bingham and Wharton: Glaciological and volcanological studies at the summit of Mt Wrangell, Alaska. (b)

Tronov and Okishev: New estimations of interactions between glaciation factors and its evolution in the Altay. (b)

MONDAY 9 AUGUST, AFTERNOON

Session 2 Climatology of glacier regions: heat balance of alpine glaciers

Krenke: Climatic conditions for glacier existence in Central Asia. (a)

Lebedeva: The heat budget and ablation of the Central Asian glaciers. (b)

Paterson: Heat transfer in the upper layers of the ablation area of Athabasca Glacier, Canada. (a)

Kraus: An energy balance model for the ablation in mountainous areas. (a)

Föhn: Short-term measurements of snow ablation and heat balance at an experimental site on Peyto Glacier, Canada. (b)

Radok and Watts: A synoptic background of glacier variations at Heard Island. (a)

Weller, Trabant and Benson: Physical characteristics of the McCall Glacier, Brooks Range, Alaska. (b)

TUESDAY 10 AUGUST, MORNING

Session 3 Snow cover and avalanches

Martinec and de Quervain: The effect of snow displacement by avalanches on snow melt and run-off. (a)

Tushinskiy: The part avalanches play in the formation and dynamics of mountain glaciers and snow-beds in the USSR. (a)

Schaerer: The mass of avalanches and terrain characteristics. (b)

Keiji Higuchi: Characteristics of mass and heat balances of perennial snow patches in central Japan. (b)

Bucher, Stauffer and Oeschger: Ablation effects on the composition of entrapped gasses in a temperate glacier. (b)

TUESDAY 10 AUGUST, AFTERNOON

Session 4 Processes of accumulation and ablation of glaciers

LaChapelle: Firnification in a maritime climate. (a)

Khodakov: Glaciers as water balance indicators. (a)

Arnold: A comparison between two methods—the stake method and the photogrammetric method—of measuring ablation on the lower part of the White Glacier, Axel Heiberg Island, Canada. (b)

Young: Accumulation and ablation patterns as functions of the surface geometry of a glacier. (b)

Orheim: Past and present mass balance variations and climate at Deception Island, South Shetland Islands, Antarctica. (a)

Drozdov and Moselova: A method of estimating glacier melting. (b)

Yemelyanov and Konovalov: Determination of total ablation on the glaciers of Central Asia. (b)

WEDNESDAY 11 AUGUST, MORNING

Session 5 Glacier as a physical system

Budd and Jenssen: Numerical modelling of glacier systems. (a)

Shumskiy: Mechanism and causes of glacier variations. (a)

Budd and Allison: An empirical scheme for estimating the dynamics of unmeasured glaciers. (b)

Dolgushin and Ospiova: Glacier surges and the problem of surge forecast. (a)

Lliboutry: The Yungou disaster. (b)

Belousova, Bogorodskiy and Ivanov: Measurements of the flow and strain rates of glaciers by the use of Doppler systems. (b)

WEDNESDAY 11 AUGUST, AFTERNOON

Session 6 Glacier mass balance and its fluctuations

Tangborn, Krimmel and Meier: A comparison of glacier mass balance measurements by glaciologic, hydrologic, and mapping methods, South Cascade Glacier, Washington. (a)

Stanley: Mass and water balance studies at selected glacier basins in Western Canada. (b)

Zubok: Half-decade study of mass balance at Sentinel Glacier, B.C., Canada. (b)

Wendler: Mass balance studies on the McCall Glacier. (b)

Hoinkes: Hydrometeorological implications of the mass-balance of Hintereisferner 1952/53–1969/70. (b)

Miller: Long-term mass changes of an Alpine glacier as determined by geophysical and geodetic methods. (b)

Reinwarth: Analyses of mass balance data from two Alpine glaciers for the period of 1963–1969. (b)

THURSDAY 12 AUGUST, MORNING

Session 7 Seasonal snow cover

Dyunin, Komarov, and Altshuller: Snow drifts in mountain regions and modern methods of study. (a)

