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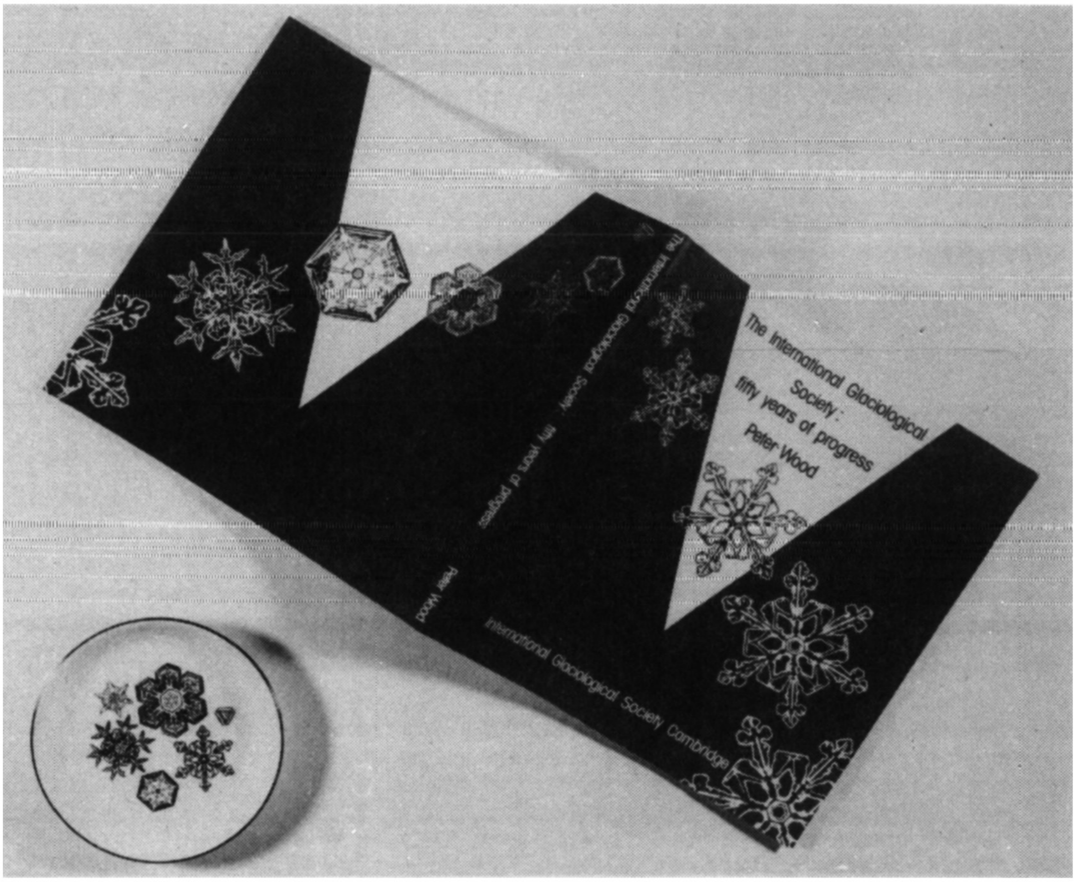
ICE

NEWS BULLETIN OF THE INTERNATIONAL GLACIOLOGICAL SOCIETY

INTERNATIONAL GLACIOLOGICAL SOCIETY

Special productions to commemorate the Society's 50th Anniversary



See page 21 of this issue of *ICE* for details

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CONTENTS

This issue of *ICE* records events organized by the International Glaciological Society in September 1986: the celebrations to mark the 50th anniversary of the founding of the Society, and the second symposium on Remote Sensing in Glaciology.

The celebrations included special lectures, covering developments during the period 1936-86 in various aspects of glaciology, and a banquet, held on 10 September in Cambridge, U.K.; and a tour of Swiss glaciers, including those on which Gerald Seligman, founder of the Society, worked in the 1930s.

This historic year was also marked by two sepcial productions:

– a history of the Society, written by Peter Wood and edited by Bernard Stonehouse;

– a special china dish, made by Royal Worcester Porcelain Company using microphotographs of ice crystals for the design, which is in gold on a white ground. (See inside front cover for photographs of the *History* and the dish.)

COVER PHOTOGRAPH: Jungfrau (centre) and Rottalhorn (left) from Jungfraujoch taken by K. Steffen, September 1986.

LECTURES ON THE DEVELOPMENT OF GLACIOLOGICAL STUDIES IN THE PAST 50 YEARS

10 September 1986, in the Chemical Laboratory,
University of Cambridge, England

Title	*Presenter*
Glacial geology	G.S. Boulton
Valley glaciers	G.K.C. Clarke
Ice sheets and ice shelves	C.W.M. Swithinbank (G. de Q. Robin, co-author)
Sea ice	T.E. Armstrong
Ice physics	J.W. Glen
Snow	S.C. Colbeck
Engineering	L.W. Gold
Technology in the advancement of glaciology	H.J. Zwally
Impact of the Society on the development of glaciology and its future role.	J. Weertman

Papers on these topics will be published as a special issue of the *Journal of Glaciology* during 1987. It will be issued free to paid-up members and subscribing libraries.

GLACIAL GEOLOGY

By the middle of the last century the work of glaciological pioneers, concentrated in European alpine regions, had established the principles of valley glacier flow and mass balance, which they associated quite naturally with the erosional activities of these glaciers. Their perceptive observations and inferences about the relation between small-scale erosional processes and products has formed the basis of a lively discussion of classification, meaurement and theory up to the present day, which was sustained through an otherwise moribund period in glaciology between the end of the last century and 1940 by work such as that of Gilbert and Johnson.

In parallel with these small-scale studies came the recognition of a distinctive glaciated highland landscape which, though well-described and analysed in a general way by such workers as W.M. Davis, Matthes and Linton, still awaits a persuasive demonstration of the way in which small-scale erosional processes combine to generate repetitive forms such as corries, U-shaped valleys, fjords and rock steps.

The pioneers of glaciology and glacial geology in alpine regions were also instrumental in introducing and popularising the concept of widespread former glaciation of the mid-latitude lowlands of Europe and North America. Long before much was understood about the behaviour of modern ice sheets, scientists such as Chamberlin and Nathorst had developed very perceptive models of the dynamic behaviour of their mid-latitude predecessors based on geological evidence alone. A reassertion of the value of such evidence in the last few years, in association with quantitative models of ice sheet behaviour, promises to yield important insights into the long term fluctuations of ice sheets.

The predominant reflection of former ice sheet expansion in mid-latitude lowlands is depositional rather than erosional, and thus much of the early work on glacial deposits was done far from any active glacier. This has led to the development of a distinctive tradition whereby large-scale models of glacier behaviour have been inferred from their sedimentary products alone with little reference to glaciological observations and theory. From time to time, bridges have been built between glaciology and geology by "dirty-ice glaciologists" such as Tarr and Martin, De Geer, Lamplugh and Gripp who studied the relationship of glacier behaviour to sediment and landform production. Their modern counterparts have directed their energies towards an analysis of ways in which such studies can help reconstruct the activity of former glaciers.

The early successes of sedimentary glacial geology were to define the extent of Quaternary glaciation, to establish the fact of repeated glaciation and to distinguish and correlate specific glacial and interglacial events over broad areas. Since the inception of the

Glaciological Society they have been able to describe and interpret the sediment and landform assemblages produced by glaciation and to develop a chronology of Quaternary glacier fluctuation, and in particular the pattern and tempo of final decay, although these have been largely achieved independently of formal glaciological concepts.

It would be of great benefit if this latter tradition of glacial geology could be more effectively fused with "dirty ice-" and "clean ice-" glaciology to help us understand how the geological effects and dynamic behaviour of ice sheets are related, and from this to understand better how ice sheets interact through time with other parts of the hydrological cycle.

VALLEY GLACIERS

Valley glaciers make a minor contribution to the earth's total ice volume but they have provided the inspiration and the data for many of the central ideas of modern glaciology. Their manageable scale, relative accessibility, situation in sublime landscapes, and richness in physical phenomena have all contributed to this important role.

I shall review the recent history of valley glacier studies giving special emphasis to the years spanned by the life of the Glaciological Society. The interplay between technical innovation and scientific progress will be examined and various milestones identified. The founders of the Society had a clear vision of glaciology as being, by its nature, a geophysical science in which the talents of the geologist and physical geographer must necessarily be combined with those of the physicist. Although in valley glacier studies this unification is still incomplete, many of the scientific achievements of the past fifty years exemplify this ideal.

