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COVER PICTURE: Seligman Crystal recipients in attendance at the Yakutat Symposium on Fast Glacier Flow. From left to right — Garry Clarke, Hans Röthlisberger, Charlie Raymond, Geoffrey Boulton, Barclay Kamb, Mark Meier, Hans Weertman (photograph by Françoise Funk-Salamí).

Scanning electron micrograph of the ice crystal used in headings by kind permission of William P. Wergin, Agricultural Research Service, U.S. Department of Agriculture

RECENT WORK

SWEDEN

(For abbreviations used see page 7)

POLAR AND ALPINE GLACIERS

Ice flux of Lomonosovfonna, Svalbard

(J. Hedfors, V. Pohjola, IGV/UUpp)

This project will establish an estimate of the mass balance of Lomonosovfonna, Svalbard. The ice cap consists of 3 major outlet glaciers, Nordenskjöldbreen (NSB), Mittag-Lefflerbreen and Grustjevbreen, which together drain most of the ice system's area (~600 km^2). By measuring the surface velocity of these glaciers and calculating the ice flux via force-budget techniques, it is possible to detect changes in the ice cap's mass balance. This will be related to environmental and climatic variations over Svalbard.

The first successful measurements of velocity and ice depth took place on NSB in spring 2000 followed by two field seasons (April 2001 and 2001) of lesser yield. Further field measurements are needed and planned for spring 2003. The use and study of satellite imagery, in combination with field measurements, is under investigation/evaluation and expected to make a major contribution to the project.

Dynamic environment on Storglaciären, Sweden, using force-budget analysis

(J. Hedfors, V. Pohjola, IGV/UUpp; P. Jansson, R. Pettersson, INK/SU)

The conditions for longitudinal "pushes" or "pulls" of ice over a bedrock threshold in the ablation area of Storglaciären was discussed earlier, but not settled. Glacier dynamics, in relation to seasonal variations in, for example, meltwater input and ice temperature, are also not very well known. To investigate these topics, a grid of 63 stakes was used to collect surface-velocity data (July 2000–July 2001) for input to a force-balance analysis. The force budget reveals spatial and temporal variations in strain rates and basal-stress conditions, which increases understanding of the interactions between glacier ice and bed topography, as well as the links to raised subglacial water pressures. This study should provide knowledge on local extrusion flow, found in a borehole investigation by Hooke (1987).

Temperature distribution within glaciers measured by radar

(P. Holmlund, INK/SU)

In 1989, we mapped the thickness of the dry surface layer (>0°C) of Storglaciären. In successive years, it has been resurveyed and other glaciers also mapped. Presently, information on thermal distribution is available for 40 Swedish glaciers. Storglaciären shows significant changes in thickness of the cold surface layer, in general thinning. There are several reasons for this: high ablation and accumulation rates, and general thickening of the glacier. Besides the direct coupling between the thermal distribution and climate, there is also an aspect of future changes of sediment load in rivers as a consequence of warmer and smaller glaciers.

Timing and rate of accumulation on Storglaciären determined by snow chemistry

(P. Jansson, INK/SU; C.M. Mörth, IGG/SU)

Glacier accumulation is a product of some combination of snowdrifting and snowfall events. The total winter accumulation on a typical mid-latitude glacier is the sum of several, but not necessarily many, such events. Since storms follow different tracks, and hence generate snow precipitated under different conditions, it is likely a combination of snow-chemistry and stable-isotope studies will yield a chemical signature for each storm. This project will see to what extent the chemical and physical stratigraphy of the snow on Storglaciären can be correlated to events that produce the snow. Preliminary results indicate that isotopes, because of their fractionation properties during evaporation, are very good indicators of snow surfaces that have been exposed to the atmosphere for longer periods. An- and cations provide different signatures reflecting differences in sea-salt content, etc.

Variation in cold surface-layer thickness and its effects on polythermal glacier dynamics

(P. Jansson, R. Pettersson, INK/SU; H. Blatter, IACS/ETH-Z)

The conditions met at the basal cold–temperate boundary involve strong gradients in stresses and strains. By investigating simultaneous surface, englacial and basal velocity and deformation in transects across both a lateral shear boundary and a terminal compressive boundary on Storglaciären, we intend to quantify how the changes in basal conditions are transmitted through the ice to the surface and also investigate how temporal variations affect the pattern of deformation through the ice in time. The terminus location is especially interesting since it provides information on the processes by which polythermal glaciers advance, their temini being frozen to the ground and pushed on by basally temperate ice from up-stream.

Recurring jökulhlaups at Sälkaglaciären, northern Sweden

(P. Klingbjer, INK/SU)

This is a case study of a jökulhlaup at a small glacier in the Sälka massif, northern Sweden. The study will describe the jökulhlaup history from the subaerial ice-dammed lake and give insight to some of the conditions favoring jökulhlaups at Sälkaglaciären. It is based on historical jökulhlaup records, a study of the thermal regime and a detailed analysis of radar measurements of ice depth. A pressure transducer has been installed in the glacier-dammed lake in order to register the jökulhlaup. A heat-transfer model has been used to study the role of long-term heating from the lake water in the cold surface layer of the glacier ice.

The behaviour of Salajekna, northern Scandinavia, in relation to climate

(P. Klingbjer, INK/SU)

The first description of Salajekna is from 1807 when Göran Wahlenberg visited the glacier and made a written description with drawings, which indicated the glacier had a large extent and was advancing. 60 years later, Fredrik Svenonius visited Salajekna and stated that the drawing made by Wahlenberg was very well done and precise, though the glacier had become significantly thinner. Today, Salajekna is part of a study of the impact of continentality on glacier parameters along an east–west transect using glaciers throughout the Scandinavian mountains. This ranges from the pure maritime Engabreen in Norway via Salajekna at the border between Sweden and Norway, to the continental Pårteglaciären in the southernmost part of Sarek national park in Sweden. For that reason, a mass-balance program was initiated on Salajekna in 1998. The study on Salajekna also includes volumetric mass changes based on aerial photographs since the 1950s, ice-velocity data extracted from InSAR imagery, ground-penetrating radar measurements and calculated balance velocities at the ELA.

The climate response of Pårteglaciären, northern Sweden

(P. Klingbjer, INK/SU; F. Neidhart, ZII)

The purpose of the Pårteglaciären study is to estimate its state of balance and explain why it retreats, while smaller glaciers in the same area seems to be in balance with the climate. In this study, we have used calculated balance velocities, based on mass-balance measurements and ice-depth data. These data are compared with field measurements of ice velocity and with photogrammetric volume estimates. Three digital elevation models for the years 1963, 1980 and 1992 have been produced for the glacier and its close surroundings, and the models are used for long-term mass-change calculations.

Debris entrainment and dynamics in a polythermal glacier snout

(R. Pettersson, P. Jansson, P. Holmlund, INK/SU; N.F. Glasser, M.J. Hambrey, CGUA)

There are several bands of debris emerging and forming ice-cored ridges on the terminus of Storglaciären. The origins of these debris bands are inferred to be subglacial. The fact that debris can be entrained in basal ice has been shown from theory and observations for both cold and temperate glaciers. However, much uncertainty lies in the mechanics of entrainment of debris at the base of a glacier and its subsequent transport towards the surface in bands. The problem lies in the mechanisms responsible for moving basally entrained material towards the glacier surface in discrete bands. GPR, ice-velocity measurements, borehole temperature, and subglacial water pressure and isotopic composition of ice surrounding the debris bands are used in an investigation of the possible origin of the bands on Storglaciären. Preliminary results show the debris bands may be formed in the transition between cold and temperate basal conditions. They also show that the circumferential rim, due to the polythermal structure of Storglaciären, is slower moving or possibly moves passively and may inhibit the movement of the more central part of the snout, causing a higher vertical ice velocity in the transition zone between temperate and cold bed conditions.

Spatial and temporal variation in hydrothermal regime of a polythermal glacier mapped with radar techniques

(R. Pettersson, P. Jansson, P. Holmlund, INK/SU; H. Blatter, IACS/ETH-Z)

The hydrothermal regime of polythermal glaciers can be mapped with GPR techniques due to the large contrast in the dielectric properties between cold (dry) and temperate (wet) ice. The boundary between the upper cold surface ice and the underlying temperate ice (CTS) on Storglaciären was mapped with synthetic aperture radar in 1989 and subsequently in 1999. The CTS surface was interpreted in the radar images, digitized, and the data points interpolated between radar profiles to get the spatial distribution of the cold surface-layer thickness. A comparison between the 1989 and 1999/2001 distribution shows a strong decrease in cold surface-layer thickness over the whole ablation area. However, in some locations the thickness has increased marginally. Since the polythermal regime on glaciers is largely governed by the climate, this change in thickness of Storglaciären will be compared with detailed mass-balance and meteorological parameters and ice dynamics to study mechanisms controlling the polythermal regime.

Englacial inclusions in a polythermal glacier mapped in three dimensions with synthetic aperture radar

(R. Pettersson, P. Jansson, INK/SU; R.W. Jacobel, Phys/SOlaf; A.F. Fountain, Geol/Port)

It is well known that radar sounding of temperate glaciers encounters problems with scattering and attenuation of the electromagnetic wave from englacial inclusions and conduits; in general, water, air or debris. A variety of studies has been conducted to study the occurrence and properties of these enclosures to better understand the hydrology of glaciers. In this study, a high-resolution synthetic-aperture radar has been used in parallel transverse profiles across the glacier, separated by about 5 m. Radar images from the upper 85 m of the ablation area of Storglaciären have revealed many strong point refractors. The strong contrast between the surrounding ice and the reflectors indicates a high permittivity difference. Such a high difference can only be caused if the inclusions are filled, or partly filled, with water. Using 3-D migration, it might be possible to locate the point reflectors with a good accuracy. Preliminary results show that some point reflectors exist in all GPR profiles at approximately the same position. A possible interpretation is that these point reflectors may be connected by englacial channels.

Mass balance of Fuegian glaciers

(V.A. Pohjola, J. Hedfors, IGV/UUpp; C. Porter, G. Casassa, CEC)

The aim of this project is to gain more information on the mass balance of glaciers in Tierra del Fuego, southern Chile. Two glaciers have been studied; "Glaciar Sinus", in the Bahia Pia catchment, Cordillera Darwin (54°45' S, 69°40' W) and "Glaciar Hook", on Isla Santa Ines (53°45' S, 72°30' W). So far, a few season's ablation and temperature records have been gathered. Coring operations to retrieve accumulation data have failed to date. Ice flux through the two glaciers was estimated using GPS measurements and ice radar data.

ANTARCTIC GLACIERS

Ice flux through Heimefrontfjella Range, Dronning Maud Land

(J. Hedfors, V. Pohjola, IGV/UUpp; SWEDARP members)

The surface-velocity distribution from the outlet glacier Kibergbreen has been constructed by: (a) tracing the motion of objects (crevasses) from SPOT images (taken in 1987 and 1995); and (b) using surface-triangulation measurements on aluminium markers during a field party in austral summer 1989/90. Ice depths were taken from several radio-echo measurements by SWEDARP expeditions. Using a simple ice-deformation model, the ice flux through the tributary glacier Bonnevie-Svendsenbreen was calculated. The calculated annual ice flux was of the same magnitude as the annual accumulation estimated from the relatively small catchment for this tributary (55 km^2). GPS and radar surveys were performed by FINNARP in austral summer 2000/01 to establish the surface velocities and ice depth of Kibergbreen. Further field work is planned with SWEDARP 2002/03 when a GPS and radar campaign will focus on collecting information on Kibergbreen and Plogbreen. We are using the force-budget technique to get a better estimate of ice flux through these ice systems, which will eventually bring us better information on the state of balance of these East Antarctic outlet glaciers.

