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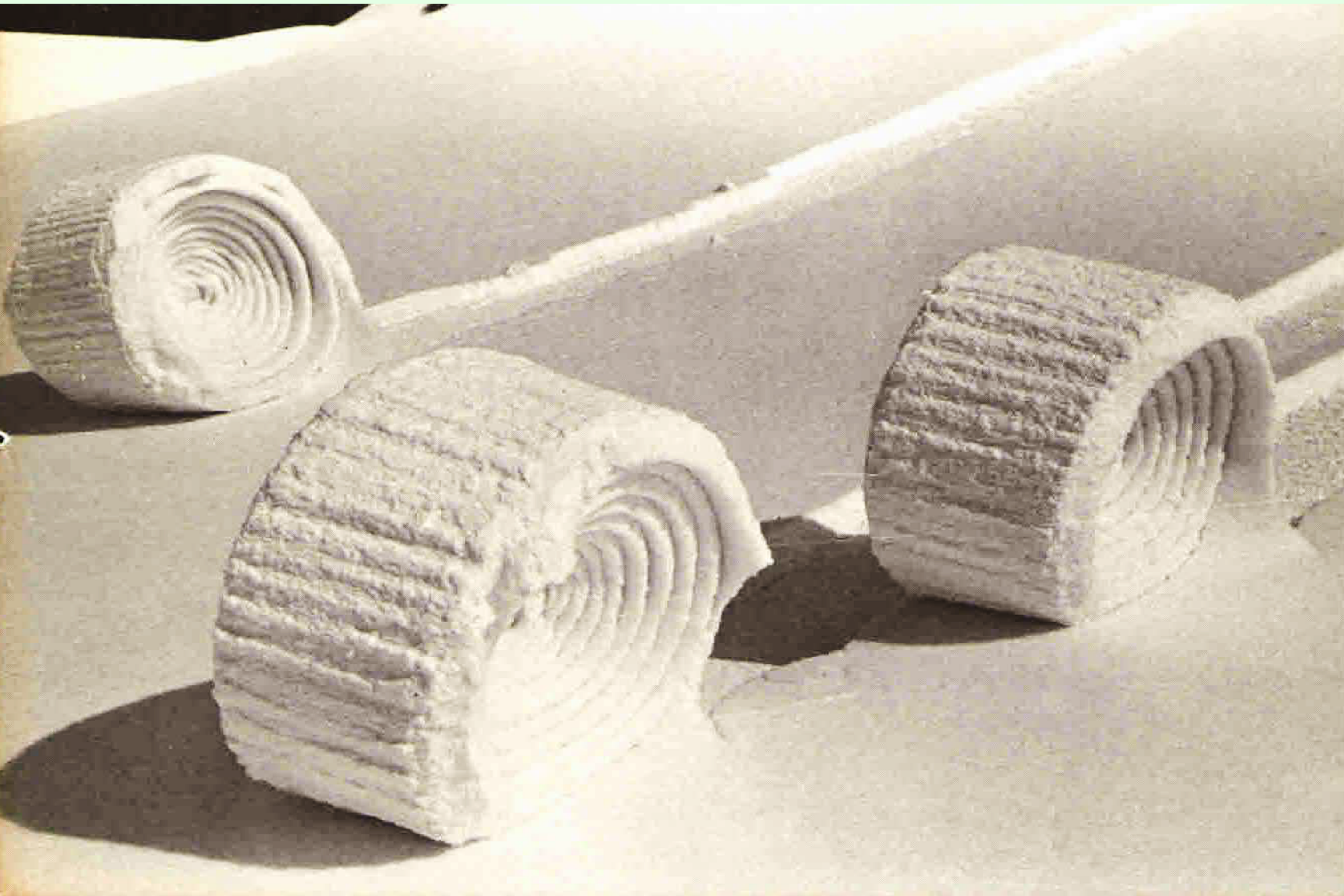


INTERNATIONAL GLACIOLOGICAL SOCIETY

MEETINGS 1976

12-17 September — Symposium on Applied Glaciology, Cambridge, England.

(The Second Circular was published in ICE Number 48 p. 22-24)

If you wish to attend the Symposium, please complete the form on p. 24 of that issue and send it with your registration fee and appropriate deposit to the Secretary of the Society.

1976 Annual General Meeting of the Society will be held during the week of the Symposium, in Cambridge.

BRANCH MEETINGS 1976

5-7 March—**Nordic** Branch in Tvärminne Zoological Station, southern Finland.

5 April—**British** Branch one-day meeting in Bristol.

Autumn—**Western Alpine** Branch in western Switzerland. (Details will be announced later.)

ICE
NEWS BULLETIN OF THE INTERNATIONAL GLACIOLOGICAL SOCIETY

3rd ISSUE 1975 — NUMBER 49

CONTENTS

AWARDS. The Council of the Society is pleased to announce the award of a Seligman Crystal to Dr **Willi Dansgaard** for his work in isotope glaciology, and the election to Honorary Memberships of Dr **A. P. Crary** and Dr **Peter Kasser**. Details on page 23 of this issue of ICE.

DEATH OF SIR CHARLES WRIGHT. Sir Charles Wright, Honorary Member of the Society, died on 1 November 1975 in hospital in Victoria, British Columbia, at the age of 88. Born in Toronto, he was educated there and at Cambridge. From 1908-10 he worked under J. J. Thomson at the Cavendish Laboratory, then joined Scott's British Antarctic Expedition 1910-13. On his return he was appointed lecturer in cartography and surveying in Cambridge. In 1914 he married the sister of Raymond Priestley, who had also been on Scott's expedition and with whom he wrote *British (Terra Nova) Antarctic Expedition 1910-13, Glaciology*, published in 1923. (Sir Raymond died in 1974 and was also an Honorary Member of the Society.)

The First World War saw Charles Wright serving with distinction in the Royal Engineers and on the General Staff (intelligence). At the end of the war, he went to the Admiralty Department of Scientific Research, later becoming head of the Admiralty Research Laboratory, and Director of Scientific Research Admiralty 1934-46, and Chief of the Royal Navy Scientific Service 1946-47. He then returned to North America, as Director of the Marine Physical Laboratory of the Scripps Institution of Oceanography. In 1964 he moved to British Columbia, and lectured in geophysics at the Institute of Earth Sciences at the University until 1968.

An obituary will be published in the Journal of Glaciology.

1977 SYMPOSIUM (Physics and chemistry of ice). Members of the Society will receive the First and Second Circulars **automatically**, so there is no need to write to the Secretary asking for these to be sent to you.

1978 SYMPOSIUM. The Symposium on Dynamics of large ice masses, to be organized by the Society, will be held in Ottawa, Canada, 21-25 August 1978. Members of the Society will receive the First and Second Circulars **automatically**, so there is no need to write to the Secretary asking for these to be sent to you.

COVER PICTURE. Snow scrolls formed on a wet snow surface. Photographer: Kihei Takahashi, whose book, "Snow of Japan — a thing of beauty", has been given to the Society's library.

RECENT WORK

AUSTRALIA

ANTARCTIC FIELD WORK

During 1973 an IAGP (International Antarctic Glaciological Project) trilateration traverse was carried out from Casey towards Vostok reaching about 300 km inland, near the 2,000 m contour. The traverse established a continuous ice movement net from the summit of Law Dome south across the saddle point of the Totten-Vanderford Glacier valley and inland approximately along a flowline to beyond the point of steepest slope of the interior ice sheet. The traverse party included a United States surveyor with a geoceiver supplied by the U.S. National Science Foundation Office of Polar Programs and the U.S. Geological Survey.

Remeasurements of some of the geoceiver sites between autumn and spring gave the first inland velocities as far as 67° 40′ S. Other measurements on route include surface elevation, ice thickness (by radio echo sounding), gravimetry, snow accumulation and surface snow sampling.

During the 1973-74 summer the 11 ice movement markers which were established around the Lambert Glacier drainage basin during the 1971-72 summer were resurveyed. Associated measurements include snow accumulation, surface strain rates, gravity, 10 m depth temperatures, and surface snow sampling. In addition aerial ice thickness sounding was continued over the $10^5 km^2$ region to a spatial resolution of about 30 km. This work together with the aerial photography, mapping and geology completes the ANARE programme in the Southern Prince Charles Mts and the Lambert Glacier basin for some time.

At Casey during 1974 an ice core drilling programme was undertaken on Law Dome (originally known as the Wilkes ice cap). Two holes were cored to about 350 m depth reaching close to bedrock approximately 3 km upstream from the previous Cape Folger hole. Most of the cores from one hole were returned to Australia for analysis. One hole was logged for temperature inclination and diameter and filled with fluid to allow continuation of the inclination measurements by preventing hole closure.

The United States geoceiver programme continued with additional stations being established on Law Dome and some of the previous inland stations being remeasured.

During the 1974-75 summer a preliminary traverse was undertaken from Sandercock Nunataks—the most inland rock of Enderby Land (about 50°E)—to the Framnes Mts. inland of Mawson, approximately 500 km along the general region of the 2,000 m contour. Surface elevation and gravity were measured along the route. The first two movement markers were established at the eastern end of the line. It is planned to extend the movement markers along the line in future years.

At Casey during 1975 a remeasurement of the 1973 trilateration net is under way. An autumn traverse was carried out in which the first 70 km was resurveyed. The United States geoceiver programme is continuing and remeasurements at 3 control sites along the net were carried out. It is planned to complete the resurvey to the end of the net during the spring summer traverse from September to December.

Theoretical and experimental work in Australia has continued in the problems of glacier surging and sliding and on the interpretation of isotope profiles. The University of Melbourne and Antarctic Division glaciologists will be moving into a new Earth Sciences Building later in the year, where visitors can also be accommodated and will be welcomed.

Bill Budd
Uwe Radok

CANADA

BARNES ICE CAP, BAFFIN ISLAND

During April and May 1975 a thermal drilling and ice-temperature measurement programme was carried out along the ss flow line of the surge area on the South Dome's south-west side. Seven attempts by a two-man party at three sites yielded instrumentation to depths of 88 m, 122 m, and 200 m. Preliminary analysis of results indicate possible basal temperate ice and a basal gradient of .026°C/m.

David F. Classen

FRANCE

LABORATOIRE DE GLACIOLOGIE

1) Dynamics of temperate glaciers

—Glacier Ampère (Kerguelen Island). In 1974 measurements of thickness of the glacier by gravimetric and seismic methods have finished the work undertaken in 1970. The study of this glacier will be a valuable contribution to the International Hydrological Decade because there is no other glacier observed at these latitudes.

—Mer de Glace (Massif du Mont Blanc). To check the theoretical work made on the dynamics of Séracs du Géant, electrical drillings have been made upstream and downstream of this part of the glacier. On Glacier du Tacul hourly velocities of stakes have been obtained and the determination of the flow law of ice is continuing with inclinometer measurements.

—Glacier de Saint-Sorlin (Grandes Rousses). The strain rates during 7 consecutive years have been computed. By plotting the aerial photographs of 1971, a recent map at 1:10 000 of the area has been achieved. The mass balance over the whole glacier in 1971-72 and 1972-73 has been determined. Lliboutry's statistical linear model, which was established for the ablation zone, can be extended to the accumulation zone.

—Glaciers de Bellecôte (Vanoise). Their thicknesses and firn coverages have been determined with 22 drillings (900 m in total).

2) Laboratory work on mechanical properties of ice

—Creep experiments between 0° and —45°C have been conducted to reach the creep laws of natural and artificial polycrystalline ice with emphasis on transient and tertiary creeps. The apparatus deals with stress tensors of any shape, and experiments on temperate ice.

—Reproduction of glacier sliding over a sine profile with "Penelope". An improved machine "Telemaque", where the ice will slide over removable rock protuberances, is under construction. Both machines will be set up in a new cold room at the melting point of ice.

—Study of the compactive viscosity and close-off of temperate firn.

—With facilities supplied by the CENG, measurement of thermal conductivity of ice between 0.4°K and 160°K as a function of the mechanical and thermal treatment and also of chemical purity.

—Study of formation of Tyndall figures.

3) Micrometeorology

The main work of the micrometeorological group during these four years was the study of heat and hydrological balances of the glacier Ampère in Kerguelen (69°E, 49°S) (a contribution to International Hydrological Decade and GARP).

The data, wind temperatures and humidity profiles, radiation and other meteorological parameters, were collected during three expeditions: 1971, 1972 and 1974. During the last expedition the data were collected in two stations: one at altitude 200 m and the other at 600 m (near equilibrium line).

Publication of the results of the second expedition is in press.

Wind and temperature profiles are always logarithmic, with a very good approximation, in a stable layer of 3 m at least (Ri is always positive). Humidity profiles are logarithmic when vapour-pressure at 2 m of ice-surface is bigger than 6.5 mb. In the other cases profile is invariant with z.

The contribution of different fluxes to ablation for all weather patterns is net radiation 58%, sensible heat 25%, latent heat 16%. When the wind blows from the north, turbulent fluxes become more important: net radiation 44%, sensible heat 32%, latent heat 24%.

4) Antarctic work

Dome C

In order to collect information for the preparation of future drilling, a summer camp was established with the support of US-NSF at 74° 40'S, 123° 50'E (3200 m elevation) for a three-week period starting on 27 December. Although the scientific programme was fully accomplished, the operation ended in a rather dramatic way with the crash of 2 LC 130 U.S. Hercules on 15 January during take-off from the Dome C camp. The determination of the U.S. Navy crews allowed however a safe return for all personnel.

The programme comprised meteorological observations and sampling (from pit and shallow drill) of the snow layers deposited during the last century. Although most of the samples have been left in the field, preliminary results may be summarized as follows:

—Mean annual temperature: 53.5°C.

—Snow accumulation: 3.7 g. cm^{-2}. a^{-1}, value calculated from the depth (2.1 m) of the 1955 radioactive fallout layer.

The low accumulation value and the fact that both accumulation and mean isotopic content are in line with the general decrease observed from the coast, along the flow line starting from Dome C, reinforce the interest of the area for further drilling.

Two other aspects of the programme must also be outlined:

—Geoceiver determinations carried out by a U.S. scientist (U.S. Geological Survey); results will help in particular in evaluating aerial radio-echo soundings results (U.K./U.S.A.) over the area.

—Stratigraphic studies and sampling performed by a Soviet scientist (Arctic and Antarctic Research Institute); this co-operation led to an exchange of samples including cores from the 1000 m deep Vostok drill hole.

Coastal Area (Terre Adélie)

At the other end of the flow line, accumulation from stakes has been measured on the first 40 km of previous IAGP traverse; velocity has been determined at the site (D 10) of a previous 300 m hole.

South Pole

With the support of the US-NSF a programme of detailed sampling (pit and shallow drill) was carried out at South Pole station in December 1974-January '75. Besides obtaining geochemical information over the last century, snow data will be compared with atmospheric observations carried out by several teams. Results are expected to help in the evaluation of data obtained in more specific IAGP Area programmes.

This work is done under the direction of C. Lorius and also supported by "Terres Australes et Antarctiques Françaises" and "Expéditions Polaires Françaises".

5) Geochemistry of snow and ice

The equipment for analyses has been transferred to our new building on the University campus. It includes low level beta counting, atomic adsorption spectrometer, particle counter, and a set for measuring the gas content of ice samples.

6) Cloud physics

The newly created group "physique des précipitations" (head: R. Montmory) studies the formation of solid or liquid condensated phases on ice forming monocrystals, in order to check the theory of ice nucleation by the VLS process.

AVALANCHES AND SNOW

Under the sponsorship of the ANENA (Association Nationale pour l'Etude de la Neige et des Avalanches), an important effort is now in progress in France on avalanche research.

A map of the probable localization of avalanches is nearly complete (scale 1/20 000, 500 000 hectares covered in the Alps and Pyrenees). The work is carried out by Institut Géographique National and Centre Technique du Génie Rural, des Eaux et des Forêts.

Near Lautaret pass, artificial release of avalanches allows measurements to be made on the dynamic pressure against rigid walls, on densities (by gamma attenuation) and velocity profiles. This work is carried out by LASP of the Nuclear Centre of Grenoble, CTGREF and Météorologie Nationale.

The movement of a powder snow avalanche in air is simulated on a reduced model by the movement of a coloured solution in a flooded channel. This experiment is carried out by the Institut de Mécanique de Grenoble with the co-operation of the Centre Technique du Génie Rural des Eaux et des Forêts.

The LASP of the Centre d'Etudes Nucléaires de Grenoble is continuing the elaboration of research apparatus for buried persons leading to the choice of the best existing apparatus. These studies about transmitters-receivers may give results in one or two years.