ICE SHEETS AND ICE SHELVES

This is not a review of contemporary knowledge but a brief history of how our perception of ice sheets has changed. Fifty years ago, modern ice sheets were seen as relics of an ice age, little relevant to the physics or the history of European or North American glaciations. Today we see them as being broadly in equilibrium with their climate throughout the period in which dramatic advances and retreats took place elsewhere. Models derived from recent progress in understanding present ice sheets have explained much that had mystified glacial geologists. New concepts have led to new terms: glacier surge, marine ice sheet, ice stream, ice wall, ice rise, and ice rumple. The extent of the Greenland and Antarctic ice sheets was fairly well known in 1936 but the greatest penetration downwards had only reached 20 metres. Sorge had got seismic reflections indicating an ice thickness of over 2000 m at Eismitte but many scientists could not believe it. Debenham as late as 1943 estimated that the average ice thickness in Antarctica was much less than 600 m. The current estimate is four times greater. The foundation of most of our knowledge of the Greenland ice sheet before 1936 came from the expeditions of F. Nansen, M. de Quervain, J.P. Koch and A. Wegener. Comparable contributions for the Antarctic came from those of R.F. Scott, E.H. Shackleton, and R.E. Byrd although many other explorers had touched the periphery of the continent. Little was added in the third dimension until seismic sounding was shown to be successful and then widely applied during the International Geophysical Year 1957-58. Nye's application of Glen's flow law to the surface form of ice sheets led to a series of refinements by others including the concept of stable and unstable profiles. Waite's demonstration of airborne radio-echo sounding led to its development, particularly in Cambridge and in Copenhagen, and its wide application to ice-sheet exploration. Hansen's development of ice-core drilling gave impetus to Dansgaard's stable isotope glaciology and to the recovery from ice sheets of climatic records of sufficient length to correlate with those of deep sea sediment cores. While Jakobshavns Isbrae has long been understood to be the fastest-moving glacier in the world, the Antarctic ice sheet, by contrast, was generally perceived as too frigid to do more than creep imperceptibly towards the sea. In the last decade, however, the use of Landsat imagery and satellite doppler positioning have revealed quite dramatic changes taking place within a few years, and ice stream velocities reaching 4 km a^{-1}. Antarctic ice shelves, the target of many recent experiments, are now seen to play an important part in maintaining the integrity of the inland ice sheet. This has led by analogy to the concept of extensive former ice shelves in the Northern Hemisphere. One area in which, despite repeated efforts, we report little significant progress over fifty years is that of the overall mass balance of contemporary ice sheets; it is not known whether they are thickening or thinning, expanding or contracting, increasing or decreasing in mass. The probable response of ice sheets to increasing atmospheric CO_2 is much discussed but little understood. Yet however incomplete, the age of exploration has yielded a framework for a wealth of derived physical characteristics that provide a basis for ice and climate models and suggest where critical experiments could be undertaken in the future. Ice-sheet glaciology, offspring of a combination of sciences, is now able to feed back to other fields its own special amalgam of understanding.

SEA ICE

A few, but outstanding, contributions had been made before 1936. After that date, progress has been considerable, being stimulated almost entirely by direct practical needs (surface shipping, aircraft, submarines).

Some salient points in subsequent development of the subject during the half-century are as follows:

1. Early Soviet research to meet Northern Sea Route needs. Data gathering from drifting ships and drifting stations (the North Pole series). N.N. Zubov's classic *L'dy Arktiki* (1945). Automatic stations (DARMS) and airborne expeditions (the Sever series).
2. The US effort came after World War II and concentrated on study of the Arctic Ocean ice, using some of the same techniques as the Russians. A number of impressive programs were undertaken.
3. Studies of the under-surface of sea ice, with data obtained from submarines. Little of this work has emerged from military files.
4. Engineering studies of the interaction of ice with ships and other structures.
5. Data-gathering techniques: recording and reporting, terminology.
6. Atlases showing distribution.

Looking ahead, emphasis over the next ten years may be on satellite observation (both passive microwave and synthetic aperture); on more data buoys; on underwater studies; and on Antarctic work.

ICE PHYSICS

Our understanding of the basic physics underlying the properties of ice has dramatically changed during the last half century. At the beginning of this period it was known that the water molecules in ice were arranged with tetrahedral hydrogen bonding, and it had just been established that the hydrogens were not crystallographically arranged on these bonds, however the way in which water molecules could reorient was unknown and the implications of this for the mechanical properties and hence for glacier flow were unexplored. The suggestion of electrical point defects in ice, the L and D defects of Bjerrum and the ionic defects, pointed the way to an understanding first of the dielectric relaxation and electrical conductivity of ice and then to a possible interaction between these electrical properties and the movement of dislocations and hence the plastic deformation of ice.

Meanwhile much work was done to study the behaviour of ice under various physical conditions and to establish more rigorous laws for many physical properties of single crystals of ice and of various forms of polycrystalline ice and much work was done to find the crystallographic structures of the various phases of ice including those already known to exist at high pressures. The intriguing appearance of a cubic form of ice at low temperatures was also investigated together with vitreous ice formed at even lower temperatures.

Many of these properties are of great interest to meteorologists trying to understand cloud physics and the physics of thunderstorm electricity as well as to astronomers thinking about ice in space, comets, the icy satellites of the planets or even on the planets themselves.

SNOW

The history of snow research is divided into four distinct periods. Before 1900 there were systematic observations of snow but the tools were just being developed to begin serious research. From 1900 to 1936 many investigations began due to the practical considerations of snow hydrology and snow avalanches. Individuals began the assessment of snow water equivalent for forecasting runoff and the observations of snow structure and texture. Quantitative and physical investigations quickened after government sponsored laboratories were established in 1936, the same year as the founding of the International Glaciological Society. From 1936 through the 1960s many detailed investigations were made into snow's physical properties and behavior. Professional organizations organized national and regional meetings and published the results of snow research. Many more laboratories became involved as knowledge about snow was developed and applied to runoff forecasting and avalanche defense. Snow research surged again during the 1970s with the establishment of a new generation of snow scientists using more advanced theory, computers and instrumentation. As demands continue for solutions to snow problems with new emphasis on old themes, snow research generates knowledge about snow for a wide variety of applications.

Engineering is the art and science concerned with the practical application of scientific knowledge. Science often provides new possibilities for engineering, and engineering challenges often provide the incentive for scientific advances. This interplay between science and engineering has been particularly effective during the past fifty years in stimulating advances in our knowledge of ice and progress in our capability to deal with ice problems.

Fifty years ago the major ice problems for engineers had to do with transportation, the production of hydro-electric power and the prevention of damage due to river ice formations. Most of the physical properties of ice were known with sufficient accuracy for engineering, but little was known about its strength or deformation behaviour. The need for information had resulted in field observations that had provided a reasonably good qualitative understanding of the dependence of the formation of ice and the development of ice covers on weather and water conditions.

During the past 50 years, engineers have been increasingly challenged by ice problems for which there was little or no previous experience. This, along with the need for field observations to obtain information required for the design, construction and operation of engineered works, has been the reason for extensive scientific and engineering investigations. Very significant advances have been made. The literature in which this work is reported has grown rapidly and increased by a factor of at least ten during the past twenty years.

Although severely hampered by the difficulties of making field measurements, impressive progress has been made on theory and engineering practice for the hydraulics of ice-affected rivers. This knowledge has been applied successfully in the development of ice control works for rivers and inland waterways, and in the design and construction of major projects such as the control structures at the mouth of the Rhine river in Holland and the St Lawrence Seaway in North America.

The need to fly in all weather conditions and to construct power transmission and communication systems in regions subject to icing, has caused the development of a good understanding of the icing process and of the dependence of its occurrence and severity on weather. Reasonably good solutions have been found for preventing icing of aircraft and helicopters that combine anti-icing technology and improved forecasting of ice-forming conditions. Transmission and communication systems are still vulnerable to extreme ice storms. Recently, increased attention has been given to icing and icing control measures for ships and offshore structures.

Ice covers have been used from the time of early man to cross water bodies. The maximum load that can be placed safely on ice covers of given thickness has been determined primarily through experience and observations. During the past fifty years, much experience has been recorded and theory and analytical procedures have been developed that are in satisfactory agreement with it. The capability to design and construct ice crossings and platforms is now well developed. Such structures are used routinely for the support and transport of very heavy loads, particularly in remote regions.

A major reason for the remarkable development of knowledge concerning ice during the past twenty years has been the energy crisis. This crisis caused the knowledge and information needs of the engineer to overlap the research interests of the scientist. Fruitful collaboration has resulted, the benefits of which are not yet fully known. The principal shared objective has been to establish the basis for determining the maximum forces that ice might exert on structures. Complementary to this is the need to develop transportation systems for bringing resources to markets from ice-affected regions.

The need for large structures for offshore petroleum exploration has provided opportunities for observing the nature of the ice-structure interaction and for measuring forces. This area of engineering is now in a rapid state of development. It has caused significant advances in our understanding of the strength and deformation behaviour of ice, and been responsible for major investigations on ice ridges, rubble fields and icebergs. Engineers now probably have a reasonably good ability to predict the type of ice feature and interaction that would cause the maximum force on a structure subject to severe ice conditions, and the size of that force, but much of the information required to make such predictions and calculations is still proprietary.

The first fifty years for the International Glaciological Society have been a period of great growth in ability to design, construct and operate for a wide range of ice conditions. Much of this progress has been recorded in the *Journal* and conference proceedings published by the Society. In providing these means of communication the Society is very effectively responding to one of its objectives and fulfilling one of the goals of its founder, Dr Gerald Seligman.

Most of the major advances in modern science have followed technological breakthroughs that provided new means of viewing and measuring the characteristics of our physical environment. As the science of glaciology developed, simple instruments were employed for measuring distance, weight, temperature, and other characteristics of snow and ice. The first principal tools of glaciologists, the microscope for studying ice crystals, the telescope for surveying, and the camera for recording ice types and distribution, greatly advanced their knowledge of the structure and deformation of ice. In recent decades, glaciologists have eagerly utilized and adapted more advanced technology to study the size, distribution, internal structure, velocity, deformation, accumulation rate, boundary conditions, physical properties, and chemical constituents of ice.

Just as the operation of military radars in the 1940s facilitated the discovery of the reflection of microwave radiation from precipitation, and opened the field of radar meteorology, the use of aircraft radar altimeters in polar regions led to the discovery of the penetration of radio waves into glaciers, and opened the field of radioglaciology. Most of our knowledge of the thickness and surface and bedrock topography of glaciers has come from radio-echo sounding, which has also provided data on internal layering and the subglacial interface. Seismic sounding, which provided the first measurement of ice sheet thickness, has recently provided the first evidence that Antarctic ice streams are underlain by deformable tills, which may be the major factor causing fast ice flow.

