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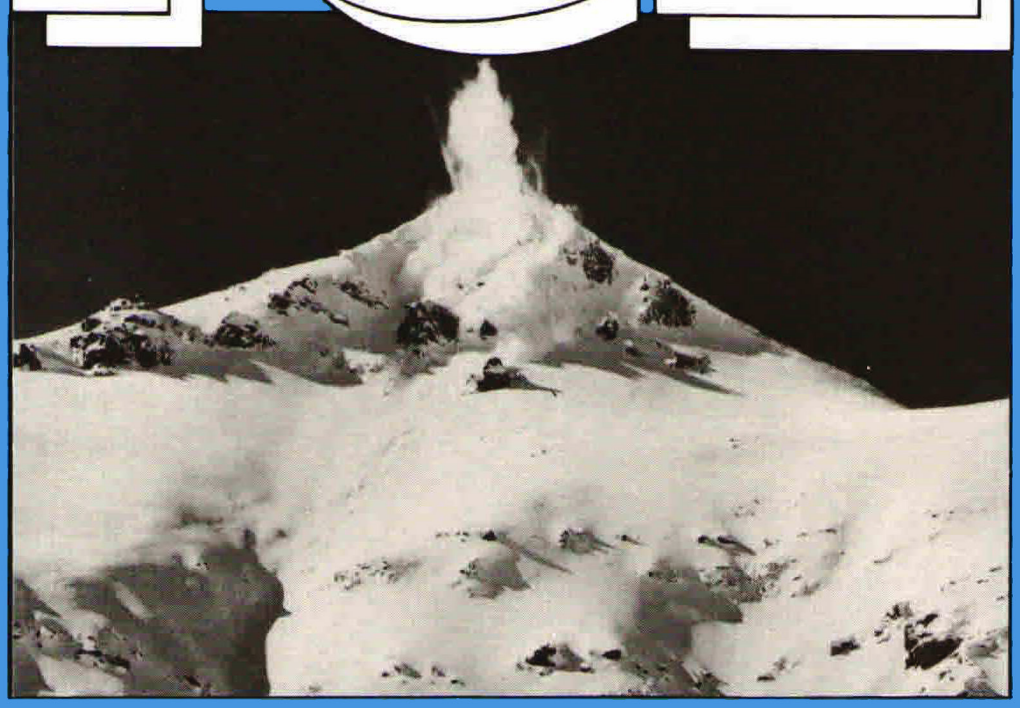
ICE



NEWS BULLETIN OF THE INTERNATIONAL GLACIOLOGICAL SOCIETY

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ICE

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COVER PICTURE: Release of avalanche in the Mount Temple area of Banff National Park 2 March 1965. Photograph from the National Research Council of Canada.

SWEDEN

SWEDISH LAPPLAND

MASS BALANCE OF STORGLACIÄREN 1988/89

(Wibjörn Karlén, Per Holmlund, Håken Grudd and Mats Eriksson, Department of Physical Geography, University of Stockholm, Sweden)

The net balance of Storglaciären 1988/89 was strongly postitive as, on average, 1.24 m w.eq. was added to its surface (3.0 km^2). This positive net balance value is the highest recorded since our measurements started in 1945/46 and the reason was a record accumulation (2.58 m w.eq.). While this winter balance value was 190% of the mean for the earlier 43 balance years, the summer balance (−1.34 m w.eq.) was quite normal or 90% of the mean value.

ICE RECESSION STUDIES

(Per Holmlund, Håken Grudd and Mats Eriksson, Department of Physical Geography, University of Stockholm, Sweden)

Since 1965 the snout recession of 20 glaciers in Lappland has been studied. During the summer of 1988, 17 of these were visited, but due to the high accumulation many snouts were snow-covered and could not be measured. In perspective, ice recession seems to be most rapid for the larger glaciers with long and flat snouts.

VELOCITY MEASUREMENTS ON STORGLACIÄREN

(Brian Hanson, Department of Geography, University of Delaware, Newark, USA; Roger LeB. Hooke and Gary Remple, Department of Geology and Geophysics, University of Minnesota, Minneapolis, USA)

A computer-controlled electronic distance meter (EDM) was aimed at a stake located in a relatively level area about 40 m down-glacier from the bergschrund. Measurements were taken every 10 min from 24 June until 21 July with only a few breaks of sufficient duration to cause problems with interpretation. Of particular interest was a peak in the velocity on 28-29 June during a period of high water input due to rain and high melt rates. This peak exceeded the mean velocity by a factor of nearly 4. Daily measurements of stakes in the upper half of the ablation area revealed a similar velocity peak there. Following this event, on 30 June the stake near the bergschrund experienced a short but distinct period of negative movement lasting several hours. We infer that the bergschrund had been opened (deepened) significantly by the preceeding period of high velocity, and that it closed once the velocity had decreased. One can think of the ice as having collapsed back against the cirque headwall. Such events offer the possiblity of intense erosion of the headwall, and thus help explain how steep cirque headwalls are excavated and maintained.

During periods of good weather, there was a diurnal variation in the velocity of the stake near the bergschrund. The amplitude of this variation was nearly double the minimum velocity. In 1988 several velocity peaks per day were detected by computer-controlled EDM measurements to a stake about 200 m down-glacier from the equilibrium line. This part of the glacier thus may be responding to subdiurnal signals.

Glacier	Size in 1963		Yearly recession			Total recession	Aspect of snout
	Area	Length	1965–77	1977–85	1985–89	1965–89	
	km^2	km	m	m	m	m	
1. Pårteglaciären	11.10	5.4	−14	−15	−11	332	E
2. Mikkajekna	7.62	4.6	−15	−18	−12	373	S
3. Ruotesjekna	5.41	4.6	−14	−11	−15	320	N
4. Rabots Glaciär	4.22	4.1	−10	−13	−11	268	W
5. Ruopsokjekna	3.63	3.9	−8	−5	−5	156	N
6. Storglaciären	3.10	3.7	−6	−4	−3	110	E
7. Riukojietna	5.53	3.3	−12	−10	−2	230	E
8. Kårsojietna	1.58	2.2	−6	−7	−7	198	E
9. Unna Räitagl.	1.95	2.1	−5	−3	−2	88	NE
10. Isfallsglaciären	1.40	2.1	−8	−7	−2	172	E
11. S.Ö. Kaskasatj.gl.	0.60	1.4	−10	−3	−2	157	S

HYDROLOGICAL STUDIES ON STORGLACIÄREN

(Jack Kohler, Department of Geology and Geophysics, University of Minnesota, Minneapolis, U.S.A.)

In experiments in 1988, water flowing into moulins near the middle of the ablation area, about 1 km from the glacier terminus, and water discharge 300 m below the terminus were monitored simultaneously. These data were analyzed, using digital signal analysis tecnniques, to determine the time delay in the drainage system. The resulting transfer function has a dominant peak at about 30 min. In a simultaneous tracer experiment, salt took about 85 min to pass through the system. If the conduit through which the water passes was an open channel over its entire length, open-channel flow theory suggests that a discharge signal should have taken about 60 min to pass through the glacier. The 30 min delay indicated by the transfer function suggests that the conduit is closed, or full, over part of its length.

BORE-HOLE STUDIES ON STORGLACIÄREN

(Viejo Pohjola, Department of Physical Geography, University of Uppsala, Sweden; Roger LeB. Hooke, Department of Geology and Geophysics, University of Minnesota, Minneapolis, USA)

Four bore holes, ranging in depth from 130 to 160 m, were drilled to the bed in the upper half of the ablation area in order to study englacial and subglacial features. It is believed that there may be a subglacial layer of deformable till in this area. An effort was made to observe this layer with a video camera, and to sample it with a coring device and with a sand trap on the drill tip. The latter retrieved medium to coarse sand from the bottoms of at least two of the holes. The coring was unsuccessful, however, although the corer was fitted with a trap door that closed fairly tightly, and with a driving hammer. The tip of the core tube was usually dented when it was returned to the surface, suggesting that it had encountered either a large rock or bedrock. The till in front of the glacier has a surface layer of cobbles and boulders, so the possibility of a till layer being present is not ruled out.

The video camera revealed between 4 and 6 englacial conduits in each hole. The conduits were crack-shaped, about 0.1 m high and wider than the 0.2 m wide bore holes. They often occurred at the boundary between white and blue ice, suggesting control by primary sedimentary layering. Not all of the conduits appeared to be draining, and flow rates were surprisingly low in those that were, despite their large size and a head of *c.* 1 m/km. This suggests that constrictions occur in them.

The bed was clearly visible in only one hole. It consisted of a few scattered sand and gravel particles in a matrix of silt. It was observed for about 1 h at midday, during which time a sliding velocity of about 90 mm/d, nearly three times the daily mean, was measured. Then a cloud of silt rose slowly around the camera, indicating an influx of water from the bed.

SEISMIC GEOPHYSICS ON STORGLACIÄREN

(Jonathan Paetz, Department of Geology and Geophysics, University of Minnesota, Minneapolis, USA)

Several seismic reflection/refraction profiles were shot in an effort to detect the till layer. Preliminary analysis of one of the records suggests the presence of three reflectors. The highest, at a depth of 44 m, is probably the boundary between cold ice at the glacier surface and ice at the pressure-melting temperature deeper in the glacier. The second, at a depth of 164 m, is almost certainly the bed. Below this is a 15 m thick low-velocity layer. This layer, however, is thicker and has a higher velocity (1160 m/s) than we would expect if it were the till layer sought.