At the same time, other work for buried persons wearing no marks have been undertaken. The first one concerns the diffusion of human odours through snow. After having established a catalogue of human odours (over 50), their diffusion and detection are studied. The other one, undertaken with the Laboratoire d'Electromagnétisme de l'Ecole des Ingénieurs d'Electronique de Grenoble, could lead to the development of a portable radiometer to detect the radio-electrical energy of the body at frequencies of about 3 GHz.

The Centre d'Etudes Nucléaires de Grenoble is also engaged in an experimental study of sonic boom effect on snow cover and in aerial thermographic studies.

During the past year in Grenoble the research activity of the Météorologie Nationale on snow was:

—Laboratory study of growth of depth hoar under a temperature gradient.

—Mathematical model for simulation of snow metamorphism.

—Study of radiation balance at the surface of snow for IR and visible light. Measurements of penetration of visible light in snow.

—Measurement of free water content in snow by capacity at 28 MHz.

—Measurement of snow creeping by continuous registration.

—Propagation of ultra-sound in snow.

—Chemical measurements of pH and resistivity of melt water and also of new fallen snow samples.

POLAND

Special snow investigations were continued in the Karkonosze Ridge of the Sudetes Mountains: in the area of Mt Szrenica by the Mountain Branch of the Meteorology and Climatology Observatory of Wrocław University, and in the area of Mt Sniezka by the Observatory of the Institute of Meteorology and Water Economy. Outside the Karkonosze area, investigations were carried out in Mt Sniezka by the Meteorology and Climatology Department of Wrocław University and by the Institute of Meteorology and Water Economy. In the Tatra Massif, the Institute of Meteorology and Water Economy worked mainly in the area of the Observatory on Mt Kasprowy but also in several other places.

SPITSBERGEN

The year 1974 was the fifth in a 5-year programme of Polish investigations in SW Spitsbergen as a continuation of the Polish I.G.Y.-I.G.C. investigations 1957-1960 and 1962. The 1974 Expedition numbered 15 scientists: 12 from Poland, 2 from St. Louis University, USA, and 1 from Lund University, Sweden. The investigations lasted for 3 months (13 June to 15 September). The Expedition had its own ship, which encountered difficulties because of pack-ice by the entrance to Hornsund Fiord. The following investigations were carried out.

Glaciology-Meteorology. Dr S. Baranowski (leader of the Expedition) and two assistants from the Meteorology-Climatology Department of the Geography Institute, Wrocław University. Field work has been concentrated on Werenskiold Glacier. The main meteorological station was, as before, at the end moraine, and four secondary stations were positioned: one on the forefield close to the front of the glacier as in 1957-1960, and three on the glacier. Measurements of accumulation, ablation, and movements along different profiles were carried out as well as investigations in ice pits. Meteorological observations were carried out also near the main buildings of the Polish Expeditions installed in Isbjornhamna in 1957.

Geophysics. Dr Teisseyre and R. Czajkowski from the Geophysical Institute of the Polish Academy of Science, Warsaw, Dr D. Duda and M. Cramer from St Louis University, USA, carried out the following work: 1) seismic measurements on the tundra along and perpendicular to the shores, by mean of 6 seismographs, to detect the local earth tremors caused by waves. 2) Tremor registrations on Hans Glacier along two lines, longitudinal and transverse to the glacier. The eight-channel seismic waves recorder, as well as the wave receivers, were constructed in the Geophysical Institute of the Polish Academy of Science, Warsaw. 3) Reconnaissance and preparations for the planned seismic measurements along the ice-fiord.

Palæontology-Geology. This section, with Dr K. Birkenmajer as leader and 3 palæontologists from the Palæontological Institute of the Polish Academy of Science in Warsaw, and one technical assistant, conducted investigations, and obtained: 1) about 100 rock samples from Devonian to Cretaceous periods for palæomagnetic investigations. The samples will be studied in Warsaw as well as in St. Louis University. 2) Snow and ice samples (taken from walls of crevasses in the firn part of Koerber Glacier) representing 23 years of accumulation, for estimating at the Central Laboratory in Warsaw the changes of type and density of pollution. 3) Samples from Quaternary formations for palæoclimatic estimation by C_{14} and O_{16}/O_{18}.

Morphology and Periglaciology. This section, with Dr A. Jahn as leader and 2 assistants from the Geography Institute of Wrocław University and one from Lund University, Sweden, made the following studies over a period of 4 weeks: periglacial phenomena, structural soils processes, peat and permafrost bogs, chemical denudation and surface water analysis.

Oceanography. In the Isbjornhamna, close to Hans Glacier front, the bathymetry, thermometry, salinity, water circulation and sea ice melting were investigated.

The Norwegian Spitsbergen Authorities were very helpful to the Expedition.

A preliminary report on the results from 1974 were presented at a Special Symposium, January 1975, and the results were published in English in *Acta Universitatis Wratislaviensis* No. 251: "Results of Investigations of the Polish Scientific Spitsbergen Expeditions 1970-1974," Vol. 1, 1975, page 196. The volume contains 13 articles concerning mainly climatological-glaciological-meteorological problems, with many tables, graphs and photographs.

Also, the scientific results of "The Polish Geographical Expedition to Vatnajökull, Iceland, 1968" were published in English in *Geographica Polonica,* page 311, with many tables, graphs, photographs and maps.

Worthy of mention is also the monograph "*Klimat Tatr*" (Climate of Tatra Mountain), 856 pages, 489 tables, 111 graphs, 1787 bibliographic references. Published in 1974 by the Polish Academy of Sciences and the Czechoslovak Academy of Sciences, it is the result of the Polish-Czechoslovak scientific collaboration of 27 authors. The problems of snow cover, hoarfrost and avalanches are considered by 7 authors in 3 articles on 86 pages, with many tables and graphs. It is the first climatological monograph of the Tatra Mountains, where there are many classical nival-firn problems, and many classical glaciogenic forms after four glaciations during the Quaternary. A. Kosiba

CAUCASUS

The Department of Glaciology of the Institute of Geography, USSR Academy of Sciences, carried out investigations in 1974 of the Marukh, Bezengy and Kolka glaciers. Long-term, multidisciplinary studies of water and heat balances and experimental lisimetric measurements in a deep pit under conditions of slow infiltration through the firn sequence were continued on the Marukh glacier. These studies were accompanied by surveys of the deformation mechanism of the glacier with the object of estimating the role of shifts in the general motion of glacier ice. It has been established that the relative motion of ice is concentrated along the shear planes and the break.

Terrestrial profiles of temperature and humidity were obtained on the Bezengy glacier. They were accompanied by aerial surveys, which enabled the investigators to determine the power and occurrence of glacier and valley winds. Long-term studies of the motion mechanism of debris and its formation and of the geological activity of glaciers were started. They are based on the application of criteria of lithology and composition of debris covering the glacier and adjoining areas.

In the basin of the surging Kolka glacier, the effect of the advanced tongue on the climate was established. The important role of turbulent exchange in its melting was shown and considerable differences between vertical gradients of frontal and convective precipitation were established. The stable rate of melting within the ablation area was established. It is accounted for by intensification of turbulent exchange in the upper part of the ablation area, caused by the growth of the wind velocity. Radiation balance changes with the increase of albedo and decrease of atmospheric radiation. Statistical methods of estimating the differences between weather types were worked out and applied.

In connexion with the analysis of climatic agents of glacier variations, the calculation of changes in mass balance of the Kazbek glaciers was carried out from meteorological data. A meteorological index of mass balance, reconstructed for 20 years, has been put forward. The statistical variability of this index, and the connexion between its fluctuations and the change of circulation forms of the atmosphere, was studied according to Vangengeym's method.

The Laboratory on the Problems of Snow Avalanches, Moscow University, obtained new data on the genesis, occurrence and recurrence of avalanches in the El'brus area. Observations of the geomorphological activity of avalanches were obtained. Stereo-photogrammetric methods determining the thickness of snow cover in snow concentration areas and the volume of broken snow layer were worked out; the avalanche air-wave was studied. The wave impact was measured, and regularities of wave propagation and attenuation were established. The equipment registering wave impacts and methods of locating it correctly in the area subject to avalanches were developed. The studies of the relation of mechanical properties of snow to its structure and the changes in snow-cover structure through creep process were continued in field and laboratory conditions.

The studies under the IHD programme have been accomplished in the Central Caucasus. The studies necessary for the determination of ice, water and heat balances were carried out in the representative glacier basin Dzankuat. The studies comprised snow surveys, studies in pits, observations of ablation by means of stakes and ropes, hydrometric measurements on the outlet, surveys on the run-off plot on the glacier tongue, meteorological surveys, and heat balance surveys on the tongue.

Mass balance of the glacier for the 1973/1974 balance year was positive and equalled, according to preliminary calculations, $+40$ g/cm^2. Observations of water percolation through the glacier were continued by electrolysis. A photogrammetric survey on the scale of 1:10 000 was carried out. Comparison of the data from surveys in 1968 and in 1974 reveal the mass balance of the glacier by photogrammetry. The following measurements were repeated on a number of glaciers in the Baksan river basin at an interval of 4-5 weeks: ablation surveys by means of stakes, snow surveys observations of the height of the firn line. The debris of the Fernau stage was studied and dated together with the studies of the occurrence and ecology of glacial algae, including the glaciological and meteorological conditions of their development.

The Institute of Geography, Georgia, carried out glaciological investigations on the glaciers of the southern slope of the Central Caucasus. Repeated photo theodolite surveys of the surface (1:2000 and 1:5000) were made on the glaciers Chalaaty and Adishy (the Ingury river basin). The surface velocities of glaciers and their vectors, the values of ablation and deformation, and the position of glacier lobes were determined. The analysis of the obtained data showed that the glaciers of the southern slope of the Central Caucasus continue to retreat (from 2 to 10 m per year). Snow and ice melting and surface run-off from the glaciers were studied in the ablation area and partially in the accumulation area of the Tbilisi and Buby glaciers (the Riony river basin). Meteorological, actinometric and gradient surveys, together with measurements of precipitation by means of totalisers, were made in the alpine zone of these glaciers (2600-3500 m). The position of the zone of temperature jump, when rocky surface merges into ice, and its dependence on meteorological parameters were determined. Elements of the water balance of the Tbilisi river during the ablation period were evaluated.

Kharkov University continued the studies of ablation on the Caucasian glaciers. Particular attention was paid to the relation between the elements of heat balance, genetic types of melting and zonation of ablation processes. Also studied were: peculiarities of the ablation regime of different morphological types of glaciers; calculations of the glacier run-off in the Teberda, Chegem and Baskan river basins; methods of reconstructing meteorological conditions and snowiness in the Teberda river basin (according to annual tree growth and with the help of computers); roundness of sand and pebbles in the Kuban and Terek basins. These studies will help determine the genesis of material and the change in paleo-geographic conditions, including the role of glaciation in its formation.

The Rostov-on-Don Hydrometeorological Observatory carried out investigations in the Terek and Kuban river basins. Meteorological, hydrological, heat balance and snow surveys were completed on the Marukh glacier. Snow and ice melting was studied. Snow surveys on eight routes were carried out on the Tseys (up to 2400 m), Besengy (up to 3000 m), Kelbashy (up to 3700 m), and the Khakel glaciers. Fluctuations of the lobes of 18 glaciers were measured. It was found that only four of them are advancing. The Bolshoy Asau glacier has advanced considerably—about 10 m for 1973/1974, and the Uilpata glacier has been advancing for three years. The rest of the glaciers retreat at the rate of 5-15 m per year.

The Alpine Geophysical Institute carried out investigations in the Central Caucasus. Atmospheric precipitation in the mountains, interaction of avalanches with fixed obstacles, heat and mass balance of glaciers and glacier constituents in the run-off of mountain rivers were studied. Peculiarities of evaporation of snow cover on slopes of various exposures and gradients were formulated; several empirical formulae, connecting the rate of evaporation with meteorological parameters, have been obtained. It has been established that winter evaporation from the surface of snow cover in the Central Caucasus makes up an essential percentage of the total amount of solid precipitation and thus should be taken into account when estimating water balances. The mass balance of the Bashil glacier has been determined for 1972-1974.

Avalanching was studied with regard to the dependence of frictional force on the avalanche velocity. This will help in understanding the length of avalanche cones and other phenomena. The problem of motion of a mass avalanche, limited at one side by a vertical obstacle of arbitrary shape, has been solved. It has been found that wave impact on obstacles, according to exponential law, is directly related to increase in avalanche snow thickness, cross-section of the obstacle and the dip angle between the plane tangent to the surface of the obstacle and avalanche direction. On the basis of the results obtained, a method of calculating avalanche impact on constructions was put forward.

Quantitative connexions between natural agents, determining forecasting parameters of glacial mudflows on the northern slope of the Central Caucasus, have been defined and specified. A number of recommendations on mudflow defence and elimination of mudflow-prone debris has been worked out.

The Transcaucasian Hydrometeorological Institute carried out a ground phototheodolite survey of the lobes of 9 glacier tongues in the Terek, Riony and Ingury river basins.

CENTRAL ASIA

The Section of Physical Geography of the Academy of Sciences, Kazakhskaya SSR, continued observations of glaciers in the Zailiyskiy, Dzhungarskiy and Kungey Alatau, in particular the glaciers of the Malaya Almatinka, Talgar and Chilik river basins. New methods of studying glacier fluctuations were continued on the Tsentral'niy Tuyuksu. The main glaciers of the Tuyuksu basin were studied by terrestrial stereo-photogrammetric survey and data were obtained on the changes in the levels of glacier surfaces and their lobes; on ice velocities; on accumulation-ablation; and on the meteorological and radiation regime of the glacial zone.

Coefficients of precipitation variation on the Zailiyskiy Alatau Range and norms of precipitation were determined according to perennial sequences. Variations in performance of different types of precipitation gauges were estimated.

New methods of making forecasts of glacial mudflows in the Malaya Almatinka and Bol'shaya Almatinka river basins were begun. With this work in view the regime of drift-dammed lakes, moraines, mudflow cones and the structure of buried ice were studied. An instrument survey of terminal debris was made in order to determine the development of thermokarst forms. Maps showing areas liable to avalanching were made for some regions of the Zailiyskiy Alatau, and parameters of avalanche danger were determined for the Avalanche Inventory of the Bolshaya and Malaya Almatinka basins.

Glaciological studies were carried out in the Sarkan, Bolshoy and Maliy Baskan river basins (the Dzhungarskiy Alatau).

Shumskiy glacier—32 profiles, 300 ablation points.

Maliy Baskan river basin—phototheodolite survey of 11 glaciers in area of 50 km^2; theory of radiation balance of glacier surface.

Sarkan, Bolshoy Baskan and Kara-Karalskiy river basins—avalanche danger zones and causes of avalanches.

The Kirgiz Hydrometeorological Service studied the glaciers of the Kungey Alatau Range. A number of glaciological, meteorological and hydrological observations was made on the Aksu Zapadniy glacier. Surveys were carried out on four glaciers of the Talasskiy and Kirgizskiy Alatau. The analysis showed that some of the glaciers had become active. The Dolonat glacier shrank 10 m only. The Aksu Vostochniy glacier retained the former rate of retreat (25 m per year). The Chongtur glacier, which began to advance in 1972, advanced 15 m by 1974. The Aksu Zapadniy glacier advanced 60 m for a year and the Golubin glacier advanced at the velocity of 15 m per year (the maximum velocity is 24 m per year). On the latter glacier a series of meteorological and glaciological surveys was made and it was established that in 1974 water equivalent before ablation was 25% less than in the previous year and ice ablation was 20% less.

The Department of Glaciology of the Central Asia Institute made long-term studies of the Abramov glacier under the IHD programme. From radar sounding and thermodrilling, new data on the structure and parameters of the glacier body have been obtained. Spatial and time non-uniformity of precipitation is caused by the peculiarities of synoptic processes and meteorological conditions. Extremely high values of accumulation gradients on the glacier (350-400 mm/100 m) were confirmed. They are brought about by snow-wind redistribution.

The following points were noted: the leading role of solar radiation in the heat balance of the glacier; the values of snow and ice melting in different altitudinal zones in relation to the radiation balance; the methods of calculating mass balance and its constituents in the total run-off with regard to internal nourishment; changes in water storage of the glacier body and its discharge in various phases of the ablation period; quantitative characteristics of mass discharge of the glacier at the expense of evaporation; the process of glacier relaxation and some of the properties necessary for the forecast of its auto-variations; regularities in the changes of ice and snow during the last century, that will help in estimatiing the changes in mass balance of the glacier.