The balanced flow of the Veststraumen ice stream, East Antarctica

(P. Holmlund, INK/SU)

Radar soundings and GPS surveys have been carried out over a 10 year period to estimate the balanced flow of Veststraumen. This is an ice stream draining the near coast area named Ritscherflya, in Western Dronning Maud Land, with only marginal contributions from the inland ice sheet. However, due to high accumulation rates in the basin, the flux at the grounding line is on the order of 15 $km^3\ a^{-1}$, which is comparable to ice streams draining the interior of Antarctica. This study is highlighting the significance of coastal areas in mass-balance calculations and in numerical modelling of the Antarctic ice sheet.

Monitoring snow accumulation and ice velocity, western Dronning Maud Land

(P. Holmlund, INK/SU)

Mass-balance measurements have been carried out since the late 1980s in the vicinity of the two Swedish Antarctic stations, Wasa and Svea, and at drill sites. In 2002/03, these surveys will be reorganized for long-term monitoring. Approximately 100 sites will be chosen for future annual surveys to follow up changes in flow speed and accumulation rate due to a changing climate.

Spatial variability in snow accumulation in Dronning Maud Land, East Antarctica

(C. Richardson-Näslund, P. Holmlund, INK/SU)

Spatial variability in snow accumulation is studied by mapping the depths of shallow snow layers (<12 m) along continuous profiles, using ground-based snow radar. We have collected an extensive dataset of radar profiles from coastal regions, as well as from the polar plateau in Dronning Maud Land, recorded during expeditions in 1991/92, 1993/94, 1996/97 and 1997/98. For various geographic regions, we study the relation between spatial variability in accumulation and other physical parameters, such as altitude, surface slope, exposition, relief and distance to the sea. The radar data are also used to produce detailed 3-D maps of snow layering at core sites to assess the geographic representativity of the cores. The radar recordings are calibrated by depth–density curves and datings obtained from firn cores.

ICE CORES

Ice coring in polythermal glaciers

(P. Holmlund, U. Jonsell, INK/SU; P. Torssander, IGG/SU)

A drilling campaign at Mårmaglaciären in 1997 was very successful and showed that climatic and atmospheric information was well-preserved in the ice core. The campaign was carried out as a test for next year's Nordic pre-site survey for the EPICA deep drillings in Dronning Maud Land, Antarctica. The core from Mårmaglaciären covers only 54 annual layers and, unfortunately, does not include any datable signals, e.g. from Icelandic volcanic eruptions. However, simple modeling and correlation to dendrochronology suggest that the core covers the period 1790–1840. Considering ice depth, ice-flow velocity and thermal regime, there is a potential to cover at least the last 500 years on Mårmaglaciären. To date, analyses have been made for ECM, sulfur, volcanic ash and organic halogens. The next field campaign is planned in collaboration with the British Antarctic Survey (R. Mulvaney). The aim will be to evaluate climate change and the fallout of anthropogenic pollutants during the last 500 years.

Climatic and environmental variations over the Svalbard Archipelago using ice-core data from Lomonosovfonna, central Spitsbergen

(V. Pohjola, IGV/UUpp; Lomonosovfonna Ice Core Project Members [Dutch, Finnish and Norwegian contributions])

Lomonosovfonna is one of the highest icefields in Svalbard and may be one of the most optimal sites for ice cores in the Svalbard Archipelago. In April 1997, a 120 m deep ice core was drilled at the ice divide at 1230 m a.s.l. (78°52' N, 17°25' E) by a Dutch–Norwegian–British–Swedish–Finish team. An additional 60 m core was drilled in April 2000. Temperature measurements in the borehole show that the ice column is below the freezing point (average temperature was –2.8°C, with a standard deviation of 0.2°C) and the melt index averaged over the whole 120 m core was 41%, with a 55% melt index over the 20th century.

Careful analysis has shown that the chemical and isotopic record is retained in the ice, albeit somewhat redistributed by percolation during warm periods in the upper snow and firn layers.

So far, we have succeded in identifying a time–depth model for the ice core, in analyzing the temporal distribution of various chemical parameters, and in reconstructing the annual accumulation rates for three centuries using annual isotope cycles. Ongoing projects are to monitor: (1) the annual accumulation of chemical and isotopic parameters; (2) climatic parameters; (3) annual accumulation of mass on the icefield; and (4) continue to investigate the chemical and isotopic record of the 120 m ice core.

Potential recovery of paleoclimate data from ice coring Scandinavian ice caps

(V. Pohjola, IGV/UUpp; J. Cole-Dai, Chem:Biochem/SDSU; G. Rosquist, A.P. Stroeven, INK/SU; L.G. Thompson,OHSU)

A 34 m ice core was retrieved by thermal drilling in April 1996 on Riukojietna, a small ice cap, situated on the windward side of the Scandinavian mountain range (68°05' N, 18°03' E). The aim of this ice-coring project is to study whether Scandinavian icefields contain valuable ice-core data. Preliminary analysis of the core suggests that ice accumulated during the 20th century was too damaged by percolated water, but ice accumulated in earlier centuries has readable signals that are promising for further ice-core research.

Diffusion rate of stable isotopes in firn

(V. Pohjola, A. Sjöberg, IGV/UUpp; H.A.J. Meijer, CIO)

The diffusion of stable isotopes of water ($\delta^{18}O$ and $\delta^{2}H$) in ice and firn is a question of interest for ice-core glaciology. The back-diffusion (or de-convolution) models used today can be improved with better knowledge of diffusivity within firn, and ice. This is a laboratory set-up where we study the diffusion rate of stable isotopes of water within a matrix of fabricated firn. We can vary layer thickness, ice density and ice temperature in our set-up and, in such a way, estimate changes in diffusion rate with these parameters. Samples of the stack are taken over consequent longer time periods. Both $\delta^{18}O$ and $\delta^{2}H$ of the water are analyzed, using isotope-ratio mass spectrometry. Comparing the results of the diffusion experiment with diffusion models will tell if the measured diffusion rate is similar to theoretical diffusion rates, or not.

Variability in snow-layer thickness and snow chemistry, western Dronning Maud Land

(M. Stenberg, M. Hansson, P. Holmlund, INK/SU)

As a part of the pre-site survey in Dronning Maud Land for the EPICA, the spatial variability of snow-layer thickness and snow chemistry were studied at two geographically different ice-core drill sites. The study aims at quantifying error bars on accumulation rates derived from firn and ice cores. One site is on the polar plateau at Amundsenisen (76° S, 08° W) and the other one in the coastal area at Maudheimvidda (73° S, 13° W). Medium-deep ice cores (100 m) and shallow firn cores (10–20 m) were drilled and snow pits (0.5–2.5 m) were dug at each site. At Amundsenisen, a large (16×6 m long and 2.5 m deep) snow pit was dug. Snow structures in this large snow pit were mapped using optical surveying equipment and documented by photography. Samples for analyses of nine ions and oxygen isotopes were collected along one depth profile. Density and in situ electrical conductivity measurements were made along three depth profiles. Snow-layer variability was studied in two different areas and at two different scales. At a regional scale, measured by snow-

radar soundings, the variability was 8% on the polar plateau and 45% in the coastal area. The variability at a microscale in the large snow pit was 9%. The results indicate that ice cores from the polar plateau are more representative for a larger area than ice cores from the coastal area. There is no doubt that there are significant error bars on high-resolution accumulation data received from firn and ice cores, especially from the coastal area, but averaging over tens of years reduces the error in accumulation estimates.

GLACIERS AND CLIMATE

Response of glacier melt and discharge to future climate change

(R. Hock, INK/SU)

High resolution energy-balance and temperature-index melt models are used to predict the sensitivity and response of selected glaciers and ice caps to future climate change as predicted from climate models. The study is restricted to the effects on mass balance and resulting discharge, as these are the most immediate responses entailing a wide range of direct environmental and socio-economic implications. The focus is on the summer melt season, as this is the main runoff period. The methodology includes combining (1) a glacier-melt and discharge model, (2) climate scenarios derived from general circulation models or regional climate models, and (3) a downscaling tool to convert the coarse resolution output of (2) into the fine-resolution format required for (1). Sensitivities for glacier melt and discharge will be assessed and regional differences evaluated. Results will be analysed with respect to changes in peak discharges, daily amplitudes and the frequency of flood events.

PALAEOGLACIOLOGY

Basal-ice conditions and hydrology of continental ice sheets

(P. Jansson, J.-O. Näslund, INK/SU, L. Rodhe, G. Sohlenius, SGU)

During a glaciation, the hydrological and thermal basal conditions of ice sheets may vary significantly in space and time. The overall aims of this study are to: (1) establish a conceptual model comprising all parts of the hydrological systems of ice sheets, (2) to quantify the amount of water produced by the systems, and (3) describe spatial and temporal variations of the basal thermal and hydrological systems during a typical glacial period in Fennoscandia. The study focuses on frontal, near-hydrological processes within ice sheets and the glaciological processes governing the spatial and temporal variations in basal hydrology. Basal thermal conditions and basal water flow will be studied by numerical modelling using new input data. The results will be evaluated against relevant geological datasets compiled within the project. Furthermore, landforms formed by glacial meltwater are used to estimate hydrological parameters of the Weichselian ice sheet, and hydrological processes at present glaciers are being studied. Together, results from the different parts of the project will provide a detailed view of the hydrology of continental ice sheets. The study is a collaboration with the Swedish Geological Survey and University of Maine, sponsored by Swedish Nuclear Fuel and Waste Management Company (SKB). SKB will use the results as input for performance and safety analyses of repositories for radioactive waste and spent nuclear fuel.

REMOTE SENSING

Synthetic-aperture radar investigations of Blåmannsisen, North Norway

(I. Brown, INK/SU)

Since 1998, regular SAR image acquisitions over the ice cap Blåmannsisen have been obtained from the JERS, RADARSAT and ERS platforms. The research includes an analysis of the stability of winter backscattering over the firn area, the seasonal response of backscatter and the identification of shallow firn accumulations. Field data, including snow and firn depth, density profiles, and dielectric data have also been acquired. Most recently, ERS repeat-pass (including tandem) interferometry has been undertaken with E.S. Rowan, Chalmers University, Göteborg, and on the neighbouring Salajekna glacier in collaboration with P. Klingbjer (INK/SU). Mass loss, flow behaviour and coherence products are being extracted. Other SAR investigations include delineation of the firn mass of glaciers across the North Atlantic region and facies mapping on the West Greenland ice sheet. In the coming winter, ENVISAT multi-polarization data will be acquired and the effect of polarization on facies delineation investigated.

PERMAFROST

Permafrost in Scandinavia

(P. Holmlund, INK/SU)

Within the framework of the EU-funded program Permafrost and Climate in Europe (PACE), two holes were drilled into bedrock close to the Tarfala Research Station to monitor changes in ground temperatures. One 100 m deep borehole is at 1540 m with a calculated permafrost depth exceeding 300 m. A 15 m borehole at 1130 m indicates about 50 m of permafrost. In combination with BTS measurements in the valley and temperature measurements on nearby glaciers, these give a detailed description of permafrost extent in the North Scandinavian high mountains. The aim of the study is to follow up potential changes in extent and thickness of permafrost as a result of climate warming.

TARFALA RESEARCH STATION

(P. Holmlund, INK/SU)

The measurements made as part of the Tarfala Research Station's routine program involve measurements in both the Tarfala Valley and the Swedish mountains as a whole. They are carried out by the glaciology group at the Department of Physical Geography and Quaternary Geology, Stockholm University (Currently: R. Hock, P. Holmlund, P. Jansson, P. Klingbjer, J.-O. Näslund, R. Pettersson).

The routine program at Tarfala

The 57 year-long mass-balance record of Storglaciären forms the basis for glacio-climatic studies in Sweden. The measurement of Storglaciären mass balance is carried out by staff from the Tarfala Research Station, situated only a kilometre from the glacier. The stake net is surveyed every week or second week throughout the melt season.

