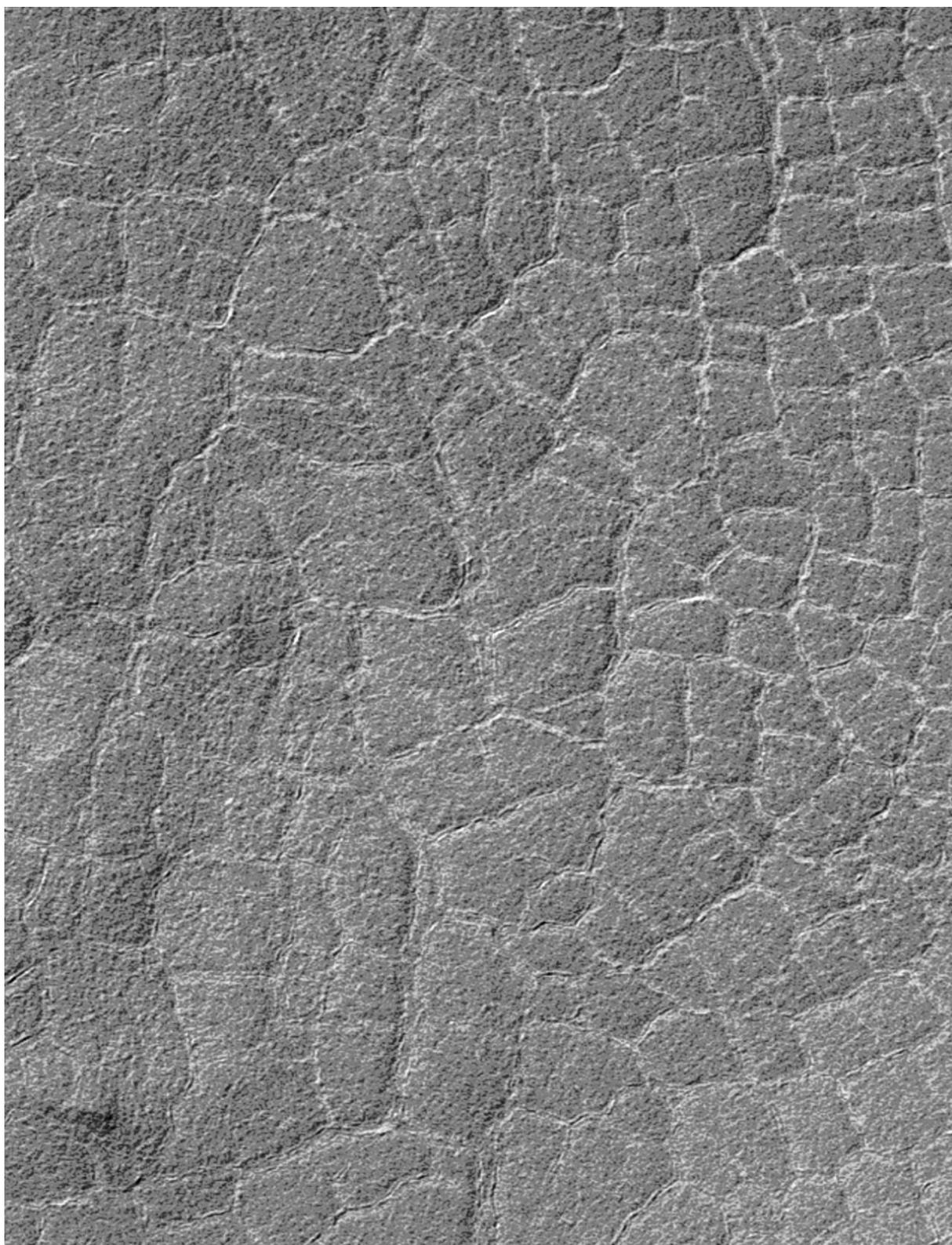


FROZEN GROUND



The News Bulletin of the International Permafrost Association

Number 26, December 2002



International Permafrost Association

The International Permafrost Association, founded in 1983, has as its objectives fostering the dissemination of knowledge concerning permafrost and promoting cooperation among persons and national or international organizations engaged in scientific investigation and engineering work on permafrost. Membership is through adhering national or multinational organizations or as individuals in countries where no Adhering Body exists. The IPA is governed by its officers and a Council consisting of representatives from 23 Adhering Bodies having interests in some aspect of theoretical, basic and applied frozen ground research, including permafrost, seasonal frost, artificial freezing and periglacial phenomena. Committees, Working Groups, and Task Forces organize and coordinate research activities and special projects.