RADAR MEASUREMENTS ON STORGLACIÄREN

(Per Holmlund and Mats Eriksson, Department of Physical Geography, University of Stockholm, Sweden)

The thickness of the cold, water-free surface layer was mapped using a high frequency radar. In the ablation area of Storglaciären the layer was approximately 30 m thick. It was thicker along the edges and thinner in the central part of the tongue. The thickness pattern shows similarities wiith the pattern of the vertical velocity on Storglaciären. Downgoing or slightly upgoing movement is associated with large depths of the cold surface layer and conversely, high rates of upgoing movement give shallow depths. The mapping was performed using a stepfrequency radar (K-radar) which, through Fourier analysis, transformed changes in phase and amplitude of continuous wave (CW) signals into the time domain. The equipment was drawn on a sledge by a snow-mobile. The system is well prepared for field use and gives a good opportunity for data processing.

ARCTIC

ICE-CORE STUDIES ON SUPERIMPOSED ICE FROM STORÖYJÖKULEN, SVALBARD

(Stig Jonsson, Department of Physical Geography, and Margareta Hansson, Department of Meteorology, University of Stockholm, Sweden)

A pilot study to identify the annual layers in superimposed ice has been completed. A short ice core was recovered in 1980 from the summit of Storöyjökulen, a small ice cap in northeastern Svalbard that is entirely fed by superimposed ice.

Large variations in ice texture (crystal size

and shape), ice structure (bubbliness), micro-particle content, and solid electrical conductivity have been found and interpreted as representing seasonal cycles as they normally vary in phase. The combination of many ice-core parameters has also allowed the clarification of many ambiguous features.

The net balance at the summit of Storöy-jökulen has been calculated and found to be 27 cm of ice between 1954 and 1979. A good correlation has been found between this net balance and the mean temperature at Hopen in southeastern Svalbard, if the temperatures are calculated per mass-balance year. This correlation also indicates that there are no missing years in the record, that is, no years with negative mass balance at the summit of the ice cap.

NORDIC RENLAND GLACIER PROJECT
(Marareta Hansson, Department of Meteorology, University of Stockhom, Sweden, and others)
Coldroom work continued in Copenhagen, Denmark, on the 325 m ice core drilled to bedrock in 1988 on a cold ice cap in East Greenland.

ANTARCTICA

ACCUMULATION STUDIES IN WESTERN DRONNING MAUD LAND
(Wibjörn Karlén and Elisabeth Isaksson, Department of Physical Geography, University of Stockholm, Sweden)
Bamboo stakes put down every 500 m between Vestfjella and Heimefrontfjella in 1988 were remeasured. The results show an average accumulation of 11 cm w.eq. between February 1988 and January 1989. Locally, no accumulation at all had taken place. The stake net was extended to the edge of the Riiser-Larsen Ice Shelf.

Twelve 10 m ice cores were retrieved with a 3 inch PICO corer between 30 m a.s.l. and 3000 m a.s.l. (360 km inland) and 10 m temperatures were noted. Oxygen analysis has been carried out at the Universities of Uppsala, Sweden, and Copenhagen, Denmark.

ICE-FLOW AND ICE-DEPTH MEASUREMENTS IN WESTERN DRONNING MAUD LAND
(Per Holmlund, Department of Physical Geography, University of Stockholm, Sweden)
Stake lines and grids were surveyed with a theodolite (Wild T-2) and a geodimeter (AGA 114) from nunataks in northern Vestfjella and central Heimefrontfjella. 14 GPS-positioned stakes were placed in the area between these nunatak ranges.

A new Norwegian radio-echo rig was installed in a McDonell 500E helicopter. The total distance of profiles measured around and between Vestfjella and the Heimefrontfjella was about 2000 km. A GPS-Magnavox MX 4400 was used for navigation.

BLUE-ICE STUDIES IN SCHARFFENBERG-BOTNEN, HEIMEFRONTFJELLA
(Stig Jonsson and Per Holmlund, Department of Physical Geography, University of Stockholm, Sweden)
The field area is located in a 3 × 6 km large, cirque-like basin on the northwestern, downstream side of the nunatak range. In 1988 a net of 28 stakes was established for studies of ablation and ice movement. Most of these stakes were remeasured in 1989. The main object has been to determine the net ablation in the basin as well as the compensating inflow from the ice sheet proper. To achieve the latter, the ice depths of all entrances to the basin (as well as the basin interior) were mapped by the use of radio-echo technique in 1988. Continuous weather data has been delivered over the Argos system between 2 November 1988 and 4 April 1989.

A maximum ablation of 20 cm of ice was measured between January 1988 and 1989. Due to the net ablation of the blue-ice area, ice movement is directed towards the ice surface in the bottom of the basin. Although all ablation of the ice surface is achieved by evaporation, the ice around darker englacial sediments (from stones down to layers of finer particles) starts to melt englacially before the particles reach the ice surface. This englacial melting process will be studied in 1990.

Submitted by Stig Jonsson

EXCLUSION CLAUSE. *While care is taken to provide accurate accounts and information in the Newsletter, neither the editor nor the International Glaciological Society undertakes any liability for omissions or errors.*

ANTARCTICA

AIRFIELDS ON ANTARCTIC GLACIER ICE
(Charles Swithinbank, Scott Polar Research Institute, University of Cambridge, and Malcolm Mellor, Cold Regions Research and Engineering Laboratory, Hanover, NH, USA)
The project involves a search for blue icefields in Antarctica suitable for use by conventional transport aircraft on wheels. Blue icefields occur in many areas both near the coast and as far south as latitude 87°S. Following an examination of air photographs of the Transantarctic Mountains, 30 blue-ice areas were reconnoitred from the air, using a ski-wheel Twin Otter operating from the South Pole. Two sites were selected as potential airfields, and ground surveys were made. On the Mill Glacier at 85°06′S, 167°15′E there is an area of smooth and level ice which gives a 7 km run directly into the prevailing wind. Five wheel landings were made there. Alongside Mount Howe there is a large area of level ice at 87°20′S, 149°50′W. It too offers a 7 km runway, but there is a strong crosswind component from the prevailing wind and some minor bumps on the ice surface need to be planed off. Preliminary results have been published as *CRREL Special Report 89-19*.

CENOZOIC GLACIAL RECORD OF THE PRYDZ BAY CONTINENTAL SHELF, EAST ANTARCTICA
(Michael J. Hambrey, Scott Polar Research Institute, University of Cambridge, W.U. Ehrmann, Alfred-Wegener-Institut, Bremerhaven, and B. Larsen, Danmarks Geologiske Undersogelse)
In early 1988 the Ocean Drilling Program drilled five sites on the Prydz Bay continental shelf. A record of glaciation spanning possibly as much as 40 million years was obtained, with full-scale ice-sheet development much earlier than previously thought, and confirming the record of glaciation in McMurdo Sound. This project aims to characterise the depositional environment, dominated by ice reaching the former continental shelf break. A manuscript detailing the stratigraphy, sedimentary facies and a wide variety of sediment parameters has been submitted for publication in ODP Leg 119 scientific results volume. Site reports and preliminary interpretations were published in ODP Leg 119 Initial Reports in August. A summary paper was published in *Polar Record* 25, 99-106.

RONNE ICE SHELF
(A. Jenkins, BAS*)
A programme of field measurements and data analysis has been completed at 28 sites on Ronne Ice Shelf. The sites lie along a flowline from Rutford Ice Stream and extend 760 km to the ice front. A steady state model indicates that basal melting occurs over the first 300 km of the flowline downstream of the grounding line. Freezing then dominates up to the final 100 km before the ice front, resulting in the accumulation of a layer of basal sea-ice up to 50 m thick. This is rapidly removed as basal melt rates increase to over 6 m/a at the ice front. The derived pattern of basal melting and freezing is consistent with a conceptually simple model of sub-ice-shelf oceanic circulation, involving a deep thermohaline convection cell. Understanding the sensitivity of the circulation to climatic change is an important goal. Estimates show that if the relatively warm Circumpolar Deep Water penetrated beneath Ronne Ice Shelf, as it does beneath George VI Ice Shelf, thinning rates could be as high as 10–15 m/a near the Rutford Ice Stream grounding line.

BASAL BOUNDARY CONDITIONS
(D.G. Vaughan and C.S.M. Doake, BAS)
A data set gathered along a flowline crossing the Doake Ice Rumples has been analysed using different mathematical models. Vaughan used a Fourier decomposition of an extension of the biharmonic equation to obtain analytic results for the variational part of an approximation to the steady state flow, while Doake applied an inverse method to solve the full conservation equations of mass, momentum and energy, in which extra boundary conditions on the surface were used to replace the unknown ones on the base. Both solutions gave the basal shear stress distribution along the flowline. Although the model results differed in detail, the agreement between them is encouraging. A common feature was the inadequacy of 2-D models to adequately describe the stress regime.

FINITE ELEMENT ICE FLOW MODEL
(R.M. Frolich, BAS)
The flow of Rutford Ice Stream and its interaction with Ronne Ice Shelf is being studied using a finite element model in which the basic momentum balance equations are integrated in the vertical direction. The model has been developed from the one used by D.R. MacAyeal from Chicago University to describe the flow of Ice Stream B on the Siple Coast. The model contains a description of the basal boundary layer in terms of a deformable till with a linear viscosity. Frolich has extended the model domain to include the catchment area so that the upstream boundary is the ice divide. Results for the ice stream indicate that friction at the side walls plays

* BAS = British Antarctic Survey, Ice and Climate Division, Cambridge, UK

an important part in providing restraint for the whole ice stream but the ice near the margins is apparently softer than in the middle. If the restraint from the ice shelf is steadily removed, the ice stream thins and the grounding line retreats. However, the influence on the inland ice sheet is relatively small and disturbances take several hundred years to propagate a significant distance upstream. This suggests that, even though ice shelves may undergo a rapid disintegration, the effect on the grounded ice could take a long time to contribute to sea-level rise.