Wakahama and Narita: Metamorphism from snow to firn and ice in snow patches in Hokkaido. (b)

Grigoriu: Improved totalizer rain and snow gauge for solid precipitation for mountain stations inaccessible in winter. (b)

Rachner: A working model for investigation of snow supply. (b)

Babikova: Winter weather conditions and their influence on the distribution of the snow in forested and unforested parts of the watershed. (b)

Turcan: Snow-storage distribution in mountain watersheds. (b)

Diaconu and Dumitrescu: Some investigations involving restitution of water from snow on impervious-made plots of wooded and clear land. (b)

THURSDAY 12 AUGUST, AFTERNOON

Session 8 Glaciers in Central Asia

Bazhev, Kotlyakov, Varnakova, and Rototayeva: The problems of present-day glaciation of the Pamirs. (a)

Kick: Application of geodesy, photogrammetry, history, linguistics and geography to the study of long-term mass balances of Central Asiatic glaciers. (a)

Shnitnikov: The intrasecular fluctuations in mountain glaciers of Eurasia during the current century and some of their regularities. (b)

Report of Working Group on Morphology and Classification of Avalanches and discussion.

Business meeting of the Commission and election of officers.

FRIDAY 13 AUGUST, MORNING

Session 9 Water in glaciers: artifical regulation of glacier run-off

Hughes: A differential ablation-longitudinal compression mechanism for generating wave trains on cold Alpine glaciers. (a)

Dansgaard, Johnsen, Clausen, and Langway: The effects of subsurface mountains on cyclical variations of the isotopic nature of ice sheets. (b)

Zotikov: Heat regime of the water within the body and the bed of mountain glaciers. (b)

Weertman: Pressure gradient in vicinity of Röthlisberger channel at base of a glacier. (b)

Derikx: The energy balance and associated run-off from an experimental site on the glacier tongue. (b)

Cedomir Marangunic: Artificial increase of glacier surface ablation by aerial dusting, Coton Glacier, Chile. (b)

Bazhev: Experiments on artificial increase of snow melting in the firn basin of a mountain glacier in order to increase the run-off. (b)

FRIDAY 13 AUGUST, AFTERNOON

Session 10 Formation of glacier run-off

Golubev: On water regime of glaciological zones. (a)

Moser, Behrens, Bergmann, Rauert, Stichler, Ambach, Eisner, and Pessl: Study of the discharge of Alpine glaciers by means of environmental isotopes and dye tracers. (a)

Loijens: Glacier melt contribution to streamflow using tritium analyses. (b)

Lvovish and Tsigel'naya: A method of studying the water balance and estimating the water resources of glacial mountain areas. (b)

Borovikova and Denisov: The condition of flow formation for mountain rivers taking into account glacial supply. (b)

Makarevich, Shabanov, and Vilesov: Liquid run-off from the accumulation areas of mountain glaciers. (b)

IV. MEETING OF OFFICERS OF THE COMMISSION AND WORKING GROUP ON AVALANCHE CLASSIFICATION AND DISASTERS

Meeting of the Officers of the Commission with UNESCO/IHD Secretariat will take place on the evenings of 9, 11 and 12 August, and if necessary on the evening of 13 and during the day of 14 August.

There will be meetings of the ICSI Working Group on Avalanche Classification and Avalanche Disasters on the evenings of 9 and 11 August.