The studies of snow cover in the mountains were continued, including tests of a radio-electronic snow-sampler. Investigations of avalanching and avalanche protection were also continued. Field studies were made to compile more accurate maps of avalanche danger in the Zeravshan, Surkhob, Obikhingou and Shirkent river basins and in Central Asia generally. Calculations on forecasting, tractive resistance, and length of cone were made, and a scheme designed to forecast "clog-snow" avalanches.

The Tien-Shan physico-geographic station of the Academy of Sciences, Kirgiz SSR, undertook basic glaciological studies on the Karabatkak glacier: temperature regime, accumulation, ablation and run-off. A repeated phototheodolite survey of the whole of the glacier was carried out. Investigations were also made on another 6 glaciers of the Terskey-Alatau Range and in the Akshiyrak massif. It was established that since 1957 all the glaciers retreated 300-400 m. The Bezimyaniy surging glacier, which was advancing in 1956, retreated 80 m and its surface lowered 30-40 m.

The Glaciological Laboratory of the Institute of Geology and Geophysics of the Academy of Sciences, Uzbekskaya SSR, investigated the regime and conditions of glaciers in the Kashkadarya river basin. The main work concerned the Severtsev glacier. Experiments were run to determine the heat-exchange regime of the glacier, and its melting, run-off, motion and denudation. It was established that in the western mountain areas of Central Asia relative intensity of geologic activity of glaciers as well as of glacier denudation grows in a southerly direction. With the Glacier Inventory it should be possible to estimate glacier denudation and its role in the silting of water storage reservoirs and irrigation systems.

Methods of calculating the glacier temperature and melting, based on the mean daily temperature of the tropospheric layer within the limits of 4-7 km and some morphological peculiarities of the glacier valley, were worked out, as were methods of calculating melting according to air temperatures at the surface. Many other calculations were made, such as those relating to melting processes on the walls of crevasses, ice-falls and debris-covered surfaces.

The Department of Glaciology of the Institute of Geography, the USSR Academy of Sciences, carried out investigations on the Pamir-Alay glaciers. On the Medvezhiy glacier, phototheodolite surveys of all the accessible bases and tectonic and glacio-morphological surveys of its surge were made. It was established that ice velocity during the most intense phase of the surge was nearly twice that of the advance of the glacier lobe. The results obtained show that the axis of the glacier tongue, limited by the marginal longitudinal faults, moved as a unique body without turbulent mixing, despite the heavy splitting of the surface by the dense network of crevasses. Field studies were made on the other surging glaciers of the Vanch river basin, and aerial surveys undertaken in the Vanch and Gunt river basins. In the accumulation areas of the East Pamir glaciers, terrestrial surveys were made for the Glacier Inventory.

Analysis of the formation mechanism of snow and ice "penitentes" showed that they are the result of selective snow and ice melting under conditions of sunny, dry and moderately cold weather, bringing about big negative values of long-wave balance and losses of heat on evaporation. The altitude of the zone of "penitentes" formation varies because of the changes in circulation processes from year to year and during the ablation period.

The Tadzhik Meteorological Service continued observations of the GGP glacier, glacio-hydrological studies on the Skagach glacier and surveys of variations on 6 other glaciers. In connexion with the Didal glacier surge (northern slope of the Khrebet Petra Pervogo), measurements of the advance of its front and ice velocity were made at various points. They were accompanied by visual surveys of the state of the whole glacier. From 1 August till 30 September 1974, the glacier advanced about 2 km. Crashes of the glacier lobe occurred periodically. The heaviest of them was observed on 13 August, when a 500 m length of the tongue crashed. Considerable mudflows, saturated with mud-stony mass and ice fragments, moved down the rivers. They were caused by the concentration of melt waters and their outburst in the glacier.

ALTAY

Tomsk University continued investigations in the mountain glacier basin in the Aktru river. The summer season of 1974 was characterized by extremely hot weather. Mean air temperatures in July at the Nizhnaya Actru station was 11.6°C, which exceeded by 2.7°C the mean temperature of the preceding 17 years. Air temperatures at high altitudes were extremely abnormal: at the Uchitel weather station (3050 m) mean daily temperatures reached 10°C. Extreme excess over the mean daily temperature made up 4.5°C. Vertical temperature gradients were lower and intense melting occurred over all the area of the glaciers; the firn line rose to 3460 m, and accumulation areas were endangered by melting. A flood of extreme intensity was observed in the Aktru river: water discharge reached 23 m^3/sec.

New data on the vertical gradient of air temperature on various slopes and glaciers were obtained in the Aktru basin. The data concern the temperature "jump", where a stony surface is adjacent to a glacier surface. The nature and the value of this "jump" depend on the circulation of the air near the glacier. On the Maliy Aktru, the glacier wind is well pronounced, it occurs usually in the 70 m layer, and above it flows the warmer valley wind. In the contact zone, inversion of temperature and greater humidity occur. The influence of the wind on the glacier regime is undoubted.

Turbidity and sediment transport of some rivers in the Aktru basin have broad variations: a great number of surface brooks on the glaciers may bring about in some cases a fall of turbidity of the general stream. Electric conductivity of the glacier water properly proved to be less than that of submerged springs.

The large Korumdu glacier (to the west of the Aktru basin) was observed. The 1936 position of its lobe was determined according to natural reference points. The lobe was at that time quite near the edge of the forest. Since then, the glacier has retreated 430 m, on the average, and young larchs cover the newly-formed area in front of the glacier. The glacier surface has altered considerably: the former blue-greyish ice has changed to white, and the bubbly surface is covered with knolls.

Important dendro-chronological data were obtained in the periglacial areas of the Aktru and Korumdu valleys. The limits of the maximum spreading of the late-Pleistocene glaciers about south-eastern Altay were defined. The geological-geomorphological data were obtained in order to substantiate the existence of two essential plans in the evolution of the late-Pleistocene Glaciation.

The Section of Physical Geography, Academy of Science, Kazakhskaya SSR, made investigations in the Kazakhstanskiy Altay, in the glacier-basin of the Belaya Berel river glacier: velocities; deformation and changes in height of glacier surfaces; accumulation-ablation of ice and snow; the thickness of ice and its temperature; elements of radiation and heat balances; the role of glaciers in the river run-off; and a topographic survey of the glacier edges.

The studies of the Department of Glaciology of the Institute of Geography, the USSR Academy of Sciences, provided information about the effect of glacier morphology and exposure on the height of the snow line. The role of exposure proved to be less important and the role of morphology more significant than in the Tien-Shan. The distribution of solid precipitation in the Altay glacial zone was determined.

SAYANY

The Geological Institute of Siberia and the Far East continued the studies of aufeis in the Stanovoye highland, and also the investigations of snow cover and avalanching in the Sayano-Baykal highland. The traces of former glaciation were studied on the southern bank of Baykal. The studies proved the assumption, that the glaciers of this area had descended into the lake, to be erroneous. It is established that during the second half of the Quaternary period their length did not exceed 25 km.

THE POLAR URALS

The Department of Glaciology of the Institute of Geography, the USSR Academy of Sciences continued the long-term, multi-disciplinary studies in the glacier-basin of the Bol'shaya Khadata river. Investigations refining the hydrological selectivity of glaciers were undertaken over all the territory of the basin (132 km^2). Photos of all the glaciers were made and their glacier coefficients estimated. A hydrometric survey was carried out during the steady drought period. It was established that in the summer drought period the specific water content of the glaciers is at least ten times higher than the background water content of the basin, situated in the best-watered mountain zone.

The fields of input and output of mass in the whole area of the Ural glaciers were obtained. The mineralization of ice and firn of Ural glaciers was found to be considerably less than in the Caucasus. Surveys of glacier variations were made on the Obruchev glacier and on the MGU glacier. Measurements of ablation and accumulation, heat balance surveys and photogeodetic studies were carried out. Attempts to plot a continuous field of albedo of the Obruchev glacier surface on the basis of point albedo survey were made. This albedo survey was accompanied by a phototheodolite survey. Field tests of a new thermodrill were accomplished on the same glacier. The core was obtained from the bore-hole down to the depth of 86 km.

Spore-pollen and micro-faunistic analyses of Quaternary deposits of the Polar Urals were continued. Six new radio-carbon datings of these deposits were obtained. A good coincidence between the basic verges of the Holocene here and in the European and Siberian columns was established. However, some differences were marked. The maximum spreading of spruce forests in the Polar Urals refers to the Atlantic period, whereas in the north of West Siberia it refers to the Boreal period. The Atlantic period of the Polar Urals is characterized by a three-phase development of vegetation with two warming maxima, while the two-phase development is typical of the Russian Plain and Siberia.

KHIBINY

The "Apatit" mine service investigated with the help of transmitters the wave impact of avalanches in natural conditions. A semi-empiric formula for the calculation of the mean and maximum avalanche pressure on the obstacle, in relation to the avalanche velocity and the density of avalanche snow, was obtained. It was established that about 75% of the avalanche energy is consumed by the impact against the lower 2 m of the obstacle. The studies of dynamic properties of avalanches were made by stereo-photogrammetric survey. Stereo-films of three moving avalanches with a volume of 50 000 m^3 were shot. The radio-transfer system of remote registering of time and place of avalanching was developed.

The Mine Institute of the Kola branch of the USSR Academy of Sciences investigated snow accumulation on the Rasvumchor plateau and snow transport in the Central and North-Western areas of the Kola Peninsula.

KAMCHATKA

The Institute of Volcanology, USSR Academy of Sciences, studied the interaction of the present-day glaciation and volcanisation. Accumulation, ablation, the structure of snow-firn sequence, ice velocity and glacier run-off were studied on the Kozelskiy glacier (the Avachinskaya group of volcanoes), the Erman and Bogdanovich glaciers (Klychevskaya group of volcanoes). The balance of glaciers for 1973/1974 was calculated on the basis of data obtained. It was proved possible to date the former eruptions from the results of chemical analyses of ice and firn. The Bogdanovich glacier was observed at the period of volcanic eruption. As a result of this eruption the middle part of the glacier, lying at a height of 2100 m, was demolished by the lava stream. The fluvioglacial plain (up to 30 m wide and 500 m long) was formed on its body.

THE ARCTIC

The Department of Glaciology of the Institute of Geography, the USSR Academy of Sciences, started long-term glaciological studies of the Spitsbergen Archipelago using the latest geophysical and geochemical methods. Data on ice thickness and the relief of the subglacial bed were obtained for 15 glaciers of Spitsbergen island. The run-off of the Vering glacier and the periglacial lake Stemme was studied. The stratigraphy of firn-ice sequence was observed in a 10 m pit, situated in the ice-divide part of the glacier. Samples were chosen for isotope and chemical analyses. Seven glaciers were found to be surging. The relationship between morainic topography and the tectonic structure of glaciers, the stratigraphy of deposits, and the interaction between debris and sea sediments were studied.

Aerial surveys of Ostrov Vrangelya island were made, and data collected on the history of the last glaciation of the Taymyr depression and isostatic motion of its crust.

The Arctic and Antarctic Institute started multi-disciplinary, long-term glaciological studies of the Severnaya Zemlya archipelago, with radio-echo sounding of the ice sheet, glacio-geomorphological surveys in the periglacial zone and temperature logging of five 80 m deep holes.

ANTARCTICA

The long-term studies under International Antarctic Glaciological Project were continued. Analyses were made of the input items of the water balance of the Antarctic continent, and a new map of nourishment of the ice sheet, including for the first time the Antarctic Peninsula, was compiled on the basis of all the data available.

The Institute of Geography, the USSR Academy of Sciences, continued, together with **Moscow University** and **the Arctic and Antarctic Institute,** the studies of the isotope-oxygen composition of the ice core from the Vostok borehole down to a depth of 950 m. About 150 integral samples, each of them covering about 100 years, were chosen. Conclusions were made on the relation between climatic and glaciological agents in the formation of the isotope profile of the ice cover at the Vostok station. It was shown that isotope shift, which took place 10 000-14 000 years B.P. and made up 5%, was brought about by the global changes in temperature and the very small variability of the height of the surface in the central part of the Antarctic Ice Sheet.

The Arctic and Antarctic Institute studied the spatial-time variability of the snow accumulation rate on the surface of the ice sheet. The zonation of ice shelves was carried out according to their intensity of self-destruction caused by the difference in hydrostatic pressures of ice and water. It was established that huge fragments of ice shelves are broken off mainly by "basic" waves. The areas of the utmost effect of these waves upon the coasts of Antarctica were distinguished.

The Laboratory on the Problems of Snow Avalanches and Mudflows, Moscow University, has compiled a map of the dry valleys, on a scale of 1:100 000. The standard morphometric characteristics of glaciers, including the largest valley glaciers in the world, were obtained. Studies were made of glacier accumulation in different altitudinal zones and of a scheme for correlating the age of debris.

The following scientific results, not mentioned in the review, relate to the main glaciological achievements of 1974.

1. Classification of the basic dynamic types of glaciers (ice sheets, broad mountain glaciers, floating ice shelves and narrow mountain glaciers); development of their mathematical models including the rheologic non-linear, three-dimensional, non-isothermal and unstable nature of ice. Closed, analytic solutions were found for several simpler cases.

2. The theory of processes occurring at the glacier bottom (the sliding of rheologically non-linear, debris-containing ice along the rough bottom, subglacial run-off, glacial erosion) including relaxation auto-variation of glaciers (surges), caused by these processes.

3. Experimental studies of a mountain glacier established that relative motion in the glacier is concentrated along shear planes and breaks. This result proves it is impossible to apply the Glen rheologic law to the description of ice motion in glaciers and opens broad prospects for the creation of a new "break" theory of movement of large glacier bodies.

4. Long-term field observations prove that the leading role in abrupt glacier surges belongs to horizontal, longitudinal shifts. There is no turbulent mixing of ice blocks in the axle part of the glacier and the ice moves as one body in the evacuation zone, despite the rough surface. This conclusion shows that some hypotheses on the mechanism of glacier surges are inadequate.

5. Methods of echo-sounding of mountain glaciers from helicopters were developed.

6. The interpretation of the observational data on the deformation and movement of ice in the central areas of Antarctica and Greenland was continued with the help of computers on the basis of the theory, developed earlier. Complete characteristics of the strain tensor and the direction of velocity vector were obtained for the first time. The analysis of the data on the fluctuations of the Obruchev glacier, the Polar Urals, was carried out by means of computers. Periods, amplitudes and phases of spectrum of the induced glacier variations for the last 20 years were determined. A transfer function relating them to the variations of the rate of ablation and accumulation was also defined.

7. The detailed measurements of the Kolka glacier, together with theoretical analyses, produced a mathematical description of the influence of debris cover upon the melting of glacier ice. The analysis showed that the rate of melting falls hyperbolically with the growth of debris thickness and with parameters depending on a number of climatic and thermophysical properties. Submorainic ablation presents an unsteady process, which contributes to the general unsteadiness of the glacier, even when external conditions are stable.

8. Conclusions about the impossibility of burying radioactive waste in the Antarctic Ice Sheet or near its bed were made on the basis of theoretical studies of heat and mass exchange in the central areas of Antarctica. These studies show that on vast territories the ice near the bed rock is at melting point. It is shown that an ice sheet is sensitive to the burying of radioactive waste, releasing heat even in its upper layers and thus this burying presents a global danger.

9. The calculated (design) scheme of avalanching and mudflows, for forecasting their dynamics, the length of the avalanche cone and the volume of sediments, was worked out. Calculations of the movement of a number of avalanches and mudflows were carried out.

10. The systematization and analysis of main problems connected with the descriptions of snow mass movement and the rational forecast of avalanches were made. The mechanism of occurrence and the movement of the air waves generated by snow avalanches were analysed. The basic mechanical problems of constructing rheologic models applicable to the description of the behaviour of a snow mass in different processes were formulated.

11. On the basis of a set of experiments on the triggering of artificial avalanches along a 100 m avalanche trough with various states of snow, it was established that the dynamic friction of the displaced snow masses behaves as friction in non-Newtonian liquid. Efficient viscosity of snow masses depends on the melting regime. Head resistance to the movement of the avalanche body exceeds considerably the air resistance to the movement of solid bodies and homogeneous systems, through destruction of the frontal snow cover and dispersion of the avalanche front.

12. Laboratory studies of the strain capacity and strength of snow samples of natural structures were made in a special installation of six-wheeled compression. The processes of intense hardening of loaded snow (under loading) were investigated. Rational methods of determination of short-term endurance of snow were put forward. The results of experiments of snow flowing were interpreted within the framework of the model of viscous liquid with two coefficients of viscosity, depending to a greater extent on the surface and initial density.