HOT WATER DRILLING
(K. Makinson and K. Nicholls, BAS)
An enhanced hot water drilling system has been developed, incorporating 400 kW of heating power to create and maintain a borehole through Ronne Ice Shelf. A new set of drill heads has been designed. The drill head now incorporates a compressible mechanical valve system to show when the head is in physical contact with the base of the hole. This warns the operator that he is jeopardising a straight and true borehole by attempting to drill too fast. A further development is the inclusion of water sprays at the back of the drill head. In the event of borehole closure above the drill head, a less powerful but still effective hot water drilling action upwards should release the drill. A set of the BAS-designed drill heads was tested by Makinson and the Norwegian Antarctic Expedition drilling team on the Suphellebreen in Norway. The results were encouraging. Nicholls has analysed the transfer of heat between ice shelf and the fluid-filled borehole, during a sequence of periods of drilling, reaming and no activity, to allow a drilling protocol to be formulated which optimises the time for which equipment can be deployed and still be recovered safely.

OCEANOGRAPHIC MEASUREMENTS
(K.W. Nicholls, BAS)
Accurate measurements of temperature and salinity are necessary pre-requisites for understanding the circulation under ice shelves. They are particularly needed to pin-point the presence of supercooled water formed by the upward movement of water involved in the melting at the base of ice shelves. For summer field work through hot-water drilled access holes a borehole-deployable CTD system that works in tandem with a slim-line water sampling bottle is required. The bottle can be fired from the surface both with and without a filter which can eliminate the frazil ice crystals that are the hallmark of supercooled water.

CALIBRATION OF THERMISTORS
(K. Makinson, BAS)
Thermistors require accurate calibration and checks on their characteristics before being chosen for critical measurements where accuracy is needed to a few milledegrees. The long-term stability of potted-up thermistor cables is now checked by immersion in a large 250 litre, well-stirred and insulated bath, containing a mixture of ice, water and salt. The eutectic freezing point (between 0° and −5°C depending on the proportion of salt) is stable to a few milledegrees for some hours. Such procedures have shown discrepancies of up to 10 millidegrees from the earlier calibrations. Calibrated thermistor cables, accurate to a few millidegrees, have been constructed and are now available for deployment next season for studies of the thermal regime of ice shelf and ocean on Ronne Ice Shelf.

TEMPERATURE PROFILES
(K. Nicholls and J.G. Paren, BAS)
Analysis of ice shelf temperature profiles has continued. A numerical model has been constructed, which uses realistic thermal properties of ice and allows the climatic and oceanographic conditions at the upper and lower surfaces of the ice shelf to be varied with time. The model has then been used to find the simplest climate history that would be needed to account for the observed present-day ice temperature profiles. The work has been extended to include ice temperature profiles from grounded ice sheets. The climate histories obtained from all the sites show a surface warming of between 1° and 3°C over a period of 20–40 years. The relationship between near-surface ice temperatures and climatic variations on annual and decadal timescales is clearly very important to this research, and is the subject of continuing study.

ICE CORE DRILLING
(D.A. Peel, A.P. Reid, BAS,
L.G. Thompson, K. Najmulski, Byrd Polar Research Center (BPRC), Ohio State University, U.S.A., C. Raymond,
B. Weertmann, Geophysical Research Group, University of Washington, USA, and B. Koci, Polar Ice Coring Office, University of Alaska, Fairbanks, USA)
The project moved into its second stage this year with deeper electromechanical drilling on Dyer Plateau (70°39′S, 65°01′W). The drilling site, on the crest of the Antarctic Peninsula, lies close to the major climatic divide separating the maritime regime of the west coast from the colder, more continental regime of the east coast. It is expected that climate at the site will be sensitive to any shift in the pattern of atmospheric circulation on the two sides of the Peninsula, and to changes in the extent of the sea-ice zone. The team successfully drilled two ice cores (233 and 235 m deep), representing approximately 600 years' snowfall, which should span completely the last major, sustained global climate event — the Little Ice Age. The cores will be analysed jointly by BAS and BPRC. Preliminary examination shows that throughout the 600-year history of

the site there has been no summer melting, hence the stratigraphic records should be exceptionally well preserved.

ICE CORE ANALYSIS

(R. Mulvaney, A.P. Reid, and G. Coulson, BAS)

Analytical work has focussed on a shallow core (7.8 m depth) collected from a site in Coats Land (77°02′ S, 22°32′ W) inland from Halley Station. The purpose of collecting this core was to test the hypothesis that springtime depletion of stratospheric nitrogen produces an increase in nitric acid in the tropospheric aerosol that is detectable in an ice core. The anionic species Cl^-, NO_3^- and SO_4^{2-}, and sodium as marine salt reference were analysed at extremely fine resolution through the 26-year profile. The NO_3^- profiles in the ice core show clear annual cycles with more NO_3^- in the early summer than sites in the Antarctic Peninsula. This may reflect the location of the polar vortex which lies mainly over central Antarctica. Analysis is underway to test whether there has been a change in the quantity or timing of the stratospheric nitrate input to the Coats Land core since the appearance of the ozone hole in the late 1970s.

METHANE SULPHONIC ACID

(D. Peel, BAS, and E. Saltzman, University of Miami, USA)

Analysis has continued on the 133 m ice core collected from Dolleman Island in 1986. A collaborative project to measure methane sulphonic acid (MSA) has produced some startling results. Concentrations are several times greater than corresponding values from ice cores collected in Greenland or from other locations in Antarctica. MSA, like much of the non-sea-salt sulphate, is a product of photochemical oxidation of marine biogenic sulphurous gases. The results are an indication of the high level of biological activity in the Weddell Sea region. An intriguing aspect of the results is that the majority of MSA appears in late autumn snowfall.

DYER PLATEAU ICE CORE

(R. Mulvaney, G. Coulson, and A.P. Reid, BAS)

A start has been made on the analysis of the ice core collected from a site (70°39′ S, 65°01′ W) on the Dyer Plateau during the 1988–89 field season. New techniques have been developed to increase the core processing speed substantially without compromising analytical quality. The anionic species Cl^-, NO_3^- and SO_4^{2-} on the upper sections of the core were measured and this will be followed later by analysis of the major cationic species and oxygen and hydrogen isotopes.

HALLEY SNOWFALL

(R. Mulvaney and E.W. Wolff, BAS)

A programme has been initiated to collect snowfall throughout the year at Halley Station, Brunt Ice Shelf. The surface will be sampled daily for at least one year, and analysed for all major chemical species. This will allow a detailed consideration of the factors — environmental, meteorological, and post-depositional — that may affect the concentrations measured in snow.

ECM

(E.W. Wolff and D.A. Peel, BAS)

An electrical conductivity measurement (ECM) system has been designed and built. This device, originally developed in Denmark, consists of a pair of electrodes that are drawn along the surface of an ice core. A high voltage is applied, and the resulting current is fed to a chart recorder. The current has been shown to indicate the acidity of the core. The BAS device has been tested on cores from Dolleman Island and from the Dyer Plateau, and gives results very similar to its Danish counterpart. The tests showed that the method gives seasonal signals that can probably be used for a provisional dating. The new device was used in the field on some of the cores drilled at Dyer Plateau in 1990.

HEAVY METALS

(E.D. Suttie and E.W. Wolff, BAS)

Techniques have been refined such that concentrations as low as 0.1 pg g^{-1} of lead can be measured. This is below the smallest concentrations expected in Antarctic snow. Using these techniques, analysis has begun of sequences of snow blocks from Dolleman Island and Coats Land. The surface concentrations appear similar to those measured elsewhere in Antarctica, and values from deeper ice will be available soon. One controversy surrounding heavy metal data from snow and ice has been the question of how much of what is measured is indicative of global-scale pollution, and how much is due to local emissions. To answer this question, snow samples were collected in 1989 at various distances and directions from a generator burning leaded petrol. Calculations show that over 50% of the lead emitted by the generator fell out within 40 m of it. Local sources at ground level may appear to have a rather small effect on snow concentrations at a distance. Lead emissions from aircraft using leaded fuel, which must spread contamination over a large area, remain the greatest concern to scientists carrying out these studies.

DIELECTRIC PROFILING

(J. Moore, BAS, and H. Narita, ILTS, Hokkaido University, Japan)

Moore spent one year on a research fellowship at the Institute of Low Temperature Science (ILTS), Sapporo, Japan, where he continued the development of the dielectric profiling (DEP) ice-core analysis system. The DEP rechnique is a non-destructive a.c. electrical analysis method that is sensitive to both the acid and the neutral salt concentrations in ice being measured. Two recently drilled 100 m cores, G15 and K5

from East Dronning Maud Land, were profiled. Narita is doing comparative ECM measurements on the cores together with thin section work. The DEP measurements of the G15 core, which covers about 800 years, show clear signs of volcanic signals. The K5 core, which spans an estimated 5–20 thousand years, shows oxygen isotope and carbon dioxide levels that are characteristic of ice deposited in the ice age. The core also has a high DEP conductivity probably caused by the high levels of marine impurities commonly observed in ice-age ice. It may be possible to date the core by comparison of notable features in the ECM and DEP records with chemical profiles from longer, well dated ice cores. Parts of both cores will be sent to BAS for major ion chemistry. By combining the physical and chemical analyses it should be possible to produce a comprehensive model of the electrical conduction process in ice from a wide range of environments.