Climate data have been collected continuously at Tarfala Research Station since 1965; the automatic weather station was computerized in 1989. Following introduction of a automated synoptic weather station in 1995, Tarfala became an official meteorological station. The hydrological regime is surveyed every year using stream gauges at 3–4 sites in the valley, with a view to establishing the glacier's hydrological balance.

The station is also used for student courses at different levels and for small conferences. Results and general information about the station are published every year in an annual report.

Glaciers as indicators of climate change

The regional representativity of Storglaciären is studied using other glaciers. These are usually visited twice a year; at the end of the accumulation and ablation periods. The total number of glaciers in the mass-balance program varies. Currently it involves Mårmaglaciären, Rabots glaciär, Riukojietna, Pårteglaciären, Tarfalaglaciären, Salajekna and Storglaciären. These glaciers have been chosen with respect to the east–west climatic gradient in the area, in which the western glaciers are influenced by a much more maritime climate than the eastern ones.

In addition to the mass-balance program, 20 glaciers are observed with respect to changes in frontal position. The full program has been run since 1965 and includes, besides surveys of glacier-front positions, photogrammetric surveys and radio-echo soundings in order to improve the time resolution. Automatic computerized weather stations have been placed at glaciers situated remote from the SMHI climate stations.

A major renovation and extension of the station was carried out in 2001 and 2002. A new lecture hall and laboratory have been build and the housing made more comfortable. After two hard years of construction scientists can now be welcomed to a modern station well suited to support high-class glaciological research.

Contributed by Peter Jansson

ABBREVIATIONS:

BPRC	Byrd Polar Research Center (OHSU)
CEC	Centro de Estudios Científicos, Valdivia, Chile
CGUA	Centre for Glaciology, Institute of Geography and Earth Sciences, University of Wales, Aberystwyth Y23 3DB, Wales, U.K.
Chem:Biochem	Chemistry and Biochemistry
CIO	Centre for Isotope Research, Groningen University, Nijenborgh 4, 9747 AG Groningen, The Netherlands
ETH-Z	Eidgenössische Technische Hochschule, CH-8057 Zürich, Switzerland
Geol	Geology/Geological Sciences
IACS	Institute for Atmospheric and Climate Science, ETH-Z
IGG	Institutionen för Geologi och Geokemi
IGV	Institutionen för Geovetenskap
INK	Insitutionen för Naturgeografi och Kvartärgeologi
OHSU	Ohio State University, Columbus, OH 43210-1002, USA
Phys	Physics
Port	Portland State University, Portland, OR 97207-0752, USA
SDSU	South Dakota State University, SD, USA
SGU	Geological Survey of Sweden, P.O. Box 670, S-751 28 Uppsala, Sweden
SMHI	Sveriges Meteorologiska och Hydrologiska Inst., S-601 76 Norrköping, Sweden
Solaf	St. Olaf College, Northfield, MN 55057, USA
SU	Stockholms Universitet, S-106 91 Stockholm, Sweden
SWEDARP	Swedish Antarctic Research Project, Swedish Polar Research Secretariat, Royal Academy of Sciences, S-104 05 Stockholm, Sweden
UUpp	Uppsala Universitet, S-751 05 Uppsala, Sweden
ZII	Z/I Imaging GmbH, Carl Zeiss Strasse 22, D-734 42 Oberkochen, Germany

INTERNATIONAL GLACIOLOGICAL SOCIETY

SELIGMAN CRYSTAL PRESENTATION

11 June 2002, Yakutat, Alaska, U.S.A.

Garry K.C. Clarke

The Society's Council agreed unanimously in 2001 that a Seligman Crystal would be awarded to Garry K.C. Clarke. The Crystal was presented at the International Symposium on Fast Glacier Flow after the following introduction, by the outgoing IGS President, Bob Bindschadler.

Thank you all for coming this evening. I will give a brief introduction, present the Seligman Crystal to our honored recipient, after which I invite you all to listen to his lecture.

It has been my distinct pleasure as the IGS President to present Seligman Crystals to revered colleagues who I have known since my earliest days as a graduate student. It reassures me that I have learned from the best and benefited by being in the company of glaciological giants for my entire career. This incredible string of good luck continues tonight, as I will soon present the Seligman Crystal to Garry Clarke of the University of British Columbia.

A highlight of my graduate student days was attending the annual Northwest Glaciology meetings. Garry was always there, with an ever-changing troupe of high-quality students. From the UBC contingent, we'd hear about the continuing growth of the bulge on Trapridge Glacier and wonder if it would ever surge. Garry exhibited extreme patience in this monitoring effort, but most who know Garry would not immediately characterize him as a quiet, patient person. Fortunately for everyone, Garry's effervescent energy and intellectual curiosity had a wonderful outlet in his students. These students contributed an astoundingly varied set of glaciological studies, expertly guided and nurtured by Garry's ever-creative mind. It was clear to all in attendance how much Garry enjoyed seeing his students mature. Over the years, the UBC contribution to glaciology has mushroomed. Garry's marvellous combination of unselfishness, his razor-sharp intellect and breadth of geophysical knowledge, to say nothing of his limitless enthusiasm, are the primary reasons UBC's glaciology program has been so prolific.

It is appropriate to honor Garry's contributions by beginning with the students he mentored. I think he would wish it so, as well. It is usually a professor's students who know him best. I contacted many of Garry's former students and received a telling set of responses. His students consistently expressed their deep and endearing appreciation for Garry and his influence on their careers. There was no need to read between the lines. They were eager to be direct. Universally, they praised Garry's intellect and energy. But just as significant, they each expressed how much they recognized Garry's attentiveness to them as people, as much as to their scientific productivity.

As important as his contribution of first-rate students is, we must at some point turn directly to Garry's own research, because it is no less inspirational and significant. Searching the Science Citation Index to view Garry's papers showed me that to praise him as just a brilliant glaciologist severely understates his accomplishments. Included in his citations are papers on mantle geophysics and geomagnetism. I also found there papers addressing important issues on snow, including sliding and wind pumping.

However, it is primarily by his research on glaciers and ice sheets that Garry has made his greatest mark on our science. For those of you still in school, it is relevant to point out to you that Garry's chronology of work began in the 1960s with contributions to numerical methods. I expect it was this solid foundation that gave Garry the ability to engage in mathematical "play" with the glaciological situations he chose to study. I can give you the outline of 99% of the talks I have heard Garry deliver. He first enthralls you with a particular topic by imparting to it an air of unsolved mystery; proceeds to identify all the relevant processes; reduces these processes to a set of fundamental parameterizations; and then shows you new and wonderful physical discoveries

employing his equation set. With this proven approach, Garry has led us to recognize the role of temperature in destabilizing cold ice masses, some of the stranger aspects of subglacial water flow, and addressed very practical concerns such as outburst floods.

To focus too much on Garry's numerical and analytical strengths runs the risk of giving short shrift to his considerable advances in field glaciology. Garry has spent a large amount of time in the field and is a master at working out what is going on, whether it is at the distant end of a borehole, or from within the ice from radio-echo soundings. It is perhaps in the field where his unflappable enthusiasm is most valuable, and where his optimistic and creative attitude reaps huge dividends through those inspired students working with him.

Another characteristic that sets Garry apart is that he is so enthusiastic about everybody else's ideas. Chances are he won't need to ask you what you are working on because he keeps himself very current, but if he ever does, be sure to tell him. He will love it, say it's great and give you mountains of encouragement. If he sees flaws with the approach, he will have the kindest way of letting you know and help head you in a productive direction. Colleagues like Garry are invaluable.

Somehow in this broad and distinguished career, Garry found the time and energy to serve our Society at a desperate time. The Society's gratitude for his service as President during a difficult financial period, and for being personally involved in the installation and use of the publishing software we still use in the production of both the *Journal* and *Annals of Glaciology*, was recognized by awarding him the Richardson Medal in 1998.

But tonight it's all about Garry's scientific prowess that is no less exemplary. He has received a senior Killam Fellowship, his own country's highest award for academic achievement, is a member of the Royal Society of Canada and is an extremely influential figure in the Canadian scientific community. Tonight, it is our Society's turn to honor him.

Garry, the IGS is the beneficiary of your decision to have spent so much of your geophysical curiosity working on glaciological problems. One of your students quoted you as once saying "Some days I wake up and thank God I'm not a seismologist". (I passed my use of this quote by some seismologists here who assured me they would not be offended). Quite on the contrary, they informed me that you even authored some seminal papers that appear in seismology textbooks. But surely, your contributions to glaciology, both in terms of your numerous students who now lead their own productive glaciological careers and in terms of your own research, are a lasting and a living legacy. In a very real sense, by your sterling glaciological contributions in the literature and at symposia such as this one, we are all your students. So, Garry, on behalf of the International Glaciological Society would you please join me on the stage and allow me to present you with the Seligman Crystal.

Thank you, Mr. President, for your generous words and thanks to all members of the Society for this award. It is a wonderful coincidence to receive this honour at a meeting on Fast Glacier Flow, surrounded by so many of the friends and colleagues who have helped to make glaciology such a rewarding undertaking, and here in Yakutat just across the border from my field area.

Looking back, it seems like a complete accident that I ended up a glaciologist, but I can recognize some important formative influences. It was my unusual good fortune to have grandparents who started one of the first motels, then referred to as "cabin camps", in the Canadian Rockies and to spend many summers of my childhood at the foot of glacier-capped Mount Temple near Lake Louise. This experience unquestionably fuelled my interest in geology, mountains and glaciers and helped steer me into the geophysical sciences.

Following my third year at the University of Alberta as a physics and geology student, I was hired to work as a field assistant on the Icefield Ranges Research Project, a scientific project conceived, and I suspect largely bankrolled, by Walter Wood of the American Geographical Society and the Arctic Institute of North America. The base camp for this project was on the shores of Kluane Lake in the Yukon and the study area was the Icefield Ranges along the continental divide directly to the east of Yakutat. For me this was a dream come true because, at the very time I was being introduced to the techniques of exploration geophysics at university, I was given the opportunity to practice them in a glorious setting. I remember being almost ecstatically inspired when I discovered Volume 3 of the *Journal of Glaciology* and, of course, the papers of Nye, Lliboutry and Weertman. However, it was the work of Gordon Robin and Hans Röthlisberger, who successfully applied geophysical sounding methods to ice sheets, that had an especially powerful influence on me at the time.

When I subsequently became a graduate student at the University of Toronto, I received, out of the blue, an invitation to work with CRREL (U.S. Army Cold Regions Research and Engineering Laboratory) as a member of the International Radar Sounding Experiment in northwest Greenland. We were working at Camp Century when Chet Langway was pulling the first deep ice core from the Greenland ice cap. Although I was one of the youngest members of the scientific party, I was, ironically, brought along to represent the "Old Ways" that were largely to be supplanted by the techniques being introduced by senior members of the expedition like Gordon Robin, Stan Evans and Bud Waite. My role was to take seismic soundings to determine whether or not radar sounding actually worked. I think every expedition participant was profoundly influenced by the experience. For me, it signalled the death of seismic sounding as a tool for measuring ice thickness. For Robin and Evans, it opened a decade of Cambridge pre-eminence in radioglaciology.

Two summers later, when I was writing up a non-glaciological doctoral thesis, I was given an opportunity to work with Stan Paterson and Jim Savage (Stan's former research supervisor) on Athabasca Glacier in the Canadian Rockies. The first edition of *The Physics of Glaciers* had just appeared, and Savage was one of my favourite professors, so I knew I was in good company. Working with this pair on Athabasca Glacier gave me an opportunity to experience, first-hand, the pleasures of glaciological field work in the "British Style" as practiced by an ascetic Scot and a surprisingly ascetic American. In essence this meant poor food, water-absorbent tents and tired, wet, sleeping bags. Stan has a much higher pain threshold than most people and is not given to emoting about trying conditions.