13. Experimental and theoretical investigations of snow-storms with very big wind velocities were made and a new classification of snow storms according to their intensity proposed.

14. A calculation model of a former mountain glacier, which can be analysed according to the practically available minimum of paleo-geographic information, was worked out. The idea of the primary role of catastrophic outbursts of glaciers (surges) in the spreading and degradation of former ice sheets was put forward, using as an example the recent spreading of the Barents Ice Sheet on the Russian Plain.

V. M. Kotlyakov

U.S.A.

BLUE GLACIER, WASHINGTON

The University of Washington field station on the Blue Glacier of Mount Olympus was again occupied during the summer of 1974. Normal climate and glacier mass budget observations were carried out for the seventeenth consecutive year. As with other Northwest glaciers, Blue Glacier experienced a strongly positive mass balance for 1974, continuing the trend of recent years. The specific net mass balance calculated at the end of the ablation season was +2.4 meters water equivalent, almost twice the largest value previously recorded.

Other work on Blue Glacier included a detailed motion survey on the lower glacier (P. Olson and others), repeating a similar survey carried out in 1958 when the surface configuration was substantially different. An effort will be made to determine if differences in the velocity trajectories can be related to the recent thickening near the terminus.

Preliminary testing of two new methods of avalanche control was also carried out on the Snow Dome by E. R. LaChapelle, P. L. Taylor and others. The first method involved inflation of air bags beneath the snow cover to disrupt the snow and induce fracturing at the surface. A 1.3 x 3.2 meter bag was placed at a depth of 2.2 m in dense summer firn. The firn failed in tensile fracture with cracks appearing at the surface when pressure in the bag reached 28 psi. This was considered to be an extreme test of combined snow weight and strength which was not likely to be matched in an ordinary winter snow cover. From these tests, the air bag system appeared to be an effective means of fracturing snow. The second method tested was a "gas exploder" system first proposed by P. L. Taylor. In this system a mixture of acetylene and oxygen is introduced into a hollow cylinder implanted beneath the snow cover. When the gas mixture is ignited, a piston is driven upward against the snow cover to initiate slab avalanche release; upward venting of the exhaust gases provides further disruption of the snow cover. The device can automatically be recharged with gas and fired as often as needed. In the Blue Glacier tests, the gas exploder was buried at various depths in hard summer firn, covered with packed firn, and detonated. Satisfactory disruption of this high density form of snow was found at depths of up to about 1 m. Both systems then underwent extensive field tests the following winter at Stevens Pass, Washington and Red Mountain Pass, Colorado. Despite a number of experimental and design problems, particularly when applied to the thick heavy snow of the Cascade Mountains, both devices appear to offer attractive alternatives to conventional avalanche control techniques.

SOUTH CASCADE GLACIER, WASHINGTON

The U.S. Geological Survey research station on Sentinel Peak was again occupied during the 1974 field season. Mass and water balance data were collected by R. Krimmel as part of the continuing International Hydrological Decade Program. Measurements included run-off, ablation, snow depth and density, and snowline photography. The maximum 1974 snow accumulation occurred in mid-May and was about 3.7 m, some 0.7 m above the average of the previous 10 years. The annual mass balance was +1.0 m, about 1.3 m above average and the third highest value on record.

Preliminary work to determine if borehole drilling can be used to study subglacial and englacial water was concluded during the 1974 season (S. Hodge and others). The basic assumption underlying this work is that water level in a borehole connecting with the subglacial water system can be related directly to the basal water pressure over a significant area of the glacier bed. Seven boreholes, ranging in depth from 65 to 169 m, were drilled in the ablation zone of South Cascade Glacier. Five of them were connected with the subglacial system, two of them via an interval connexion. The water level was continuously recorded in one hole for five weeks, and was sounded daily in all five holes for a nine-week period. Fluctuations of up to 40 m were observed over periods of several days, the peaks usually occurring about two days after large changes in water input at the glacier surface. The mean water level decreased throughout the summer and then started to increase during the fall, supporting the concept of seasonal storage and release of liquid water.

A larger project is now underway to drill additional boreholes and to keep them open for at least one full year. Water level measurements in these holes will be supplemented with data on short-term surface and sliding velocities, as well as on liquid water input and output.

GLACIER HYDROLOGY, NORTH CASCADES, WASHINGTON

A hydrometeorological method has been employed by W. V. Tangborn (U.S. Geological Survey—Tacoma) to determine the annual mass balance history of glaciers in the Thunder Creek drainage basin for the past fifty years. The method is based on a comparison of monthly run-off figures from this glacierized basin with those from a nearby unglacierized basin. Adjustment for precipitation differences between the two basins is made using data from a local low-altitude precipitation station. The low-altitude precipitation data are sufficient to allow estimation of glacier winter balances; however, calculation of the summer balances requires the application of a simple heat balance model together with information on mean monthly maximum and minimum temperatures at the same low-altitude station. Although relatively simple, this model appears to perform well—the correlation with 17 years of annual mass balance data from the nearby South Cascade Glacier is 0.93. During the period already studied, the most striking aspect of the mass balance history is the abrupt end of great losses in glacier mass in about 1945. Since then, glaciers in the Thunder Creek drainage have been gaining slightly in mass, probably for the first time on a sustained basis since the end of the 19th century. As both precipitation and temperature data have been collected in this area since about 1880, further analysis is planned which should ultimately provide an annual record of glacier accumulation, ablation, and balance during the past 100 years.

VARIEGATED GLACIER, ALASKA

A comprehensive program to define cyclic changes in the state of a surge-type glacier is being conducted by C. F. Raymond (University of Washington) and W. D. Harrison (University of Alaska), in cooperation with personnel from the U.S. Geological Survey and the California Institute of Technology. The primary objective is to obtain a history of geophysical data as the glacier builds up to its next surge (expected to occur in about 10 years) which can be used to test possible surging mechanisms.

During summer 1974, the second field season, additional depth measurements were made seismically, monitoring of surface elevation, velocity, and mass balance were continued, and internal ice temperatures observed. Special attention was given to variations in velocity, averaged over periods of several days. Seismic noise from the glacier was also recorded to provide a baseline for future monitoring. Markers placed on ridges and peaks surrounding the glacier provided ground control for aerial photography carried out by the U.S. Geological Survey. The 1974 photo set, together with older ones from 1961 and 1948, will establish a long-term history of the changes in surface geometry.

Results from the field work carried out to date indicate that the present mode of flow of Variegated Glacier could be termed "normal", that is, given the present geometry of the glacier, its surface velocity is about what would be expected for a non-surging glacier. At the same time the mass balance studies give evidence of a thickening of the upper part of the glacier. Although the spatial distribution of surface velocity can be theoretically explained by internal deformation without any sliding, the pattern of temporal variations in velocity indicates that sliding does take place. The temperature condition of the basal ice implied by this observation and of the near-surface ice as determined directly with thermocouples indicates that Variegated Glacier is a temperate glacier. Therefore, its surges can not be explained by thermal triggering. Variability of the sliding rate is apparently not controlled by changes in base stress, which suggests that variations in liquid water input at the upper surface are the probable cause. If this is true, the hydraulic system which drains water from the surface must communicate with substantial portions of the glacier bed. Several theories suppose that primary control of the onset of a surge is related to water production near the bed resulting from the dissipation of mechanical work; water input from the upper surface is assumed to have no important influence. This is apparently not the case on Variegated Glacier.

Results from field work carried out in 1973 and 1974 are presented in two detailed data reports available from the World Data Centers: Glaciology.

COLUMBIA GLACIER, ALASKA

For the last few years investigators from the U.S. Geological Survey—Tacoma have observed the behavior of several Alaskan tidal glaciers in an effort to assess their potential hazard to the increased shipping in the area. Studies by A. Post indicate that tidal glaciers which end in water depths exceeding about 80 m retreat catastrophically. The large Columbia Glacier near Port Valdez is the only Alaskan glacier which still terminates near its most advanced Neoglacial position. To determine the probable future stability of this glacier, water depth soundings near the terminus were made in July 1974 by M. Meier, A. Post, and L. Mayo using the University of Alaska's research vessel *Acona* and its radio-controlled, unmanned launch *Firefish.* The glacier was found to terminate on shoals, believed to be terminal moraines, which extend completely across the fiord. Although water depths at these shoals averaged only 2 to 30 m, a small retreat could lead to instability of the glacier and catastrophic retreat with vastly increased iceberg discharge into nearby shipping lanes.

A triangulation net was also placed around the lower 30 km of the glacier by M. Meier, S. Hodge, and R. Krimmel. This is being used to compile a topographic map and to determine changes in surface elevation which have occurred over the last twenty years. A generalized computer program to perform a three-dimensional, least-square adjustment of a triangulation net in geodesic coordinates has been developed for this purpose by W. Sikonia. R. Watts and A. T. England (US Geological Survey—Denver), together with R. Vickers of the Stanford Research Institute, successfully measured ice depths in this "wet" temperate glacier using a new monopulse radio-echo sounder. The deepest sounding obtained was 1,300 m. For at least 30 km above the terminus the glacier bed is below sea level. Columbia Glacier thus fills one of the deepest fiords in Alaska.

The historic record of terminus changes in Columbia Glacier has been examined by Post Many minor advances and retreats have taken place, but there has been little overall change in terminus position. Thus, although the glacier has the potential for catastrophic retreat, iceberg discharge is not expected to change materially as long as it continues to terminate in shoal water.

BLACK RAPIDS GLACIER, ALASKA

Studies of Black Rapids Glacier were continued by personnel from the U.S. Geological Survey. The installation and initial surveying of the triangulation net was completed in July 1975. The net now consists of 30 monuments, a sufficient number to use resection techniques from the glacier surface. About 30 stakes were also set out on a longitudinal and two transverse profiles to observe ice velocity, elevation changes, and mass balance. Measurements are made twice a year, in late winter and early fall. Plans are to continue to monitor the geometric changes of this glacier through the anticipated surge, sometime in the 1980's.

MT. WRANGELL, ALASKA

Glaciers near the summit of Mt. Wrangell, the northernmost active volcano on the Pacific rim, have been studied periodically since 1953 by investigators from the University of Alaska (C. S. Benson, L. H. Shapiro and others). It has been found that the vertical components of the glacier flow are significantly greater than can be accounted for by snow densification and equilibrium glacier flow. The reason for this excess vertical velocity appears to be enhanced basal melt due to the large volcanic heat flux near the mountain's summit. Recent surveys in the north crater indicate average settling rates of 2.5—12.5 m/year over the last eight years. Between 1953 and 1964 the general altitude profile of the snow surface in the north crater varied only slightly, so that the dramatic changes have all occurred between 1965 and the present. The volume of ice melted since 1965 is estimated to be about 2.10^7 m^3, corresponding to an average heat flux of 1200 $\mu cal/cm^2$ sec—roughly 1000 times the average geothermal heat flux. Plans are to continue monitoring changes in activity at the summit of Mt. Wrangell using both conventional aircraft and satellite imagery.

McCALL GLACIER, ALASKA

Studies on McCall Glacier were continued for the sixth consecutive year by investigators from the University of Alaska (C. S. Benson, W. D. Harrison, N. I. Ishikawa, L. H. Shapiro, N. A. Streten and G. D. Wendler). The glacier is located in the eastern part of the Romanzof Mountains of the Brooks Range and is the only arctic glacier being studied in the United States at the present time.

Comparison of data from an automatic weather station on the glacier with simultaneous and long-term observations from permanent meteorological stations in northern Alaska has revealed that the temperature and wind regimes near the glacier differ greatly from those in the interior valleys and the arctic coast. In addition, the estimated annual precipitation of 0.5 m is significantly higher than that of any other station in the region. Wind observations in the glacial valley indicate a frequent downslope component which resembles the summer drainage flow in the coastal portions of the polar ice caps, rather than the flow commonly associated with lower altitude glaciers. Efforts are also being made to determine the effects of slope aspect and mountain screening on insolation and summer ablation. It is expected that such studies will enhance the overall understanding of the relationship between glacier balance and climatic variation.

A study of the structural and thermal regimes of the glacier is also in progress. Of particular interest in this part of the program are the mechanisms of heat and mass transfer in the lower part of the percolation facies which occur in the upper portion of the glacier. Investigations of foliation development are being conducted on the lower part of the glacier where the longitudinal foliation, characteristic of the entire glacier surface below the firn, is overprinted by a transverse spoon-shaped foliation. This appears to be a common phenomenon on other glaciers and is associated with a pronounced change in the strain rate field. McCall Glacier is ideal for a study of this foliation because the processes occur without the complication of an icefall.

Field work included the establishment of a new cross-sectional profile on the lower glacier to supplement the one established further up the glacier in 1969. Survey points in the aufeis field, velocity stakes, and strain grids were all resurveyed. Nine new strain grids were set up and several additional velocity stakes were put out near the strain grid network. Existing thermistor and thermocouple strings were measured, and three new thermocouples were emplaced. Structural mapping of the lower end of the glacier was extended and observations relating to the foliation problem were made. Pit studies were conducted in both the upper and lower cirques.

AERIAL PHOTOGRAPHY OF NORTH AMERICAN GLACIERS

Aerial surveys of glaciers in western North America are conducted annually by the U.S. Geological Survey Office in Tacoma, Washington. During 1974 photographic reconnaissance of selected glaciers in the San Juan and Front Ranges of Colorado, the Wind River Mountains of Wyoming, the Cascade Range of Washington, the Coast Mountains of British Columbia and Alaska, the Fairweather and Alaska Ranges, and the Chugach, Kenai, St. Elias and Wrangell Mountains of Alaska was carried out by A. Post. L. Mayo photographed other areas in the Alaska Range and Chugach and Kenai Mountains. Exceptionally low snowlines were observed from Colorado to SE Alaska; however, unusually high snowlines and heavy ablation were evident in the St. Elias, Chugach, and Kenai Mountains and the Alaska Range.

Glaciers undergoing surges included: (i) "Michael" Glacier (Michael Creek, Alsek Ranges, Canada), recognized as a surging glacier but not previously seen when active, and (ii) Tenas Tikke (in the same area), which has advanced into the Grand Pacific Glacier and appears to be completing an extremely strong surge first noted in 1972. The Tweedsmuir Glacier was spilling ice into the Alsek River at a number of points but the damming was incomplete as no large lakes were seen. Turner and Marvine Glaciers, which appear to surge at somewhat random but frequent intervals (3 to 10 years), were both very active. The most noteworthy change in tidal glaciers was the collapse of the remaining fragment of Plateau Glacier in Glacier Bay, allowing Wachusetts Inlet to extend westward to the terminus of Carroll Glacier. This large surging glacier has now become a tidal glacier and could retreat catastrophically.

REMOTE SENSING OF SNOW AND FRESH ICE

M. F. Meier and R. M. Krimmel (U.S. Geological Survey—Tacoma) have used imagery from the ERTS satellite to determine glacier mass balances (accumulation area ratios), glacier movements, and equivalent snowline altitudes. Long-term surface velocities of selected glaciers were obtained by comparison of recent ERTS pictures with maps produced from earlier data. Measurements included velocities on Malaspina Glacier over a 10 year period and short-term velocity changes at the margin of Hubbard Glacier. Surging glaciers were readily identifiable on the images and surge displacements on the Lowell, Tenas Tikke, Tweedsmuir, and Lednik Medvezhiy glaciers were determined. It was also found that satellite pictures of large glaciers, when taken under conditions of low sun angle and complete snow cover, show previously undetected slope changes which can be interpreted as dynamic flow features or as reflections of subglacial topography. Snowline mapping in several drainage basins in the Pacific Northwest was also carried out using ERTS imagery. In connexion with this work, rapid and accurate techniques to measure snow-covered area of equivalent snowline altitude were developed by M. F. Meier with the cooperation of Stanford Research Institute. The data can be extracted either by manual or electronic console methods, and should be very useful for streamflow predictions and reservoir regulation. Fully automatic processing of satellite data to obtain snow-covered area does not yet appear to be possible unless the region is known to be cloud-free.