The IPA became an Affiliated Organization of the International Union of Geological Sciences in July 1989. The Association's primary responsibilities are convening International Permafrost Conferences and accomplishing special projects such as preparing maps, bibliographies, and glossaries. The first Conference was held in West Lafayette, Indiana, USA, 1963; the second in Yakutsk, Siberia, 1973; the third in Edmonton, Canada, 1978; the fourth in Fairbanks, Alaska, 1983; the fifth in Trondheim, Norway, 1988; the sixth in Beijing, China, 1993; and the seventh in Yellowknife, Canada, 1998. The eighth will be in Zurich, Switzerland in 2003. Field excursions are an integral part of each Conference, and are organized by the host country.

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Vice Presidents

Dr. Felix E. Are, Russia

Professor Wilfried Haeblerli, Switzerland

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Dr. Jerry Brown, U.S.A.

Dr. Truls Mølmann, Norway

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Permafrost Engineering

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Coastal and Offshore Permafrost

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United Kingdom

United States of America

FROZEN GROUND

The News Bulletin of the
International Permafrost Association
Number 26, December 2002

Frozen Ground, the News Bulletin of the International Permafrost Association, is currently published annually.

The IPA is a non-governmental association of national organizations representing 23 countries or groups of countries. The success of the bulletin depends upon the willingness of IPA participants to supply information for publication. News items from any IPA participant or others are very welcome, as are interesting photographs. To submit news items or photos please contact:

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This issue of *Frozen Ground* was compiled by Hanne H. Christiansen and Jerry Brown.

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Cover: Polygons on the floor of an ancient impact crater on the northern plains of Mars, suggest the presence of ice-rich permafrost close to the terrain surface. The polygons measure 50-100 m across and in places display what look like open cracks. The picture covers about 1000 m across; and is illuminated from the upper left corner. The image was obtained by Mars Global Surveyor in May 1999, MOC2-150; NASA/JPL/Malin Space Science Systems. Similar polygonal forms are found in both the Arctic and Antarctic as illustrated in the report on planetary permafrost and astrobiology (this issue of *Frozen Ground*). See also the French national report for additional discussion of Mars. Mars has a diameter of 6,787 km. The surface air pressure is about 7 mb and main constituents of the atmosphere are 95% carbon dioxide, 3% nitrogen and 1.6% argon. The mean annual surface temperature is about 218K, -55°C.

Executive Committee Report

All members of the Executive and the Secretariat met in Arundel, U.K., in early November. We reviewed the status of planning for the Zurich conference, the report of the Nominations Committee, the current and future budget requirements, the status of Working Parties, and discussed possible changes to the constitution and a variety of international activities. Several of these items are reported elsewhere in this issue of *Frozen Ground*.

Vice-President Wilfried Haerberli reported upon preparations for the 8th International Conference on Permafrost. Over 200 papers are expected to be published in the proceedings. The Final Circular will be distributed by the end of 2002, with on-line registration and details posted on the conference website. The Swiss Organizing Committee has developed a programme of travel assistance (see website). The newly formed International Advisory Committee, chaired by former Vice-President Kaare Flaate, has been providing guidance to the conference organizers.

Funding constraints continue to limit the activities of the Association. However, the EC is pleased to note that most Adhering Bodies are continuing to provide their annual contribution on a regular basis. Truls Mølman has been investigating new funding sources for support of the Secretariat. We agreed to provide travel expenses for those Council Members who require support for the Zurich conference, and to continue support for preparing and printing *Frozen Ground*.



Participants at the Executive Committee meeting in Arundel November 2002.

The IPA Secretariat, under the direction of Hanne H. Christiansen, is in its new location at the University Courses on Svalbard, and continued to operate smoothly and efficiently throughout the year.