When I started my first real job at the University of British Columbia, it never occurred to me that I was moving into a very good neighborhood. At the time I did not think of myself as a glaciologist and, most certainly, my employers did not. But Charles Raymond and Mark Meier were working just across the border from Vancouver and shortly after I arrived at UBC the Northwest Glaciologists somehow got launched, although no one quite remembers how this happened. Mark Meier has many gifts and one of them is to get a very good idea and then to convince someone else that they thought of it. I'm pretty certain this is how it worked with the Northwest Glaciologists, and it was definitely the case with the first conference on Fast Glacier Flow that we later held at Whistler.

A final formative influence was my growing awareness that somehow we were doing glaciology both the hard way and, most probably, the wrong way. Certainly this was what I had learned by participating as a seismologist on the Greenland radar experiment but I kept learning the same lesson over and over again. Glacier surveys using triangulation, logarithmic and trigonometric tables, and glacier drilling using an electrothermal "hotpoint" are other examples—none would now argue that melting through a glacier at several metres an hour was a good way to proceed.

I don't know if this is a common malaise for glaciologists but I've had the feeling that for much of my career I've been a Prisoner of Nature and that my scientific agenda keeps being hijacked by natural events. The surge of Steele Glacier in the mid-1960s sparked my interest in the cause of glacier surging and soon after we set to work on Rusty, Trapridge, Steele, Lowell and Hazard Glaciers. The Steele surge created an ice-dammed lake that unexpectedly, in the late 1970s, started to produce annual outburst floods: so we shifted our efforts to study, with limited success, floods from this lake. In 1980, we planned a scientific siege that would instrument the lake and glacier in unheard of manners. But the lake surprised us by draining months early, and days before the start of our field campaign, so we abandoned this effort and redirected our attention to Trapridge Glacier, salvaging what might have been an embarrassing situation. Despite its reluctance to surge, Trapridge Glacier has been very good to me and the diversity and complexity of its physical processes have held my interest for several decades.

Besides being a Prisoner of Nature, it is clear I have been a willing Slave of Technology. Although it is becoming socially unacceptable to be a technology enthusiast, glaciology has been entirely transformed by technological advances that affect not only our ability to do science, but our level of comfort while doing it. I am not ashamed of the fact that I prefer to be warm and dry when I am working and I think of meals as being more than fuelling stops. When I started glaciological field work, a common feature was that much of the equipment and food was "war surplus". Given that the war had ended some 20 years previously and that the military never had a high regard for the lifestyle of its troops, the comforts of glacier living and the epicurean delights of glacier dinners were greatly circumscribed. Glaciologists now take high-tech instrumentation for granted and even medium-tech tools, like hot-water drills, have opened many new avenues of research. Data loggers have made year-round field measurements a reality and portable computers have made banal tasks simple and allowed in-field interpretation of subtle phenomena. Finally, big fast computers are making it possible to apply our understanding of fundamental glacial processes at the scale of continental ice sheets.

If glaciology were a solitary activity it would be no fun at all. All the best (and a few of the worst) experiences stem from the close associations that one forms when conducting field work. The field companion to whom I owe the greatest debt is Sam Collins, a remarkable and eccentric individual who served as our volunteer surveyor and participated in every mad undertaking of the first decade of my research career. At that time, I had almost no research funding and the fact that Sam was willing to work for no salary, and did not object to paying his own travel expenses from the eastern US to the Yukon, qualifies him as one of my most significant supporters at the time it was most needed.

The best thing about working at a university is the opportunity to work closely with bright young people. I hope I've held up my part of the bargain and influenced a few students along the way, but I confess to having been profoundly influenced by the students I've worked with. David Crossley was my second graduate student and gets credit for drawing me back to glaciology — a field I thought I was done with. Others stand out because, like grains of sand sprinkled onto a critically self-organized sand pile, they have set in motion huge avalanches of research activity. Among those who have generated a cascading legacy, I would like to single out Barry Narod, my first radioglaciologist, who launched a cascade which engulfed Francis Jones and Guy Cross. Erik Blake, the Leonardo da Vinci of subglacial instrumentation, triggered his own cascade which entrained Dan Stone, Brian Waddington, Urs Fischer, Tavi Murray, Jeff Kavanaugh and Gwenn Flowers. Ed Waddington was my first ice-dynamics modeller and

accepted this challenge when it was barely feasible and I was too poor to endow long computer runs. More than a decade later, Shawn Marshall returned to this task with faster, but cheaper, computers and initiated his own cascade that captured Gwenn Flowers, Dave Hildes, Doug LaPrairie and Nicolas Lhomme. Many others, not mentioned, deserve recognition as well. Though unacknowledged they are not forgotten. Lastly, I am grateful to have shared my life with two wonderful sons, Lawrence and Julian, and, most of all, with my wife, Julie, who as luck would have it is crazy in the same way I am. If I may close with a bit of matrimonial advice for young glaciologists, it would be to marry an anthropologist — they can stand anything.

Thank you everyone.

SELIGMAN CRYSTAL PRESENTATION

13 June 2002, Yakutat, Alaska, U.S.A

Geoffrey C. Boulton

The Society's Council agreed unanimously in 2001 that a Seligman Crystal would be awarded to Geoffrey C. Boulton. The Crystal was presented at the International Symposium on Fast Glacier Flow after the following introduction, by the new IGS President, Liz Morris.

Geoffrey, members of the Society and friends:

The most pleasant of the duties of the President of the Society must be the task of presenting the Seligman Crystal to a fellow glaciologist. I feel very fortunate to have this opportunity so early in my term of office. It is especially fitting that we are able to honour Geoffrey Boulton's outstanding contribution to glaciology here at a conference on Fast Glacier Flow — a research field in which his ideas have had a profound influence. We are delighted that you have been able to join us here in Yakutat to receive the award, Geoffrey, and of course to add your ideas to the stimulating discussions on this intriguing and complex topic which are in progress here.

The Seligman Crystal has been awarded to Geoffrey for his work on subglacial processes, in particular the research which led to an important change in our understanding of how glaciers move over their beds. When Geoffrey began his field studies, 30 years ago, basal sliding was a "hot" topic — then as now. John Nye and Hans Weertman had analyzed the flow of ice over bedrock obstacles by plastic flow and regelation, and Louis Lliboutry was stressing the importance of water pressure in basal cavities as another mechanism for controlling resistance to flow. But all this work assumed a rigid rock bed. Of course we knew that there was sediment beneath glaciers, but it was Geoffrey who pointed out that underlying sediment layers could shear — and thus contribute to glacier motion. This was indeed a paradigm change.

The idea that sediment saturated with water under pressure could lose its shear strength was part of Geoffrey's intellectual heritage — he was trained as a geologist at Birmingham University and worked briefly as a hydrogeologist in Kenya — but the application of this idea to subglacial sediments was quite new. I like to think that this leap of the imagination came because Geoffrey insisted on observing processes in the field, and that the many months he spent on the forefields of glaciers in Spitsbergen and Iceland brought their due reward.

Geoffrey spent 18 fruitful years in the School of Environmental Sciences at the University of East Anglia before moving north to Edinburgh, where he is now Vice-Principal of the University. For a while, he also commuted to the University of Amsterdam where he was an "Extraordinary Professor". Throughout these moves, he has maintained his interest in glaciology and his devotion to field observation.

He has published papers on flutes, drumlins and roches moutonnées, geotechnical properties of tills, basal sliding, erosion and sedimentation, and glaciomarine processes. His range has been wide indeed, from detailed process studies on modern glaciers to large-scale modelling of past ice sheets and long-term studies connected with risk assessments for nuclear-waste disposal.

One of the reasons why Geoffrey has been so successful in bringing new ideas into the mainstream of glaciological research has been his gift for encouraging co-workers to translate his ideas into mathematical models and use these to explore with him the implications of his geological insights. An impressive list of mathematicians and physicists have been inspired

and cajoled by Geoffrey into working on basal processes and their consequences: Alan Jones, Leslie Morland, George Smith, Richard Hindmarsh and Tony Payne have all collaborated with Geoffrey at one time or another. The papers they wrote together have been widely influential and are classics of their kind.

Geoffrey has also passed on his skills and enthusiasm to students and young post-docs including Nick Eyles and Caroline Eyles, Jane Hart, Chris Clarke, Matthew Bennett and myself. My introduction to fieldwork with Geoff was probably typical, and certainly unforgettable. Time has mellowed the more hair-raising incidents into good after-dinner stories, but what remains, undiluted, is the realization that direct observation lies at the heart of our subject. Modelling and laboratory experiments have their part to play, but to develop the intuitive "feel" for glacial processes which lies behind the work which we are honouring tonight, we must spend time in the field — watching, measuring, speculating and dreaming.

Geoffrey's students have, in their turn, had "grand students" so his scientific legacy is being passed on to a new generation: David Roberts, Rob Watts, Richard Waller, Anjana Khatwa, Chris Stokes, Paul Dunlop... and I am sure others yet to come. But this does not mean that Geoff is retiring with his slippers to a corner by the fire. He still maintains an active scientific life and still seems to be in perpetual motion from one field trip to the next. So, we can be assured that more stimulating and original contributions to glaciology are yet to come.

Geoffrey has received many honours recognizing his contributions to science — he has been elected Fellow of the Royal Society and of the Royal Society of Edinburgh and was appointed an Officer of the Order of the British Empire in the Millennium Honours List. Now it is the turn of the Society to recognize his outstanding contribution to glaciological science, and it is a pleasure to do so in the presence of six outstanding glaciologists whom we have honoured in the past: Barclay Kamb, Hans Weertman, Mark Meier, Hans Röthlisberger, Charlie Raymond and Garry Clarke.

Geoffrey: on behalf of the International Glaciological Society, I am delighted to present to you the Seligman Crystal.

President, I am proud that the Society should think me worthy of this award, and particularly pleased to have received it from you, on a much less painful occasion than when we worked together trying to measure directly the shear stress at the base of the Glacier d'Argentière. I was there when one of the first Seligman Crystals was presented by Valter Schytt to John Nye, who determined so much of the trajectory of modern glaciology. Valter wondered how, after its award to John, anyone else could be deemed worthy of it. I am humbled and honoured that the Society has awarded it to me.

My first brush with practical glaciology came at the age of 15. Having been inspired by Mummery's book, *My Climbs in the Alps and Caucasus*, two school friends and I hitch-hiked to the Alps and tried to find our way over the glaciers, ridges and peaks of the Mont Blanc range, guided by a Michelin Road Atlas and the reminiscences of a Victorian gentleman climber.

My first serious glaciological efforts came in 1964 when, after postgraduate work in commerce and government, I decided to try, without a PhD, for the freedom of a University job. But I had first to get myself some research. As a motorway was being constructed nearby, with deep cuttings through Pleistocene glacial sediments, I threw myself into their study and emerged, after a three-week struggle with tills and striated boulders, with a research portfolio that the University of Keele, in their wisdom, accepted as a basis for employment as a demonstrator in glacial geology.

The objective of my new research was the classical geological one, following the precepts of Hutton and Lyell in using the present as key to the past in interpreting an area of Pleistocene glacial sediments in England. I had expected to find numerous publications describing how sediments were produced by real glaciers. But apart from classical work by such as De Geer and Gripp in Spitsbergen, Tarr and Martin in Alaska, Okko in Iceland, Carol and Forbes in the Alps, there was very little, and almost nothing that related sedimentary processes and their products to the new ways of understanding glaciers that the relatively recently formed Glaciological Society was helping to create. I would clearly have to find out for myself. That was a happy conclusion. Without it, I might not have been able to justify glaciological wanderings to Spitsbergen, Greenland, the Ross Ice Shelf, the Antarctic Dry Valleys, Baffin Island, Iceland, the Alps, Norway, studies of the marine geology of the Norwegian Sea, North Atlantic and Davis Strait, and studies of ancient glaciation in Mauretania, Morrocco and Arabia.