V. OTHER GLACIOLOGICAL FUNCTIONS DURING THE GENERAL ASSEMBLY

1. A meeting of the *SCAR Working Group on Glaciology* will be held in the evening, Monday 9 August.
2. Meetings of the *Coordinatinating Council of the International Antarctic Glaciological Project* will be held: Friday, 30 July—morning and afternoon; Saturday, 31 July—morning; Saturday, 7 August—morning.
3. A meeting of a group of specialists on *theoretical problems of the Antarctic Ice Sheet* convened by Dr W. Budd will be held morning and afternoon, Friday 6 August.
4. On the evening of Tuesday 10 August the *Glaciological Society* will hold its Annual General Meeting, followed by a party to which all glaciologists are invited. The cost of the party will be £3/7 roubles/US $7.20 each person. Cheques should be made payable to the Glaciological Society and sent to the Secretary, The Glaciological Society, Cambridge CB2 1ER, England, **before 1 July**, or the money may be paid at the time of registration in Moscow, making it clear that the money is for the Glaciological Society party.

VI. EXCURSIONS

(a) **Sunday 8 August:** Tour of Moscow.

(b) **Sunday 15 August:** Excursion to a small town near Moscow with 12th, 16th and 17th century buildings.

(c) **Monday 16 to Wednesday 25 August: Excursion to the Caucasus**

The cost of this excursion is 204 roubles and the number of participants is limited. Reservations should be made in advance through your local INTOURIST office or agent.

Monday 16 August: Fly from Moscow to Mineral'nye Vody and then by bus to Pyatigorsk. Tour in the Pyatigorsk region and stop for night.

Tuesday 17 August: By bus to Terskol for the night. Here the party will be split into two groups for glaciological trips in the Elbrus region.

GROUP 1 (Only for those fit enough to climb to a height of 4200 m on Elbrus)

Wednesday 18 August: By cable car to Cheget Peak and walk to Donguzorun Lake.

Thursday 19 August: By car and on foot to Adil-Su valley to see IHD representative glacier basin and Djankuat Glacier.

Friday and Saturday 20-21 August: By car and on foot to the hotel 'Priut Odinnadtsati' (Hut of eleven) at 4200 m on the Southern slope of Elbrus and stop the night, returning to Terskol the next day.

Group 2

Wednesday 18 August: By cable car to the observation point 'Stary Krugozor' and walk to Maly Azau Glacier.

Thursday 19 August: By cable car to Cheget Peak and walk to Donguzorun Lake.

Friday 20 August: By car and on foot to Adil-Su Valley to see IHD representative glacier basin and Djankuat Glacier.

Saturday 21 August: By bus and on foot to Shkel'da Glacier.

Whilst in the Elbrus region all participants will be able to see the scientific station of Moscow University, where several talks about Russian glaciological work will be given. Documentary and feature films will also be shown.

The excursion to 'Priut Odinnadtsati' is rather difficult and is only suitable for those with experience of mountaineering at 4000-4500 m. The period of altitude acclimatization is very short and participants will be chosen after a medical examination. Participants need warm clothing and mountain boots; warm clothing is necessary for the other excursions in the vicinity of Elbrus. It may be necessary to vary the excursions in the Elbrus region on account of the weather.

Sunday 22 August: All participants travel by bus from Terskol to Ordgonikidze for the night.

Monday 23 August: Alternative excursions:

(a) to the beautiful Tsey valley and glacier;

or (b) to the surging Kolka Glacier and Assetic, 'city of the dead'.

Tuesday 24 August: Travel by bus from Ordzhonikidze via the famous Georgian military road and the Krestovy pass to Tbilisi for the night.

Wednesday 25 August: Tour of Tbilisi and visits to glaciological establishments of Georgia. Leave by plane for Moscow in the evening.

V. M. Kotlyakov
Symposium Convener
Geographical Institute
Academy of Sciences
Staromonetny St 29
Moscow - 17
USSR

20 May 1971

W. H. Ward
Secretary, CSI
147 Rickmansworth Road
Watford, Herts
England

SYMPOSIA ON THE ROLE OF SNOW AND ICE IN HYDROLOGY

(Banff, 6-20 September 1972)

Symposium on Properties and Processes (convened by Unesco)

Symposium on Measurement and Forecasting (convened by WMO)

Both organized with the collaboration of WMO and Unesco respectively, the Canadian National Committee for IHD, and the International Association of Scientific Hydrology.