ICE PETROGRAPHY, STABLE ISOTOPES AND SALINITY IN FIRST-YEAR AND MULTI-YEAR SEA ICE FROM THE ANTARCTIC PENINSULA

(Jean-Louis Tison, Département des Sciences de la Terre et de l'Environnement, Université de Bruxelles, Belgium, Elizabeth M. Morris, British Antarctic Survey, Cambridge, Roland Souchez, Université Libre de Bruxelles, Belgium, and Jean Jouzel, Laboratoire de Géochimie Isotopique, Saclay, France)

Ice petrography, stable isotopes and salinity are used to determine sea-ice stratigraphy. The combined stable isotopes and salinity profiles allow the determination of the growth rates and of the conductive heat flux through the ice cover in suitable conditions. The same profiles record possible fluctuations in the composition of the parent water and therefore may allow the sea-ice growth processes occurring in front of large ice-shelves to be related to melting events at their base. Preliminary results form a 5.54 m multi-year sea-ice core from the rift area south of George VI Ice Shelf (Antarctica) give isotopes and salinity profiles that show large-scale synchronous variations, indicating the primary effect of changing parent waters. Applying mixing models that take into account the composition of the various water sources in the environment and the plausible range of fractionation coefficients for isotopes and salts during water–ice phase changes, major dilution events of the Circumpolar Deep Water by meltwaters from the base of the George VI Ice Shelf could be reconstructed. Mixing coefficients probably reach 15% of fresh water during the winter (three major events) and up to 80% during the summer. A total accretion between 1.0 and 1.5 m could be accounted for by the freezing of these mixed waters. A study of the spatial variability of the process is currently undertaken by analyzing other cores from the same area. Synchronous sampling of first-year sea ice and recording of detailed meteorological data are currently undertaken near Rothera Base to relate major meteorological events to the variability of the ice types in the sea-ice cover.

STRUCTURE AND DYNAMICS OF THE LAMBERT GLACIER–AMERY ICE SHELF SYSTEM

(Michael J. Hambrey, Scott Polar Research Institute, Cambridge, W.U. Ehrmann, Alfred-Wegener-Institut, and B.K. Larsen, Danmarks Geologiske Undersogelse)

In order to provide constraints on sediment transport paths to the Prydz Bay sites, a detailed assessment has been made of the structure of the Lambert Glacier–Amery Ice Shelf system. The question whether this system is in or out of balance has been much debated in recent years, and surge-type behaviour has been suggested. The structure is dominated by a longitudinal foliation ("flow-lines" to many glaciologists), and shows that the flow through the basin is in steady state. Further, the Lambert Glacier contributes only about one quarter of the ice reaching the seaward limit of the Amery Ice Shelf, the remainder originating from more northerly sources. Landsat images have been analysed and a structural map produced.

ARCTIC

DYNAMICS OF SVALBARD SURGE-TYPE GLACIERS

(Gordon Hamilton and Julian Dowdeswell, Scott Polar Research Institute, University of Cambridge)

A small late quiescent surge-type glacier in central Spitsbergen was identified from air photographs for detailed field investigation. The glacier, Bjuvbreen, has developed a large wave-like bulge in its upper catchment, above which ice is accumulating. Below this feature stagnation is occurring. The first field season was in summer 1989. Over a two-month period ice-surface velocities and strain rates were repetitively surveyed, an hourly record of proglacial stream discharge was obtained and samples of suspended sediment concentration were collected. These data will aid our understanding between the subglacial hydrological system and short-term ice-velocity fluctuations. Preliminary data analyses indicate that velocities in the upper reaches of the glacier have increased since measurements made in 1986 by Norsk Polarinstitutt.

OKSTINDAN GLACIER PROJECT

(Wilf Theakstone, Geography Department, University of Manchester, Tvis Knudsen and Jens Tyge Moller, Aarhus University, Denmark, He Yuanqing, University of Manchester)

Glacier hydrological, mass balance and surface deformation studies at Austre Okstindbreen have been made since 1976, and observations

of glacier change since 1970. Although routine sampling of glacier river water for isotopic and chemical analyses continued, studies in 1989 (three field seasons: May, July–August, September) concentrated on accumulation area processes. Spatial and temporal variations of inputs to the glacier's drainage systems are being related to local weather conditions, fractionation processes and the composition of deposited snow.

SVARTISEN RESEARCH PROJECT
(Wilf Theakstone, Geography Department, Manchester University, Tvis Knudsen and Jens Tyge Moller, Aarhus University, Denmark, and He Yuanqing, Manchester University)
The project, which studies glacier change in relation to climate especially through photogrammetry, is now in its fourth decade. Maps of the Svartisen glaciers based on 1985 aerial photographs are being produced in Aarhus for comparison with earlier maps (1945, 1968) as part of the programme of investigation of glacier change in relation to climatic parameters, glacier geometry and glacier dynamics.

REMOTE SENSING

RADIO TRANSMITTING TRACERS FOR GLACIAL HYDROLOGY
(Mike Walford, University of Bristol. Department of Physics)
Radio waves travel through ice water as long as the material has sufficiently low conductivity. So the progress of a small radio transmitter could be monitored by a receiver on the glacier surface and, furthermore, data could be transmitted from within the ice. The results of a pilot experiment, in which a transmitter was lowered down a water-filled bore hole, were analysed in terms of a model involving a single polarizable body near the hole. The transmitters have been reduced in size; they now can fit inside a 35 mm film container.

DISINTEGRATION OF WORDIE ICE SHELF, WEST COAST ANTARCTIC PENINSULA
(D.G. Vaughan and C.S.M. Doake, BAS)
The positions of the ice front have been mapped from ground surveys, aerial photographs and satellite images and show a pattern of episodic retreat. The confused nature of the surface, which in many areas resembles large blocks of ice "glued" together with sea ice and snow, calls into question the definition of an ice shelf. Although there has been a very significant change in the ice shelf itself, there is no firm evidence that corresponding changes in the flow of the outlet glaciers off the mainland have occurred. A possible explanation of the ice shelf breakup is that a steady atmospheric warming has led to increased ablation during the summer and made the net annual mass balance negative. This would loosen the "glue" and allow icebergs to be dispersed readily by the wind and oceanic currents.

RADAR SOUNDING
(H.F.J. Corr, BAS)
An impulse radar has been designed and built to provide high resolution data on internal structures and basal conditions. A broad band transmitter and receiver system uses a tuneable aerial constructed from resistively loaded elements. Each received waveform is digitised at up to 200 MHz and stacked to improve the signal-to-noise ratio. Corr was invited by the Norwegian Antarctic Expedition to carry out experiments and tests with his equipment on the Fimbul Ice Shelf during the 1989–90 season. He used separate transmitting and receiving dipoles with a centre frequency of 30 MHz to obtain several profiles along the flow line at a Norwegian hot-water drilling site. The data will be processed for, among other things, the continuity of the reflecting layers. One of the aims of this work is to compare the depth of reflecting layers with that of significant chemical and physical horizons detected in ice cores and to extrapolate these horizons over larger areas.

ERS-1
(A.P.R. Cooper, C.S.M. Doake and J.G. Paren, BAS)
The forthcoming launch of the ERS-1 satellite, now due for early 1991, offers exciting possibilities for investigating many aspects of the Antarctic Ice Sheet. Accurate surface elevations from radar altimetry are expected to be some of the most popular items of data. In preparation for the demand, Cooper has been specifying algorithms for the Earth Observation Data Centre that will be used to correct the data for the offset caused by surface slopes. Cooper, Doake and Paren are Principal Investigators for the European Space Agency (ESA) international project called Ice Sheet Research using ERS-1 (ISRERS-1). Plans include using a Synthetic Aperture Radar (SAR) interferometric technique for obtaining the surface topography of Rutford Ice Stream close to the Ellsworth Mountains.

SATELLITE ALTIMETRY OVER ICE SHEETS AND SHELVES
(Jonathan Bamber, Wyn Cudlip, David Mantripp, Chris Rapley and Jeff Ridley, Mullard Space Science Laboratory, Department of Physics and Astronomy, University College, London)
The use of altimeter data for mass balance and seasonal surface snow studies is being investigated. Techniques for producing high precision topographic maps are also being developed and include new methods for retracking and estimating the slope-induced errors. Satellite altimeter data have been analysed over the Larsen Ice Shelf. From these a topographic map has been produced and a number of surface features identified

including points along the grounding line, crevassing and areas of increased surface roughness. Work on penetration by the radar signal into the surface snow layers is continuing and new techniques for retracking the waveform are being investigated which are independent of this effect. MSSL has the responsibility for defining the methods for processing the ERS-1 altimeter data over the ice-sheets and shelves and this work has now been completed. A recently acquired dataset of a year's worth of Geosat repeat tracks is being analysed for seasonal trends in the penetration signal from the waveforms and a repeat of the Larsen work is anticipated using these data to test repeatability and consistency between satellites.

SATELLITE ALTIMETRY OVER SEA ICE
(S.W. Laxon, Mullard Space Science Laboratory, Department of Physics and Astronomy, University College, London)
Recent work has involved the analysis of more than two years worth of data from the Geosat radar altimeter to provide mapping of Antarctic sea-ice extent. Comparisons of the total Antarctic ice extent mapped by altimetry with that mapped by the SMMR passive microwave instrument show good agreement, except during the latter part of the melt period. A future aim is to investigate the possible causes for this difference by directly comparing data from the two sensors. In another study the freeboard of two giant tabular icebergs was measured on several occasions using data from the Geosat altimeter. Freeboard measurements of one of the icebergs cover a period of more than one year, and show a significant decrease which is attributed to basal melting.