In 1965, I engineered an invitation to join one of Brian Harland's Cambridge University Geological Expeditions to Spitsbergen. I was immediately struck by the large amounts of sediment being produced on top of the glaciers, rather than beneath or beyond them, as reading had led me to expect. The key to sedimentary deposition was clearly the way that debris was transported by the ice, which must reflect glacier properties such as thermal regime and flow structure. Could we use the correspondence between sedimentary structures and sequences in Spitsbergen and in areas of former glaciation to infer the nature of glaciation in the latter?

However, the style of sedimentation by the only continental ice sheets where it was possible to observe most of the bed, those of the Pleistocene of Eurasia and North America, studied using the then newly available satellite-based imagery, showed that streamlined, drumlinized sediments, and not supraglacial sediments, were the norm. I therefore shifted attention to glaciers where these forms occurred.

Excellent mapping by Bob Price had shown that a large, easily accessible glacier in southern Iceland, Breiðamerkurjökull, was creating a streamlined and drumlinized till surface on an extensive flat plain, potentially an excellent analogue for Pleistocene ice sheets. Much to our surprise, we found out, by dint of

hard, tunneling labour, that the till was not transported in the ice and deposited by lodgement, but was transported by subglacial shear deformation and emplaced when this ceased. Alan Jones, Richard Hindmarsh and I argued that the bed of a glacier could no longer be regarded as passive and rigid, with the glacier's dynamic behaviour determined by ice properties alone, but that the sediment beds typical of lowland glaciers must be products of coupling between the dynamics of the glacier and the properties of the subglacial sediments. Because those properties are strongly influenced by water pressure in the sediment, understanding the subglacial drainage system is vital in developing a theory of the coupling. These are vital insights. If sediment deposition is a result of coupling between ice processes and sediment and drainage-system properties, rather than a simple consequence of glacial action, we should be able to infer the glaciological behaviour of past ice sheets through whole glacial cycles from the evidence of the till and meltwater sediments that they have created. The ferment of activity in the field holds out great promise for important new concepts and theories.

Since Louis Agassiz introduced the glacial theory in the 1840s, glacial geologists have primarily worked to establish a narrative of the extent and frequency of former glaciations, based primarily on the extent and stratigraphy of tills and the locations of moraines. The concept of a coupled ice–bed system is a basis for creation of a palaeoglaciology, reconstructing the evolution of the ice-sheet system from its geological impacts. It should be a prime objective for glaciologists and the Society, and I am confident that it will be yet another example of Mark Twain's dictum about good science, that "one gets such wholesale returns of conjecture from such trifling investments of fact".

NEW SECRETARY GENERAL

The International Glaciological Society is pleased to announce the appointment of Magnús Már Magnússon to succeed Simon Ommanney as the next Secretary General.

Magnús is particularly well-known to those of our members who work on snow and avalanches.

He is a graduate of the University of St. Andrews, Scotland (Physics and Electronics) and the University of Washington, Seattle, WA, U.S.A. (Glaciology).

Since 1988, he has been working for the Icelandic Meteorological Office in Reykjavík, Iceland.

He expects to take up his new position on 28 April 2003 and will enjoy an overlap with Simon until August.

Coincidentally, he also has a Canadian wife, Karen Young, who, together with their two boys, will join him at the end of the Icelandic school term.

Simon and Margaret plan to return to Canada in August and live in Toronto so they can be close to their children and grandchildren.

They intend to spend the summers at their cottage in northern Ontario and the winters in Toronto.

Both Simon and Magnús will attend the IGS Symposium on Snow and Avalanches in Davos in June 2003.

DONORS

The IGS wishes to thank all those who have helped further its objectives from 1998 to 2002 by generously paying a higher membership rate. The names of all those who have not requested anonymity are acknowledged below:

Contributing Members

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For 2003, the rate for Contributing Membership will be £100 and for Supporting Membership £200 per year.

ANNALS OF GLACIOLOGY, VOLUME 36

The following papers from the International Symposium on Fast Glacier Flow held in Yakutat, Alaska, U.S.A., 10–14 June 2002 have been accepted for publication in *Annals of Glaciology* Vol. 36, edited by C.F. Raymond and C.J. van der Veen:

R B Alley, D E Lawson, E B Evenson and G J Larson
Sediment, glaciohydraulic supercooling, and fast glacier flow

S Anandakrishnan
Dilatant till layer near the onset of streaming flow of Ice Stream C, Antarctica, determined by AVO (amplitude vs offset) analysis

D J Barclay, G C Wiles and P E Calkin
A 850 year record of climate and fluctuations of the iceberg-calving Nellie Juan Glacier, south central Alaska

R Bindschadler, P Vornberger, M King and L Padman
Tidally-driven stick-slip motion in the mouth of Whillans Ice Stream, Antarctica

H Björnsson, F Pálsson, O Sigurðsson and G E Flowers
Surges of glaciers in Iceland

G S Boulton, M Hagdorn and N R J Hulton
Streaming flow in an ice sheet through a glacial cycle

G A Catania, H B Conway, A M Gades, C F Raymond and H Engelhardt
Bed reflectivity beneath inactive ice streams in West Antarctica

P Christoffersen and S Tulaczyk
Thermodynamics of basal freeze-on: predicting basal and subglacial signatures of stopped ice streams and interstream ridges

L Copland, M J Sharp and J A Dowdeswell
The distribution and flow characteristics of surge-type glaciers in the Canadian High Arctic

G Diolaiuti, M Pecci and C Smiraglia
Liligo Glacier, Karakoram, Pakistan: a reconstruction of the recent history of a surge-type glacier

K J Eijpen, C R Warren and D I Benn
Subaqueous melt rates at calving termini: a laboratory approach

D R Fatland, C S Lingle and M Truffer
A surface motion survey of Black Rapids Glacier, Alaska, U.S.A

A L J Ford, R R Forster and R L Bruhn
Ice surface velocity patterns on the Seward Glacier, Alaska/Yukon, and their implications for regional tectonics in the Saint Elias Mountains

G H Gudmundsson, G Aðalgeirsdóttir and H Björnsson
Observational verification of predicted increase in bedrock-to-surface amplitude transfer during a glacier surge

S Hansen
From surge-type to non-surge-type glacier behaviour: midre Lovénbreen, Svalbard

W D Harrison and A S Post
How much do we really know about glacier surging?

C L Hulbe, W Wang, I R Joughin and M J Siegert
The role of lateral and vertical shear in tributary flow toward a West Antarctic ice stream

H Jiskoot, T Murray and A Luckman
Surge potential and drainage-basin characteristics in East Greenland

I R Joughin, S M Tulaczyk and H F Engelhardt
Basal melt beneath Whillans Ice Stream and Ice Streams A and C, West Antarctica

B Kulessa and T Murray
Slug-test derived differences in bed hydraulic properties between a surge-type and non-surge-type Svalbard glacier

C S Lingle and D R Fatland
Does englacial water storage drive glacier surges?

A Luckman, T Murray, H Jiskoot, H Pritchard and T Strozzi
ERS SAR feature-tracking measurement of outlet glacier velocities on a regional scale in East Greenland

R J Motyka, L Hunter, K Echelmeyer and C Connor
Submarine melting at the terminus of a temperate tidewater glacier, LeConte Glacier, Alaska, U.S.A

T Murray, A Luckman, T Strozzi and A.-M Nuttall
The initiation of glacier surging at Fridtjovbreen, Svalbard

M Nolan
The "galloping glacier" trots: decadal-scale speed oscillations within the quiescent phase

B R Parizek, R B Alley and C L Hulbe
Subglacial thermal balance permits ongoing grounding-line retreat along the Siple Coast of West Antarctica

P R Prescott, J P Kenneally and T J Hughes
Relating crevassing to non-linear strain in the floating part of Jakobshavn Isbræ, West Greenland

B T Rabus and O Lang
Interannual surface velocity variations of Pine Island Glacier, West Antarctica

B T Rabus, O Lang and U Adolphs
Interannual velocity variations and recent calving of the Thwaites Glacier Tongue, West Antarctica

D M Rippin, M J Siegert and J L Bamber
The englacial stratigraphy of Wilkes Land, East Antarctica, as revealed by internal radio-echo sounding layering, and its relationship with balance velocities

J J Roush, C S Lingle, R M Guritz, D R Fatland and V A Voronina
Surge-front propagation and velocities during the early-1993–95 surge of Bering Glacier, Alaska, U.S.A., from sequential SAR imagery

P Skvarca, B Raup and H de Angelis
Recent behaviour of Glaciar Upsala, a fast-flowing calving glacier in Lago Argentino, southern Patagonia

D C Trabant, R M Krimmel, K A Echelmeyer, S Zirnheld and D H Elsberg
The slow advance of a calving glacier: Hubbard Glacier, Alaska, U.S.A

M Truffer and K A Echelmeyer
Of isbræ and ice streams

D G Vaughan, A M Smith, P C Nath and E le Meur
Acoustic impedance and basal shear stress beneath four Antarctic ice streams

A Vieli and A J Payne
Application of control methods for modelling the flow of Pine Island Glacier, Antarctica

S W Vogel, S Tulaczyk and I Joughin
Distribution of basal melting and freezing beneath tributaries of Ice Stream C: implication for the Holocene decay of the West Antarctic ice sheet

C R Warren and M P Kirkbride
Calving speed and climatic sensitivity of New Zealand lake-calving glaciers

I Willis, D Mair, B Hubbard, P Nienow, U H Fischer and A Hubbard
Seasonal variations in ice deformation and basal motion across the tongue of Haut Glacier d'Arolla, Switzerland

JOURNAL OF GLACIOLOGY

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

B Cheng and T Vihma
Idealized study of a 2-D coupled sea-ice/atmosphere model during warm-air advection

M Gay, M Fily, C Genthon, M Frezzotti, H Oerter and J-G Winther
Snow grain-size measurements in Antarctica

Y Iizuka, M Igarashi, K Kamiyama, H Motoyama and O Watanabe
Ratios of Mg^{2+}/Na^{+} in snowpack and an ice core at Austfonna ice cap, Svalbard, as an indicator of seasonal melting

D Iliescu and I Baker
Correspondence. Imaging of uncoated snow crystals using a low-vacuum scanning electron microscope

Kang Shichang, K J Kreutz, P A Mayewski, Qin Dahe and Yao Tandong
Stable-isotopic composition of precipitation over the northern slope of the central Himalaya

E J Klok and J Oerlemans
Model study of the spatial distribution of the energy and mass balance of Morteratschgletscher, Switzerland

S Li and M Sturm
Patterns of wind-drifted snow on the Alaska arctic slope detected with ERS-1 interferometric SAR

C Mätzler
Relation between grain-size and correlation length of snow

F Pattyn
Transient glacier response with a higher-order numerical ice-flow model

F Pattyn and D Derauw
Ice-dynamic conditions of Shirase Glacier, Antarctica, inferred from ERS SAR interferometry

W T Pfeffer and R Mrugala
Temperature gradient and initial snow density as controlling factors in the formation and structure of hard depth hoar

INTERNATIONAL SYMPOSIUM ON SNOW AND AVALANCHES

Davos, Switzerland, 2–6 June 2003

CO-SPONSORED BY

Swiss Federal Institute for Snow and Avalanche Research

SECOND CIRCULAR

The International Glaciological Society will hold an International Symposium on Snow and Avalanches in Davos, Switzerland, in June 2003. The Symposium will be organized with the Swiss Federal Institute for Snow and Avalanche Research SLF, Davos and held at the International Congress Centre, Davos, with registration on 1 June 2003 and sessions from 2–6 June 2003.