Formal requests to host the 9th ICOP in 2008 were received from the Chinese Academy of Sciences (Lanzhou) and the University of Fairbanks-Alaska. A decision will be made at the Council meeting in Zurich. Vice-President Zhu Yuanlin reported on the progress to complete the railroad across the Qinghai-Xizang Plateau by 2006-2007. Jerry Brown reported upon a number of Association projects including ACD, GGD and the CAPS CD, GTN-P, and CALM, and the status of Working Parties (see following reports for details). It is noted that permafrost is represented in two climate assessments: the IPCC and the Arctic Climate Impact Assessment (ACIA).

During the past year EC members and other IPA leaders have been engaged in discussions with several related international organizations concerning future activities. An informal joint Task Force was established to address common scientific interests between the IPA and the International Commission on Snow and Ice (ICSI). As a result of several IPA initiatives with the Scientific Committee on Antarctic Research (SCAR), IPA is now identified in two Antarctic activities: the Regional Sensitivity to Climate Change and the newly formed Permafrost Action Group. Our permafrost interests are included in the World Research Climate Programme on Climate and Cryosphere (CliC). Finally, Dr Peter Bobrowski, IUGS Vice-President, was designated as the official liaison between IPA and the International Union of Geological Sciences (see details in following reports).

We are looking forward to the conference and the Council meetings in Zurich and to learning of new advances in permafrost science and engineering. For those who cannot attend we will make a special effort to disseminate information on web sites and in the next issue of *Frozen Ground*.

The Executive Committee notes with great sadness the passing of two distinguished colleagues: Nikolai Grave (Russia) and Duwayne Anderson (USA).

In memorium: Nickolai A. Grave



Died in Moscow on October 13, 2002, at the age of 88. He was well-known and respected among permafrost colleagues in the former Soviet Union, North America, Europe and China. He was among the founding members of the International Permafrost Association in Fairbanks in 1983, and participated in many of the early IPA meetings and permafrost conferences. His self-taught command of the English language and expertise contributed to the successes of numerous bilateral visits and exchanges in Canada and the United States, and visits to Europe.

He graduated the Moscow State University in 1939 having specialized in physiography and geomorphology. During the World War II he conducted engineering and geological research in Yakutia related to building airports for transportation of airplanes from Alaska to Siberia. In 1945 he received a Candidate's Degree on *Ground Ice in the Lena-Aldan Watershed* from the Obruchev Permafrost Institute. In the same year he became head of the Anadyr Permafrost Station of the Obruchev Permafrost Institute in Chukotka. The research role of the station increased under his leadership. His research on the Koryaksky Range and the coast of the Bering Sea, from the Bay of Providence to the Schmidt Cape resulted in 1958 in the Doctoral Degree on *Conditions and Regulation of Permafrost Development, Chukotka-Koryaksky Region and Kamchatka*.

From 1956 to 1959 Grave worked at the Northeastern Department of the Permafrost Institute and took charge of a comprehensive

expedition to the Suntar-Khayata Range as part of the International Geophysical Year (IGY). During the period 1966 to 1975 Grave was at the Institute of Geography, and at the Design and Research Institute of Construction in Moscow. In 1975 he returned to Yakutsk and the Permafrost Institute, Siberian Branch, Russian Academy of Sciences. At the Institute he headed a group working on environmental protection that compiled maps for permafrost landscapes sensitivity to technogenic impact. The first stage of this work was completed in 1987 in *The Permafrost-Landscape Map of the Yakut Republic* at a scale of 1: 2500000, and published in 1991. He also served as Vice Director of the Institute.

Nickolai Grave was concerned with the training of young scientists in Yakutia, directed student's dissertations, and participated in many state examinations at the Department of Biology and Geography, Yakutsk State University.

In 1987 he became scientific secretary of the USSR National Committee on Permafrost to the International Permafrost Association. He also served as a member of the International Commission on Periglacial Morphology and the Commission on Snow and Ice Research. At the National Committee he made important judgements on the selection of Russian reports for international conferences.

Grave was author of over 50 scientific publications. His personal scientific contacts with leading scientists from foreign countries enhanced the prestige of Russian permafrost science. In cooperation with these colleagues, he published 10 scientific works abroad including the monograph in English, and later in Russian, entitled *Surface Disturbance and Protection During Economic Development of Northern Areas*, co-authored with Jerry Brown.