ENGINEERING

GLACIAL HAZARDS IN THE CORDILLERA BLANCA, PERU
(John M. Reynolds, Department of Geological Sciences, Polytechnic South West, Plymouth)
Since 1987, work has continued with Hidrandina SA, Huaraz, in assessing potential hazards in the Cordillera Blanca. Particular emphasis has been on determining the likely risk associated with a variety of hazard types, such as rock and ice avalanches, possible struzstroms, and aluviones. In 1988, emergency remedial engineering work, funded by the Austrian and British governments, was instigated at Hualcán and has successfully reduced the imminence of a glacially induced aluvión. The response of the local glacier to the artificial lowering of water level in a proglacial lake is being monitored. The hazard assessment work is currently being prepared for publication. In October 1989, a Geological Hazards Assessment, Mitigation and Information Unit was established in the department of Geological Sciences, Polytechnic South West, Plymouth, as a contribution to the UN International Decade for Natural Disaster Reduction (1990–2000). The work in Peru, which is one of the projects currently being undertaken by the Unit, has been drawn to the attention of the Association of Geoscientists for International Development in order to highlight the importance of hazard-assessment work in glacierised terrains.

ICE FORCES ON OFFSHORE STRUCTURES
(Andrew Palmer, Andrew Palmer and Associates Ltd, London)
This project is examining the influence of non-simultaneous failure mechanisms, in which fracture occurs at different times across the contact zone, on the forces developed when an ice sheet moves against a fixed structure. There are signs of chaotic behaviour, in which the mode switches irregularly between large-fragment fracture with small forces and small-fragment crushing with much larger forces.

SEABED ICE GOUGING AND MARINE PIPELINES
(Andrew Palmer, Andrew Palmer and Associates Ltd, London)
This project is being carried out for Canada Oil and Gas Lands Administration, in collaboration with Fleet Technology and Golder Associates. It examines the geotechnics of ice-gouging mechanisms, and interactions between gouging and pipelines buried in the seabed. Development of gouging models for cohesionless and cohesive seabed, and correlation with model-scale tests and observations of iceberg gouging is in progress. Analysis of strength of pipeline in zone 3, below the level of active soil deformation, but where large soil stresses are present, has been completed; the model demonstrates that a pipeline can withstand these stresses.

MISCELLANEOUS

PERMAFROST EVOLUTION
(Lesley Morland and R. Kelly, School of Mathematics, University of East Anglia)
The motion of a freezing front through saturated ground due to surface cooling is determined numerically, based on an idealised mixture theory model.

FLUX AND SOURCE OF SEDIMENT AND SOLUTE IN AN ALPINE, GLACIERISED CATCHMENT
(M. Clarke, A.M. Gurnell, M. Tranter, University of Southampton, K. Richards, and M. Sharp, University of Cambridge)
We aim to quantify the flux of solute and sediment during the ablation season in the upper Arolla catchment, Switzerland. The aim is to be able to construct a model which will allow the prediction of sediment and solute yield from glacierised catchment. Full chemical and sediment sampling was

undertaken from late May to early September. There is already a most complete set of cation data for these catchments. Trace metals may have great potential for determining source regions for sediment and solute. Novel chemical methods of hydrograph separation are being investigated.

SNOWMELT HYDROLOGY
(Lesley Morland, R. Kelly, School of Mathematics, University of East Anglia, and Elizabeth Morris, BAS) We have developed a mixture theory model of a four-constituent snowpack (ice, water, water vapour, inert air) incorporating mass exchanges between the three active constituents. Mass, momentum and energy balances determine the complex system of differential equations which describe the motions, melting, and refreezing in a snowpack.

STRUCTURAL STABILITY AND GENERICITY IN GLACIOLOGY
(John Nye, Department of Physics, University of Bristol)
The history of the changing form of an ice sheet shows certain features that are generic (that is, they will appear without any special conditions) and also structurally stable (that is, they survive perturbation). The identification of such features can be helpful in interpreting field observations. These ideas have been applied to the interpretation and dating of terminal moraines, to families of parallel erosional and depositional features, and to the evolution of topographic features on the surfaces of ice sheets.

RECENT GLACIER FLUCTUATIONS: NORTH PATAGONIAN ICECAP
(W.A. Mitchell, School of Earth Science, Luton College of Higher Education, Luton)
Geomorphological mapping and observations have been carried out on two of the main western outlet glaciers of the North Patagonian Icecap as part of the scientific work associated with Operation Raleigh 13B Expedition to southern Chile in early 1988. Around part of the ice margin of the Ventisquero San Quintin which is the second largest glacier in Chile and the major western outlet glacier of the icecap, mapping has revealed a series of terminal moraine ridges and associated meltwater channels. These are associated with a series of terraces which indicate the existence of a proglacial lake at a series of levels and extent. Since the production of the first topographic map in 1975, retreat of the ice margin has allowed the lake to become more extensive and abandon a major outlet channel. Observations were also made on the neighbouring Ventisquero San Rafael which is the most northerly tidewater glacier in the southern hemisphere. It is retreating at present. A second project is the detailed logging of the sedimentary sequence along the banks of the Rio Tempano which links the Laguna San Rafael to the main fjord, the Golfo Elephantes. This has shown a sequence from predominantly glacial deposition northwards into a glaciofluvial and glacioaqueous sequence.

SUBGLACIAL DRAINAGE THROUGH TILL
(A.C. Fowler, Oxford University and J. Walder, USGS, Vancouver, WA, USA)
We are seeking to describe the sliding process of glaciers and ice sheets over deformable, water-saturated till. To provide a sliding law, we require a prescription for the effective pressure in the till, which requires a theory for drainage. In seeking to produce a Röthlisberger-type theory for drainage through deformable till, using a Boulton–Hindmarsh power-law rheology, we have examined the simple problem of closure of till surrounding a cylindrical cavity. Depending on the flow law, a solution may not exist! For Boulton and Hindmarsh's measured values, the closure rate is essentially independent of the applied stress. We have used this result to produce a theory for drainge in till. Preliminary results are encouraging, and shed light on the behaviour of ice streams. Of fundamental importance to the theory is the mechanism of glaciofluvial sediment transport.

CREEP-BRITTLE BEHAVIOUR OF ICE. EXPERIMENTAL TRIAXIAL DEFORMATION AND ACOUSTIC EMISSION STUDIES
(Stan Murrell, Martin Rist and Peter Sammonds, University College London, Geological Sciences Department)
Our aim is to produce a micro-mechanical model and constitutive relations to describe realistically and accurately the creep-brittle deformation of ice (fresh-water and sea ice) based on experimental triaxial deformation studies covering a range of confining pressures and temperatures. Martin Rist was awarded his Ph.D. for his thesis "The effect of temperature and strain-rate on the triaxial deformation and strength of pure polycrystalline ice: an experimental study".

DEFORMABLE GLACIER BEDS: MEASUREMENT AND MODELLING
(Tavi Murray, University College of Wales Aberystwyth and Julian Dowdeswell, Scott Polar Research Institute, University of Cambridge)
Recognition of unlithified, deformable beds as an important mechanism by which many past and present ice masses move has resulted in speculation into how and under what conditions these sediments will deform, and the effect this deformation has on the overlying ice. This project involves a laboratory study into the shear strengths and rheological properties of subglacial sediments from various sources and the subsequent numerical modelling of ice masses. Completed: laboratory investigation into rheology of sediment fines as a function of water content, temperature and sediment source. Investigated:

yield and shear strengths of sediment fines. Undertaken: an SEM investigation into the mechanisms of failure of artificially deformed sediments.

THE DYNAMICS AND GEOLOGY OF ICE-SHEET COALESCENCE
(Jane Hart, University of Southampton, and Richard Hindmarsh, University of Edinburgh)
We investigated the sedimentary, glaciotectonic and glaciodynamic processes associated with ice-sheet coalescence, using theoretical models and a geological example from North Wales. All three sites in North Wales have now been examined and the results analysed, and basic glaciodynamic models have been produced.

THE EFFECT OF INTERCRYSTALLINE WATER VEINS ON THE BULK PHYSICAL PROPERTIES OF ICE
(John Nye, Mike Walford and Heidy Mader, Bristol University, Physics Department)
Experimental work to date includes the geometry of the vein system in laboratory-grown polycrystalline ice and observing how the veins are affected by changes in the temperature and impurity concentration of the sample environment. Theoretical models have been developed to explain the behaviour of an individual vein in a sample of ice. Our measurements show that the value of the dihedral angle (angle of contact where water meets a grain boundary) can vary from 25° to 110°. This wide range means that the veining system is irregular in its geometry and, more importantly, that veins can be missing altogether. Experiments show that the temperature in the veins varies roughly as the inverse of the vein cross-section. This forms the starting point for a macroscopic continuum theory of heat diffusion in a glacier.

ICE XI
(Robert Whitworth, Rachel Howe, Andrei Zaretskii, and Professor M. Oguro, School of Physics and Space Research, University of Birmingham)
Ice XI is the ordered phase into which ice Ih transforms below 72 K. Pure ice cannot undergo the transition because it lacks the point defects required to reorient the H_2O moelcules, but the transformation can be produced in ice doped with KOH. We have determined the structure of ice XI using the high-resolution powder diffractometer on the ISIS spallation neutron source at the Rutherford Appleton Laboratory, and we have made extensive dielectric measurements on polycrystalline samples to study the role of the KOH and the process of transformation. Work on single crystals is in hand.

Submitted by J.G. Paren

International Glaciological Society

JOURNAL OF GLACIOLOGY

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

W R HAMMOND, K F SPRENKE
A PC-based portable ice-radar receiver.

G S H LOCK, I B FOSTER
Experiments on the growth of spongy ice near a stagnant point.