SYMPOSIUM ORGANIZATION

C. Simon L. Ommanney (Secretary General, International Glaciological Society)

LOCAL ARRANGEMENTS COMMITTEE

Walter J. Ammann (Chairman), Perry Bartelt, Jakob Rhyner, Veronika Stöckli, Paul M.B. Föhn, Barbara Miller, Madeleine Oberhänsli

EDITORIAL BOARD

Paul M.B. Föhn (Chief Editor), Massimo Barbolini, Robert L. Brown, Richard Essery, Bruce Jamieson, Eric Martin, Mohamed Naaim, Kouichi Nishimura, Frode Sandersen, Jürg Schweizer, Michael Staudinger, Matthew Sturm

PARTICIPATION

This circular includes forms for registration and accommodation. The registration form and accompanying payment should be returned before 7 March 2003. There will be a £50 surcharge for late registration. The participant's registration fee covers organization costs, a set of abstracts, the icebreaker party, the banquet, the mid-week excursion, and a copy of the *Annals of Glaciology*. The accompanying person's registration fee includes organization costs, the icebreaker, the banquet, and the mid-week excursion. It will be possible to organize additional trips through the local tourist office. There is an extra administration charge of £30 for participants who are not members of the International Glaciological Society.

REGISTRATION FEES	**UK £**
Participant (IGS member)	270
Participant (not IGS member)	300
Student and Retired IGS members	100
Accompanying person aged 18 or over	55
Late registration surcharge (after 7 March)	50

Refunds on registration fees will be made on a sliding scale, according to date of receipt of notification, up to 16 May 2003. After that date, it may be impossible to make any refund. See registration form for methods of making payment. All who pre-register will receive a copy of the third circular and programme prior to the meeting.

THEME

The properties of snow in mountainous and polar regions and the processes taking place within the snow cover will be discussed as a base for numerical models of the snow cover and for avalanche dynamics, but also for the interpretation of climate response data or of remote-sensing signals. In most mountainous areas, avalanches pose a significant threat to human life and property. Profound knowledge of avalanche initiation and avalanche dynamics opens up new and powerful prospects for improving avalanche forecasting, hazard mapping and technical measures for an integrated risk-management approach.

This Symposium will focus on those aspects of snow science related to understanding the snow cover, its properties and interactions, as well as its movement.

TOPICS

The suggested topics include:

- snow properties (mechanical, physical, electromagnetic, chemical)
- modelling snow and ice
- snow-cover (distribution, evolution, variability, modelling, climate change)
- snow-cover monitoring, remote sensing
- snowdrifting, blowing snow
- snow cover and permafrost
- snow-cover hydrology
- snow-cover ecology (interaction with flora and fauna)
- artificial snow
- snow and winter sports
- avalanches (formation processes, avalanche forecasting, snow-cover stability, modelling, monitoring, experiments)
- avalanche-risk management

SESSIONS

Oral presentations will be held on four full days and one half-day. There will be ample opportunity for poster displays.

PAPERS

(I) SUBMISSION OF ABSTRACTS

Participants who want to contribute to the Symposium should submit an abstract of their proposed presentation. This abstract must contain sufficient detail to enable us to judge its scientific merit and relevance. It should not exceed one page of typescript, on international-size paper A4 (210 x 297 mm). References and illustrations should not be included. Place the title and author(s) names and address(es) at the top of the abstract, not on a separate sheet. Indicate at the bottom which specific topic(s) it intends to address, and whether a poster or oral presentation is preferred. When selecting material, authors should bear in mind that the final version of their paper on this topic should not exceed 5 printed pages in the *Annals*; extra pages will be charged at the rate of £90 per page. Honoring page charges (also £90 per page) for the first five pages is encouraged. Send abstracts by e-mail, fax or regular mail to: Secretary General, International Glaciological Society, Scott Polar Research Institute, Lensfield Road, Cambridge CB2 1ER, U.K.

LAST DATE FOR RECEIPT OF ABSTRACTS: 30 NOVEMBER 2002

(II) SELECTION OF ABSTRACTS

Each abstract will be assessed on its scientific quality and relevance to the topics of the Symposium. Authors whose abstracts are accepted will be invited to make either an oral or poster presentation at the Symposium and submit a paper for publication in the *Annals of Glaciology* (included in the ISI Science Citation Index®). First or corresponding authors will be advised in mid-January 2003 of the acceptance or otherwise; other authors will not be informed separately. Authors who have not received notification by 27 January 2003 should contact the IGS office in Cambridge in case their abstract was not received. Acceptance of an abstract means that the paper based on it should be submitted to the *Annals of Glaciology* and not to another publication. Note: Abstracts alone will not be published in the *Annals of Glaciology*.

(III) DISTRIBUTION OF ABSTRACTS

A set of the accepted abstracts will be provided to participants upon registration on 1 June 2003.

(IV) SUBMISSION OF PAPERS AND PUBLICATION

FOUR copies of each paper, doubled-spaced with wide margins, should be sent to the Secretary General, International Glaciological Society, Scott Polar Research Institute, Lensfield Road, Cambridge CB2 1ER, U.K., by 17 March 2003. ALL AUTHORS ARE EXPECTED TO ADHERE TO THIS DEADLINE. Papers should be prepared in accordance with the instructions sent to authors with the abstract acceptance notification. Papers will be refereed according to the usual standards of the Society before being accepted for publication. Final papers, based on presentations at the Symposium, which have been submitted and accepted by the Editorial Board following review, will be published in English in the *Annals of Glaciology* (Vol. 38). Final, revised versions of papers, diskettes and original art work must be submitted by 14 July 2003. Speedy publication of the *Annals of Glaciology* will depend upon strict adherence to deadlines.

LAST DATE FOR RECEIPT OF PAPERS: 17 MARCH 2003

MID-WEEK EXCURSIONS

As part of the registration fee, there will be mid-week excursions to various locations depending on weather conditions and the number of participants. Sign-up for these will be on 1 June 2003, during registration.

PRE/POST-SYMPOSIUM TOUR

Although no pre- or post-symposium group tours are planned, personal excursions may be arranged locally: see the Davos website (www.davos.ch).

TRAVEL AND ACCOMMODATION

The HOTEL BOOKING FORM (available on www.igsoc.org/symposia/2003/davos) provides a wide range of hotel accommodation from 2 to 4 stars. Participants are strongly encouraged to use this form and to book early. The Symposium will probably end late Friday afternoon so you may need to spend Friday night in Davos. Please note that the journey from Davos to the airport in Zürich takes approximately 3–4 hours by train.

Once checked in at your hotel in Davos, you will be given a "Davos" Guest Card which entitles you to free use of the Davos Transport Services Bus Lines, in accordance with the valid route plan within the Region of Davos, for the period of the card's validity.

All sessions will be at Congress Centre Davos, Promenade 92, 7270 Davos-Platz.

For more information, please visit the official Symposium website (see above).

IMPORTANT DATES

Abstracts due	30 November 2002
Notification of acceptance	15 January 2003
Pre-registration deadline	7 March 2003
Papers due	17 March 2003
Accommodation-booking deadline	18 April 2003
Deadline for full refund	18 April 2003
Deadline for refund	16 May 2003
Registration for conference	1 June 2003
Conference starts	2 June 2003
Final revised papers	14 July 2003

REGISTRATION FORM

Family Name: _____

First Name: _____

Address: _____

_____

_____

Tel: _____ Fax: _____ E-mail: _____

Accompanied by:

Name: _____ Age (if under 18) ____

Name: _____ Age (if under 18) ____

Name: _____ Age (if under 18) ____

REGISTRATION FEES	£	£
Participant (Member of the IGS)	270	___
Participant (Not a member of the IGS)	300	___
Student or Retired IGS Member	100	___
Accompanying person aged 18 or over	55	___
Late registration surcharge (after 7 March 2003)	50	___
TOTAL REGISTRATION FEES AND DEPOSITS SENT		____

ACCOMMODATION

Please complete the Hotel Booking Form and return it to the Davos Tourist Office.

Payment of registration fee, in pounds sterling drawn on a UK bank, may be made by cheque to:

INTERNATIONAL GLACIOLOGICAL SOCIETY

or by Access/Eurocard/MasterCard or VISA/Delta

Card No.																Expires				

Name on card: _____

Signature: _____

Payment may also be made to: National Westminster Bank plc, Account no: 54770084, 56 St. Andrew's Street, Cambridge CB2 3DA, UK (any Bank or Transfer charges must be included).

INTERNATIONAL SYMPOSIUM ON ICE–WATER–ICE: PROCESSES ACROSS THE PHASE BOUNDARY

Portland State University, Portland, Oregon, U.S.A., 26–30 July 2004

CO-SPONSORED BY

Department of Geology, Portland State University

FIRST CIRCULAR

The International Glaciological Society will hold an International Symposium on Ice–Water–Ice: Processes Across the Phase Boundary, in 2004. The Symposium will be held at Portland State University, Portland, Oregon, U.S.A. with registration on 25 July, and sessions from 26–30 July.

THEME
Interactions between water and ice span a wide range of topics, from some of the fundamental problems in glaciology to the daily lives of people who depend on alpine watersheds. This Symposium will be devoted to the macro and micro interactions between ice and water, providing new avenues for discussion across the phase boundary. For example, investigations of basal water-drainage systems in glaciers have an affinity with studies of subglacial melting and freezing processes, both of which are in turn connected to studies of glacier and ice-sheet flow rates, in both modern and paleo-environments; glaciologists, hydrologists and biologists can share knowledge regarding the timing and rate of melt and meltwater discharge and its downstream effects; and similarities and differences between glacier and ice-shelf calving processes can be explored.

TOPICS
The suggested topics include:
1. Glacier and ice-sheet hydrology
2. Snow/water interactions
3. Calving glacier and ice-shelf processes
4. Effects of water on glacier and ice-sheet flow
5. Water, ice and biological activity
6. Lake and river ice
7. Physics of ice and water

SESSIONS
Oral presentations will be held on four full days and one half-day. There will be ample opportunity for poster displays.

PUBLICATION
Selected papers from the Symposium will be published by the Society in the *Annals of Glaciology*. All papers (including those based on posters) will be refereed and edited according to the Society's regular standards before being accepted for publication.

ACCOMMODATION
Details will be given in the Second Circular. A full range of hotel accommodation will be available.

FURTHER INFORMATION
If you wish to attend the Symposium, please return the attached form as soon as possible. The Second Circular will give information about accommodation, the general programme, and preparation of abstracts and final papers. Copies of the Second Circular will be sent to those who return the attached reply form. Members of the International Glaciological Society will automatically receive one.

SYMPOSIUM ORGANIZATION
Simon Ommanney (International Glaciological Society)

CHIEF SCIENTIFIC EDITOR
Douglas R. MacAyeal

LOCAL ARRANGEMENTS COMMITTEE
Christina L. Hulbe (Chair), Andrew G. Fountain, Carolyn L. Driedger, Laurie Padman, Joe S. Walder

INTERNATIONAL SYMPOSIUM ON ARCTIC GLACIOLOGY

Geilo, Norway, 23–27 August 2004

CO-SPONSORED BY

International Arctic Science Committee (IASC)
Working Group on Arctic Glaciology

FIRST CIRCULAR

The International Glaciological Society will hold an International Symposium on Arctic Glaciology in 2004 in collaboration with the Working Group on Arctic Glaciology of the International Arctic Science Committee (IASC). The Symposium will be held in Geilo, Norway, with registration on 22 August and sessions from 23–27 August 2004.