In the words of his Russian colleagues: 'Nickolai Alexandrovich Grave – a great scientist, kind and intelligent man – will always be in the hearts of those who knew him and worked with him'.

Prepared by Jerry Brown based on the obituary prepared by A. A. Mandarov, scientific secretary of the Melnikov Permafrost Institute.

Thaw vs Melt: An Editorial

For many years the English-speaking permafrost community has seen the need to standardize terminology. In the early 1980's, the Associate Committee on Geotechnical Research (ACGR) of the National Research Council of Canada established a Terminology Working Group to update the earlier 'Permafrost Terminology' volume first developed by R. J. E. Brown and W. O. Kupsch (1974). The result was the widely used 'Glossary of Permafrost and Related Ground Ice Terms' (ACGR, 1988). This was followed by the IPA-sponsored 'Multi-language glossary of permafrost and related ground-ice terms' in 12 languages (van Everdingen, 1998). This volume also includes a list of definitions, references, and illustrations, many of which had appeared in the 1988 publication.

In all publications there are numerous terms that include the word 'thaw'. However, 'melt' is a commonly used synonym in both the scientific and popular literature. For example, it is common to refer to 'melting permafrost', where the word 'melt' is used in an adjectival sense, or to state that 'permafrost is melting' where the word is used as a gerund (e.g. Earth Observatory News, December 10, 2001; The National Post, November 14, 2002). Today, the potential impact of global warming upon the distribution of permafrost necessitates that a clear distinction be made in the permafrost literature between the words 'thaw' and 'melt'. I believe the term 'permafrost melting' is incorrect or, at best, imprecise language. Moreover, and equally unfortunate, there is a degree of overlap of meaning attached to these two words if one consults the Oxford English Dictionary, the Collins English Dictionary, or others.

I recommend that the term 'thaw' be used when soil and/or rock becomes either warmer or passes to an unfrozen state. The alternative term is 'degrade', as in 'permafrost degradation' or 'permafrost aggradation'. By contrast, the term 'melt' should be used only when there is a change from a solid to a liquid state. Thus, although permafrost can degrade and its temperature will change, its physical state may, or may not, change. This often depends upon the degree of consolidation of the soil or rock. However, the critical issue from the terminological perspective is whether the permafrost is ice-bearing or ice-

bonded, i.e. the amount of ice present in the permafrost. Therefore, it seems appropriate to refer to the 'thaw' of soil and/or rock when referring to permafrost degradation but to the 'melt' of any ground ice contained within the permafrost. For example, it is more appropriate to refer to the 'thaw' of ice-rich permafrost and the 'melt' of massive ground ice. Likewise, it is more appropriate to refer to the 'thaw' of the active layer than to its 'melt'. In the case of a collapsing pingo, one might refer to the 'thaw' of the overburden and the 'melt' of the ice core.



Thawing permafrost near Sabine Point, Yukon coastal plain, Western Canadian Arctic. Photo: Hugh French.

The frozen and/or unfrozen state of water within permafrost and the associated terminological problems are central to this discussion. The distinction between the thermal and physical state of permafrost, first highlighted by van Everdingen (1978), is relevant to the definition of the active layer (e.g. see Burn, 1999) and to monitoring programmes such as CALM.

Hugh French, University of Ottawa, Canada

References:

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- Brown, R. J. E. and Kupsch, W.O. 1974. Permafrost Terminology. Associate Committee on Geotechnical Research, National Research Council of Canada, Technical Memorandum 111.
- Burn, C. R. 1999. The active layer: Two contrasting definitions. Permafrost and Periglacial

- Processes, 9, 411-416.
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New study shows early signals of climate change in Earth's cold regions. Media Alert Archives, NASA, Boulder, Colorado, USA. See: <http://www.colorado.edu/PublicRelations/NewsReleases/2001/1533.html>
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- van Everdingen, R. O. (compiler and editor) (1998). Multi-language Glossary of Permafrost and Related Ground-Ice Terms. International Permafrost Association.
- The National Post, Ottawa, Canada, Thursday, November 14, 2002. Kyoto: myths and science. Andrew Weaver. pA5.