INFORMATION NOTE NO. 1

A. Introduction

The present Information Note No. 1 provides advance notice for those wishing to attend the Symposia and in particular for those who may submit papers. Information Note No. 2, to be issued later in 1971, will provide full details on registration and the submission of papers.

B. Origin and Purpose of Symposia

A Symposium on "Hydrology of snow and ice" was proposed by the Coordinating Council of IHD and a Symposium on "Forecasting of run-off from snow and ice melt" was proposed by WMO. Being closely related, these symposia are being organized within the framework of the International Hydrological Decade to run concurrently under the general title of "Symposia on the role of snow and ice in hydrology".

The purpose of the Symposia is to present and discuss the present state of the art and to evaluate future developments in both fields by means of survey and research papers covering current and "avant garde" developments.

C. Date and Place of Symposia

At the kind invitation of the Government of Canada it is planned to hold the Symposia in the Banff School of Fine Arts, Banff, Alberta, from 6 to 20 September, 1972. Technical sessions are planned for 6 to 13 September inclusive, followed by field excursions from 14 to 20 September. These dates may be modified to fit the technical programme as it develops and to allow for possible short field excursions before the Symposia.

Registration will be possibe as of 5 September and the weekend of 9 to 10 September will be free for local tours.

D. Scientific Organization

Several experts will be invited to present papers covering major sections of the programme; these papers will be based on topics sent to the authors so as to ensure scientific co-ordination. Papers will also be accepted from participants at large.

In order to achieve an ordered programme papers to be presented and published will be selected by the Symposia Programme Committee in consultation with Unesco, WMO and IASH.

E. Provisional Programme

The scientific and technical programme will be developed in the two Symposia as outlined below:

Symposium on properties and processes
(convened by Unesco)

1. Physics of snowfall and snow distribution in space and time
   - — atmospheric
   - — physiographic
   - — transport phenomena
   - — physical changes
2. Conditioning, ripening and melting of snow cover
   - — total energy exchange at air-snow interface (including meso-scale approach)
   - — heat and mass (water) flux through snow cover
   - — metamorphism and changes in physical properties
3. Ground conditioning and water movement
   - — as above, both on and in the ground
   - — including frozen soil and permafrost
4. Properties and processes of glaciers
   - — those specific to glaciers
5. Properties and processes of river and lake ice
   - — formation and metamorphism
   - — dissipation
   - — movement
   - — physical properties

Symposium on measurement and forecasting
(convened by WMO)

1. Measurement in space and time
   - — snow cover
   - — snow melt
   - — other elements (i.e. radiation, etc.)
   - — run-off
   - — new techniques
2. Forecasting run-off
   - — the forecast problem, theoretical
   - — operational practices—regional
   - — special purpose forecasting—small scale
   - — new techniques
3. Measurement and forecasting specific to glaciers
4. Measurement and forecasting specific to river and lake ice
5. Modification of snowfall, snow cover and ice cover
   - — both operational and theoretical including scientific techniques

F. Participation

1. Announcement

Unesco, WMO and IASH will each announce the Symposia through their regular channels.

2. Correspondence

All correspondence concerning the Symposia should be addressed to:

Dr I. C. Brown, Secretary, Canadian National Committee for the International Hydrological Decade, c/o Department of Energy, Mines and Resources, No. 8 Building, Room G-29, 870 Carling Avenue, Ottawa 1, Ontario, Canada.

A copy of correspondence concerning the Unesco Symposium should be sent to:

Office of Hydrology, Unesco, Place de Fontenoy, Paris 7e, France.

A copy of correspondence concerning the WMO Symposium should be sent to:

Hydrometeorology Division, World Meteorological Organisation, Case Postale no. 1, CH-1211 Geneva 20, Switzerland.

3. Registration

The decision as to which experts are to participate in the Unesco Symposium rests with the Director-General of Unesco. Details of registration and provisional registration forms for both Symposia will be included in Information Note No. 2.