D V MUHLL, W HAEBERLI
Thermal characteristics of the permafrost within an active rock glacier (Mustèl/ Corvatsch, Grisons, Swiss Alps).

G RAJU, W XIN, R K MOORE
Design, development, field observations, and preliminary results of the Coherent Antarctic Radar Depth Sounder (CARDS) of the University of Kansas, U.S.A.

J S GARDNER, K HEWITT
A surge of Bualtar Glacier, Karakoram Range, Pakistan: a possible landslide trigger.

G A SCHOHL, R ETTEMA
Two-dimensional spreading and thickening of *aufeis*.

R J BRAITHWAITE, O B OLESEN
A simple energy-balance model to calculate ice ablation at the margin of the Greenland ice sheet.

E M MORRIS, R J KELLY
A theoretical determination of the characteristic equation of snow in the pendular regime.

R J BRAITHWAITE, O B OLESEN
Response of the energy balance on the margin of the Greenland ice sheet to temperature changes.

HUANG MAOHUAN
On the temperature distribution of glaciers in China.

D M McCLUNG
A model for scaling avalanche speeds.

J CHEN, M FUNK
Mass balance of Rhonegletscher during 1882/83–1986/87.

N R IVERSON
Laboratory simulations of glacial abrasion: comparison with theory.

N HUMPHREY, K ECHELMEYER
Hot-water drilling and bore-hole closure in cold ice.

J B JOHNSON, R C METZNER
Thermal expansion coefficients for sea ice.

INTERNATIONAL SYMPOSIUM ON SNOW AND SNOW-RELATED PROBLEMS

Nagaoka, Japan, 14 – 18 September 1992

Co-sponsored by Japanese Society of Snow and Ice and Nagaoka City

FIRST CIRCULAR: May 1990

The Society will hold an international symposium on Snow and Snow-Related Problems in 1992. Registration will take place on Sunday 13 September and sessions will be from Monday 14 September to Friday 18 September in Nagaoka, Japan.

TOPICS

The symposium will mainly address the physical processes and properties of seasonal snow. Interest will range from results of basic research to treatment of problems of widespread interest.

The following topics will be open for discussion:

1. Physics of snow (mechanical, thermal and electrical properties, including snow friction)
2. Distribution and changes of snowpacks
3. Snowfall and related phenomena (including blowing snow and accretion of snow and ice)
4. Snow avalanches
5. Snow removal and ice control
6. Social problems relating to snow
7. Role of snow in climate
8. Snow on sea ice (its role for the energy and mass budgets)
9. Use of snow and ice

SESSIONS

Sessions will be held on four full days and one half-day. An excursion will be held on one half-day. We plan to provide ample opportunity for poster displays. In the Second Circular we will ask you to indicate, when submitting your summary, if you wish to participate in the poster sessions.

PUBLICATION

The Proceedings of the symposium will be published by the Society in the *Annals of Glaciology*. Papers will be refereed and edited according to the Society's usual standards before being accepted for publication.

ACCOMMODATION

Details will be given in the Second Circular.

GROUP TRAVEL AND TOURS

We plan to offer group travel arrangements from Europe and North America. Details will be given in the Second Circular. Some attractive post-symposium tours are planned. Details will be given in the Second Circular.

FURTHER INFORMATION

You are invited to attend the symposium. Please return the attached form as soon as possible. The Second Circular will give information about accommodation, general programme, preparation of summaries and final papers, group travel and tours. Requests for copies of the Second Circular* should be addressed to the Secretary General, International Glaciological Society, Lensfield Road, Cambridge CB2 1ER, U.K.

*Note: Members of the International Glaciological Society will automatically receive a copy.

SYMPOSIUM ORGANIZATION

H. Richardson (Secretary General, I.G.S.)

LOCAL ARRANGEMENTS COMMITTEE

Tsutomu Nakamura (Chairman)

Norio Hayakawa	Teruyoshi Umemura
Shun'ichi Kobayashi	Katutosi Tusima
Masayoshi Nakawo	Katsuo Kanzo
Tsutomu Yamada	Sumio Igarashi

INTERNATIONAL GLACIOLOGICAL SOCIETY SYMPOSIUM ON SNOW AND SNOW-RELATED PROBLEMS

Family Name . . . . . .

First Names/s . . . . . .

Address . . . . . .

. . . . . .

I hope to participate in the symposium in September 1992 [ ]

I expect to submit a summary of a proposed paper [ ]

I will be interested in a group travel arrangements [ ]

I will be interested in a post-symposium tour [ ]

TO BE SENT AS SOON AS POSSIBLE TO: Secretary General, International Glaciological Society, Lensfield Road, Cambridge CB2 1ER, U.K.

BRITISH BRANCH

12–13 September 1990

The Annual Conference of the British Branch of the International Glaciological Society will be held on Wednesday 12 and Thursday 13 September 1990 at Mullard Space Science Laboratory, Hombury St Mary, Surrey. The unconventional choice of midweek days has been taken to ease travel by members from more northerly regions who may throw themselves at the mercy of Britain's motorway network. The meeting has been timed to fit in with the IGS meeting in USA, the ICSI meeting in USSR and the RSS meeting in Swansea, but as members will doubtless be aware, the tendency of glaciology and climate-related meetings to snowball (sorry) is increasing, and it is getting harder to avoid clashes. Please accept our apologies if the dates are inconvenient to you.

The meeting will start at 11.00 on Wednesday 12 September, with registration and coffee from 10.00. The AGM will take place from 16.00 on Thursday 13 September. As glaciation has not troubled Surrey in the recent millennia, no field trip will be possible, and the Annual Dinner will take place on the Wednesday evening, at a venue to be decided.

All those with glaciological interests are welcome to attend. This includes those who are not members of the International Glaciological Society, though they would of course be encouraged to join. Presentations of work-in-progress and completed work are welcomed. There will also be display space for posters.

TRANSPORT

Although MSSL is in Surrey, it has also contrived to be quite isolated. We will organise collection of members travelling by public transport to British Rail, Guildford, which is served by express trains from London Waterloo to Portsmouth Harbour, and Gatwick or London Heathrow airports. Recommended services will be forwarded with the second circular. Maps for those arriving by road will also be included. During the meeting, travel by minibus will be provided between the Laboratory and accommodation centres.

ACCOMMODATION

Accommodation has been arranged at the University of Surrey in Guildford. The Surrey Campus is pleasant and spacious, and within easy walking distance of Guildford rail station. The inclusive cost per night for bed and breakfast is £18.11. Alternatively, members may wish to stay at the Holmbury St Mary YHA (telephone Dorking 730777), which is situated on a wooded hill approximately 2 miles from the Laboratory. You will have to make your own bookings if you choose to do this! Due to the widespread homes of the Remote Sensing Group members, it will be difficult this year to provide much sleeping-bag floorspace. However, in order to ease the burden on student members, it has been decided to offer a 50% subsidy to those IGS members in full-time study who wish to use University of Surrey accommodation. Please provide some form of attestation of status if you wish to take advantage of this.

A buffet lunch will be available on 12 and 13 September at MSSL. We have to give numbers, so please fill in the section on the registration form. The cost of the Annual Dinner will be in the region of £10–£15: details of this will be sent with the second circular.

REGISTRATION

The registration fee of £7.50 includes coffee and tea, and the distribution of abstracts. Please make cheques payable to "British Branch of the International Glaciological Society".

If you require a registration form, please write immediately to David Mantripp, Mullard Space Science Laboratory, University College London, Holmbury St Mary, Dorking, Surrey RH5 6NT.

ANNALS OF GLACIOLOGY

The following papers are published in Volume 14, Proceedings of the Symposium on Ice and Climate, held at the University of Washington, Seattle, Washington, USA, 21–25 August 1989.

R B ALLEY
Multiple steady states in ice–water–till systems.

R B ALLEY, B R KOCI
Recent warming in central Greenland?

E L ANDREAS, M W MILES, R G BARRY, R C SCHNELL
Lidar-derived particle concentrations in plumes from Arctic leads.

R A BINDSCHADLER, E P ROBERTS, A IKEN
Age of Crary Ice Rise, Antarctica, determined from temperature-depth profiles.

W J BOHMER, K HERTERICH
A simplified three-dimensional ice-sheet model including ice shelves.

R J BRAITHWAITE, O B OLESEN
Increased ablation at the margin of the Greenland ice sheet under a greenhouse-effect climate.

W F BUDD, P RAYNER
Modelling global ice and climate changes through the ice ages.

P C CHU
Air–ice–ocean feedback mechanism and ice oscillation on millennial time scales.

K H COOK
The atmosphere's response to the ice sheets of the Last Glacial Maximum.

T J CROWLEY, G R NORTH
Modeling onset of glaciation.

J A CURRY, E E EBERT
Sensitivity of the thickness of Arctic sea ice to the optical properties of clouds.

G DEBLONDE, W R PELTIER
A paleoclimatic model of the mid-Pleistocene climate transition.

J E DIBB
Recent deposition of ^{210}Pb on the Greenland ice sheet: variations in space and time.

M B ESCH, K HERTERICH
A two-dimensional coupled atmosphere–ice-sheet–continent model designed for paleoclimatic simulations.

I S EVANS
Climatic effects on glacier distribution across the southern coast mountains, B.C., Canada.

D A FISHER
A zonally-averaged stable-isotope model coupled to a regional variable-elevation stable-isotope model.

G M FLATO, W D HIBLER III
On a simple sea-ice dynamics model for climate studies.

J P F FORTIUN, J OERLEMANS
Parameterization of the annual surface temperature and mass balance of Antarctica.