Nominations Committee Report

The IPA Nominations Committee, consisting of Johan-Ludvig Sollid (Norway), Rupert (Bucky) Tart (USA) and Vice-President Felix Are (Russia), submitted their report in July. On behalf of the IPA, I thank them for their work. They nominated the following individuals for the 2003-2008 Executive Committee:

President (1):

- Jerry Brown (USA)
- Wilfried Haeberli (Switzerland)

Vice-Presidents (2):

- Charles Harris (UK)
- Georgiu Perlshteyn (Russia)
- Zhu Yuanlin (China)

Members (3):

- Don Hayley (Canada)
- Hans W. Hubberten (Germany)
- Douglas Kane (USA)
- Truls Mølmann (Norway)
- Sarah Springman (Switzerland)
- Dario Trombotto (Argentina)

Neither Jerry Brown nor Wilfied Haeberli wish to stand for other positions. The Report was distributed to all Adhering Bodies in December 2002, as required by the IPA constitution, along with short statements by candidates of

qualifications and future interests in the IPA.

The report indicates there will be elections for all EC positions. It raises, by implication, a number of important long-term issues for the Association. These are complex and are currently being discussed within the EC. They include the fact that current membership in the IPA is by national Adhering Bodies and not through individual memberships. The EC wishes to promote discussion within the Association on this issue noting that the IPA currently has 23 Adhering Bodies, and that each has an equal vote regardless of the degree of permafrost activities or their annual contribution. To facilitate fair, open, and orderly election at the Zurich Council meeting in 2003, voting guidelines will be circulated prior to the meeting; no additional nominations will be accepted after April 1, 2003. A proposed change in the Constitution, to be effected by postal ballot by March 1, 2003, will be circulated together with the report of the Nominations Committee. If approved, this would allow an individual of the country hosting the next ICOP to hold any position on the EC rather than, at present, being required to hold either the President or a Vice-President position.

The EC hopes that a more comprehensive discussion of the IPA Constitution, and its longer term implications, will be undertaken at the Zurich Council meeting, and that appropriate follow-up actions will be initiated by the EC that is elected in 2003.

Hugh French, IPA President, 1998-2003

Report of Working Parties

At its 1998 meeting in Yellowknife, the IPA Council approved the formation or continuation of one Standing Committee, six Working Groups (WG) and three Task Forces (TF); collectively referred to as Working Parties (WP). Task Forces are intended to be short-term activities resulting in assessments or recommendations on specific subjects. Additional details on the guidelines for Working Parties and international liaison are found in Frozen Ground Number 22.

The following reports present summaries of activities and accomplishments since Yellowknife including those during the past year. Special issues of several journals were published this year based on WP activities and several more are planned (*Polar Geography, Reports of Polar and Marine Research, Progress in Physical Geography, and South African Journal of Science*). Several invited reports in the section *Other News* reflect current and future research opportunities for the current and new WPs. Most Working Parties plan to meet during the 8th International Conference on Permafrost to discuss future plans. Several WP are co-sponsoring technical sessions.

Members of WP represented the IPA in a number of international activities and organizations. These include among other organizations the World Meteorological Organization (WMO) and the Food and Agricultural Organization (FAO) programmes for Global Climate Observatory System (GCOS) and Global Terrestrial Observing System (GTOS), the World Climate Research Programme's (WRCP) Climate and Cryosphere (CliC) project, the International Association of Hydrological Sciences' (IAHS) International Commission on Snow and Ice (ICSI), the International Union of Geological Sciences (IUGS), the International Geographical Union (IGU), the International Union of Soil Science (IUSS), and the Scientific Committee for Antarctic Research (SCAR).

The following reports were reviewed and edited by Jerry Brown, Member, IPA Executive Committee (jerrybrown@igc.org).

Standing Committee

Data, Information, and Communications

The objectives of the SCDIC are to initiate and implement IPA strategies for data, archiving, information product development, and communi-

cation within and beyond the permafrost community.

In addition to the co-chairs Roger Barry (USA) and Mike Clark (UK); members include Julia Branson (UK), Margo Burgess (Canada), Daniel Vonder Muehll (Switzerland), Hanne Christiansen (Norway), Evgeny Melnikov (Russian), and Jerry Brown (USA) as liaison for the Executive Committee.