Ice-core drilling opened several new dimensions to glaciologists and climatologists. Physically, it opened the inside of glaciers to probing of ice fabric, temperature, deformation, and subglacial characteristics of critical importance to understanding ice dynamics. Of even broader interest, it opened the past record of atmospheric composition, temperature, precipitation, and contaminants for detailed examination of the global conditions influencing the earth's ice cover over more than 100 thousand years. Development of techniques for dating and analyzing ice and its entrapped elements has paralleled the acquisition of ice cores. Methods of modern physics and chemistry, employing mass spectrometers, lasers, and other techniques for analyzing atomic composition and radioactive decay, have been essential to the extraction of information from the ice cores. For example, the amount of carbon dioxide and dust in the atmosphere during the Wisconsin glaciation have been determined and the effects of specific volcanic eruptions during recent centuries are being studied.

Data buoys with electronics for determining positions from satellite transmitted signals and for automatic recording and satellite relay of data have been widely used for sea ice studies. Information on ice motion and wind forcing derived from data buoys has been essential to the advance of sea ice dynamics research since 1970. For both sea and land ice, laser ranging devices have become the standard tools for measuring distances and strain rates between stakes or natural markers in the ice. Submarine-sonar and airborne-laser profiling have measured sea ice thickness, ridging, and ice type distribution. Accurate 3-dimensional positioning of surface receivers of satellite signals is now a routine method for ice sheet velocity measurement.

In recent years, satellite remote sensing has opened additional dimensions: global views of snow and ice fields at daily intervals, detailed high resolution multispectral imagery of ice features, and large-scale repetitive measurement of previously unobtainable parameters. Ice margins, velocities, flowlines, snow facies, and ice divides have been mapped with enhanced Landsat imagery. The Weddell polynya and significant amounts of open water in the Antarctic winter ice pack were discovered with passive-microwave imagery. Sea ice velocity fields have been obtained from radar imagery, and passive microwave imagery is providing new information on the distribution of multiyear ice in the Arctic ocean and on the convergence/divergence of the winter ice pack. Radar altimetry has provided detailed maps of ice sheet topography to accuracies of a few meters, and characteristics of the seasonal snow cover are being derived from microwave data. Large high-speed computers have become essential tools for ice dynamics modeling and the handling of large volumes of satellite data.

In the future, the advanced technology of satellite remote sensing will play a major role in investigation of global-scale processes, global change, and the interactions of ice with the ocean, land, and atmosphere. Problems such as the mass balance of the polar ice sheets can only be answered with precision laser altimeters on polar-orbiting satellites. Improved methods of drilling and core analysis will provide new insights to the past and future global environment. Detection of changes in snow and ice cover, investigation of the causes and effects of changes, and prediction of future behaviour require extensive data sets that can be provided by continued application of today's technology to glaciology.

IMPACT OF THE SOCIETY ON THE DEVELOPMENT OF GLACIOLOGY AND ITS FUTURE ROLE

After the end of World War II glaciology entered a new golden era, which has yet to end. The quality of this golden age is comparable to the classic period of the 19th century. The International Glaciological Society has been the major catalyst, through its very active and cooperative international membership and its *Journal of Glaciology*, in setting the modern major advances in the science of glacier and ice phenomena in motion and sustaining them. The precursor of this surge in glaciological knowledge was the research, just before World War II, of the founder of the Society, Gerald Seligman, and his associates. If a new researcher read only the papers published in *Journal of Glaciology*, from its early issues to the present, he or she should have a reasonably complete understanding of the field of glaciology and of the experimental, theoretical and field work that lead to our present knowledge. Much credit must go to the leaders of the British Glaciological Society for the foresight that lead them to change the British Glaciological Society into the international organization in which the science of glaciology has made its major advances.

HISTORY OF THE SOCIETY

This was published on 1 September 1986. It was researched and written by Peter H. Wood and edited by Bernard Stonehouse: 120 pages of text, with illustrations, in a 210 mm x 210 mm format, with a pale blue cover patterned with white ice crystal shapes. It costs £10, with an additional charge for surface post and packing, and may be ordered from the Society's office.

ANNIVERSARY DISH – LIMITED EDITION

We have commissioned a special dish to mark the 50th anniversary. It was made by Royal Worcester, a company that has been producing porcelain and fine china since 1751. It costs £6 with an additional charge for surface post and packing, and may be ordered from the Society's office.

This unique limited edition dish (1000 were made) shows some of the seven main types of ice crystals, formed under differing weather conditions. Variations on the basic hexagonal shape include a simple plate, a star, a fern. Those shown on this dish were reproduced from micro-photographs of ice crystals.

Proceeds from the sale of this dish will be devoted to the objects of the Society: to encourage research into the scientific and technical problems of snow and ice and to publish the results of that research.

Photographs of the *History* and the dish are on the inside front cover of this issue of *ICE*.

160 people attended the 50th anniversary banquet in King's College, Cambridge, on 10 September 1986. The 100 participants in the Remote Sensing symposium were joined by members who had come to Cambridge specially for the day of celebrations and by guests invited in recognition of their support of and services to the Society over many years.

After an excellent meal in the historic hall, lined with paintings of benefactors and famous alumni of the college (founded in 1440 by Henry VI), one of our Honorary Members, Dr Robert F. Legget, proposed a toast to the Society, and the President replied. The President also referred to the many messages of congratulations and good wishes that had been received from all over the world. The Institute for Snow and Avalanche Research in Davos presented a specially-commissioned pewter plate, suitably inscribed. This is now on display in the headquarters office.

Dr Robert F. Legget, Honorary Member, proposed the toast to the Society.

The Golden Jubilee Tour was organized by the President, Dr Hans Röthlisberger, and his colleagues at VAW-ETH, Zürich. Contributions from other groups (Switzerland, U.K. and Belgium) were included in the programme. About 35 people, participants and helpers, were involved.

There was a wealth of technical documentation and practical demonstrations. We reproduce on page 11 the talk given by the President at the Jungfraujoch observatory to mark the work by Seligman in the 1930s.

Lorne Gold's report of the week-long tour, with David Drewry's report of the two days spent by the "mountaineers" group, are illustrated by photographs taken by them and by Koni Steffen of VAW-ETH.

On 13th September, about 30 people including organizers and guides, made their way by several means to the Hotel Rutli in Lucerne to take part in one of the most memorable post-conference tours organized by the Society. The credit for this success goes to the President, Hans Röthlisberger, his wife Doris and his colleagues at VAW-ETH. When it became apparent that the number of participants would be small, this group put together an excellent program to commemorate the Fiftieth Anniversary of the Society and the glaciological interests of its founder, Gerald Seligman, utilising the efficient Swiss public transportation system.

It was not until breakfast at 7.15 Sunday morning that it could be confirmed that all the participants had assembled, and even then there was some doubt concerning Jay Zwally. However, all were on the train at 8.22 for Engelberg after leaving their luggage by 7.45 for Doris to look after. The special feature of this narrow-gauge railway was soon appreciated, particularly by Dr R.F. Legget, a student of all things to do with railroads, when it easily made its way up the steep slopes that lead to the town below the Titlis Glacier.

From the station at Engelberg, it is a short walk to the terminus of a new, six-passenger cable car system that carries one to Trüebsee, about half-way to Kleintitlis. The views from the gondola that carries you from Trüebsee to the station adjacent to the restaurant at the top of the Titlis Glacier were a splendid introduction to what was to be enjoyed for the next six days.

Shortly after arriving at the top at 10.12, the technical program began on the glacier adjacent to a radio tower of the Swiss PTT. There, under almost clear skies, Wilfried Haeberli gave a description of foundation problems due to the perennially frozen rock and its inclusions of ice and the work carried out at the site by VAW-ETH.

The convenience of modern transportation systems was clearly evident by the number of people climbing over ice, loose stones and sharp boulders wearing running shoes, street clothes and open-toed high-heeled shoes. The IGS group, however, had been fully instructed by Hans and were properly clothed. Evidence of high tech on the mountain tops was present in the cafeteria and in the washrooms where one could have hands automatically wetted, soaped, rinsed, and blow-dried by simply extending them into an apparatus and gently rotating.

The technical program at Kleintitlis and Trüebsee was completed with a visit to the tunnel below the restaurant in which it was possible to see the contact of the ice with the rock at the glacier bed, and a subsequent description of the problems of maintaining the ski run over a steep part of the glacier affected by ice avalanches. Conditions in this area of the glacier are being monitored by VAW-ETH.

The group left Kleintitlis at 13.30 to make its way to Engelberg and then to Grindelwald. It was necessary, unfortunately, to take a longer route as the original plan to travel by way of the Brünig Pass had to be cancelled due to rock and mud slides. Hans gave regular briefings during the journey on the geology of the country and the culture of the cows. Apparently people who really know Switzerland can determine just where they are by the subtle shades of bovine brown, white and yellow. Arrival at Grindelwald was 18.21 and dinner at 19.15 after a 5-minute walk from the station to the Hotels.

After the first day the significance of the exact times given in our itinerary was appreciated by all members of the group. It was a tribute to the group, and to the shepherding skills of the organizers, that no one was left behind. The fact that if one missed a connection it would probably take a day to catch up certainly helped. And there was always the comforting feeling that Doris was somewhere in the valley and would probably welcome some help with the luggage.

At least six glaciers were visited during the next four days. On Monday it was the glaciated area adjacent to facilities that have been constructed at the Jungfraujoch. From the vantage point of the Sphinx, a briefing was given on the local geology and on some of the glaciological, geophysical, and environmental studies that have been carried out on the Jungfraufirn and connecting glaciers. The group was introduced to some of the technical problems experienced in the construction and maintenance of the structures on this high mountain location. A demonstration of core-drilling equipment of VAW-ETH was given on the glacier below.