THEME
Approximately two-thirds of the Earth's small glaciers and ice caps are located in the Arctic, in addition to the 1.7 million km^2 Greenland ice sheet. The enhanced climate warming predicted for the Arctic is likely to have important consequences for the mass-balance and dynamics of Arctic ice masses; accelerating melting has been observed in some parts of the Arctic already, providing a significant contribution to observed global sea-level rise. Cores from Arctic ice masses are also a key source of high-resolution palaeoclimatic information. Understanding the flow-behaviour of these ice masses is also important both to modelling future cryospheric responses to climate change and to interpreting ice-core records. The understanding of the past, present and likely future responses of Arctic ice masses to climate change is the key aim of this conference. Approaches using and integrating field observations, remote sensing and modelling are welcomed.

TOPICS
The suggested topics include:

1. Climate records from Arctic ice cores
2. Quaternary (Pleistocene and Holocene) history of Arctic glaciers
3. Glaciers and greenhouse warming: future response, fresh-water flux and sea-level response
4. Mass balance of glaciers and ice caps
5. State and balance of the Greenland ice sheet
6. Modelling
7. Remote sensing
8. Dynamics, surging glaciers

SESSIONS
Oral presentations will be held on four full days and one half-day. There will be ample opportunity for poster displays.

PUBLICATION
Selected papers from the Symposium will be published by the Society in the *Annals of Glaciology*. All papers (including those based on posters) will be refereed and edited according to the Society's regular standards before being accepted for publication.

ACCOMMODATION
Details will be given in the Second Circular.

FURTHER INFORMATION
If you wish to attend the Symposium, please return the attached form as soon as possible. The Second Circular will give information about accommodation, the general programme, and preparation of abstracts and final papers. Copies of the Second Circular will be sent to those who return the attached reply form. Members of the International Glaciological Society will automatically receive one.

SYMPOSIUM ORGANIZATION
Simon Ommanney (International Glaciological Society)

CHIEF SCIENTIFIC EDITORS
Julian A. Dowdeswell and Ian C. Willis

LOCAL ARRANGEMENTS COMMITTEE
Jon Ove Hagen (Chairman), Elisabeth Isaksson, Jack C. Kohler, Kjetil Melvold, Erik Roland

SYMPOSIUM ON ICE WATER ICE
Portland, Oregon, U.S.A., 26–30 July 2004

Family Name: .....
First Name(s): .....
Address: .....
.....
Tel: .....
Fax: .....
E-mail: .....
I hope to participate in the Symposium in July 2004 ☐
I expect to submit an abstract ☐
My abstract will be most closely related to topic(s):

Am interested in an accompanying person's programme ☐

SYMPOSIUM ON ARCTIC GLACIOLOGY
Geilo, Norway, 23–27 August 2004

Family Name: .....
First Name(s): .....
Address: .....
.....
Tel: .....
Fax: .....
E-mail: .....
I hope to participate in the Symposium in August 2004 ☐
I expect to submit an abstract ☐
My abstract will be most closely related to topic(s):

Am interested in an accompanying person's programme ☐

PLEASE RETURN AS SOON AS POSSIBLE TO:

International Glaciological Society, Scott Polar Research Institute, Lensfield Road, Cambridge CB2 1ER, U.K.
Tel [44](1223) 355-974; Fax [44](1223)336-543; Int_Glaciol_Soc@compuserve.com; http://www.igsoc.org/symposia/2004/

SCAR — SEVENTH INTERNATIONAL SYMPOSIUM ON ANTARCTIC GLACIOLOGY

25–29 August 2003, Milano, Italy

CO-SPONSORED BY

International Glaciological Society (IGS)
Italian Antarctic Research Programme (PNRA)
Italian Glaciological Committee (CGI)
University of Milano–Bicocca (UNIMIB)
Department of Environmental Sciences (DISAT)
Agency for New Technology, Energy and the Environment (ENEA)

SECOND CIRCULAR

The Seventh International Symposium on Antarctic Glaciology will take place from 25 to 29 August 2003 at the University of Milano–Bicocca, Italy. The Symposium is organized by the SCAR Standing Scientific Group for Physical Sciences with local arrangements provided by a committee from the Italian Antarctic Research Programme.

THEME

Over the past decades, Antarctic glaciology has become, more and more, a field of study of general interest. This has resulted from the profound concern for the past, the present and the future of the Earth's environment, indicators of which are locked in the Antarctic ice sheet. Major problems are still open in Antarctic glaciology that require intensified and co-ordinated research, such as evaluation of the ice-sheet mass balance, ice-sheet dynamics, and understanding ice–ocean–atmosphere interactions in a changing climate. Unique information can be extracted from ice, sub-glacial lakes and permafrost concerning past atmosphere and climate, environmental change and life adaptation. The Symposium will offer Antarctic glaciologists (particularly young scientists) a forum at which results from research conducted during the last five years, related to various Antarctic themes identified, can be presented and discussed. Special sessions will be devoted to the international co-ordinated scientific programmes, will focus on future targets, and advance ideas for new scientific programs.

TOPICS

Ice-sheet mass balance
Ice-sheet dynamics
Ice-shelf/ocean interaction
Snow/ice/atmosphere interaction
Sea-ice processes and sea-ice/atmosphere/ocean interaction
Climate change and atmosphere chemistry during the last 200–1000 years
Paleoclimate at the millennial scale
Long-term records from ice cores
Subglacial lakes
Meteorites and ice
Remote sensing
Permafrost in Antarctica
Glacial and periglacial geomorphology

PROGRAMME

All sessions will take place in the University of Milano–Bicocca, Piazza Ateneo Nuovo 1, Milano (Italy), from Monday morning to Friday afternoon. Poster sessions are expected to form an important part of the Symposium. Oral presentations will be held on four full days and one half-day. A detailed programme will be sent out to all registered participants. Special sessions/meetings on ITASE, InterICE, ISMASS and SALE will be organised before, during and after the Symposium. Other sessions/meetings may also be organised if requested prior to the 28 February 2003. Meetings/workshops of other bodies and international programmes are also encouraged and meeting rooms will be available throughout the week. Please contact the organizing committee in advance so we can announce your meeting in our programme and reserve rooms.

INFORMATION ABOUT THE SYMPOSIUM MAY BE OBTAINED FROM

Department of Environmental Sciences, University of Milano Bicocca, Piazza della Scienza 1, I-20126 Milano (Italy)
Fax: [+39] 02 64482895; E-mail: isag7@unimib.it; Web: http://www.disat.unimib.it/isag7

Registration and accommodation: PROMO-EST s.r.l. Via M. Buonarroti, 2 - 20145 Milano - Italy
Phone: +39 0248018422 Fax: +39 0248018575
E-mail: glaciology@promoest.com

PARTICIPATION

The registration and accommodation forms should be obtained from PROMO-EST. The registration form and accompanying payment should be returned before 30 April 2003. There is a surcharge for late registrations. The participant's registration fee covers organization costs, a set of abstracts, the icebreaker, mid-day lunches, coffee breaks, half-day tour in Milano and a copy of the *Annals of Glaciology*. The accompanying person's registration fee includes organization costs, the icebreaker and a half-day tour in Milano. It will be possible to organise additional trips through the local tourist office.

REGISTRATION FEES (in Euros)	(until 30 April 2003)	(from 1 May 2003)
Participant full cost	400	500
Student and Retired	200	250
Accompanying person aged 18 or over	100	120
Half-day excursion to Lake Como (up-grade)	48	48
Post-congress field trip (approx.)	400	400

IMPORTANT DATES

Abstracts due:	**28 February 2003**
Notification of acceptance:	1 April 2003
Registration deadline:	30 April 2003
Papers due:	**21 June 2003**
Deadline for full refund:	8 July 2003
Deadline for refund:	10 August 2003
Conference starts:	**25 August 2003**
Post-symposium tour starts	30 August 2003
Deadline for final revised papers:	**10 October 2003**

To avoid disappointment, please respect the above deadlines

Cancellation refunds of registration fees will be made on a sliding scale, according to date of receipt of notification, up to 10 August 2003. After that date, it may be impossible to make any refund. See booking form for methods of making payment. All who register will receive a copy of the third circular and programme prior to the meeting.

PAPERS

(I) SUBMISSION OF ABSTRACTS

Participants who want to contribute to the Symposium should submit an abstract of their proposed presentation. This abstract must contain sufficient detail to enable us to judge its scientific merit and relevance. It should not exceed one page of typescript, on international-size paper A4 (210 x 297 mm). References and illustrations should not be included.

Abstracts submission may be made (i) on-line at <www.disat.unimib.it/isag7>, (ii) by e-mail (preferably in rft format) to <isag7@casaccia.enea.it> or (iii) on diskette (rtf-format) to Dr. Umberto Gentili, ENEA Casaccia, Via Anguillarese 301, S.M. di Galeria (Roma), 00060, Italy.

For e-mail and diskette submissions, place the title and author(s) names and address(es) at the top of the abstract, not on a separate sheet. Indicate at the bottom which specific topic(s) it intends to address, and whether a poster or oral presentation is preferred.

Authors should bear in mind that the final version of their paper should not exceed 5 printed pages in the *Annals of Glaciology*; extra pages will be charged at the rate of UK£90 (€142) per page. Honoring page charges (also £90 – €142 per page) for the first five pages is encouraged.

LAST DATE FOR RECEIPT OF ABSTRACTS: 28 FEBRUARY 2003

(II) SELECTION OF ABSTRACTS

Each abstract will be assessed on its scientific quality and relevance to the topics of the Symposium. Authors whose abstracts are accepted will be invited to make either an oral or poster presentation at the Symposium and submit a paper for publication in the *Annals of Glaciology* (included in the ISI Science Citation Index®). First or corresponding authors will be advised in late March of the acceptance or otherwise; other authors will not be informed separately. Authors who have not received notification by mid-April should contact the organizing committee at <isag7@unimib.it> in case their abstract was not received. Acceptance of an abstract means that the paper based on it should be submitted to the *Annals of Glaciology* and not to another publication. Note: Abstracts alone will not be published in the *Annals of Glaciology*.

(III) DISTRIBUTION OF ABSTRACTS

A set of the accepted abstracts will be provided to participants upon registration on 25 August 2002.

(IV) SUBMISSION OF PAPERS AND PUBLICATION

FOUR copies of each paper, single-sided and doubled-spaced with wide margins, should be sent to the Production Manager, *Annals of Glaciology* 39, International Glaciological Society, Scott Polar Research Institute, Lensfield Road, Cambridge CB2 1ER, U.K., by 21 June 2003.

ALL AUTHORS ARE EXPECTED TO ADHERE TO THIS DEADLINE

Papers should be prepared in accordance with the style instructions sent to authors with the abstract acceptance notification. Papers will be refereed according to the usual standards of the *Annals of Glaciology* before being accepted for publication. Final papers, based on presentations at the Symposium, that have been submitted and accepted by the Editorial Board, following review, will be published in English in the *Annals of Glaciology* (Vol. 39). Final, revised versions of papers, diskettes and original art work must be submitted by 10 October 2003. Speedy publication of the *Annals of Glaciology* will depend upon strict adherence to deadlines.

LAST DATE FOR RECEIPT OF PAPERS: 21 JUNE 2003

LAST DATE FOR RECEIPT OF FINAL PAPERS: 10 OCTOBER 2003

MID-WEEK EXCURSION

There will be a mid-week tour of Milano (free for all participants and accompanying persons) or an excursion to Lake Como (at an additional charge of €48, and depending on weather conditions and the number of participants).

POST-SYMPOSIUM TOUR

A post-symposium field trip of five days (30 August–3 September) to visit major and more accessible Italian glaciers is planned.

The proposed itinerary includes the glaciers of Monte Bianco (Miage debris-covered glacier, Brenva glacier and associated recent rock avalanches, Courmayeur), Monte Rosa (Belvedere surging glacier and epiglacial lake, Macugnaga) and Central Alps (Val Cedech and Forni glaciers, Bormio). Historic sites along the route will be visited. A typical Valtellina wine cellar will be also visited with a taste of wine and local foods. High-mountain clothes and shoes are recommended. The cost of participation will be about €400 (subject to confirmation).