Y FUIJII, K KAMIYAMA, T KAWAMURA,
T KAMEDA, K IZUMI, K SATOW, H ENOMOTO,
T NAKAMURA, J O HAGEN, Y GJESSING,
O WATANABE
6000-year climate records in an ice core from the Høghetta Ice Dome in northern Spitsbergen.

W GRAF, O REINWARTH, H MOSER
The 520-year temperature record of a 100 m core from the Ronne Ice Shelf, Antarctica.

P M GROOTES, M STUIVER, T L SALING,
P A MAYEWSKI, M J SPENCER, R B ALLEY,
D JENSSEN
A 1400 year oxygen isotope history from the Ross Sea area, Antarctica.

W HAEBERLI
Glacier and permafrost signals of 20th-century warming.

J O HAGEN, O LIESTOL
Long-term glacier mass-balance investigations in Svalbard 1950–88.

U C HERZFELD, P HOLMLUND
Geostatistics in glaciology: implications of a study of Scharffenbergbotnen, Dronning Maud Land, East Antarctica.

M M HUSTON, J BRIGHAM-GRETTE,
D M HOPKINS
Paleographic significance of Middle Pleistocene glaciomarine deposits on Baldwin Peninsula, northwest Alaska.

P HUYBRECHTS
The Antarctic ice sheet during the last glacial–interglacial cycle: a three-dimensional experiment.

M IKEDA
Feedback mechanism among decadal oscillations in northern hemisphere atmospheric circulation, sea ice, and ocean circulation.

T IWASAKI
An apparent one-year lag relationship of heavy snow years between Eurasia and North America.

T H JACKA
Antarctic and Southern Ocean sea-ice and climate trends.

T KAMEDA, M NAKAWO, S MAE, O WATANABE,
R NARUSE
Thinning of the ice sheet estimated from total gas content of ice cores in Mizuho Plateau, Antarctica.

G KASER, A AMES, M ZAMORA
Glacier fluctuations and climate in the Cordillera Blanca, Peru.

T S LEDLEY
Meridional sea-ice transport and its impact on climate.

T S LEDLEY
The impact of Milankovitch solar radiation variations on sea-ice and air temperature in a coupled energy-balance climate–sea-ice model.

B LEFAUCONNIER, J O HAGEN
Glaciers and climate in Svalbard; statistical analysis and reconstruction of the Brøgger-breen mass balance for the last 77 years.

G A LESHKEVICH, D W DEERING, T F ECK,
S P AHMAD
Diurnal patterns of the bi-directional reflectance of fresh-water ice.

C S LINGLE, A C BRENNER, H J ZWALLY
Satellite altimetry, semivariograms, and seasonal elevation changes in the ablation zone of West Greenland.

W W LOCKE
Quantitative approximation of mountain glacial climates.

R LORRAIN, W HAEBERLI
Climatic change in a high-altitude alpine area suggested by the isotopic compositon of cold basal glacier ice.

T V LOWELL, R STUCKENRATH
Late Wisconsin advance and retreat pattern in the Miami sublobe, Laurentide ice sheet.

W B LYONS, P A MAYEWSKI, M J SPENCER,
M S TWICKLER, T E GRAEDEL
A northern hemisphere volcanic chemistry record (1869-1984) and climatic implications using a south Greenland ice core.

D R MacAYEAL, D R LINDSTROM
Effects of glaciation on methane-hydrate stability.

P A MAYEWSKI, M J. SPENCER, M S TWICKLER,
S WHITLOW
A glaciological survey of the Summit region, Greenland.

L R MAYO, R S MARCH
Air temperature and precipitation at Wolverine Glacier, Alaska; glacier growth in a warmer, wetter climate.

J C MOORE, J G PAREN, R MULVANEY
Chemical evidence in polar ice cores from dielectric profiling.

E MOSLEY-THOMPSON, L G THOMPSON, P M GROOTES, N GUNDESTRUP
Little Ice Age (neoglacial) paleo-environmental conditions at Siple Station, Antarctica.

M NAKAWO, Y AGETA, H JIANKANG
Climatic information from the Chongce Ice Cap, West Kunlun, China.

J F NYE
Interpreting the field evidence of past ice sheets: structural stability and genericity.

O ORHEIM, B LUCCHITTA
Investigating climate change by digital analysis of blue ice extent on satellite images of Antarctica.

J M PALAIS, S KIRCHNER, R J DELMAS
Identification of some global volcanic horizons by major element analysis of fine ash in Antarctic ice.

C L PARKINSON
Search for the Little Ice Age in Southern Ocean sea-ice records.

C L PARKINSON
The impact of the Siberian high and Aleutian low on the sea-ice cover of the Sea of Okhotsk.

W S B PATERSON
Summary of final discussion.

A PAYNE, D SUGDEN
Climate and the initiation of maritime ice sheets.

M PELTO, S M HIGGINS, T J HUGHES, J L FASTOOK
Modeling mass-balance changes during a glaciation cycle.

D K PEROVICH, G A MAYKUT
The treatment of shortwave radiation and open water in large-scale models of sea-ice decay.

D POLLARD, I MUSZYNSKI, S H SCHNEIDER, S L THOMPSON
Asynchronous coupling of ice-sheet and atmospheric forcing models.

D A ROTHROCK, D R THOMAS
The Arctic Ocean multi-year ice balance, 1979–82.

K SATOW, O WATANABE
Seasonal variation of oxygen isotopic composition of firn cores in the Antarctic ice sheet.

SHI YAFENG, REN JIAWEN
Glacial recession and lake shrinkage indicating a climatic warming and drying trend in central Asia.

I SIMMONDS, W F BUDD
A simple parameterization of ice leads in a general circulation model, and the sensitivity of climate to change in Antarctic ice concentration.

R SOUCHEZ, J -L TISON, J JOUZEL
An isotopic method of estimating conductive heat flux through Antarctic first-year sea ice.

S N STEPHENSON, R A BINDSCHADLER
Is ice-stream evolution revealed by satellite imagery?

W V TANGBORN, A G FOUNTAIN, W G SIKONIA
Effect of area distribution with altitude on glacier mass balance — a comparison of North and South Klawatti glaciers, Washington State, U.S.A.

W H THEAKSTONE
Twentieth-century glacier change at Svartisen, Norway: the influence of climate, glacier geometry and glacier dynamics.

L G THOMPSON, E MOSLEY-THOMPSON, M E DAVIS, J F BOLZAN, J DAI, L KLEIN, N GUNDESTRUP, T YAO, X WU, Z XIE
Glacial stage ice-core records from the subtropical Dunde Ice Cap, China.

S USHIO, M WAKATSUCHI
A laboratory study of heat flux through coastal polynyas during frazil-ice production.

C P WAKE, P A MAYEWSKI, M J SPENCER
A review of central Asian glaciochemical data.

C R WARREN, N R J HULTON
Topographic and glaciological controls on Holocene ice-sheet margin dynamics, central West Greenland.

G WELLER, G WENDLER
Energy budgets over various types of terrain in polar regions.

J S WETTLAUFER, N UNTERSTEINER, R COLONY
Estimating oceanic heat flux from sea-ice thickness and temperature data.

G C WILES, P E CALKIN
Neoglaciation in the southern Kenai Mountains, Alaska.

T D YAO, J R PETIT, C LORIUS, P DUVAL
Climatic record from an ice margin area in East Antarctica.

FIELD STATIONS

The Council of the Society has decided that field stations may apply to obtain a discount on their subscriptions to the *Journal of Glaciology*, *Annals of Glaciology*, and *ICE*. People responsible for placing such subscriptions with the Society should write to the Secretary General, providing evidence of the bona fide status of the stations.

Future meetings (of other organizations)

SYMPOSIUM ON GLACIERS–OCEAN–ATMOSPHERE INTERACTIONS

24–29 September 1990, Leningrad, USSR

The International Symposium on Interaction of Glaciers with the Ocean and Atmosphere will be held on 24–29 September 1990 in Leningrad, USSR. The Symposium is organized by the Institute of Geography, Academy of Sciences of the USSR, Moscow, and by the Arctic and Antarctic Research Institute, Leningrad, under the umbrella of the International Commission of Snow and Ice, IUGG, International Association of Meteorology and Atmospheric Physics, and International Association for the Physical Sciences of the Ocean.

The interaction of glaciers with the ocean and atmosphere is of great importance to the global change processes and thus this meeting can be considered as a glaciological contribution to the International Geosphere–Biosphere Programme.

Registration for the symposium will take place on Monday 24 September and sessions will be from Tuesday 25 to Friday 28 September. A post-symposium tour is planned to start on Saturday 29 September.

Organizing committee: Convenor, V.M. Kotlyakov; Secretary, A.F. Glazovskiy

Sessions will be held on: Ice cores as the indicators of global changes; Sea ice in the global interaction system; Modelling of ice sheets and their components; Glaciation and the global sea level; Glaciation–atmosphere interaction.

The languages of the Symposium are English and Russian. Simultaneous translation will be provided for all oral sessions.

38 abstracts have been accepted for presentation in plenary sessions, and 38 in poster sessions. Authors of accepted abstracts are invited to submit a full paper including a short abstract (not more than 200 words) in English to the Organizing Committee by 1 July 1990.

GENERAL INFORMATION

The Organzing Committee apologizes for being late with detailed information. We are now examing different opportunities for accommodation, transport, meals, and a post-symposium tour. We will send an additional information note with full details to all interested persons later.

Leningrad is a beautiful northern city with an interesting history. During the Symposium an opportunity will be provided to see the city and its surroundings. This time of year is the beginning of autumn and it is advisable to be prepared for rain. Academic and formal dress will not be required for any activity included in the Symposium programme.