A tribute to Gerald Seligman and the glaciological work that he did in 1938 as the leader of a British Jungfraujoch research party was presented by Hans in a conference room in the Institute building high above the Jungfraufirn. The party included Dr Max Perutz, crystallographer, Dr T.P. Hughes, physicist, Dr A.E. Benfield, and Mr A.E. Ferguson. It set up a cold laboratory near the Institute and various installations on the firn below the Sphinx, including a shaft built to a depth of 30 m. The party studied the density, structure, and thermal conditions of the firn in great detail. Its work was a significant contribution to our understanding of the behaviour of temperate glaciers. The day at the Jungfrau was particularly appreciated by Dr Legget and Bill Ward for the memories that it brought them of events and people and earlier visits. After returning through the moutain to Kleine Scheidegg in the cog-wheel train, some of the group chose to hike to Grindelwald on the trail that runs below the foreboding north face of the Eiger. The remainder took the train by way of Wengen and en route had a spectacular view of the Lauterbrunnen valley.

On Monday, those that had signed up for the "half-tour" departed from the group at various times during the day. Those on the full tour took the cable car to Pfingstegg above Grindelwald, and hiked to the restaurant Stieregg located on a plateau above the present terminus of the lower Grindelwald Glacier. This glacier reaches the lowest elevation of any in the Alps, advancing at times down into the fertile valley farmland. As a result, there are numerous photographs, paintings and written records dating back to about 1600, from which the fluctuations in the position of the snout can be constructed in great detail. After several years of retreat, the glacier has been advancing again since 1959.

The visit to the Lower Grindelwald Glacier was highlighted by talks by Hans and Marcus Aellen on the local geology and glacial history; by the delivery of provisions to the restaurant by helicopter; and by an outdoor lunch of bündnerfleisch, cheese, bread and wine in a typical glaciological setting. The more energetic of the group were challenged to hike quickly to the upper Grindelwald Glacier in order to have time to climb the ladders that take one to a position above its terminus. The more reasonable members walked the distance at a comfortable pace and arrived in time to observe the progress of their compatriots while enjoying a beer on the patio of a conveniently located restaurant.

All were back at the railway station at Grindelwald to catch the 15.45 train for Gstaad.

The most gripping part of the tour was probably a trip by cable car that is at the upper part of the route from Col de Pillon near Gstaad, to the Glacier Les Diablerets station. What really made one pay attention was Hans' comment while waiting for the car that "the cable certainly is worn". The swaying of the car as it approached the cliff above which was located the station, and the need to wait until the wind and car settled down before continuing over the top, gave one ample opportunity to contemplate the remarkable rocky landscape that stretched for several hundred feet below.

Fortunately, the way down was by foot across the Glacier de Tsanfleuron. This was done in an unpredictable mix of sun and wind and rain. The rain brought out a most remarkable mixture of rain gear, umbrellas and colours. The prize for variety of hats went to Niels Haakensen, who had a different and more unique one each day. Again, through normal glaciological good fortune, the wind was always on our back and it stopped raining for briefings and lunch.

In the usual efficient Swiss manner, the group arrived at the terminus just in time for a picnic lunch and an exposition by Professor Souchez and his colleagues from the Laboratoire de Géomorphologie of the Université Libre de Bruxelles, who had come from the other direction. They are investigating subglacial carbonate deposits that can be observed in the marginal zone of the glacier. It was a memorable experience to enter a very damp ice cave at the base of the glacier and to move from there through a low passage into a sizeable cavern that had developed within the glacier as it flowed parallel to a low rock cliff. Sufficient light came through the relatively thin glacier ice ceiling and wall to allow one to see things quite clearly. The final hike through the terminal moraine and outwash plain of the glacier to the roadside stop for the post bus to Sion was in a thunderstorm and heavy rain. The fact that she did not quite make a jump across one of the meandering streams did not add much to Joan Gold's already wet condition.

The Lower Arolla and Tsijiore-Nuove glaciers are two of several water sources in the Zermatt-Matterhorn-Arolla region feeding the Grand Dixence hydroelectric scheme. Engineer A. Bezinge, a manager of the hydroelectric authority and a member of IGS, described this major system to the group when it visited the Lower Arolla glacier. We were shown the structure at the base of the glacier that is used to remove rocks, stones and finer sediments from the outflow prior to pumping it to Lac de Dix about 350 m higher in altitude. The Lower Arolla glacier is presently advancing at a rate that, if continued, will cause it to over-run the structure within about five years.

Mr Bezinge and members of his staff transported the party in various vehicles to the base of the Tsijiore-Nuove glacier to view a similar sediment settling structure. Once at the glacier, a table was quickly set up and we again enjoyed a lunch of bündnerfleisch, cheese, bread and the wine of the Valais. This break was the opportunity for Angela Gurnell and Mike Clark from the University of Southampton, who were also part of the touring group, to describe the work that the University has been carrying out on sediment transport from the glacier and on the hydrologic regime of the area. Both Mike and Angela were very excited over a major flow of water along the edge of the glacier, which was not present when they were on the site in August. Bob Asher set up his camera to take periodic photographs in case something unusual occurred during the remainder of the afternoon while the group hiked to a higher altitude. Hans, who was also intrigued by the unusual flow of water, Mindy Brugman, and Amédée Zryd, one of Hans' students who had joined the group the previous day, climbed along the ridge of the 40 m high moraine that flanked the glacier, to see if they could determine the source.

Still under the soporofic effects of the wine, accentuated by the altitude, the unaccustomed activity of the previous days, and the warmth of the sun, the group made its way upward to the departure point for the climbers who were to stay overnight in the Cabane des Dix. Roger Braithwaite, Jay Zwally and even Dave and Jill Drewry were beginning to wonder as they struggled under their loads why they had signed up for the climb that still lay ahead of them. It was with a mixture of regret and thankfulness that those that stayed behind returned to Sion for a leisurely meal after watching the climbers disappear in the distance.

David Drewry writes: . . .

The walk up the Col de Chèvre was a slow, toilsome business after the gastronomic rigours of the morning. The skies threatened rain as clouds over Mont Blanc de Cheilon and the distinctive Pigne d'Arolla gathered in the late afternoon. Two guides from VAW-ETH had come with us to assist the party (Willi Schmid and Martin Funk). At the Col we had spectacular views over the Glacier de Cheilon to the Cabane des Dix perched high on a rocky knoll (the Tête Noire) on the far side of the glacier. Our descent to the glacier was down a 30 m vertical rock face aided by iron ladders set into the wall. We soon forgot the splendid views as we carefully descended to the moraines below. Willi came down last yodelling with delight as he mostly slid down the rungs! We arrived at the Cabane (2938 m) run by the Swiss Mountaineering Federation in time to arrange our bunks before settling down to a fine evening meal on wooden benches amongst the gathering gloom. The next morning a wash in ice-cold mountain water and fine drizzle envigorated us after rising at 5.30 am. David and Gill Drewry left early for Grand Dixence dam via the Glacier de Cheilon. The remaining party donned harnesses and roped-up to cross the Col de Cheilon to the Glacier de Giétro. The snow was soft and wet, but with care the end of the glacier was reached, overlooking the impressive Mauvoisin dam. Thereafter the descent to the dam wall was by a very steeply descending slope of muddy moraines and rock. . .

While the climbers made their way the next morning to the reunion point at the Mauvoisin power dam, the group in Sion had the opportunity to look at the oldest pipe organ in Europe and to visit an arachaeological, geological and historical exhibit on the Valais displayed in the Sion museum. The reunion with the climbers took place on the crest of the 237 m high Mauvoisin dam. The group was received by the site manager, M. Foullet of the Mauvoisin Power Authority, served an "apéritif" which was more like a banquet in the nearby restaurant, and then taken for a tour of the dam and its adjacent facilities. Movements of the dam are measured by an extensive and sensitive monitoring system and these measurements have shown that the strains induced by the filling of the reservoir have been appreciably less than predicted. A graphic description was given of the ice dam lake that was created at the site in 1817 by the rapid advance of the glacier de Giétro and the devastation that followed when the dam failed the following year. Records show that a similar catastrophe occurred in 1595.

That evening the group gathered in their hotel in Martigny for the final dinner of the tour – traditional Swiss raclette. The spirit of the evening reflected the fellowship, adventure and hospitality that had made the tour such a memorable happening. Doris had safely delivered all the luggage and Karin Schram was able to account for all members of the party, much to her relief. Throughout the evening all of us expressed to Hans, Doris, and Hans' colleagues our thanks and appreciation for what they had done for us. Through their efforts, the generous reception of the Grand Dixence and Mauvoisin Power Authorities, and the efficiency and cooperation of the ubiquitous Swiss transportation system, we had properly celebrated the Fiftieth Anniversary of the Society.

Lorne Gold

TALK GIVEN BY HANS RÖTHLISBERGER AT JUNGFRAUJOCH ON 15 SEPTEMBER 1986

That it is appropriate to commemorate Gerald Seligman at Jungfraujoch can hardly be questioned. In 1938 he led a British research party who spent several months at Jungfraujoch and vicinity. Their ambitious objective was to study the glacier from the source to the tongue, in Seligman's (1941) words by "first investigating the raw material, the falling snow lying upon the older firn, and then tracing its history in correct chronological sequence as it became firn and then ice". The Jungfraujoch Research Station offered ideal conditions for this enterprise with its railway access to the high part of the accumulation area.

The 1938 Jungfraujoch Research Party consisted of representatives of different fields of the physical sciences with Dr M.F. Perutz (in 1962 one of the Nobel Prize recipients for chemistry) as crystallographer and Dr T.P. Hughes as physicist, both from Cambridge. Gerald Seligman, as the author of *Snow structures and ski fields* (1936), was thoroughly familiar with annual snow and its metamorphosis. Further Cambridge participants were Dr A.E. Benfield, who did the preliminary physical work, and Mr A.E. Ferguson. Valuable advice was given by Dr Bowden of Cambridge and Professor H.W. Ahlmann of Stockholm. Particularly valuable was the contact with the Snow and Avalanche Research Station at the Weissfluhjoch above Davos, the Swiss research organization also celebrating its 50th Anniversary this year. Dr Henri Bader and Dr Robert Haefeli worked there at the time.