A maximum of 50 persons will be accepted. The post-symposium field trip will be cancelled if fewer than 10 people register.

WEATHER CONDITIONS

The weather in Milano during the second half of summer (August to September) is normally good and warm. Temperatures range from 17°C (night) to 27°C (afternoon), with relative humidity around 60% to 70%, mean monthly precipitation 90 mm, and prevailing clear sky. Thunderstorms can occur during the afternoon, but normally the Po Plain, where Milano is located, is characterized by weak winds.

ACCOMMODATION

Milano provides a wide range of hotels. The Hotel Booking form (available from PROMO-EST) provides a choice of 2- to 4-star hotels. The Symposium will end 29 August (Friday), late afternoon, so you may need to spend Friday night in Milano.

TRANSPORTATION

Airports

Linate (LIN), is in the eastern outskirts, some 10 km from downtown. A shuttle-service runs to and from the central railway station and there is a bus (No. 73) to and from the city center. Both take about 30 min, depending on traffic.

Malpensa (MXP), is located towards Lake Maggiore, some 50 km from downtown. The Malpensa Express shuttle-train runs to and from the Ferrovie Nord railway station.

Orio al Serio (BGY), a smaller international airport near Bergamo, is used increasingly as an airport for Milan. There is a bus service to and from the central railway station.

Railways

Stazione Centrale, the main station, the departure point for international and high-speed trains.
Stazione Garibaldi, many regional trains leave from this station
Stazione Nord, covers the area north of Milan: the final stop of the Malpensa Express.
The Symposium venue may be reached easily by surface and underground public transportation systems. Details will be given in the third circular and web site (www.disat.unimib.it/isag7).

SHOPS AND BANKS (TIME AND LOCATIONS)

The currency in Italy is the Euro (€). The exchange with the US$ is around 0.98 (October 2002). All banks (except in airports) are closed on Saturday and Sunday. During the week, the banks open from 8.30 to 14.00 and from 15.00 to 16.00. Money can be obtained from automatic tellers (practically all banks), that work with the main credit cards.

Italy is on European Central Time (GMT +1), but during the summer legal time is one hour more (GMT +2).

August is the holiday period in Italy, so some shops may be closed. Shops are normally open from 8.30 to 13.00 and 15.00 to 19.30 and some may accept US$ and UK£; most accept credit cards.

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INSURANCE AND VISA

All insurance is the responsibility of participants. The Organizing Committee accepts no liability or responsibility for death or illness or injury to, or financial loss by, any person attending the Symposium, whatever the cause. It is strongly recommended that non-European Union participants arrange their own health and accident insurance. Participants are advised to check their individual circumstances for entry.

LOCAL ORGANIZING COMMITTEE

Giuseppe Orombelli (Chairman), Massimo Frezzotti, Valter Maggi

GLACIOLOGICAL DIARY

** IGS sponsored * IGS co-sponsored

2003

13–14 January 2003
Conference on Cryospheric Systems, Geological Society, Burlington House, London, UK
Charles Harris, Department of Earth Sciences, University of Wales, P.O. Box 914, Cardiff CF1 3YE, U.K. (Tel [44](29)2087-4336; Fax [44](29)2087-4326; harrisc@cardiff.ac.uk)

14 February 2003
Röthlisberger Symposium, Milestones in Physical Glaciology: From the Pioneers to a Modern Science, Auditorium Maximum, ETH Zürich, Switzerland
M. Funk, Versuchsanstalt für Wasserbau, Hydrologie und Glaziologie (VAW), ETH-Zentrum, Gloriastrasse 37/39, CH-8092 Zürich, Switzerland (Tel [41](1)632-4132; Fax [41](1)632-1192; funk@vaw.baug.ethz.ch)

19 February 2003
* Royal Meteorological Society meeting on Polar Weather and Global Climate, Zoological Society of London Meeting Rooms, Regent's Park, London, UK
John C. King, British Antarctic Survey, High Cross, Madingley Road, Cambridge CB3 0ET, England (Tel [44](1223)221-487; Fax [1](1223)362-616; j.c.king@bas.ac.uk; http://www.royal-met-soc.org.uk/wednot030219.html)

4-8 March 2003
The Changing Cryosphere: Implications for Recent Climate and Environmental Changes, 99th Annual Meeting of the Association of American Geographers, New Orleans, Louisiana, USA
E. Mosley-Thompson, Byrd Polar Research Center, Ohio State University, 108 Scott Hall, 1090 Carmack Road, Columbus OH 43210, USA (Tel [1](614)-292-6662; Fax [1](614)292-4697; thompson.4@osu.edu; box.11@osu.edu; http://www.aag.org/)

12–13 March 2003
* Symposium on Mass Balance of Andean Glaciers, Centro de Estudios Científicos, Valdivia, Chile,
Gino Casassa, Centro de Estudios Científicos (CECS), Valdivia, Chile (Tel [56](63)234-540; [56](63)234517; gcasassa@cecs.cl: http://www.cecs.cl/MassBalance/massbalance.html)

12–14 March 2003
Section de Glaciologie–Nivologie réunion and 7th Alpine Glaciological Meeting, Grenoble, France
Christian Vincent, Laboratoire de Glaciologie et de Géophysique de l'Environnement, 54, rue Molière, BP 96, F-38402 Saint Martin d'Hères, France (Tel: [33](4)76-82-42-47; Fax: [33](4)76-82-42-01; vincent@lgge.obs.ujf-grenoble.fr)

27 March–3 April 2003
10th EU/Nordic Arctic Research Program Glaciology Practical Training Course, Tarfala, Sweden
J.C. Moore, Arctic Centre, University of Lapland, P.O. Box 122, FIN-96101 Rovaniemi, Finland (Tel [358](16)341-2757; Fax [358](16)341-2777; jmoore@urova.fi; http://www.urova.fi/home/hkunta/jmoore/glacioeurolab5/istpage.html)

7–11 April 2003
* EGS-AGU-EUG Joint Assembly, Nice, France (15 Cryospheric Sciences sessions co-sponsored by the International Glaciological Society)
EGS Office, Max-Planck-Str. 13, D-37191 Katlenburg-Lindau, Germany (Tel [49]5556-1440; Fax [49]5556-4709; egs@copernicus.org; http://www.copernicus.org/egsagueug/index.html

10–11 April 2003
12th Midwest Glaciology Meeting, Institute for Quaternary and Climate Studies, University of Maine, Orono, Maine, USA
Gordon Hamilton, Institute for Quaternary and Climate Studies, University of Maine, 316 Global Sciences Center, Orono, ME 04469-5790, USA (Tel [1](207)581-3446; Fax [1](207)581-1203; gordon.hamilton@maine.edu; http://www.ume.maine.edu/iceage/Seminar/mgmindex.html)

2–6 June 2003
** International Symposium on Snow and Avalanches, Davos, Switzerland
Secretary General, International Glaciological Society, Lensfield Road, Cambridge CB2 1ER, UK (http://www.igsoc.org/home.htm)

4–6 June 2003
60th Annual Meeting, Eastern Snow Conference, Sherbrooke, Quebec, Canada
M.A. Ecclestone, Department of Geography, Trent University, 1600 West Bank Drive, Peterborough, Ontario K9J 7B8, Canada (mecclestone@trentu.ca; http://www.easternsnow.org)

30 June – 11 July 2003
XXIII General Assembly of the International Union of Geodesy and Geophysics, Sapporo, Japan (http://www.jamstec.go.jp/jamstec-e/iugg/html/frist.htm)
Remote Sensing of the Cryosphere (JSH01)
Snow Processes: Representation in Atmospheric and Hydrological Models (JWH01)
Cryosphere–Climate Interactions (JSM10)
Global Sea Level Rise, Global Climate Change and Polar Ice Sheet Stability (JSM11)
Nakaya–Magono Celebration on the Growth of Ice Crystals and Snow (JSM15)
Role of Atmospheric Processes in Mass Balance Exchange in the Polar Regions (JSM16)

21–25 July 2003
* 8th International Conference on Permafrost, Zürich, Switzerland
W. Haeberli, Department of Geography, University of Zürich-Irchel, Winterthurerstrasse 190, CH-8057 Zürich, Switzerland (Tel [41](1)635-51-20; Fax [41](1)635-68-48; haeberli@gis.geogr.unizh.ch)

25–29 August 2003
• Seventh International Symposium on Antarctic Glaciology (ISAG-7), Milan, Italy
G. Orombelli, Department of Environmental Sciences, Via Emanueli 15, I-20126 Milano, Italy (Tel [39](2)6447-4403; Fax [39](2)6447-4400; 2a@alpha.disat.unimi.it)

3–8 September 2003
Sixth Symposium, International Commission on Glacier Caves and Karst in Polar Regions (GLACKIPR), Ny-Ålesund, Svalbard, Norway
Carmen Domingez, Department of Applied Mathematics, University of Salamanca, P/ de la Merced s/n, ES-37008 Salamanca, Spain (Tel/Fax [34](923)600-637; karmenka@usal.es)

8–12 September 2003
International Symposium on Antarctic Earth Sciences (ISAES IX), Potsdam, Germany
H.-W. Hubberten, Alfred-Wegener-Institut für Polar- und Meeresforschung, Forschungsstelle Potsdam, Telegrafenberg A43, D-14473 Potsdam, Germany (Tel [49](331)288-2100; Fax [49](331)288-2137; isaes@awi-potsdam.de)

9–20 September 2003
Fourth Karthaus Course on Ice Sheets and Glaciers in the Climate System, Karthaus/Certosa, Schnalstal, Italy
J. Oerlemans, IMAU, Utrecht University, Princetonplein 5, NL-3584 CC Utrecht, The Netherlands (Tel [31](30)253-3272; Fax [31](30)254-3163; j.oerlemans@phys.uu.nl)

4–9 October 2003
EuroConference on the Comparison of Ice Core Records with Marine Sediments and Climate Models, San Feliu de Guixols, Spain
H. Miller, Alfred-Wegener-Institute for Polar and Marine Research, Columbusstrasse, Postfach 120161, D-27515 Bremerhaven, Germany (Tel [49](471)483-1210; Fax [49](471)483-1149; miller@awi-bremerhaven.de; http://www.esf.org/euresco)

13–17 October 2003
* Third International Conference on Mars Polar Science and Exploration, Lake Louise, Alberta, Canada
S. Clifford, Lunar and Planetary Institute, 3600 Bay Area Boulevard, Houston, TX 77058, USA (Tel: [1](281)486-2146; Fax: [1](281)486-2162; clifford@lpi.usra.edu; http://cass/jsc.nasa.gov/meetings/polar98/)

2004

5–8 July 2004
Fifth International Conference on Snow Engineering, Davos, Switzerland
Barbara Miller, Eidgenössische Institut für Schnee- und Lawinenforschung SLF, Flüelastrasse 11, CH-7260 Davos Dorf, Switzerland (Tel [41](81)417-02-24; Fax [41](81)417-08-23; miller@slf.ch; http://www.snow2004.ch)

26–30 July 2004
** International Symposium on Ice–Water–Ice: Processes Across the Phase Boundary, Portland State University, Portland, Oregon, USA
Secretary General, International Glaciological Society, Lensfield Road, Cambridge CB2 1ER, UK (http://www.igsoc.org/home.htm)

23–27August 2004
** International Symposium on Arctic Glaciology, Geilo, Norway
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2005

** Sea Ice, New Zealand
Secretary General, International Glaciological Society, Lensfield Road, Cambridge CB2 1ER, UK (http://www.igsoc.org/home.htm)

** High-elevation Glaciers and Climate Records, Lanzhou, People's Republic of China
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Editor: C.S.L. Ommanney (Secretary General)

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