The main activities this past year focused on developing and implementing plans for the Global Geocryological Database (GGD) and its Circumpolar Active-Layer Data System (CAPS) Version 2 CD, and liaison with several international organizations and programmes. Members communicated via email, although a number of them had met in 2001 in Rome during the First European Permafrost Conference and at annual meetings in Pushchino and the American Geophysical Union to discuss progress on the GTN-P and the GGD.

A revised GGD IPA-funded brochure was prepared this past year at the National Snow and Data Information Center (NSIDC) and copies were provided to Council Members and Working Parties co-chairs for distribution to members and others. Since the Yellowknife Conference, the IPA web site was redesigned by staff of the GeoData Institute and it was periodically updated including the posting of full text (pdf) versions of Frozen Ground 21-25. Four annual issues of Frozen Ground were produced totalling approximately 200 pages (including FG 26) by Hanne Christiansen and assisted by Jerry Brown and Donna Valliere (FG 22). The Geography Department at the University of Copenhagen provided production support. The digital version of the IPA map is now available in Arc/Info, ArcView and raster formats from NSIDC.

A GGD meeting was hosted on 16-17 January 2002 at the World Data Center (WDC) for Glaciology, Boulder, co-located with the NSIDC, to develop plans to produce the CAPS 2 CD for release in Zurich. The project is primarily supported by the International Arctic Research Center (IARC) and is under the direction of Tingjun Zhang and Mark Parsons. Data and information from major IPA-coordinated programmes are included; namely the Global Terrestrial Network for Permafrost (GTN-P), the Circumpolar Active

Layer Monitoring (CALM), the Arctic Coastal Dynamics (ACD), and the Cryosol database project, the Southern Hemisphere Working Group bibliographic compilation. Individual data sets, digital maps, and the cumulative permafrost bibliography including the Antarctic bibliography and several specialised Russian bibliographies are also part of the GGD/CAPS. Provisional GGD plans include development of a new search engine with an interactive data access through the CD-ROM. Members met with Parsons during the CALM workshop in Lewes, Delaware, in November 2002 to review progress on the CAPS 2. During the same meeting Co-chair Barry along with Jerry Brown and Hanne Christiansen had an extensive teleconference with Co-chair Clark related to future web site access. Christiansen will visit GeoData Institute in January 2003 to continue the discussions. A small CAPS 2 review group plans to meet in Boulder in late February to finalize input to the CD.

At the Council meeting in 1998, the IPA resolved to lead the development of a functional international network for permafrost monitoring. Following meetings and recommendations of the GCOS/GTOS Terrestrial Observations Panel for Climate (TOPC) the Global Terrestrial Network-Permafrost (GTN-P) was officially approved (1999) and is coordinated by the IPA and its SCDIC. Both measurement of 'permafrost thermal state' and 'active layer' are designated parameters of the GTN-P. Borehole information is maintained on the GTN-P web site developed by the Geological Survey of Canada (Burgess et al. 2000). Several workshops and meetings related to boreholes and active layer were attended in Fairbanks (1999), Rome (2001), Copenhagen (2001), Mongolia (2001) and annually in Pushchino. Details on the Circumpolar Active Layer Monitoring (CALM) programme is presented in the Global Change WG report. Coordination with PACE and national projects such as **Permafrost Monitoring Switzerland** (PERMOS) were maintained.

Hanne Christiansen represented IPA at several meetings of the Scandinavian-North European Network of Terrestrial Field Bases (SCANNET). These stations offer the opportunity to establish and maintain frozen ground observations (see *Other News* for CEON discussion).

The WCRP Climate and Cryosphere (CliC) project produced a draft Implementation Plan (see web site). Frozen ground issues and proposed actions are presented in Chapter 5.3. and monitoring networks in Chapter 10.3.2. The CliC SSG, for which Barry is co-Vice Chair, met in Beijing October 20-25, 2002, to expand on specific projects to be proposed under CliC (see Climate Observing reports).