Seligman's party established a cold laboratory and various installations on the Mönchfirn, east of the permanent structures of the main scientific station. A shaft was excavated to a depth of 20 m in order to collect firn specimens and to install thermocouples. By drilling an additional 10 m, a maximum depth of 30 m was reached. Temperatures were found to be at the pressure melting point (at 0°C within the accuracy of the measurement) below 15 m. It has conclusively been shown that rapid warming during the first half of June cannot be explained by heat conduction, but is the effect of the flow of meltwater from the surface into successively deeper layers of the firn, where it freezes. From the fact that all of the 30 m of investigated firn reached the pressure melting point long before the summer was over, it was concluded that the main ice body of Aletschgletscher would be at the pressure melting point. The ice apron on the ridge leading from the Jungfraujoch proper to the Sphinx, on the contrary, showed an almost constant temperature of a few degrees below the melting point. A cold laboratory was successfully operated in this ice apron; the temperatures could be kept at −3 to −4°C throughout the summer, except during times when there were too many visitors.

Density and structure of the firn were investigated in great detail. The change from permeable firn to impermeable glacier ice was found to occur at densities between 0.80 and 0.84 Mg m^{-3}. At the site of the shaft (3460 m a.s.l.) the depth of this transition was not reached, but it rose closer to the surface with decreasing altitude. The specimens for these latter measurements were collected in crevasses.

One of the primary interests of the Jungfraujoch research party concerned the structure of firn and glacier ice in relation to movement. Studying thin sections under polarized light revealed many intriguing facts on grain growth, preferred crystal orientation and the formation of blue bands. The increase of grain size within the deep layers of the firn was found to be insignificant compared to the grain growth occurring later somewhere between the névé field and the glacier tongue. Further studies on this question would have been one of Seligman's further research subjects, if the war had not prevented him from continuing his original plan to study the glacier from the source to the terminus. Concerning preferred crystal orientation, an abundance of steep c-axes was observed near the snow surface. Such an orientation no longer existed in deeper firn, except in ice layers. Rotational motion of grains or groups of grains during settling of the firn was found to be the reason for this. Old glacier ice was studied in an artificial cave at Eigergletscher (near the lower end of the railway tunnel leading to Jungfraujoch). Three types of blue bands were discerned: original sedimentary layers formed on the névé field, vertical or steeply inclined bands related to former crevasses, and bubble-free layers formed mechanically. Detailed flow measurements showed that one of the latter type of band was closely related to particularly active shearing. It intersected a series of parallel (sedimentary) bands.

Hydrological observations of meltwater production and percolation through the firn rounded off this comprehensive study that is well worth remembering. Apart from the data, valuable descriptions of procedures, methods and tools are contained in the publications.

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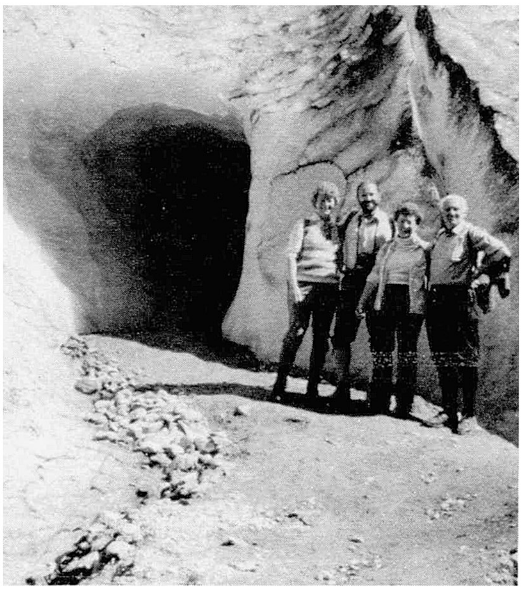
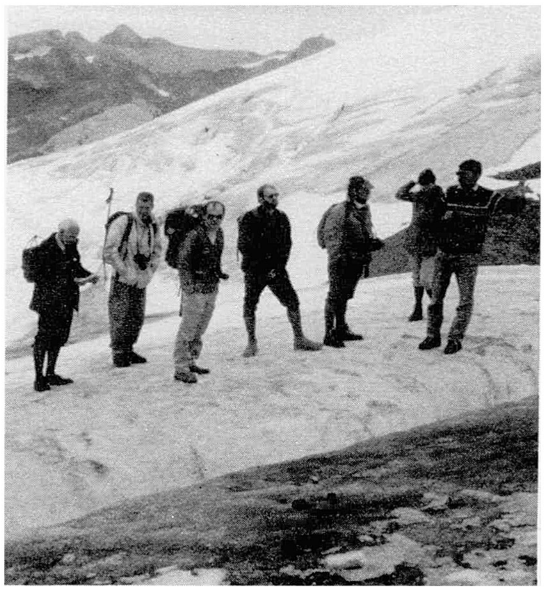
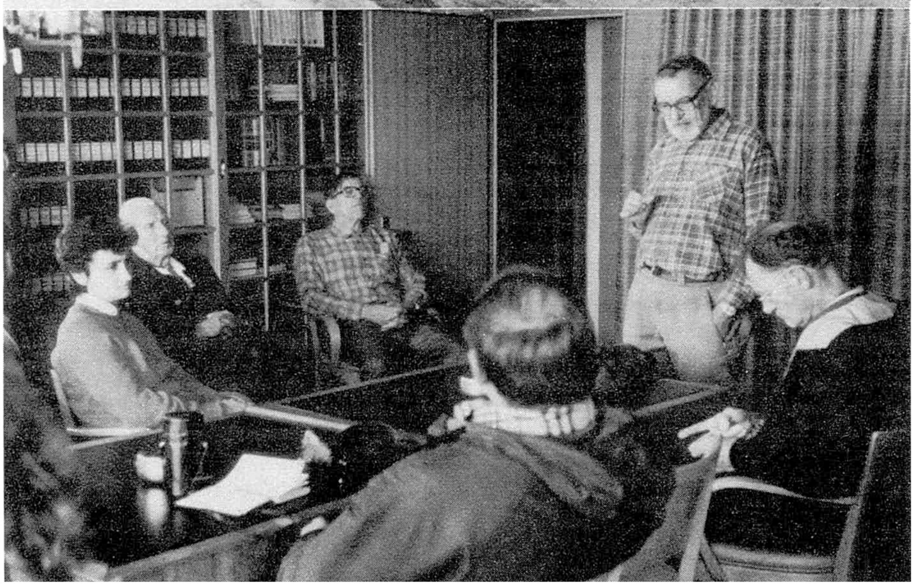