ADDRESS FOR MAIL

Professor V.M. Kotlyakov and Dr A.F. Glazovskiy, "Glaciers–Ocean–Atmosphere", Institute of Geography, Academy of Sciences USSR, Staromonetny Per., 29, 109017 Moscow, U.S.S.R.

Glaciological Diary

** IGS Symposia
* Co-sponsored by IGS

1990

10-12 July
Northern Hydrology Symposium, Saskatoon, Saskatchewan, Canada. Sponsored by the National Hydrology Research Institute and Canadian Water Resources Association. (C.S.L. Ommanney, Scientific Information Division, National Hydrology Research Institute, 11 Innovation Boulevard, Saskatoon, Saskatchewan, Canada S7N 3H5)

21-25 July
Western Pacific Geophysics Meeting, Kanazawa, Japan. (Christine N. Hooke, American Geophysical Union, 2000 Florida Avenue N.W., Washington, DC 20009, U.S.A.)

20-23 August
10th IAHR International Symposium on Ice, Helsinki University of Technology, Espoo, Finland. (Mauri Määttänen, Helsinki University of Technology, Department of Mechanical Engineering, Otakaari 1, SF-02150 Espoo, Finland)

27-31 August
** IGS Symposium on Ice–Ocean Dynamics and Mechanics, Hanover, NH, U.S.A. (Secretary General, IGS, Lensfield Road, Cambridge CB2 1ER, U.K.)

18-20 September
2nd International Conference on Ice Technology, Downing College, Cambridge, U.K. (Elizabeth Newman, Conference Secretary, Computational Mechanics Institute, Ashurst Lodge, Ashurst, Southampton SO4 2AA, U.K.)

24-28 September
3rd General Assembly of the European Network of Experimental and Representative Basins, Conference on Hydrological Research Basins and the Environment, Wageningen, The Netherlands. (IAC-Section OCC, P.O. Box 88, 6700 AB Wageningen, The Netherlands)

23-28 September
ICSI International Symposium on Interaction of Glaciers with the Ocean and Atmosphere, Leningrad, USSR. (V.M. Kotlyakov, Institute of Geography, Academy of Sciences USSR, Startomonetny 29, Moscow 109017, U.S.S.R.)

9–10 October
CIV '90. Avalanches and Planning of Mountain Territory, Arabba (BL), Italy. (CIV '90, Regione Veneto, Centro Sperimentale Valanghe e Difesa Idrogeologica, 32020 Arabba (BL), Italy)

29-31 October
IWAIS '90: 5th International Workshop on Atmospheric Icing of Structures, organized by the Japanese Society of Snow and Ice, Tokyo (IWAIS '90 Secretariat, c/o Inter Group Corporation, Akasaka Yamakatsu Bldg., 8-5-32, Akasaka Minato-ku, Tokyo 107, Japan)

29 October-7 November
Second World Climate Conference, sponsored by WMO, UNEP, UNESCO and ICSU, Geneva, Switzerland. (Co-ordinator SWCC, c/o World Meteorological Organization, P.O. Box 2300, 1211 Geneva 2, Switzerland)

1991

May
Symposium on Tropospheric Chemistry of Southern High Latitudes, Boulder, CO, U.S.A. (B.A. Bohharne, NOAA Environmental Research Laboratory, 325 Broadway, Boulder, CO 80303-3328, U.S.A.)

23-28 June
OMAE 1991. 10th International Conference on Offshore Mechanics and Arctic Engineering: Arctic/Polar Symposium (including ice mechanics and properties of ice, and remote sensing), Stavanger Forum, Stavanger, Norway. (Nirmal K. Sinha, Member, Executive Committee, Offshore Mechanics and Arctic Engineering Division (OMAE/ASME), Division of Mechanical Engineering, National Research Council of Canada, Ottawa, Ontario, Canada K1A 0R6.

2-9 August
XIII INQUA Congress, Beijing, China. (Chinese Academy of Sciences, 52 Sanlike, Beijing 100864, China)

11-15 August
ISOPE-91. Offshore and Polar Engineering Conference, Heriot-Watt University, Edinburgh, U.K. (ISOPE-91 Edinburgh Secretariat, 4 Frederick Sanger Road, Surrey Research Park, Guildford, Surrey GU2 5YJ, U.K.)

11-24 August
20th General Assembly of the International Union of Geodesy and Geophysics, Vienna, Austria.

26-30 August
** IGS Symposium on Mountain Glaciology relating to Human Activities, Lanzhou, China. (Secretary General, IGS, Lensfield Road, Cambridge, CB2 1ER, U.K.)

1-6 September
Symposium on the Physics and Chemistry of Ice, Sapporo, Japan. (Norikazu Maeno, Institute of Low Temperature Science, Hokkaido University, Sapporo 060, Japan)

1992

17-22 May
** Symposium on Remote Sensing of Snow and Ice, Boulder, CO, U.S.A. (Secretary General, IGS, Lensfield Road, Cambridge CB2 1ER, U.K.)

29 June-3 July
Interpraevent 1992: Protection of Habitat against Floods, Debris Flows and Avalanches, Berne, Switzerland (Interpraevent 1992, c/o Bundesamt für Wasserwirtschaft, Postfach 2743, CH-3001 Bern, Switzerland)

14-18 September
** Symposium on Snow and Snow-Related Problems (as part of an International Forum on Snow Areas), Nagaoka, Japan. Co-sponsored by the Japanese Society of Snow and Ice and the City of Nagaoka. (Secretary General, IGS, Lensfield Road, Cambridge CB2 1ER, U.K.)

News

AWARDS

Barclay Kamb, California Institute of Technology, has been elected a member of the U.S. National Academy of Sciences.

INTERNATIONAL PERMAFROST ASSOCIATION

The Association announces that its News Bulletin, *Frozen Ground*, is available through the national officer for each IPA member country. Enquiries should be addressed to those offices. For USA, the contact person is Jerry Brown, 1808 N. 21st Street, Arlington, VA 22209.

TIBETAN SNOW SAMPLES

Brian Davison, University of Lancaster, Department of Environmental Science, Lancaster, U.K., writes that he has some data on snow chemistry from samples taken while on a trip to the east face of Mount Xixabangma in Tibet in October 1987. Due to problems in Tibet at that time the samples were delayed in return to England. The majority are from a 2 m snow pit sited at 6180 m in the collection basin of the Phola Glacier on the east face of Mount Xixabangma. He realises that interpretation of the incomplete data set is of limited value, but feels that the data may be of use to others carrying out snow chemistry work in the area. Anyone interested should write to Brian Davison at the address given above.

New members

Graeme A.J. Boyce, Department of Geography, University of Manchester, Manchester M13 9PL, U.K.

Ute C. Herzfeld, Scripps Institute of Oceanography, A-015, University of California San Diego, La Jolla, CA 92093, U.S.A.

Martin W. Miles, Cooperative Institute for Research in Environmental Sciences, University of Colorado, Boulder, CO 80309, U.S.A.

Andrew Ruddell, 1 Carmel Court, East Bentleigh, Victoria 3165, Australia.

Daniell Vonder Mühll, Department of Glaciology, Versuchsanstalt für Wasserbau, Hydrologie und Glaziologie, ETH Zentrum, CH-8092 Zürich, Switzerland.

Hans E. Wennerström, Kláveskársgatan 48, S-421 59 V. Frölunda, Sweden.

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S.C. Colbeck

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C.S. Benson	G. Lock
H.S. Boyne	W.K. Lyon
A.W. Hogan	W.A. Meneley
R. LeB. Hooke	J. Weertman
M.A. Lange	

Other members who are supporting the work of the Society through these higher rates of membership wish to remain anonymous. They are therefore not listed above.

We are grateful to all our Supporting and Contributing Members for their help.

Advertisement

SOLAR ECLIPSE

11 July 1991

Traveller's World, a specialised group travel company with headquarters in London, England, has reserved hotel accommodation in Hawaii during July 1991.

It is from the "Big Island" of Hawaii, where several renowned astronomical observatories are located on the summit of Mauna Kea, that the rare total solar eclipse of 4 minutes and 10 seconds can be seen on 11 July.

Members of the Royal Astronomical Society and of the International Glaciological Society are offered first choice of places on this specially arranged tour. The programme is being formulated with the assistance of experts in the University of Hawaii.

Because demand for accommodation is already exceeding supply, we recommend early application to:

Traveller's World

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London W1H 5AF

U.K.

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Lensfield Road, Cambridge CB2 1ER, England

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INTERNATIONAL GLACIOLOGICAL SOCIETY

Lensfield Road, 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 General. No proposer or seconder is required.

ANNUAL PAYMENTS 1990

Private members	Sterling	£30.00
Supporting members	Sterling	£130.00
Contributing members	Sterling	£50.00
Junior members	Sterling	£15.00
Institutions, libraries	Sterling	£90.00 for Volume 36 (Nos.122, 123, 124)

Annals of Glaciology – prices vary according to size of volume. For further information, apply to the Secretary General.

Note: Payments in currencies other than £ sterling should be calculated at the exchange rate in force at the time of payment. Then add sufficient money to cover the bank charges (currently £6). The Society needs the full payment, so that the extra £6 to cover bank charges should be paid by you. Thank you.

ICE

Editor: H. Richardson (Secretary General)
Assisted by D.M. Rootes and S. Stonehouse

This news bulletin is issued to members of the International Glaciological Society and is published three times a year. Contributions should be sent to the Secretary General, International Glaciological Society, Lensfield Road, Cambridge CB2 1ER, England.

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Sterling £12.00

All enquiries about the International Glaciological Society should be addressed to the Secretary General of the International Glaciological Society, Lensfield Road, Cambridge CB2 1ER, England.