4. Papers and Presentation

Full information on the procedure for the submission of papers and their format will be included in Information Note No. 2.

The working languages of the Symposia will be English and French. Simultaneous interpretation in these two languages will be provided.

G. Local Arrangements

Living accommodation will be provided at nominal rates at the Banff School of Fine Arts. A list of local hotels together with rates will be provided on request for those wishing to make their own arrangements. The School is about 15 minutes' walk from downtown Banff. Banff is 129 kilometers (80 miles) west of the International Airport at Calgary, Alberta.

INQUA, IX INTERNATIONAL CONGRESS, NEW ZEALAND 1973

The congress will be held at the University of Canterbury, Christchurch, New Zealand, 2-10 December 1973. The sponsor is the Royal Society of New Zealand. The programme will include plenary sessions, section meetings, symposia, business meetings of commissions and sub-commissions, local one-day excursions and several pre- and post-Congress excursions and field conferences. Glaciologists will find that there are several relevant excursions from which to choose; these include studies of glacial sequences and periglacial phenomena, and scenic flights over glaciers. Papers will be published as extended abstracts of not more than 1,000 words. The first circular planning questionnaire should be returned before 30 June 1971. This, and other information, may be obtained from Professor Jane M. Soons, Secretary-General, IX INQUA Congress, Department of Geography, University of Canterbury, Christchurch, New Zealand.

GLACIOLOGICAL DIARY

1971

5-9 July
Conference on Crystal Growth, Marseille, France. (Secretariat ICCG-3, Faculté des Sciences, Marseille St. Jérôme, 13-Marseille-13e, France.

28 July–14 August
XVth General Assembly of IUGG, Moscow, U.S.S.R. Joint symposia:
(a) Energy fluxes over polar surfaces. Organized by Commission on Polar Meteorology of IAMAP. (Prof. S. Orvig, Department of Meteorology, McGill University, Montreal 2, P.Q., Canada.)
(b) Air-sea interactions with floating ice. Organized by IAMAP. (Prof. H. Charnock, Dept. of Oceanography, The University, Southampton, England.)
(c) Interdisciplinary studies of snow and ice in mountain regions. Organized by CSI, local convener Dr V. Kotlyakov, Moscow. (Dr W. H. Ward, 147 Rickmansworth Road, Watford, Herts., England.)
(See p 24 of this issue of ICE.)

18-27 August
Pacific Science Association, congress, Canberra, Australia. (Australian Academy of Science, Gordon St., Canberra, A.C.T., Australia.)

1972

10-17 August
International Geographical Union, 22nd Congress, Montreal, Canada. (Secretariat, 22nd Internationl 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.) (See p 28 of this issue of ICE.)

Mid October
Radiocarbon Conference. Royal Society of New Zealand. (Dr T. A. Rafter, Institute of Nuclear Sciences, Private Bag, Lower Hutt, New Zealand.)

1973

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.) (See p 30 of this issue of ICE.)

1974

(date not fixed, but will be during first part of the year)
National Research Council of Canada, Sub-committee on glaciers, Symposium on "Thermo region of glaciers".

1975

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

NEWS

The Committee on Polar Research of the U.S. National Academy of Sciences-National Research Council is concerned with research activities in both the Arctic and Antarctic. Periodically the Committee reviews the status of knowledge and needs and opportunities for future investigations in the general area of polar research, and makes recommendations to the various operating agencies of the U.S. Government. A number of Society members are at present serving as members of the 16-man Committee. These are L. M. Gould (Chairman), C. R. Bentley, E. F. Roots, N. Untersteiner, A. L. Washburn, W. F. Weeks and J. H. Zumberge.

Eight subject panels report to the Committee, two of which are chaired by Society members: the Panel on Geology and Solid Earth Geophysics (C. R. Bentley) and the Panel on Glaciology (W. F. Weeks). Most of the members of the latter 14-man panel are Society members: F. I. Badgley, C. Bull, B. L. Hansen, C. C. Langway, M. Martinelli, J. M. Mitchell, F. Müller, L. H. Nobles, T. L. Péwé, N. Untersteiner, W. F. Weeks, J. Weertman and J. H. Zumberge.