Oberer Grindelwaldgletscher (Gill Drewry, David Drewry, Joan Gold, Gunnar Østrem

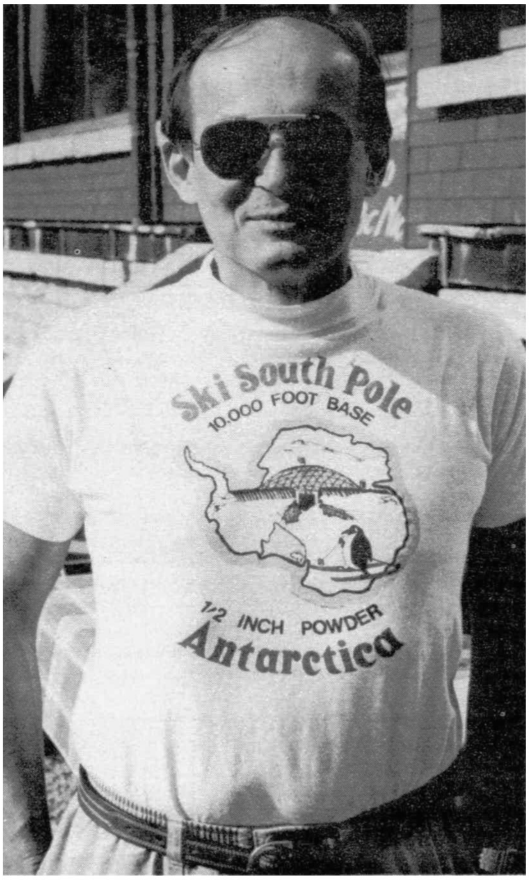


Wilfried Haeberli describing the dynamics of Titlis Gletscher

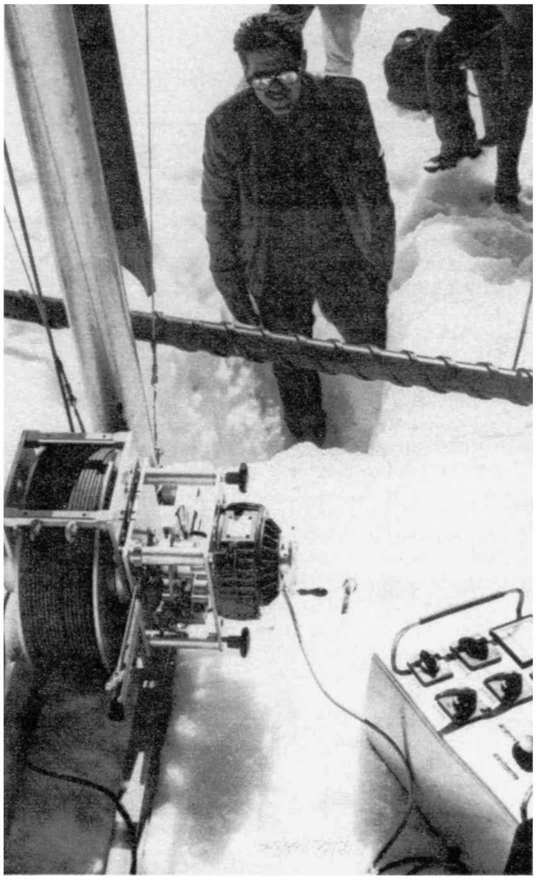


The President (Hans Röthlisberger) paying tribute to the work of Gerald Seligman

Wilfried Haeberli explaining some of the field projects of VAW-ETH



Jay Zwally advertising the ultimate in cross-country ski resorts



Bernhard Staufffer with Rüfli ice core drill below the Sphinx, Jungfraujoch

Photographs by K. Steffen and L.W. Gold

SELIGMAN CRYSTAL AWARD 1986

12th September 1986, Cambridge, England

The Society's Council agreed unanimously in 1985 that the Seligman Crystal be awarded to Gordon Robin in Cambridge in 1986, during the week of the 1986 Symposium on Remote Sensing in Glaciology. He was chosen to receive the Crystal in recognition that knowledge and know-how has repeatedly been enriched by his creative geophysical contributions to the field of glaciology. His pioneering work with the seismic method during the Maudheim Expedition 1949-52, his seminal paper on the temperature distribution in the great ice sheets, his initiation of deformation studies in ice shelves, his contributions to the assessment of the mechanisms of surging, and his straightforward approach to problems of water effects in crevassing and sliding at the bed are examples of his ability to see the problems and find solutions. Since Stan Evans received his Seligman Crystal in 1974 for his contributions to the development of radio echo sounding, Gordon has been influential in developing the method further, applying it in a broad sense in Antarctica and in advancing interpretation.

As fruitful as his research were his 24 years of directorship of the Scott Polar Research Institute in Cambridge, his activities in the Scientific Committee on Antarctic Research, and the successful guidance of research students.

After presentation of the Crystal, in the presence of Mrs Loris Seligman, widow of Gerald Seligman, Dr Robin gave a stimulating lecture, part of which we publish here.

I am greatly honoured to receive this award commemorating the name of our Founder who did so much for glaciology. It is a great privilege to see my name added to the list of holders of this award. However, when I look at the great contributions made by many other glaciologists not on the list, I must say I think the Awards Committee have a horrible job. I realise that during my time as Director of the Scott Polar Research Institute, my name has been linked to some extent with all glaciological research carried out in the Institute by both staff and research students. I have indeed been fortunate in almost 25 years in the excellence of my colleagues and their glaciological research; especially to Stan Evans for building up our radio-echo programme, to David Drewry for analysing and publishing the extensive results, and to Peter Wadhams for building up a first-rate sea-ice group. It would take too long to mention all the research students and others who have contributed so much, but I thank them all most sincerely for all their support over the years – and not only for their support but for their disagreements. The best theses often come from those who disagree with their supervisors – provided they convince their supervisors/examiners that they are right. There are few tasks so rewarding as supervising a good PhD student. So in accepting this award I do it not only for myself but on behalf of the whole glaciological team at the SPRI.

I must admit that it was never my intention to become a glaciologist, although as an undergraduate around 1939 I decided that I wanted to go to Antarctica. After 4 years in the Navy and a year as a research student my chance came when my Vice-Chancellor in Birmingham, Raymond Priestley, pointed me in the right direction, towards the SPRI in Cambridge and James Wordie. I wrote to him and had a telegram in reply asking if I could go to the Antarctic in two weeks' time as a geologist, surveyor or meteorologist. With my background, meteorology seemed the subject I could acquire most easily in two weeks, so off I went by air in 1946 as a meteorologist to catch up the expedition ship in South America along with Ray Adie, also on his first trip. While Ray was trapped by ice for a third year in Antarctica, I returned to Birmingham and was asked if I was interested in going as a physicist with the Norwegian-British-Swedish Antarctic Expedition. The concept of international cooperation and science being the driving force behind the expedition, instead of political bickering over territorial claims, appealed to me very much. I was given responsibility for upper wind measurements and seismic sounding of ice thickness. On this occasion I had ample time to learn the techniques before departure. The seismic sounding technique I learned from the Swedish suppliers, Elektrisk Malmletning, at that Mecca of glaciologists, Stör Glacier on Kebnekajse where I first came under the spell of Hans Ahlmann. In the Antarctic I learned a great deal about glaciology from Valter Schytt and Charles Swithinbank who gave great help with the seismic programme. The interest they stimulated and the desire to expand on my successful seismic results led me into glaciology properly and somehow it has remained as my central interest ever since – because I enjoy the subject and like my colleagues. Indeed, the NBSAE was the most exciting and rewarding time of my professional life. It led to my continued activity and research in polar regions and in international cooperation in polar science.

I will turn now to speculating about some future trends in glaciology, bearing in mind the aims of the Society stated in our constitution as: "To encourage research into the scientific and technical problems of snow and ice and to publish the results of that research". My nuclear physics professor, Mark Oliphant, gave a similar definition of research objectives to his students: "To seek the truth and having found the truth proclaim it".

I like the conciseness and the broad sweep of this definition, although it does not define what we mean by truth. Is it the same as knowledge? Can it change with time – or is it something rather vague and without meaning? I think it was Oliphant's enjoyment in finding out the nature of things, in his case on the nuclear scale, that is basic to all studies – especially in the sciences. I remember also the famous statitician Ronald Fisher, who was President of Caius College when I came to Cambridge in 1958, who used to say that the trouble with statistics was that the enjoyment went out of the work when it became a University subject – or something like that. After 50 years of better organised glaciology, is this becoming true of glaciology? I doubt if this will ever be true of fieldwork in glaciology – our studies are made in some of the most beautiful or most remote parts of the world. It could however be lacking in fascination for anyone whose studies are limited to the laboratory and computing room. Certainly glaciology is being taught in the universities to an increasing extent, text books are being written, and this tends to fix the quoteable "truth" on certain concepts. These often make suitable examination questions. However, as graduates, research workers must question what they learned as undergraduates if they are properly seeking the "truth".

One argument I have always been unwilling to accept from a research student is – "it must be true because so-and-so (a recognised authority) said so". I have even had some old statements of my own quoted at me in this way long after I had realised they were wrong. It is the substance of the statement that must be considered – not who made it – even though the latter may be useful for exams. One should not put anyone on a pedestal and accept all he says as correct. At this point, let me balance the kind things the President said about my work, by making the claim that I have probably written or said more things that time has shown were not true than any other holder of the Seligman Crystal. This is because of the way I work – first by speculation – then by testing. However, the more one speculates, the more likely one is to follow false ideas and these must be recognised and abandoned. I do not intend to mend my ways, so I will continue to discuss the search for "the truth" in our subject.

A mathematician may feel that he has the truth if he obtains an exact solution to a set of equations describing ice flow. It is reasonable for a mathematician to provide a solution for "a model which violates no physical principle, and the correctness of which can neither be proved or disproved", to quote from a reply from an eminent researcher to one of my criticisms. If the answer can neither be proved or disproved, it is not to my mind "the truth" to a glaciologist since it does not give a satisfactory explanation of the real world of glaciology – even though the solution is mathematically correct. A glacial geologist may be satisfied he has found the truth by relating till deposits to the source, erosion, transport and deposition of rock debris. A physicist may be satisfied when he has determined the flow law of ice in the laboratory and so on. However, a glaciologist should only be satisifed that he has found the truth when the proposed theory is correct in regard to its mathematics, physics, geology, hydrology, other geophysical data, geochemistry, and perhaps evidence from oceanography, meteorology, climatology and, we must not forget, materials science. It is important to know what substances are deforming – ice, or till, or what.

The need for such a wide-ranging approach is shown in other earth sciences. Wegener's continental drift hypothesis received little support from earth scientists – especially geo-physicists – for 40 years because mathematical physicists did not produce an adequate theory. Then came the discovery of magnetic stripes associated with mid-oceanic ridges followed by systematic seismic data showing earthquakes along these ridges due to consistent shear motion along the ridges. This led to plate tectonics – a refined form of continental drift. Mathematical physicists found this could be explained if material below the crust and lithosphere was softer than previously thought and driven by convective motion.

In my opinion a similar position to the continental drift idea is now being reached in regard to basal deformation beneath glaciers and ice sheets. We are rapidly learning about material within and below basal layers of ice. Geoff Boulton has been telling us for some years that glacier sliding/motion is often due to deformation of soft till beneath glaciers. The Wisconsin group have found soft till under ice stream B in Antarctica; Engelhardt, Kamb, Harrison and colleagues have found hard till under Blue Glacier and Variegated

Glacier. We know from soil mechanics that such till deforms according to a simple friction law provided it is porous and water pressure is right. Lliboutry and Reynaud have been telling us that they can explain observer glacier motion on Athabasca Glacier and Mer der Glace by a similar solid friction law rather than by the accepted sliding law related to a power of basal shear stress. Does this all add up to a clear shift in the pattern of glaciological thought as claimed by Geoff Boulton in *Nature* in July? I think so in some conditions, but we need to know where and when his ideas apply and where they do not – a lot of glaciological theory fits observation quite well although some does not. We should not readily discard theory where it works. This applies largely to internal deformation of glaciers, but not to sliding when rock debris is present.

I think we should not merely try to adapt existing theory to the observed basal materials. I think we need some revision of existing theory – especially when we are dealing with glacier sliding and erosion. At the May 1986 Whistler Conference on fast glacier flow, I tried to convince people that when bedrock slope exceeeds surface slope on mountain glaciers and sliding is taking place, (1) we seem to get an increased sliding component of flow, (2) we can expect erosion to increase by an order of magnitude in this situation, and (3) that pressure barriers opposing sliding occur where bedrock slope decreases and that

Mrs Seligman, widow of Gerald Seligman after whom the award is named, with Gordon Robin after the presentation

Gordon Robin and the President

this is important to the stability of glacier flow. I considered taking advantage of the presence of a captive audience tonight to try and convince you of the need of such a change in glaciological thought. I decided that this was not practicable since the ideas are still on the border of the speculative phase. I will therefore leave this subject with the message to younger glaciologists that there is a great deal to be done in glaciology, both in collecting field data and in revising glaciological theories, especially in relation to sliding: and I should add that a great deal is being done.