Investigators at the Goddard Space Flight Center (P. Gloersen, V. V. Salomonson, and others) have used ERTS photographs to correlate snow extent and mean run-off in seven drainage basins in the Wind River Mountains of Wyoming. This study extends previous work carried out in the Indus River Basin using lower resolution data from Nimbus-3 and 4 satellites. It was found that the general character of specific run-off and snow cover variation depended on watershed elevation. The specific run-off from the lower watersheds had a smaller peak flow that occurred earlier in time than the higher watersheds, characteristics consistent with the snow cover depletion curves which show the snow cover disappearing more rapidly due to smaller snow depth and higher temperatures at the lower altitudes. Additional data will be gathered in the next few years to see if snow cover area observations will be useful to better characterize and perhaps predict run-off from watersheds in these mountains.

Forests and clouds present major problems in the routine monitoring of snow and ice. When the forest canopy is not complete, it has been possible to use a multi-spectral analysis to detect areas which combine the signatures of snow and forest; with a dense forest there appears to be little hope of determining the extent of the snow cover. Despite the low resolution of microwave radiometers, relatively detailed all-weather information regarding the snow cover can be obtained. For example, M. F. Meier has shown that the per cent area covered by snow within an individual cell can be related to the average brightness temperature of that cell. Microwave sensors have also proved to be useful in mapping sea ice and the polar ice caps. Using Nimbus-5 data, P. Gloersen has calculated brightness contours for both the Antarctic and Greenland ice caps, showing large differences in emissivity pattern between the two areas which are apparently related to whether or not the upper part of the snow cover has undergone melting.

At the University of Alaska, B. E. Holmgren, C. S. Benson and G. E. Weller have utilized ERTS imagery to investigate the relationship of regional variations in the break-up of the seasonal snow cover on the Alaskan North Slope to physiographic features and to stream flow data. They are also attempting to determine how brightness levels on the satellite images are related to: (i) dust sediments on the snow surface, (ii) deposits of river overflow ice which are common on rivers of the Arctic Slope, and (iii) areas of thin and discontinuous snow before the main melting period. The presence of dust (both natural and man-made) on the snow was indicated by markedly lower brightness in the near infrared images at the start of, or during, the melt season, indicating enhanced melting. Aufeis deposits on the Sagavanirktok, Ivishak, and Echooka rivers were identified in the satellite pictures and their areas measured. These aufeis deposits are significant hydrological features (with a maximum area of over 100 km^2) which persist through a major part of the summer. ERTS data, supplemented with aircraft measurements, have also been used by G. D. Wendler, R. F. Carlson and D. L. Kane to investigate the potential value of high resolution satellite imagery as a tool in predicting the spring break-up of Alaskan rivers and the forecasting of resulting floods. Such floods cause a serious loss to the state each year. The most important information needed for such predictions is the time when melting is initiated and the rate at which the snow cover is eliminated. Comparison of the satellite data with direct snow measurements and a snow-melt model showed good agreement, suggesting that, in the future, satellite analysis will make possible greatly improved forecasts.

Several advances in instrumentation for the remote sensing of ice and snow have recently been made. The first successful radio-echo sounder which can be used in wet, temperate glaciers was developed by R. Watts and A. England (U.S. Geological Survey—Denver) in cooperation with the Stanford Research Institute and the Tacoma Project Office. New microwave absorption instruments for measuring the liquid water content of snow were also developed by W. I. Linlor (NASA-Ames) in cooperation with M. F. Meier.

REMOTE SENSING OF SEA ICE

Increasing demand for sequential synoptic data on sea ice, together with the rapid evolution of remote sensing tools and platforms, has spurred the utilization of satellite imagery, resulting in a greatly improved understanding of the nature and behavior of the polar ice packs. Investigators from the University of Alaska, University of Washington (AIDJEX), U.S. Cold Regions Research and Engineering Laboratory (CRREL), U.S. Naval Oceanographic Office (NAVOCEANO), National Aeronautics and Space Administration (NASA), and the U.S. Geological Survey are actively involved in a variety of programs aimed at instrument development, data acquisition, and data analysis.

G. D. Wendler and others at the University of Alaska have used satellite photography to map ice extent in the Bering, Chukchi, and Beaufort Seas and to examine variations in the amount of open water in relation to synoptic weather patterns. During major break-ups of the arctic ice pack in March 1973 and again in March 1974, the amount of open water was found to be exceptionally large—15% in March 1973 and 11% in March 1974. Open water areas of this magnitude would dramatically alter the regional rates of heat exchange between the atmosphere and the ocean. ERTS and NOAA-3 satellite imagery has also been used to determine the behavioral characteristics and delineate the boundary of shore-fast ice along the Alaskan coasts. It was found that the boundary of grounded shore-fast ice can generally be related to the 18 m depth contour. Significant deviations from this generalization, however, appear in certain areas such as Harrison Bay where shore-fast ice may be found in water as deep as 27 m. A technique was also developed to obtain without ambiguity the velocity vector of sea ice movement from satellite imagery. This was achieved by superimposing a positive transparency of one satellite pass over a negative of the next pass.

At the University of Washington, AIDJEX investigators have employed ERTS imagery to test certain assumptions used in their theoretical model of sea ice dynamics. D. A. Rothrock and R. T. Hall have measured strain rates and fractional area changes of thin ice in sequential ERTS photographs to check the hypothesized mathematical description of the production of open water and the redistribution of thin ice into pressure ridges. They found that only about the thinnest 5% of the ice was involved in ridging and that the yield curve for plastic flow of the ice pack was somewhat thinner than previously assumed. No evidence of anisotropy was seen in the redistribution of ice, but it was noted that the ice did not undergo compression parallel to the predominent lead orientation in any of the four cases treated thus far. J. F. Nye and D. R. Thomas have also used ERTS photography to test the hypothesis that pack ice can be modelled as a continuum and to examine the spatial scales involved. Results indicated a spatial variation of ice velocity on scales of 500 km, with smaller-scale variations superimposed. Large-scale velocity varied from 0-8 km/day, while small-scale variations were on the order of 0.3 km/day. The analysis also suggested that measurements over a gauge length of 50 km could give strain rates differing from the regional average by as much as 1%/day; for a gauge length of 100 km the difference was about 0.4%/day. These results in general support the adoption of a continuum model for pack ice. It should be noted, however, that the number of cases examined in both of the above studies was exceedingly small and analysis of additional cases would be highly desirable. In the past there has usually been little, if any, ground truth data with which to compare values calculated from the satellite photographs. Recently, R. T. Hall has obtained extremely good correlations between satellite-derived ice velocity vectors in the Beaufort Sea and the more accurate values determined using position data from the AIDJEX array. ERTS imagery thus appears to have sufficient resolution for relatively accurate calculations of the dynamic behavior of the ice, but the applications remain limited by the infrequent occurrence of cloud-free conditions in the polar regions.

S. F. Ackley, W. K. Crowder, W. D. Hibler, and others at CRREL have also used satellite data to analyze the movement and deformation of ice in the Arctic Ocean. Strain calculations were carried out over a 5-day period in March using ERTS multispectral imagery of an area covering approximately 14 thousand square kilometers northeast of Point Barrow. Strain rates in this marginal ice zone were found to be 3-5 times larger than those typically measured in the interior of the pack; maximum rates of shear and divergence were on the order of 0.5% per hour. Shear rates were also calculated as a function of distance from the shore-fast ice. In all cases the shear dropped to large negative values about 40 km from the stationary ice, becoming positive at a distance of about 70-80 km, the magnitude of the shear rates was roughly an order of magnitude larger at the boundary of the shear zone than in the main pack. The results generally indicated that the ice pack as a whole was rotating clockwise and slipping within a narrow (on the order of 50 km) region near the margin. VHRR infrared imagery from the NOAA-2 satellite were also used to measure ice deformation and lead production over the Beaufort Sea for a 10-day period in March. Efforts were then made to correlate these data with atmospheric driving forces as determined from the pressure field. Due to the presence of a persistent high pressure system over the region, divergence rates in the ice were an order of magnitude larger (1% per hour) than those previously found in the area.

Because visible techniques can be used only sporadically over the polar oceans, considerable effort is being devoted to the development of all-weather means of observing floating ice. Both active and passive microwave sensors are being tested. Side-looking radar (SLR) has provided high resolution images in which a great amount of detail can be seen. Although SLR appears to have great potential value, there remain serious questions regarding interpretation and analysis of the images. Passive microwave imagery, despite its lower resolution, appears to offer a consistent method of distinguishing various ice types. S. G. Tooma, R. D. Ketchum, and others from the U.S. Naval Oceanographic Office have flown microwave radiometers (19 and 31 GHz) over sea ice near the east coast of Greenland. Using infrared and laser data as support, they were able to distinguish five ice conditions: (i) open water/new ice, (ii) smooth first-year ice, (iii) ridged first-year ice, (iv) second-year ice, and (v) other multi-year ice. Large-scale microwave mosaic maps of the ice pack have been constructed by W. J. Campbell (U.S.G.S.) and P. Gloersen, V. V. Salomonson, and others (NASA) using data obtained on aircraft flights over the 1970, 1971, and 1972 AIDJEX camps in the Beaufort Sea, as well as from the 1973 Bering Sea Experiment. The mosaics show the ice pack to be a heterogeneous mixture of first-year and multi-year ice, with various zones being discernible by the different proportions of these two types of ice. Near the coast it was possible to distinguish a shore-fast zone, a shear zone, and an interior zone. With sequential imagery, changes in the widths of these zones could be seen over periods of a few days. Microwave signatures of ice in the Bering Sea were substantially different from those obtained in the Beaufort Sea. Microwave images from the NIMBUS-5 satellite have provided a means of routinely mapping pack ice boundaries in both the Arctic and Antarctic. Areas of first-year ice can be distinguished in the satellite data, but the resolution is still too low for this to be quantitatively useful.

SEA ICE MECHANICS

Investigators (R. D. Nelson, W. M. Sackinger, L. E. Shapiro, and others) from the University of Alaska have made measurements at a number of locations along the Alaskan North Slope which are designed to provide better information on the magnitude of stresses generated within various types of coastal sea ice. The 25 kW (10 cm wavelength) radar operated at the Naval Arctic Research Laboratory at Barrow has been used with time-lapse photography to observe and record the building of pressure ridges, the movement of large masses of ice from the coast during mid-winter storms, and the break-up of shore-fast ice during the summer months. In conjunction with the radar observations, stress transducers were embedded in the ice to provide a continuous record of variations in ice stress. Effects of tidal and temperature variations were evident in the stress data, producing 12-hour and 24-hour cycles. Stresses on the order of 3.4×10^5 newtons/m^2 were observed as a result of these forces. The stress data were also correlated with wind and nearby ice motions as monitored by the radar. Complementary data on crystal size, crystal orientation, and brine content were obtained using conventional ice-core analysis. Stress transducers were also placed in the ice surrounding an artificial sediment island in Mackenzie Bay near Adgo Island, Canada. Measurements were carried out between 1 February and 15 May 1974. Other stress transducers were implanted in the ice near the center of Gwydyr Bay, a shallow protected bay at the mouth of the Kuparak River. Stresses were monitored from March through May 1974. As a result of these measurements, a more complete picture of the mechanics of stress generation in shore-fast ice is beginning to emerge.

OPTICAL PROPERTIES OF SEA ICE

During the summer of 1974, T. C. Grenfell and F. Rigby (University of Washington) measured spectral albedos and attenuation coefficients in multi-year sea ice adjacent to Ice Island T-3 in the Arctic Ocean. The primary objective of the program was to determine how the optical properties of sea ice depend on wavelength, ice type, and conditions at the upper surface. In addition, an effort was made to determine whether significant temporal changes occur in the optical properties of the ice as a result of the large increase in brine volume which takes place over the summer melt season.

Observations of downwelling irradiance beneath the ice were made at about 55 sites using a submersible spectrophotometer specially designed for this purpose; data were recorded beneath snow-covered ice, as well as beneath bare white ice, blue ice, and melt pond ice over a thickness range of 115 to 250 cm. Spectral albedos were measured at roughly 200 sites, including white ice, blue ice, melt ponds, and snow. To determine vertical variations in attenuation, backscattering and forward scattering profiles were taken in both the ice and the snow using a second spectrophotometer which was connected to a small fiber optics probe.

Significant spatial and temporal variations were evident in the optical properties of all ice types, with the largest differences being in the melt ponds. Dry compacted snow albedos ranged from about 0.92 at 500 nm to about 0.8 at 1000 nm. Wet melting snow had a maximum albedo in the 500-600 nm region of 0.75-0.80, dropping more strongly in the infrared to about 0.55. Albedos of the white ice exhibited a broad maximum at about 500 nm, decreasing continually at longer wavelengths to about 70-75% of maximum at 1000 nm. Melt pond albedos were found to be extremely sensitive to conditions at the bottom of the pond—pond bottoms ranged from very clear blue ice to bubbly grey ice. Albedos at 500 nm ranged from 0.60 over small slushy ponds with a high density of bubbles in the underlying ice to 0.20 for clear ponds above clean blue ice. At longer wavelengths, the albedos dropped steeply reaching values of 0.05-0.10 at 100 nm. Water depth appears to be an important factor in the albedos in the 700-1000 nm range. Attenuation coefficients in the white ice ranged from 0.012-0.020 cm^{-1} at 500 nm; values beneath the pond-covered ice ranged from 0.006-0.12 cm^{-1}, the lowest value being taken at the end of the melt season when the amount of internal melting had reached a maximum. Analysis of the profile data indicated that the granular surface layer in multi-year ice had an attenuation coefficient of 0.033 cm^{-1} at 500 nm; intermediate values of about 0.025 cm^{-1} were obtained in the ice immediately below the surface scattering layer, and values of 0.011 cm^{-1} in the interior of the ice.

Ice Island T-3, which had been manned for over two decades, was temporarily abandoned in the fall of 1974 because its motion had carried it into a stagnant region near Ellesmere Island where conditions were not typical of those found throughout much of the remainder of the Arctic Basin.

AIDJEX LEAD EXPERIMENT

During periods of divergence, a sea ice cover typically cracks open, exposing areas of open water. The rapid formation and growth of ice in these leads affects the large-scale mechanical properties of the ice pack, the structure and dynamics of the mixed layer beneath the ice, and the heat exchange with the atmospheric boundary layer. Ice production, the input of salt and short-wave radiation to the ocean, and turbulent heat input to the atmosphere all take place roughly two orders of magnitude more rapidly over leads than over perennial ice. Continued growth of ice in a lead causes a drastic decrease in the exchange rates and a marked increase in the overall compressive strength of the ice pack.

In March and April 1974 scientific groups from three universities participated in a field experiment designed to gather information on the growth of ice in leads and the effects of this growth on interactions between the atmosphere and ocean. This experiment was a sub-program of the Arctic Ice Dynamics Joint Experiment (AIDJEX) and was conducted near Point Barrow, Alaska. Principal investigators were C. Paulson (Oregon State University), J. Businger and J. D. Smith (University of Washington), and B. Holmgren and J. J. Kelly (University of Alaska).

Preliminary observations and instrument testing were carried out in artificial leads constructed on near-shore ice in Elson Lagoon by pumping sea water into two shallow ponds, 10 m and 20 m in diameter. Because of the random occurrence and rapid freeze-up of natural leads, deployment of the field program posed serious logistic problems. Usually less than 24 hours were available to locate a lead, set up the camps, and begin the observations. Each morning fixed-wing aircraft would begin searching for a suitable lead within 50 km of Barrow, while instrument huts and living quarters were being prepared for helicopter transport. Each shelter was self-contained with a power generator, fuel, heat, and the rude essentials needed for safety and comfort; shelter design was such that they could be rendered operational in only a few hours.

Two successful experiments were conducted, the first from 19-21 March and the second from 25-26 March. Both camps were established about 30 km from Barrow; six helicopter and seven Cessna flights were required to transport the five buildings and 17 people to the sites. Elapsed time from first sighting of the lead to complete deployment was about 6 hours in both cases. Smaller experiments were also carried out from 2-5 April and 8-10 April, primarily to gather additional oceanographic data. Measurements of turbulent and radiative heat exchange were made over the refreezing leads, while STD casts and velocity profiles were obtained immediately beneath them. Analysis of the data is currently in progress.

ICE ISLAND RECONNAISSANCE—BEAUFORT SEA

In April 1974 the Canadian Polar Continental Shelf Project (PCSP) reported the sighting of a large ice island about 160 km north of the MacKenzie River delta. There was considerable interest in the island as a possible site for a research station to replace the one on T-3, and as a possible logistic base for AIDJEX operations in 1975-76. It was therefore decided to send out a field party to survey the island and install automatic instrumentation to record position and weather. An extensive search was begun in late April to relocate the island; at least 15 missions were flown before the island was again found on 14 June. A few days later a VHF beacon was dropped on the island to serve as a homing aid. Several smaller (1 km or less) ice islands were also seen in the vicinity of the larger one.