NOAA, the National Oceanic and Atmospheric Administration, was created within the U.S. Department of Commerce on 3 October 1970. Its formation brings together the functions of several government bodies with the aim of making possible a balanced Federal programme to improve understanding of the resources of the sea and to permit their development and use while guarding against thoughtless exploitation. The interim organization includes: the National Ocean Survey (combining the activities of the ESSA Coast and Geodetic Survey and the U.S. Lake Survey); the National Weather Service (formerly the ESSA Weather Bureau); the National Marine Fisheries Service (composed of the Bureau of Commercial Fisheries and the Marine Game Fish Research Programme); the National Environmental Satellite Service (formerly ESSA's National Environmental Satellite Center); the Environmental Research Laboratories (formerly ESSA's Research Laboratories); and the Environmental Data Service (combining the ESSA Environmental Data Service and the National Oceanographic Data Center).

AWARDS

The President of the Society, Dr Valter Schytt, was appointed on 1 July 1970 to a professorship in glaciology at the Natural Science Research Council of Sweden. There are six professors at the Council and they are appointed by the King of Sweden upon a proposal from Parliament.

Dr Charles Swithinbank has been awarded the 1971 Patron's Medal of the Royal Geographical Society, for glaciological exploration and research. (The Patron of the R.G.S. is the Queen and the Patron's Medal is one of two gold ones awarded annually.) Most members know of Dr Swithinbank's work in the Antarctic, where he has taken part in the Norwegian-British-Swedish Expedition and in expeditions from Britain, the U.S.S.R. and the U.S.A. He is in charge of the glaciological programmes for the British Antarctic Survey and works at the Scott Polar Research Institute. He has served on the Council of the Glaciological Society and is an editor of the Journal of Glaciology.

NEW MEMBERS

Albertsson, Kristinn, Sléttahraun 16, Hafnarfjördur, Iceland.

Arsenault, Mrs Lyn, 150 Liard Street, P.O. Box 526, Stittsville, Ontario, Canada.

Balfour, D. J. H., Department of Geography, The University, Sheffield S10 2TN, England.

Barge, Mrs B., Department of Meteorology, McGill University, Montreal, P.Q., Canada.

Björnsson, Helgi, Hjardarhagi 26, Reykjavík, Iceland.

Blair, W. F., Operations Branch, St. Lawrence Seaway Authority, P.O. Box 98, Cornwall, Ontario, Canada.

Branson, Mrs M. K., H. H. Wills Physics Laboratory, University of Bristol, Royal Fort, Bristol BS8 1TL, England.

Búason, T., P.O. Box 684, Reykjavik Iceland.

Butler, L. W., 9761 Garnet Drive, Sandy, UT 84070, U.S.A.

Chronic, T., Geology Department, Arizona State University, Tempe, AZ 85281, U.S.A.

Clark, R., 2101 Black Friars Road, Ottawa 13, Ontario, Canada.

Clowes, A., Department of Geography, University College of Wales, Aberystwyth, Wales.

Cofer, C., School of Earth Sciences—Geology, Stanford University, Stanford, CA 94305, U.S.A.

Colby, Lynne R., 30 McEwen Avenue, Apt. 1407, Ottawa, Ontario, Canada.

Crécy, Louis de, 2 rue de la Paix, 38 - Grenoble, France.

Croasdale, K. R., c/o Imperial Oil Ltd., 339 50th Avenue SE, Calgary 24, Alberta, Canada.

Dalinger, René E., Luis Maria Campos 1520, 7° "A", Buenos Aires, Argentina.

Derikx, A. L., Inland Waters Branch, No. 8 Temporary Bldg., Room A-228, Carling Avenue, Ottawa, Ontario, Canada.

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