Finally, I wish to point out that within the Scientific Committee on Antarctic Research we have been fortunate in that, thanks to the IGY, the scientific community established itself as fitted to organise Antarctic science. Scientists of all nations working in Antarctica share a common search for truth and share the difficulties of the Antarctic environment. They leave political problems to their home governments – who nevertheless cooperate in supporting their field activities. We are fortunate in glaciology in that we also have a splendid homebase organisation in the International Glaciological Society that does so much to support the search for truth and to proclaim the truth through its symposia and splendid publications. We owe a great deal to the foresight and energy of our founder Gerald Seligman in starting us all on the right track. It is a great privilege to be awarded the Seligman Crystal tonight and I thank you all for coming.

ANNUAL GENERAL MEETING 1986

MINUTES OF THE ANNUAL GENERAL MEETING ON THE INTERNATIONAL GLACIOLOGICAL SOCIETY

12th September in the Chemical Laboratory, University of Cambridge, England

The President, Dr Hans Röthlisberger, was in the Chair. 60 members from 15 countries were present.

1. The Minutes of the 1985 Annual General Meeting, published in ICE No.78/9, 2nd/3rd Issues 1985, p.44-46, were approved and signed by the Chairman.

2. The President gave his report for 1985-86. It is for the first time since 1977 that the AGM takes place in Cambridge, after recent meetings were held far from here last year in Reykjavik, Iceland, and in Sapporo, Japan, in 1984. Combining the AGM with the 2nd Symposium in Remote Sensing and the 50th Anniversary Celebrations of IGS was the obvious thing to do.

Our membership is still around 830, and library subscriptions stand at around 550. Currently about 30% of the members live in the USA, 17% in the United Kingdom, 12.5% in Canada and 10.4% in Japan. Switzerland has 4.8%, the Federal German Republic 3.6%, and Norway and France each about 3%; there are members also in Argentina, Australia, Austria, Belgium, China, Czechoslovakia, Denmark, Finland, Greenland, Iceland, Ireland, Israel, Italy, the Netherlands, New Zealand, Poland, Saudi Arabia, South Africa, Spain, Sweden, USSR, and the United Arab Emirates.

Three issues of the *Journal* were published during the current year. Publication time has come down to 8.5 months and is now already close to the target of 8 months. However, a closer look into the statistics has shown that the deviations from the mean value of 8.5 months are considerable, showing a spread from 4 to 18 months. Further efforts to avoid delays will therefore be needed.

Volume 8 of the *Annals*, the Proceedings of the Iceland Symposium on Glacier Mapping and Surveying, has been published within the 9-month period from the date of the event laid down by Council.

Three issues of *ICE* have come out - thanks to Simon Ommanney, who has completed his term as Editor. Council has decided to bring the editing back to Headquarters, where Hilda Richardson will resume as Editor (as for the first 64 issues) with help (as needed) of people for the field-work reports. The lastest issue (No.80) was already produced in Cambridge with a new cover showing the Society's name. *Newsletters* from the Secretary General went to members in October 1985, February 1986 and August 1986, in mailings by air of routine items - in order to communicate more quickly than is possible with *ICE*, which is mailed by surface.

As a special publication the *History* of the first fifty years of the Society, written by Peter Wood, was published by the Society. Part of the cost of this volume has been met by a legacy from the late P.D. Baird. I am taking the occasion of this report to assure his family of our gratitude. Also in connection with the Golden Jubilee it is planned to print the *Anniversary Day Lectures* as a special issue of the *Journal*, which will be distributed free to members and libraries.

The office has been very busy with the extra work for the Symposium on Remote Sensing in Glaciology and the 50th Anniversary. Especially for the Secretary General, Hilda Richardson, it was no easy task. She has not had a full-time assistant since January 1986. There are three assistants working in the satellite office: one works 24 hours a week, one 21 hours, and one 20 hours during school terms and 10 hours in school holidays. This situation will be rectified soon, because the Secretary General has appointed a new full-time assistant, who will begin a trial period on 1 October.

The main events of the year have been the successful Remote Sensing Symposium in Cambridge, 8-12 September, and the 50th Anniversary Celebrations. On the evening of 9 September the Seligman Crystal was presented to Gordon Robin, awarded by the Council in 1985 in Reykjavik, followed by a memorable lecture by the recipient in the Keynes Theatre of King's College. The Anniversary Celebrations culminated on 10 September in a day's lectures by nine distinguished speakers and a delightful Banquet that brought, with 160 bookings, full house to King's College. During the Anniversary Day it was the President's pleasure to present a gift from the Society to Miss Doris Johnson in recognition of her outstanding service as an editor of the *Journal* for over 35 years. He was able also to announce that the Council, at its meeting on Saturday, 6 September, accepted the recommendation of the Awards Committee and unanimously decided to appoint Mrs Hilda Richardson an Honorary Member of the Society. The Golden Jubilee Tour to

Switzerland will follow next week, participation in that event being considerably lower than that for the banquet.

Future events being organized by IGS are the Symposium on Ice-Core Analysis to be held from 30 March - 4 April 1987 in Bern, Switzerland; the Symposium on Ice Dynamics to be held from 14-19 February 1988 in Hobart, Australia; the Symposium on Snow and Ice Processes & their Effect on Human Living Conditions, to be held in September 1988 in Lom, Norway, and the Symposium on Ice and Climate to be held in Seattle, USA at the end of August 1989. Plans for later meetings are already progressing.

I am closing my report by expressing the Society's and my personal gratitude to the Secretary General, Hilda Richardson. Her office staff - namely Pat Lander, Beverley Baker and Mary Parker - the House Editors Ray Adie and Eric Richardson, Scientific Editors and Referees, Reference Editor Sylva Gethin, Treasurer John Heap and all those who have helped the cause of the Society by participating in Council, Committees or in any other way, all merit our grateful thanks.

3. The Treasurer, Dr J.A. Heap, submitted a report:

"I regret that, once again, I cannot be with you to present my report.

As you will see from the Audited Accounts for 1985, there was a surplus on the General Income and Expenditure Account of £4,785 following a deficit in 1982 of £2,120 and surpluses in 1983 and 1984 of £6,136 and £3,831 respectively. Over the last four years the Accumulated Fund, an indicator of the general state of the Society's finances, has moved from showing a deficit of £13,251 in 1982 to a surplus of £7,883 in 1985. In my report for 1982 I emphasised the need for action to reverse the downward trend in the Society's finances. In my report for 1983 I noted a stop had been put to the downward trend and in my report for 1984, made to you last year, I had become cautiously optimistic.

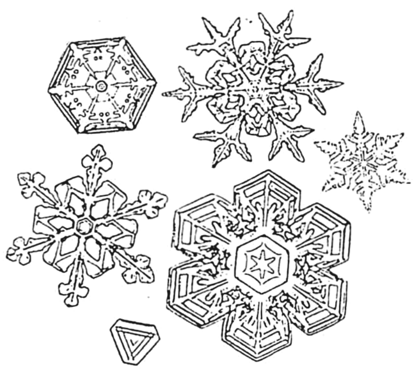
The 1985 accounts show that the finances of the Society have now been satisfactorily stabilized after what was a serious decline which I first noted in 1982. We need to be clear that the means of achieving this turn around (the sustained enlargement, via the *Annals*, of the Society's scale of business and the application of new technology to the Society's major function as a publisher) are phenomena which cannot be repeated. The implication of this is that we have to keep a hawk-eye on the operation of the Society as a business. The major economies have been made - we shall now be chasing increased efficiencies and savings of a few per cent.

Lastly, I recommend that Council adopt the audited accounts for 1985."

4. Election of auditors for the 1986 accounts. R.S. Willams proposed and J.W. Glen seconded that Messrs Peters, Elworthy and Moore of Cambridge be elected auditors for the 1986 accounts. This was carried unanimously.

5. Elections to the Council 1986-89. After circulation to all members of the Society of the Council's suggested list of nominees, no further nominations had been received. The following people were therefore elected unanimously:

Elective Members (4)	Roger Hooke
	Norikazu Maeno
	Ron Perla
	David Sugden



SECOND SYMPOSIUM ON REMOTE SENSING IN GLACIOLOGY

The symposium was held in the Chemical Laboratory, University of Cambridge, on 8, 9, 11, and 12 September 1986. It was organized by the International Glaciological Society and the proceedings will be published in *Annals of Glaciology*, as Vol. 9, in May 1987. A list of the contents will be published in *ICE* early in 1987.