On 25 and 26 June three helicopter flights were made to the island. Field personnel included: P. Martin, P. Taylor and A. Thorndike (AIDJEX); F. Hunt (PCSP); R. Grauman (AES); and W. Denner and R. Dickerson (Naval Arctic Research Laboratory). The island was found to measure about 4 km by 7 km and to have an average thickness of about 15 m. A number of sharply angular rocks were found on one part of the island. Several empty fuel drums, bearing U.S. military markings for automotive gas dated 1957, were also found. While the history of these drums is being investigated, it seems likely that the island calved off the Ward Hunt ice shelf along the northern coast of Ellesmere Island in 1967.

A position buoy, tracked by the Interrogation, Recording, and Location System (IRLS) aboard the NIMBUS D satellite, was installed by AIDJEX personnel on the island. A backup IRLS buoy was also set out on a small ice island fragment adjacent to the main island.

In the center of the island, F. Hunt and B. Grauman installed an experimental automatic weather station with magnetic tape recording and data relay via ERTS satellite. Unfortunately, neither the ERTS data relay nor the backup IRLS buoy has communicated successfully with their respective satellites; however, daily positions are being received from the primary IRLS buoy. Although the ice island moved only about 30 km during the summer of 1974, it should pass north of Point Barrow during the spring or summer of 1975 if it follows the normal drift track.

G. A. Maykut

"BIG BEAR"

As of the last day in September 1975 the main AIDJEX camp, "Big Bear", was located at 73°30'N, 136°28'W. The ice in the vicinity of the camp had survived the summer in good condition and the long C-130 runway had remained intact. The fall resupply flights had begun, using DC-3's and the twin otter from NARL. Things were better than anyone would have expected. This was not to remain the case.

At 0645 on 1 October a lead opened under the mess-hall leaving the building hanging over open water and splitting the camp in two. Further cracks developed through the runway. Ultimately the lateral displacement along the main lead through camp was 600 m. Following the crack formation most of the station personnel were evacuated while camp buildings were moved to the larger part of the split floe and away from the leads. This move had hardly been completed and the buildings rewired when on the afternoon of 12 October another crack, oriented perpendicular to the initial set of leads, split the new camp. At this time it was decided to abandon Big Bear and move the principal operational base for AIDJEX to one of the three satellite camps (Caribou) which is located on very heavy ice. As of 27 October the movement of fuel and equipment between was progressing rapidly and it was planned to abandon Big Bear completely before the dark period set in.

W. F. Weeks

ANTARCTICA—ROSS ICE SHELF PROJECT

The large Antarctic program completed its second year of field work during the 1974-75 Austral summer. This report summarizes the U.S. activities of the 28 people from eight institutions and three countries who took part in the program. A number of camps were supported by six LC-130 and two Twin Otter aircraft.

1) **Precipitation Chemistry**—J. A. Warburton, G. O. Linkletter, M. S. Owens and D. A. Trachte

The relationships between precipitation processes and snow chemistry are being studied in time and space over the Ross Ice Shelf. Sampling of snowfalls was done sequentially as storms moved inland from the Ross Sea; bulk samples of rime, hoar frost and falling snow were collected; and replicas of falling snow crystals were made. In addition, detailed meteorological observations and surface snow samples were collected. The analysis of this data is expected to provide informatiion on the removal of chemical substances from the air by precipitation.

2) **Drill Site Survey**—J. W. Clough, K. C. Jezek and J. D. Robertson

A geophysical survey was done on the Ross Ice Shelf in anticipation of the 1975-76 drilling program. Radio-echo sounding, seismic surveys and radar surveys of bottom crevasses were completed. Ice thickness, water layer thickness, crystalline basement velocities and bottom crevasses locations were determined. The narrow, bottom crevasses have no corresponding surface feature.

3) **Glaciological Measurements**—R. H. Thomas and D. H. Eilers

The large strain networks near the RISP camp were remeasured showing ice velocities of 200 to 400 m yr^{-1}. Several new strain networks were established and geoceiver position fixes were made. Ten-meter temperature reading taken during this season show a slight temperature increase between 1958 and 1974.

4) **100 m Ice Cores**—J. H. Rand and C. C. Langway, Jr.

The CRREL shallow drill was used both on the Ross Ice Shelf and at the South Pole with continuous core retrieval. The 100 m core could be retrieved at rates up to 1 m per minute when operated by two people.

Bore hole temperatures and core densities were measured. Only gross stratigraphic features were obtained before shipment back to the laboratory. Detailed physical properties and chemical analyses are planned.

5) **Geophysical Survey**—J. W. Clough and J. D. Robertson

Ice thickness and gravity, water depth and seismic and radiowave velocities were determined at various sites. Maps of ice thickness, ocean bottom depth and water layer thickness have been prepared. The areas of thick ice representing major ice streams were defined.

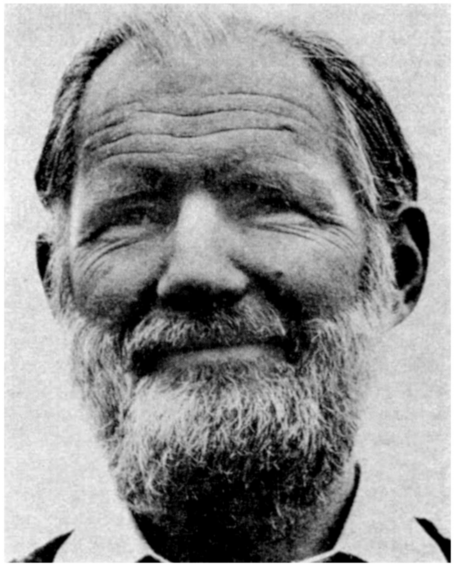
ANTARCTICA—BYRD STATION DRILL HOLE RESURVEYED

D. E. Garfield and H. T. Ueda

The drill hole at Byrd Station was resurveyed to determine the sub-surface ice flow patterns. Only 1537 m of the original 2141 m was accessible because of refreezing of subglacial water in the hole. The results confirm earlier reports of a complicated flow pattern in this area. The velocity vector shifts about 135 degrees over a depth of less than 1400 m.

S. C. Colbeck

CHARLES SWITHINBANK



Not many people who have made snow and ice their livelihood can have started life in such an unlikely place as Burma, but Charles Swithinbank's father worked in the Indian Civil Service, in the days when Burma was part of the British Empire, and it was in Pegu that Charles was born in November 1926. In 1933 the family returned to England and settled in Kent. Charles attended school in nearby Maidstone until 1939, when he went to Bryanston School, Dorset, a boarding school, where he became one of its best oarsmen. From 1944-46 he served in the Royal Navy, before going to Pembroke College, Oxford to read for a degree in the Honours School of Geography, 1946-49.

During his undergraduate days at Oxford, Charles rowed for his college and for the University "Isis" crew. At the Geography School, he specialised in geomorphology, which in many countries is included in the curriculum of university geology faculties, and went on two expeditions, to very different environments: Iceland and the Gambia. A senior member of the University was Kenneth Sandford, who had been involved with the early days of the association that was to become the British Glaciological Society, and served for a time as a Vice President; he was also a leading member of the University Exploration Club, of which both Charles Swithinbank and Geoffrey Hattersley-Smith were members. Hattersley-Smith (see profile in ICE 18) had come up to Oxford after war service, and was also specialising in geomorphology. Sandford encouraged him and Swithinbank to go and see Gerald Seligman, founder of the British Glaciological Society, and discuss with him their growing enthusiasm for glaciology. In this way began two careers in the discipline.

In the spring vacation 1949, Charles joined the Stockholm University Expedition to Kebnekajse where he worked with Hans Ahlmann and Valter Schytt. The Expedition was partly a training ground for members of the Norwegian-British-Swedish Antarctic Expedition to Dronning Maud Land, 1949-52, on which Charles served as Assistant Glaciologist, Valter Schytt as Chief Glaciologist and Gordon Robin as Physicist. Thus, within the space of a few years, Swithinbank had met and worked with scientists who were already, or were soon to become, international leaders in snow and ice studies.

His work on the Maudheim Expedition reflected his precise and careful nature. Until this time, knowledge of the mechanism of movement of ice shelves was based almost entirely on theory. His painstaking and difficult measurements on a network of stakes on the Maudheim ice shelf gave the first systematic information about the details of the pattern of movement in an ice shelf and about the mass balance. Done, as they were, with a baseline and theodolite, these pioneering but precise measurements were the forerunners of the repeated tellurometer surveys done more recently on the Ross Ice Shelf. Only a moderate amount of clothing could be worn, as a full set of reindeer skin clothing was too bulky and could accidentally disturb the tripod. Up to 96 km a day were covered by tractor (Weasel) in near darkness and twilight during the winter period, in temperatures ranging from −25°C to −45°C.

No doubt these early experiences account for his cautious, but by no means uncourageous, attitude to polar field work. All safety measures must be taken: his friends know well the picture of Charles driving a snow toboggan with long reins from far behind the sledge, and well before seat belts for cars were available in Britain he made his own. He has become an experienced pilot and has tried parachuting—though no doubt he insisted on wearing a couple of spare parachutes for safety.

On successive expeditions, to Greenland (Clavering Island 1952), to the North-West Passage (sea ice studies 1957), and to the Antarctic (U.S., Soviet and British expeditions 1959 onwards), Swithinbank's growing ability to organize and conduct first-class research became recognised and appreciated.

He spent the years from late 1952 until 1955 partly in Stockholm and partly in Oxford, working on the results of the Maudheim Expedition. He gained a D.Phil. from Oxford University in 1955 and then moved to Cambridge, as a Research Fellow at the Scott Polar Research Institute. Here he worked on a project sponsored by the Canadian Defence Research Board—an ice atlas of Arctic Canada. This involved him in a visit to the Arctic, when he circumnavigated Baffin Island in the icebreaker HMCS "Labrador", and took him on journeys totalling 60,000 miles to Norway, Denmark, USA, and Canada, visiting libraries, archives, hydrographic and meteorological institutions, governmental establishments and the Hudson's Bay Company. The atlas was published by the Canadian Defence Research Board in 1960. This was one of three ice atlases compiled in the Scott Polar Research Institute, the other two being: T. E. Armstrong, "Sea ice north of the USSR", published by the London Admiralty Hydrographic Department in 1959, and J. A. Heap, "Sea ice distribution in the Antarctic between longitudes 70°W and 92°W", published by the same Department in 1963.

In 1959, Charles moved to Ann Arbor, U.S.A., as a Research Associate and lecturer at the University of Michigan, which had a long established tradition of work in polar sciences inspired by W. H. Hobbs and L. M. Gould. In 1957, a new series of polar expeditions began, for the International Geophysical Year, led by James H. Zumberge. The deformation of the Ross Ice Shelf near the Bay of Whales, Antarctica, was studied by the Michigan group in the period 1957-63, and Swithinbank was a member of the 1959-60 expedition, led the 1960-61 and 1961-62 expeditions, and helped to organize the 1962-63 expedition. The object of the research was to measure the volume of ice discharged into the ocean and the movement of the giant glaciers that transect the mountain range on the west side of the Ross Ice Shelf. New methods of travelling and working on fast moving, heavily crevassed ice surfaces were evolved, including transport by helicopter to each drill site, at which the observer was lowered by winch and raised again after drilling and emplacing stakes while the helicopter hovered nearby.

Early in 1963 Charles returned to Cambridge with a delightful family: wife Mary, widow of Alaska geologist Robert E. Fellows, her daughter Anne, and new small daughter Carol; a son, Kelvin, was born a year later. He took up a research appointment at the Scott Polar Research Institute to develop the glaciological programmes of the British Antarctic Survey, whose Director, Sir Vivian Fuchs, was President of the Glaciological Society 1963-66. From late 1963 until 1965 Swithinbank became the first British Exchange Scientist with the Soviet Antarctic Expedition, and wintered at Novolazarevskaya, while studying the movement of the inland ice sheet in the vicinity.

One of Charles' characteristics is his gift with languages. He learned very quickly a good Norwegian Scandinavian at Maudheim and switched over easily to excellent Swedish Scandinavian during his year in Stockholm. On his visit to Leningrad with the returning Soviet Antarctic Expedition he gave a lecture in Russian to the Arctic and Antarctic Institute—the Russians were very impressed.

During the period 1966-72, he took part in three radio echo sounding expeditions to Antarctica, using equipment developed by the Scott Polar Research Institute under its Director, Gordon Robin. Two of these expeditions were to the Antarctic Peninsula, where Swithinbank developed an effective aircraft technique for taking radio echo soundings of the warm ice, involving level flight at a height of only 10 metres above the ice surface. Two interesting pieces of work also occurred during this period. In 1969 he acted as consultant glaciologist to British Petroleum on the specially strengthened oil tanker SS "Manhattan", during tests to discover whether a tanker route through the North-West Passage was practicable. In 1971 he visited the North Pole in the British nuclear-powered submarine HMS "Dreadnought", to study the Arctic Ocean pack ice from below.

1974 saw his appointment as Head of the Earth Sciences Division, British Antarctic Survey, responsible for geology, field geophysics and glaciology. He has received honours and awards in recognition of his contributions to glaciology from Norway, Sweden, U.S.A. and, in the U.K., the Royal Geographical Society. He has served on the governing bodies of North American, British, and international organizations such as the International Commission of Snow and Ice and the International Glaciological Society, of which he is at the moment a Vice President.

INTERNATIONAL GLACIOLOGICAL SOCIETY

AWARDS

SELIGMAN CRYSTAL

Seligman Crystals are awarded "from time to time to one who has contributed in a unique way so that the subject is now significantly enriched as a result of that contribution." At its meeting on 24 May 1975, the Council agreed that a Crystal be awarded to **Dr Willi Dansgaard** for his pioneering work in isotope glaciology. From isotopic analysis of ice cores obtained from Greenland, Dr Dansgaard and his team at the Geophysical Isotope Laboratory, Copenhagen University, established the records of past climates. The Crystal will be presented at the next Annual Meeting of the Society, in September 1976 in Cambridge, England.

HONORARY MEMBERSHIP

Under the Constitution of the Society, "Honorary Members shall be elected by the Council in recognition of eminent contributions to the objects of the Society, and shall not exceed ten in number." At its meeting on 24 May 1975, the Council elected the following Honorary Members, who have undoubtedly made such contributions:

Albert P. Crary, U.S. National Science Foundation, for his important contributions to the geophysical and geographical exploration of polar regions.

Peter Kasser, Head of the Hydrology and Glaciology Section of the Hydraulic Research and Soil Mechanics Laboratory, E.T.H., Zürich, Switzerland, for his contributions in the field of engineering problems associated with snow and ice and for the building up of the Section, which plays a leading role in international glaciology.

The Honorary Members were thus ten in number after the Council Meeting in May 1975, but with the death of Sir Charles Wright they now are nine: **A. P. Crary, W. O. Field, R. Haefeli, P. Kasser, R. F. Legget, M. de Quervain, R. P. Sharp, S. Thorarinsson and Z. Yosida.**

BRANCH NEWS

At the end of November 1975, nearly two-thirds of our members were resident in the territories of our 4 branches. Because we have no official membership of branches, circulars about branch meetings are sent to IGS members in the respective territories:

British	195
Nordic (Denmark, Finland, Iceland, Norway, Sweden)	85
N.E. North American (Eastern states of U.S.A., eastern Canada)	241
Western Alpine (Belgium, France, Italy, western Switzerland)	107
	628

BRITISH

The 1976 meeting of the British Branch will be held at the H. H. Wills Physics Laboratory, Tyndalls Avenue, Bristol BS8 1TC, on 5 April 1976. Members of the Society who wish to attend should write to Miss Elizabeth Morris, Institute of Hydrology, Maclean Building, Crowmarsh Gifford, Wallingford, Oxon., as soon as possible.

NORDIC

The 1977 meeting of the Nordic Branch will take place at the Zoological Station at Tvärminne, southern Finland, 5-7 March. After the meeting there will be a trip on an icebreaker ("Urho") for 3-5 days depending on ice and weather conditions. Those members coming to the meeting from other Nordic countries will meet first of all on the ferry from Stockholm and have an overnight journey on the boat; there may even be some introductory lectures during the evening. The Editor of ICE is confident that this whole event will yield interesting material (including photographs) for one of the 1976 issues.

WESTERN ALPINE

A report of the 1975 meeting, held in October at Barcelonnette, will appear in the next issue of ICE.

JOURNAL OF GLACIOLOGY

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

SYMPOSIUM ON THERMAL REGIME OF GLACIERS AND ICE SHEETS (Vol. 16, No. 74)

G. de Q. Robin:
Reconciliation of temperature-depth profiles in polar ice sheets with past surface temperatures deduced from oxygen-isotope profiles.

T. C. Chang, P. Gloersen, T. Schmugge, T. T. Wilheit and H. J. Zwally:
Microwave emission from snow and glacier ice.

T. J. Hughes:
The theory of thermal convection in polar ice sheets.

Gilbert Dewart:
Seismic evidence of a wet zone under the west Antarctic ice sheet.

K. Philberth:
On the temperature response in ice sheets to radioactive waste deposits.

W. F. Budd, N. W. Young and C. R. Austin:
Measured and computed temperature distributions in the Law Dome ice cap, Antarctica.

R. H. Thomas:
The distribution of 10 m temperatures on the Ross Ice Shelf.

Fritz Müller:
On the thermal regime of a high Arctic valley glacier.

Gorow Wakahama, Daisuke Kuroiwa, Tatsuo Hasemi and Carl S. Benson:
Field observations and experimental and theoretical studies on the superimposed ice of McCall Glacier, Alaska.

L. Lliboutry:
Physical processes in temperate glaciers.

C. F. Raymond:
Some thermal effects of bubbles in temperate glacier ice.

W. D. Harrison and C. F. Raymond:
Impurities and their distribution in temperate glacier ice.

G. de Q. Robin:
Is the basal ice of a temperate glacier at the pressure melting point?

L. Lliboutry, M. Briat, M. Creseveur and M. Pourchet:
15 m deep temperatures in the glaciers of Mont Blanc, (French Alps).

Steven M. Hodge:
Direct measurement of basal water pressures: a pilot study.

D. C. Ford, R. S. Harmon, H. P. Schwarcz, T. M. L. Wigley and P. Thompson:
Geo-hydrologic and thermometric observations in the vicinity of the Columbia Icefield, Alberta and British Columbia, Canada.

Garry K. C. Clarke:
Thermal regulation of glacier surging.

Robert Bindschadler, William D. Harrison, C. F. Raymond and Claude Gantet:
Thermal regime of a surge-type glacier.

Garry K. C. Clarke and Gary T. Jarvis:
Post-surge temperatures in Steele Glacier, Yukon Territory, Canada.

B. Barry Narod:
Bridge optimization for thermistor measurements.

Other issues will include the following papers:

G. S. Boulton:
The origin of glacially fluted surfaces—observations and theory.

David McClung:
Snow pressure on rigid obstacles.

Theodore E. Lang:
Measurements of acoustic properties of hard-pack snow.

Arnold D. Kerr:
The bearing capacity of floating ice plates subjected to static or quasi-static loads.

R. A. Smith:
The application of fracture mechanics to the problem of crevasse penetration.

Bernard Hallet:
The effects of subglacial chemical processes on glacier sliding.

R. W. Taylor, J. P. Kovach and N. P. Lasca:
Instruments and methods: Automated seismic monitoring system for Lake Michigan ice studies.

Short Notes

G. O. Linkletter and J. A. Warburton:
A note on the contribution of rime and surface hoar to the accumulation on the Ross Ice Shelf, Antarctica.

J. F. Lea
A concise method for analyzing the ice-melting performance of a heated disc.

RECENT MEETINGS (of other organizations)

INTERNATIONAL ASSOCIATION FOR HYDRAULIC RESEARCH: SYMPOSIUM ON ICE PROBLEMS

(Hanover, N. H., USA, 18-21 August 1975)

A symposium on Ice Problems was held at Dartmouth College, co-sponsored by the Cold Regions Research and Engineering Laboratory (CRREL). Major themes of the conference were: extended season navigation, ice jam control, and effects of sea ice on marine structures. Papers presented are listed below. The Proceedings of the Symposium may be obtained from USA CRREL, P.O. Box 282, Hanover, New Hampshire 03755, USA.

INVITED PAPERS

John F. Kennedy (University of Iowa, Iowa City, Iowa, USA): Ice jam mechanics

K. R. Croasdale (Imperial Ool Limited, Calgary, Alberta, Canada): Ice forces on marine structures

Vasili V. Balanin (Leningrad Water Transport Institute, Leningrad, USSR): Extended season navigation of inland waters of the USSR

Erkki Palosuo (University of Helsinki, Helsinki, Finland): The development of winter navigation and ice information service on the Baltic

CONTRIBUTED PAPERS

Theme 1—Extended season navigation

W. E. Webb & W. F. Blair: Ice problems in locks and canals on the St. Lawrence River

E. Tesaker: Accumulation of frazil ice in an intake reservoir

F. Boulanger, E. Dumalo, D. LeVan, L. Racicot: Ice control study, Lake St. Francis-Beauharnois Canal, Quebec, Canada

J. Peter & T. Kotras: Computer simulation of lock operations during winter ice months

D. J. Calkins & M. Mellor: Cost comparisons for lock wall deicing

V. Aleksandrov, V. Balanin, G. Onipchenko, V. Tronin: Inland navigation and maintenance of hydraulic structures at negative air temperature in ice-bound conditions

J. V. Danys: Ice movement control by the artificial islands in Lac St. Pierre

G. Tsang: A field study on ice piling on shores and the associated hydro-meteorological parameters

C. Argiroff: Planning the Great Lakes—St. Lawrence Seaway navigation season extension program

B. Michel & D. Berenger: Algorithm for accelerated growth of ice in a ship's track

G. D. Ashton: Experimental evaluation of bubbler-induced heat transfer coefficients

Theme 2—Ice jam control

P. H. Burgi: Hydraulic model studies of ice booms to control river ice

I. N. Sokolov & Ya. L. Gotlib: Ice jam control upstream and downstream from hydro power plants

M. S. Uzuner: Stability of ice blocks beneath an ice cover

E. Kanavin: Water velocity in open and frozen rivers—control of ice production

T. E. Osterkamp: Observations of the Tanana River ice

T. O. Hanley & B. Michel: Temperature patterns during the formation of border ice and frazil in a laboratory tank

V. V. Degtyarev, I. P. Butyagin, V. K. Morgunov: Investigation of ice jams on the Siberian rivers and measures taken to prevent them

J. M. Mariusson, S. Freysteinsson, E. B. Eliasson: Ice jam control. Experience from the Burfell Power Plant, Iceland

E. Zsilak: Some new relationships of the jammed ice motion

B. Michel & R. Abdelnour: Break-up of a solid river ice cover

R. Gerard: Preliminary observations of spring ice jams in Alberta

P. Rozsnyoi & I. Pados: Regulation of the development of ice barriers in the reach of the Tisza River above the barrage of Tiszalok for a secure winter operation of the barrage

R. R. Rumer, C. Atkinson, T. Lavender: Effects of Lake Erie-Niagara River ice boom on the ice regime of Lake Erie

Theme 3—Effects of sea ice on marine structures

P. Tryde: Intermittent ice forces acting on inclined wedges

M. Maattanen: Ice forces and vibrational behaviour of bottom founded steel lighthouses

R. C. Byrd & T. Carstens: The oscillating icebreaking platform

A. Assur: Problems in ice engineering

J. Schwarz: On the flexural strength and elasticity of saline ice

L. J. Zabilansky, D. E. Nevel, F. D. Haynes: Ice forces on simulated structures

L. Racicot & R. E. Perham: Forces on an ice boom in the Beauharnois Canal

A. Traetteberg, L. W. Gold, R. Frederking: The strain rate and temperature dependence of Young's modulus of ice

A. I. Pekhovitch, V. M. Zhidkikh, I. N. Shatalina, S. M. Aleinikov: Control of thickness and strength of ice cover

D. V. Reddy, P. S. Cheema, A. S. J. Swamidas, A. K. Haider: Stochestic response of a three dimensional offshore tower to ice forces

K. D. Vaudrey & M. G. Katona: Viscoelastic finite element analysis of sea ice sheets

R. J. Hodek & J. O. Doud: Instrumented piles for the measurement of ice-uplift forces

A. D. Kerr: Ice forces on structures due to a change of the water level

K. Hirayama, J. Schwarz, H. C. Wu: Ice forces on vertical pile indentation and penetration

F. G. Bercha & J. V. Danys: Prediction of ice force on conical offshore structures

M. Metge, A. Stilchuk, P. Trofinenkoff: On recording stresses in ice

Yu. V. Dolgopolov, V. P. Afanasiev, V. A. Korenkov, D. F. Panfilov: Effect of hummocked ice on the piers of marine hydraulic structures

R. J. Evans & D. A. Rothrock: Stress fields in pack ice

W. D. Hibler, W. B. Tucker, W. F. Weeks: Measurement of sea ice drift and deformation far from shore using Landsat and aerial photographic imagery

G. D. Rose, D. M. Masterson, C. E. Friesen: Some measurements of laterally-loaded ice sheets

R. F. Carlson, D. L. Kane, R. D. Seifert: Alaskan Arctic coast ice and snow dynamics as viewed by the NOAA satellites

V. M. Sinjavskaja & P. G. Dick: Field studies of ice action on structures

R. Gerard: A simple field measure of ice strength

SOCIETE HYDROTECHNIQUE DE FRANCE

The Glaciological Section of the Société Hydrotechnique de France made its 26th annual tour on 9-11 September 1974, visiting Val de Bagnes in Switzerland. Traces of recent and ancient variations of glaciers (especially the Otemma Glacier) are there particularly visible and well studied.

The 1975 annual meeting took place in Grenoble, St Martin d'Hères, on 6-7 March, and was attended by more than 80 scientists from France and Switzerland.

A—Avalanches

G. Bon Mardion, A. Eybert-Berard, C. Guelff, P. Perroud, L. Rey, (Laboratoire d'Applications Spéciales de la Physique, Centre d'Etudes Nucléaires de Grenoble): Mesures dynamiques dans l'avalanche. Résultats de la campagne 73-74.

J. Cl. Tochon-Danguy et E. Hopfinger (Institut de Mécanique, Université de Grenoble): Simulation des avalanches de neige poudreuse en canal noyé.

G. Bon Mardion, A. Eybert-Berard, C. Guelff (LASP, CENG): Cable transporteur d'explosif pour déclenchement préventif d'avalanches.

G. Bon Mardion et J. Meunier (LASP, CENG): Etude critique du capteur à empreinte pour avalanches.

B—Etude du manteau neigeux et de la surface des glaciers

F. Delsol (Centre d'Etudes de la Neige, Météorologie Nationale): Simulation de la formation du givre de profondeur.

M. Heyraud (Laboratoire de Glaciologie, Centre National de la Recherche Scientific): Transformation du névé en glace en présence d'eau.

J. P. Navarre (CEN, Météo.): Modèle mathématique de transfert d'énergie et de masse dans la neige.

A. Poggi (LG, CNRS): Bilan thermique en zone d'ablation du Glacier Ampère.

C—Observations glaciologiques

P. Veyret (Institut de Géographie Alpine, Université de Grenoble): Nouvelles observations glaciologiques sur les glaciers du Mont Blanc.

H. Gumuchian (IGA, Univ.): Glacières de Chartreuse.

M. Vallon (LG, CNRS): Campagne sismique aux Kerguelen.

D—Bilans glaciaires

L. de Crecy (Centre Technique du Génie Rural et des Eaux et Forêts): Bilan du glacier de Sarennes pour 1973-1974.

P. Kasser (Laboratoire d'Hydraulique, Hydrologie et Glaciologie, Institut Fédéral de Technologie, Zurich): Les variations des glaciers suisses en 1973-1974.

S. Martin (LG, CNRS): Corrélation entre bilans glaciaires et certains facteurs météorologiques.

E—Glaciologie interne

D. Raynaud (LG, CNRS): Implications de la teneur totale en gaz des glaces polaires.

F—Déplacements des glaciers

P. Duval (LG, CNRS): Rôle de la texture et de la teneur en eau dans la vitesse de fluage de la glace.

L. Lliboutry (LG, CNRS): Nouveaux développements sur la théorie du glissement des glaciers.

P. Desperrier (Institut de Géographie Alpine): Vitesses comparées en surface et au fond du glacier d'Argentière.

L. Reynaud (LG, CNRS): Recherches des fluctuations de vitesses à l'échelle de l'heure sur la Mer de Glace.

INTERNATIONAL COMMISSION OF SNOW AND ICE

During the 1975 Congress of the International Union of Geodesy and Geophysics (IUGG) in Grenoble, France, ICSI met under the Presidency of J. F. Nye. A Symposium was held on Isotopes and impurities in snow and ice and 92 papers were presented. The proceedings will be published by the International Association of Hydrological Sciences, the parent body of ICSI within IUGG. Enquiries about the Symposium should be addressed to Dr Fritz Müller (who was Secretary of ICSI at that time), Geographisches Institut, E.T.H. 8006 Zürich, Sonneggstrasse 5, Switzerland.

At the business meeting of the Commission, the following officers were elected:

President —	Uwe Radok (Australia)
Vice-Presidents —	V. M. Kotlyakov (USSR) E. R. LaChapelle (USA) H. Oeschger (Switz.)
Secretary —	M. Mellor (USA)
Chairmen of Divisions—	
Glaciers & Ice Sheets	C. Swithinbank (UK)
Ground Ice	J. R. Mackay (Canada)
Sea, Lake & River Ice	N. Untersteiner (USA)
Seasonal Snow Cover & Avalanches	B. Salm (Switzerland)

Tours of interest to glaciologists were held on a private basis after the Symposium; official tours had been cancelled. L. Lliboutry and R. Vivian organized separate groups and took considerable trouble to give visitors an insight into the laboratory and field work in the Grenoble area and in the Savoy Alps. Particularly memorable was the visit to the Argentière glacier, where more than 20 people, filmed by a professional television team, saw at first hand the research projects of various groups on and under the glacier.

The following Resolution, passed at the business meeting of ICSI, was adopted by the Plenary Meeting of IAHS and, on the recommendation of the Resolutions Committee, on the floor of the Union.

RESOLUTION

INTERNATIONAL UNION OF GEODESY AND GEOPHYSICS, (IUGG)

1) **Recognizing** that the International Commission for Snow and Ice (ICSI) of the International Association of Hydrological Sciences (IAHS), acting as a Working Group on Snow and Ice for the IHD Coordinating Council, has successfully initiated, promoted and supported the implementation of inventories of perennial snow and ice masses in many parts of the globe, and

2) **Emphasizing** the importance of this work
   a) for monitoring climatic change, and
   b) for the world water balance.

3) **Recalling** that ICSI in 1974 established a **Temporary Technical Secretariat**
   a) to coordinate and expedite the completion of national inventories
   b) to collect and standardize all this information
   c) to make it computer-compatible in one system
   d) to produce a global summary of the data, and
   e) to analyse this information,

4) **Recommends** that Member Countries, through their National Committees, co-operate with the Temporary Technical Secretariat for the World Inventory of Perennial Snow and Ice Masses, and assist ICSI in obtaining financial support, and

5) **Invites** the relevant international organisations (ICSU, UNEP, UNESCO, WMO) to participate in this cooperation and assistance.

Grenoble, 1 September 1975

GLACIOLOGICAL DIARY

1976 6–8 April
German Society of Polar Research 10th International Polar Meeting, Zürich, Switzerland. Main topic: "Climate and environment of glaciated regions". (Deutsche Gesellschaft für Polarforschung, c/o Institute für Geophysik, D-44, Münster (Westf.), Gievenbecker Weg 61, W. Germany.)

21–23 May
Quaternary Soils Symposium and field trip, Toronto, Canada. York University. (Dr W. C. Mahaney, Dept. of Geography, York University, 4700 Keele St., Toronto, M3J 2R7, Canada.)

22–26 July
Symposium on the geography of the polar regions, Leningrad, USSR, prior to International Geographical Congress. (A. F. Treshnikov, Organizing Committee of the 23rd International Geographical Congress, symposium: The Geography of the Polar Regions, Staromonetny per.29, Moscow 109017, USSR.)

26–30 July
Cloud Physics Conference, Boulder, CO, USA. Sponsored by International Association of Meteorology and Atmospheric Physics and International Commission on Cloud Physics; co-sponsored by American Meteorological Society. (H. K. Weickmann, NOAA/APCL, Boulder, CO 80302, USA.)

28 July–3 August
23rd International Geographical Congress, Moscow, USSR, (V. Annenkov, Institute of Geography, Academy of Sciences USSR, Staromonetny 29, Moscow 109017, USSR.)