The papers were divided into the following topics:

Remote sensing of glaciers (imaging sensors);

Remote sensing of glaciers (radar altimetry);

Radio echo and seismic sounding of glaciers;

Acoustic sounding of ice and snow;

Remote sensing of snow;

Satellite synthetic aperture radar imaging of ice and snow;

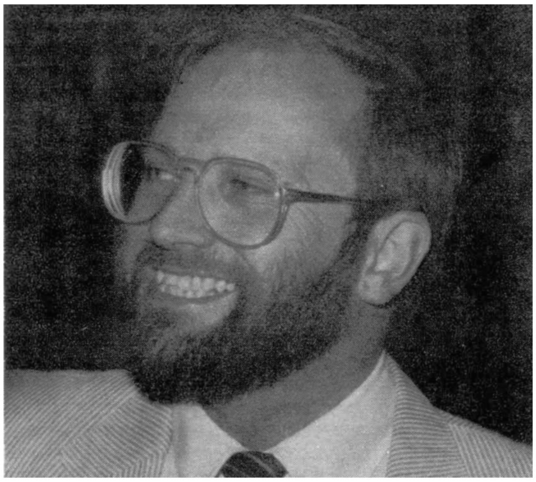
Satellite remote sensing of sea ice;

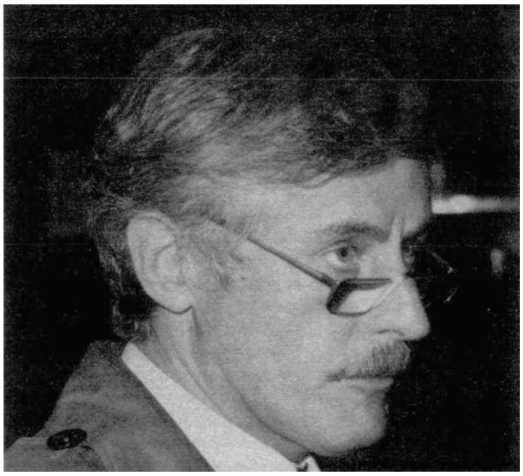
Monitoring of glaciers with various remote sensing methods.

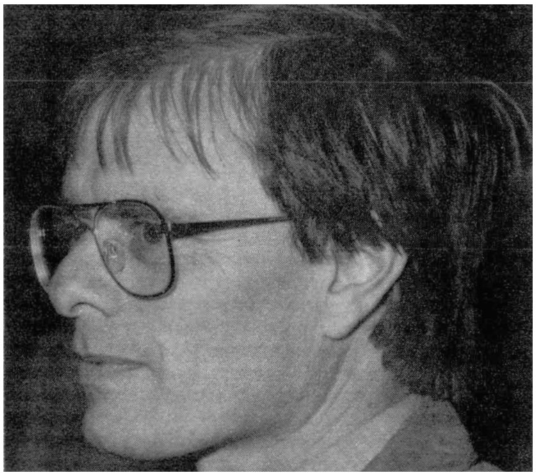
Social events included an Icebreaker in King's College on Sunday evening 7 September, a reception given by the Scott Polar Research Institute on Monday 8 September, the banquet at King's College on Wednesday 10 September, and private parties on other evenings.

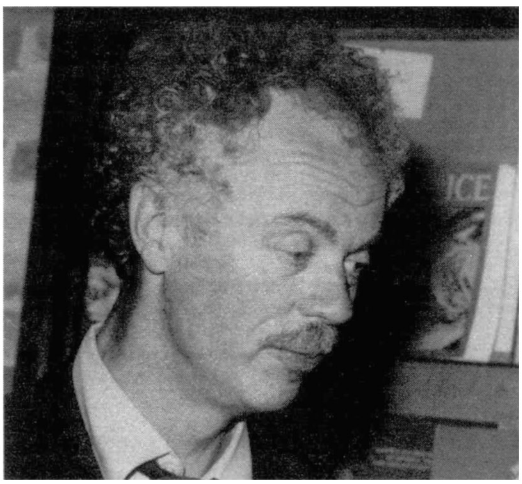
Marcel de Quervain (President 1975-78), Sir Vivian Fuchs (President 1963-66), Hans Röthlisberger (President 1984-87), Charles Swithinbank (President 1981-84)


Hans Valeur

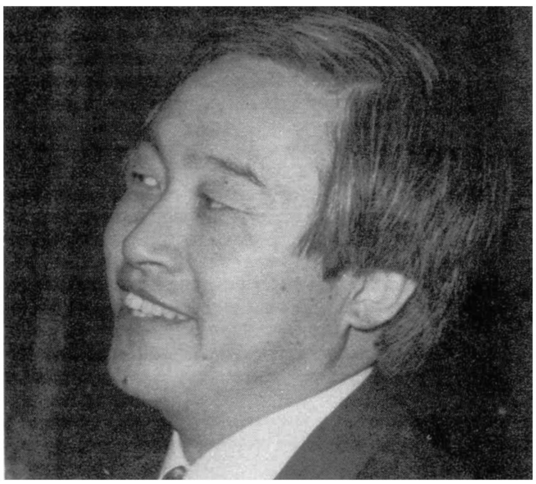

David Drewry

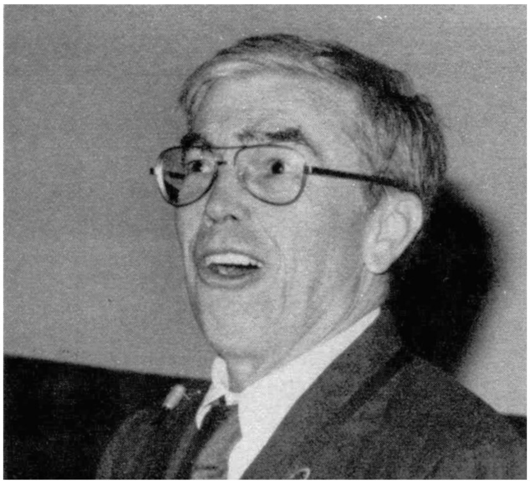

Heinz Kohnen


Heinz Blatter

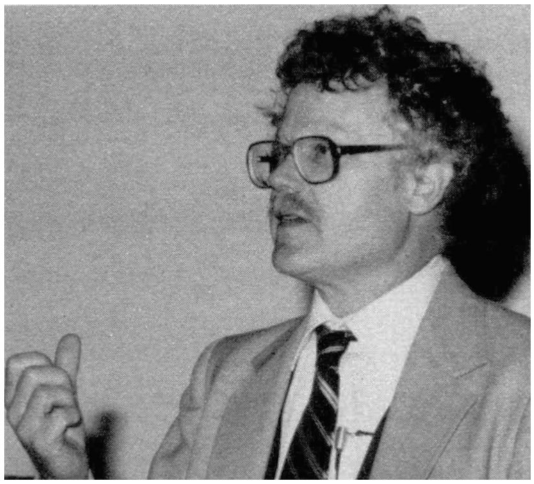


Garry Clarke


Shinji Mae



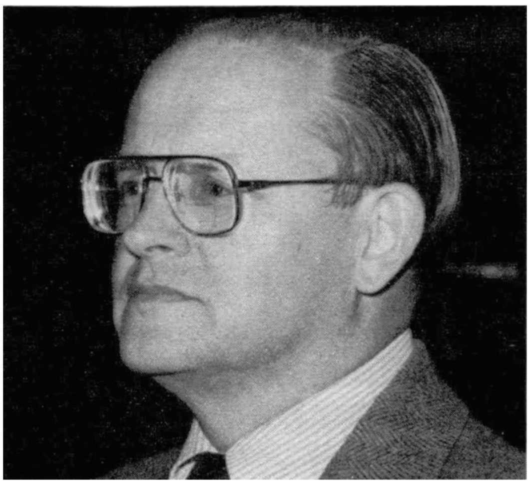
Hans Weertman



Sam Colbeck

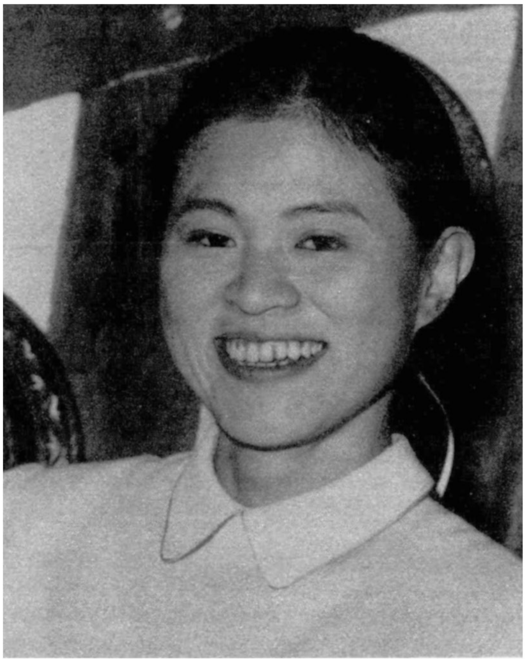
Geoffrey Boulton

Lorne Gold

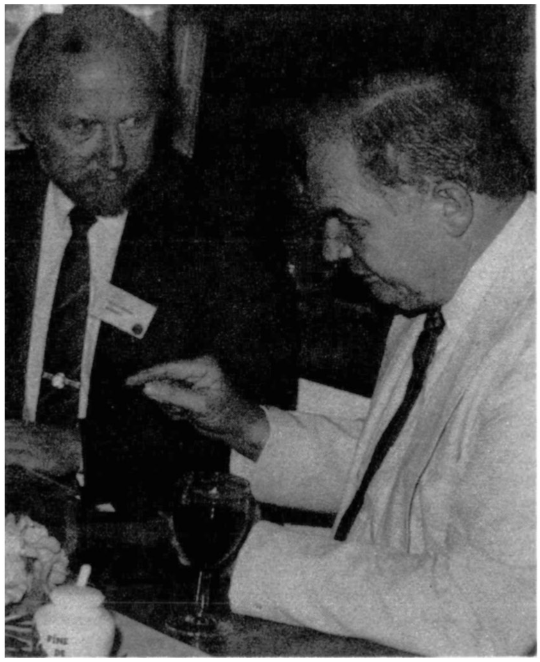


Richie Williams

Yuriy Macheret



Yuriko Nishimura



Olav Orheim and Eric Richardson

Zeng Qunzhu

Hilda Richardson and Charles Bentley

INTERNATIONAL GLACIOLOGICAL SOCIETY

Founded by G. Seligman

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c/o SCOTT POLAR RESEARCH INSTITUTE, University of Cambridge, Lensfield Road, Cambridge CB2 1ER, England

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Lensfield Road, Cambridge CB2 1ER, England

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ICE

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