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

23–27 August
International Weather Modification Conference, Colorado Springs, CO. Sponsored by International Association of Meteorology and Atmospheric Physics/International Commission on Cloud Physics and Weather Modification Panel of World Meteorological Organization; co-sponsored by American Meteorological Society and Academy of Science of Australia. (H. K. Weickmann, NOAA/APCL, Boulder, CO 80302, USA.)

12–18 September
Symposium on Problems of Applied Glaciology, Cambridge, England. International Glaciological Society. (Mrs H. Richardson, Secretary, Cambridge CB2 1ER, England.)

28 September–12 October
International Workshop on Dynamics of glacier variations and surges, Alma Ata, USSR. Section of Glaciology, Soviet Geophysical Committee. Tour to Tashkent and Moscow. (ICSI sponsorship). (Dr V. M. Kotlyakov, Institute of Geography, USSR Academy of Science, 29 Staromonetny Street, Moscow 109017, USSR.)

7–11 October
Conference and field trips with central theme: "Hot and cold deserts during the last glaciation", Tempe, Arizona, USA. American Association for Quaternary Research. (Dr Troy L. Péwé, Dept. of Geology, Arizona State University, AZ 85281, USA.)

1977 16–24 August
International Union for Quaternary Research, 10th Congress, Birmingham, England. Sponsored by the Royal Society. (Dr J. W. Jardine, Dept. of Geology, University of Glasgow, Glasgow G12 8QQ, U.K.)

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

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

1978 10–13 July
Third International Conference on Permafrost, Edmonton, Alberta, Canada. National Research Council of Canada. (M. K. Ward, c/o National Research Council of Canada, Ottawa, Ontario K1A 0R6, Canada.)

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

Arctic and Alpine Environments. Eds. J. D. Ives and R. G. Barry. Methuen, London, 1974, 999p. This impressive volume comprises 35 papers by specialist contributors in the first published book in which arctic and alpine environments are viewed together as parts of the same whole. There are seven major sections: present environments comprising climate, hydrology and ice; past environments, comprising palaeoclimatology and history of glaciation; present biota, comprising treelines, vegetation and terrestrial vertebrates; development of biota, comprising historical plant geography, and palaeoecology and palaeozoogeography; abiotic processes, comprising geomorphic processes and soils; man in cold environments, comprising bioclimatology and archaeology; and small and large scale exampling of man's impact on the environment.

Most of the chapters attempt a general treatment at a level comprehensible to the intelligent layman, and some (for instance Larsen and Barry on Palaeoclimatology, and Andrews on Cenozoic glaciations of the Arctic) contribute review articles which will be a real value to specialists in those fields. In most of the chapters however, the examples selected are predominantly north American, and the two chapters on Archaeology deal explicitly with the peopling and occupation of arctic North America (McGhee) and the Rocky Mountains (Husted).

In the preface, the editors stress the importance of the task of learning to understand the dynamics of the world's major ecosystems and the complex relationships between atmosphere, biosphere and lithosphere in which the arctic, as a relatively undisturbed area, has a considerable part to play. This task is given particular urgency by Seller's question, quoted by Larsen and Barry, whether the earth's climate always rests precariously in unstable equilibrium, and at the present day at the brink of an ice age; a question which endows many superficially obscure and academic studies with immediate relevance. Thus, our alarming ignorance of many dynamic interactions in the natural environment, referred to by the editors, should be a matter of wide concern. It is precisely here that the editors' hope, expressed in their preface, to identify gaps in our understanding, is, without reflection on them or the contributors, most harshly realised, for the structure of our knowledge reflects disciplinary boundaries defined by compartmentally organised scholarship over many years. As the editors imply, it is at the disciplinary interfaces that study of environmental interactions would be most profitable to our understanding. Clearly a chapter on the hydrological cycle and budget, or the relationships between soil and plant development, might usefully have been written, but in our present state of knowledge would probably have produced either trite generalisations, or over concentration upon specific examples, a pitfall which contributors have largely succeeded in avoiding.

Some of the omissions are a little surprising, however. The absence of chapters on the marine environment is a very serious lack. In the arctic, the seas form a fundamental link in the animal food chain, they have long been the staple support of human populations, they are currently a major problem in attempts to develop the arctic, they are one of the most critical links in the hydrologic cycle and a major determinant of climatic behaviour. It is also strange that one of the most powerful geomorphic processes in arctic areas, that of glacial erosion, is lost between chapters on geomorphic processes exclusive of glacial processes, and present ice cover exclusive of geomorphic processes.

In a book such as this, composed of articles from disparate disciplines, it is useful to have a matrix into which the individual studies can be fitted. The obvious matrix chapters are the historical ones of Larsen and Barry on palaeoclimatology, and Andrews on Cenozoic glaciations and crustal movements. The book would have been even more useful if the editors had themselves attempted to provide an overview.

Everyone with an interest in Arctic or Alpine areas will wish to buy this book, be he specialist or interested layman. The articles help fill out knowledge in an easily accessible way and enrich understanding of those environments. Unfortunately, the worst feature of the book is its price (£35): presumably it is aimed almost entirely at the library market. We urge the publishers to re-think their policy, and reproduce the book for the larger general sales that it deserves.

G. S. Boulton

Ice Ages: Ancient and Modern (Geological Journal Special Issue No. 6). Eds. A. E. Wright and F. Moseley. Seel House Press, Liverpool, 1975, 320p.

This book contains the lectures delivered at the 21st Inter-University Geological Congress, held in January 1974 at Birmingham University. Its theme is the study of glaciation through time: modern, then Pleistocene, then ancient. The papers can be summarised as follows.

Following an introduction by F. W. Shotton, G. S. Boulton's "Processes and patterns of subglacial sedimentation" discusses the roles of ice thickness, sliding velocity, particle size and shape and sub-glacial water pressure in controlling erosion, sedimentation and sediment deformation. With 17 figures and 38 equations, this paper is rich in new measurements, ideas and predictions, and should stimulate much thought and observation. "Glacial sediments", by E. A. Francis, includes a discussion of nomenclature and a review of work on till fabrics. "Glacitectonic structures", by P. H. Banham, again emphasises water pressure, and discusses the 100 m erratics and the 40 m diapirs in the 'Contorted Drift' of Norfolk. R. B. G. Williams reviews the 'periglacial' evidence for "The British climate during the Last Glaciation". This is a valuable summary of some hitherto scattered evidence bearing on temperature and precipitation, wind and pressure systems. W. H. Zagwijn discusses "Variations in climate as shown by pollen analysis, especially in the Lower Pleistocene of Europe": the record in NW Europe yields most information on mean summer temperatures, but in southern Europe on precipitation. G. R. Coope reviews the evidence of the Coleoptera for "Climatic fluctuations in northwest Europe since the Last interglacial". Beetles react much more quickly than pollen to climatic change, which may be one reason for the conflicting evidence on events some 43,000 and 12,000 years ago. "Changes of climate", by H. H. Lamb, emphasises the importance of geological and historical studies in discovering and explaining changes of climate which could hardly be predicted by meteorology alone.

R. F. Flint reviews and recommends the use of "Features other than Diamicts as evidence of Ancient Glaciations": erosional forms, rythmites, dropstones, ice contact drift and outwash, glacial loess and glacial marine sediments. "Glaciations through time", by W. B. Harland and Kay N. Herod, reviews reports of tillites in Caenozoic, Palaeozoic and Precambrian (especially 600-1000 and 2000-3000 Ma) time. A major problem is the association of the Varangian tillite with tropical (?) redbeds and dolomites. The paper has a valuable bibliography. "Late Precambrian glaciation in the North Atlantic region", by A. M. Spencer, describes the Varangian tillite more fully (660-680 Ma old, up to 1000 m thick, at least 1 interglacial). L. J. G. Schermerhorn on the "Tectonic framework of Late Precambrian supposed glacials" argues that many 'mixtites' may be mudflows deposited in response to tectonic activity. The controversy here is touched on in the previous two papers and in the final one. P. Allen, on "Ordovician glacials of the central Sahara", describes and illustrates a variety of glacial features excellently preserved in the middle of today's hot desert. These glacials may have been the cause of eustatic fluctuations deduced from the U.K. Ordovician. R. J. Adie on "Permo-Carboniferous glaciation of the Southern Hemisphere" reviews the abundant evidence from five continents and feels that it reflects a continental rather than local scale of glaciation. A. E. Wright and F. Moseley present a well-organized summary of the discussions.

Summarising the book as a whole, this is an excellent series of reviews, by experts. Those in the first, Pleistocene, part are of topics that tend to be reviewed fairly frequently in journals, but those in the second, "Ancient", part should form a standard reference, in line with Coleman's (1926) and Nairn's (ed. 1964) well known books. The book is essential for a library: the individual purchaser may be deterred by the price of £12 or $33.

J. T. Hollin

NEWS

PUBLICATIONS

Mountain glaciers of the Northern Hemisphere

This three-volume work, edited by **W. O. Field**, is a geographic study. Two volumes of text give detailed descriptions, with reference sources, of numerous glaciers and glacier groups. Special emphasis is given to fluctuations of the ice margins in historic times. An atlas volume shows the locations and outlines of glaciers in 49 plates. The work was performed by the American Geographical Society on behalf of the U.S. Army.

VOLUME 1 (704 pp)
- Western Europe
- Soviet Union
- Southern Asia
- Latin Asia
- United States (excluding Alaska)
- Western Canada

VOLUME 2 (932 pp)
- Alaska and Adjacent Canada
- Arctic Canada
- North Atlantic Islands

ATLAS (49 maps)
8½ x 11 inches
$20.00 ($22.50 outside USA)

The three-volume set is available from the National Technical Information Service, Springfield, Virginia. If you wish to receive an **order form**, please write to: U.S. Army Cold Regions and Engineering Laboratory, Technical Information Analysis Center, Box 282, Hanover, NH 03755, USA.

The **Bibliography on Cold Regions Science and Technology** was first published in 1951 and is a continuing publication of the Cold Regions Bibliography Section of the Library of Congress. It is sponsored and prepared for the Technical Information Analysis Center of USA CRREL. To date over 60,000 documents have been accessioned.

The present volume, edited by Geza T. Thuronyi, contains material accessioned between July 1974 and June 1975 numbered from 28-1 to 28-4032. Subject coverage deals principally with the physics and mechanics of snow, ice and frozen ground. Also covered are all aspects of cold regions and engineering such as road and building construction, earthwork, pipe laying, operation of vehicles, transportation, city planning, etc. During the past three years special emphasis has been placed upon ice engineering and the ecology of northern areas.

Periodical literature is the primary source for material in the bibliography. Approximately 500 journals which have been found to contain pertinent material are regularly searched. Indexes, abstracting journals, bibliographies and individual references are systematically covered to locate earlier published materials. Theses and dissertations, government documents, report literature, books and published patents are also regularly searched. Other published and unpublished reports are obtained through contact at scientific meetings and exchange agreements. Approximately 50% of all accessions are Russian.

Volume 28 is available from the National Technical Information Service, Springfield, Virginia. Earlier volumes are also available. Prices for each volume are $15.00 ($17.50 outside USA). If you wish to receive an **order form,** please write to: U.S. Army Cold Regions Research and Engineering Laboratory, Technical Information Analysis Center, Box 282, Hanover, N.H. 03755, USA.

The **Bollettino del Comitato Glaciologico Italiano** No. 22 (342 pages and 65 figures) was published in July 1975. This volume includes the following articles:

F. Röthlisberger: Glacier passages and climate variations. A study of the Col d'Hérens (Valais, Switzerland).
G. Nangeroni: Geomorphology by snow.
A. Desio: A visit to Kuthian, a glacier in Central Karakorum (Pakistan).
M. Panizza: Crumbling phenomena connected with glacio-pressure actions.
A. Riccoboni: Glaciological researches carried on in the Brenta Group up to today.
G. Perna: Interglacial and postglacial landslides in Southern Trentino (Northern Italy).
M. Pantaleo: Toponomastic notes about the glaciers of the Italian western and Pennine Alps.
C. Lesca: Italian contribution to the "World Inventory of perennial ice and snow masses".
C. Lesca: Glacier surface velocity measured by topographical methods.
C. Lesca: Glacier surface velocity and corresponding depths measured by analytical photogrammetry.

In 1975 42 operators examined 169 glaciers.

The Bollettino del C.G.I. can be got in exchange for glaciological publications or in payment (Lit. 7,000 to be sent to Comitato Glaciologico Italiano—Via Accademia delle Scienze, 5-10123 Torino, Italy).

The Board of Governors of the **Arctic Institute of North America** voted, in May 1975, to move the Institute's headquarters from Montreal to Calgary, Canada. At the same time, the Institute's information centre and publication programme were left in Montreal. The new location for the headquarters will be on the campus of the University of Calgary. Mr Robert C. Faylor, appointed Acting Executive Director, effective 1 June 1975, will supervise the establishment of the new office. Mr K. de la Barre will continue as director of the Montreal office.

Dr Robert H. Rutford, Director of the Ross Ice Shelf Project Management Office at the University of Nebraska-Lincoln, left on 14 April 1975 to become Head of the Office of Polar Programs at the U.S. National Science Foundation. The position of Head had been vacant since Mr J. O. Fletcher left OPP last year. Dr Rutford had been Principal Investigator and Project Co-ordinator of RISP and Director of the Management Office since June 1972.

Dr John W. Clough was appointed Science Director of the RISP Management Office as of 1 July 1975. He was formerly at the University of Wisconsin-Madison, where he received his Ph.D in geophysics. He has been active in research programs in Antarctica since 1965 and most recently was Senior Scientist for the Ross Ice Shelf Geophysical and Glaciological Survey. His research interests are in radio-echo sounding and seismic exploration.

Dr James H. Zumberge, Chancellor of the University of Nebraska-Lincoln since 1971, has resigned to become President of Southern

Methodist University, Dallas, Texas, effective 1 October 1975. Dr Zumberge established the RISP Management Office at Lincoln in June 1972, serving as its first Director. He was appointed to the National Science Board (the governing body of the U.S. National Science Foundation) last year and to its Executive Committee last May. He is also Chairman of the U.S. National Academy of Sciences' Polar Research Board, as well as the U.S. delegate to the Scientific Committee on Antarctic Research (SCAR).

Dr Robert Vivian, of the Institut de Géographie Alpine, rue Maurice Gignoux, 38031 Grenoble cedex, France, was awarded the Docteur d'Etat in 1975. The subject of the thesis is incorporated in his book "Les glaciers des Alpes Occidentales", which may be purchased through him. This is a geographical study of the glaciers of the Western Alps and comprises four parts, each preceded by a summary in English.

NEW MEMBERS

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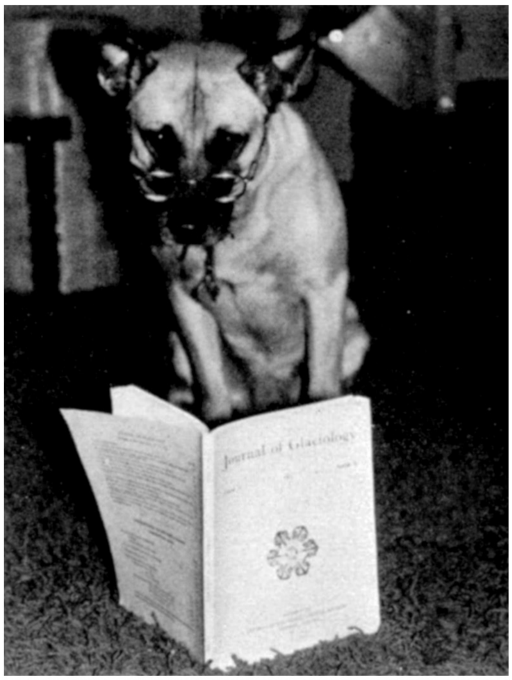

Our newest member?

(Photograph contributed by W. D. Harrison)

INTERNATIONAL GLACIOLOGICAL SOCIETY

Cambridge CB2 1ER, England

DETAILS OF MEMBERSHIP

Membership is open to all individuals who have scientific, practical or general interest in any aspect of snow and ice study. Payment covers purchase of the Journal of Glaciology and Ice. Forms for enrolment can be obtained from the Secretary. No proposer or seconder is required. Annual payments 1976:

Private members	Sterling:	£10.00
Junior members	Sterling:	£4.00 (under 25)
Institutions, libraries	Sterling:	£10.00 for Volume 16 (Number 74) £20.00 for Volume 17 (Nos. 75, 76, 77)

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

ICE

Editor: Hilda Richardson

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