Selected Publications:

- Brown, J, Haerberli, W., Barry, R. and Nelson, F.E. 2001. The proposed international permafrost monitoring network and service. In R. Paepe and V. Melnikov, (eds). *Permafrost Response on Economic Development, Environmental Security and Natural Resources*, Kluwer Academic, 601-606.
- Burgess, M. M., Smith, S.L., Brown, J., Romanovsky, V., and Hinkel, K. 2000. *Global Terrestrial Network For Permafrost (GTNet-P): permafrost monitoring contributing to global climate observations*, Geological Survey of Canada, Current Research 2000 E-14, 8p., (online; <http://www.nrcan.gc.ca/gsc/bookstore>).
- Zhang, T., Heginbottom, J.A., Barry, R.G. and Brown, J. 2000. Further statistics on the distribution of frozen ground and permafrost. *Polar Geography* 24(2), 126-131.

The SCDIC will meet during the Zurich conference, discuss future plans, recommend to the IPA Council nominees for co-chairs, and identify additional members for this permanent committee. Presentations of posters on national and international data activities are planned.

Web:

- CAPS and IPA maps: nsidc.org/frozenground/
 CliC: clik.npolar.no/impl/plan.html
 GTN-P: sts.gsc.nrcan.gc.ca/gtnp/index.html

Roger Barry (rbarry@kryos.colorado.edu)
Jerry Brown (jerrybrown@igc.org)

Working Groups

Global Change and Permafrost

Working Group objectives are to facilitate analysis of changes in permafrost and its distribution induced by climate change, and to promote knowledge about the impact of these changes on natural systems and human activities. F.E. Nelson (USA) and Oleg Anisimov (Russia) are the Working Group co-chairs. A subgroup, headed by K.M. Hinkel (USA), coordinates the CALM network. Membership is opened to all interested individuals and was based initially on those who attended the Yellowknife WG meeting.

At the Yellowknife conference, the newly reconstituted WG proposed five primary goals for the 1998-2003 period:

- The WG should play a major role in preparing the cryosphere section of the Intergovernmental Panel on Climate Change (IPCC) Third Assessment Report (TAR) and related programmes or initiatives.
- The WG should continue to play a major role in developing the Circumpolar Active Layer Monitoring (CALM) programme.
- Members of the WG should play a role in developing a set of standardized criteria for thermal measurements in boreholes and analysing the resulting data sets.
- The WG should play an advocacy role in promoting development of a spatial perspective in permafrost research.
- The WG should act as an advocate of permafrost research to the larger global-change research community.

Progress on the five topics is described below:

IPCC Third Assessment Report: Permafrost was treated extensively in Chapter 16 of the 'Impacts, Adaptation, and Vulnerability' volume of the TAR (Anisimov et al., 2001). This chapter, titled 'Polar Regions (Arctic and Antarctic)', addresses permafrost from both regional and systems perspectives. Permafrost topics received far more space than in previous IPCC reports; besides receiving its own section, permafrost was woven into text treating ecology, hydrology, feedbacks, polar drivers, and impacts on human communities. Permafrost also received attention in the first volume of the IPCC report 'The Science of Global Change', in the context of its contribution to the balance of greenhouse gases in the climate system. Permafrost was also discussed in other regional chapters, including North America and Asia. Permafrost-related issues were also incorporated in the IPCC Technical Paper on Biodiversity, published in 2002. This resulted from meetings of the IPCC writing team in Canberra (October 2001) and Barbados (January 2002).

Arctic Climate Impact Assessment (ACIA): ACIA's mission is to assess climatic change and its impacts with special reference to the Arctic. One of its primary goals is to produce a comprehensive overview of the Arctic system in the context of climatic change. Like IPCC, ACIA draws conclusions and makes recommendations based only on published scientific results. Permafrost occupies a central place in Chapters 5 title 'The Cryosphere and Hydrologic Variability' and 15 'Infrastructure' of the projected volume. The IPA Global Change WG is represented in ACIA by O.A. Anisimov and V.E Romanovsky (see *Other News* for more details).



Participants in the CALM Workshop in Delaware, USA, November 2002. Photo: Hanne H. Christiansen

Circumpolar Active Layer Monitoring (CALM) Programme: The CALM programme received funding from the U.S. National Science Foundation in early 1998, through the University of Cincinnati, for a five-year programme of site development, environmental monitoring, and database construction. During this period CALM has evolved into an extensive network of more than 120 sites with a semi-standardized observational protocol and affiliations with several international monitoring programmes. Data from the network are available to interested researchers on the CALM website and transferred periodically to the National Snow and Ice Data Center (NSIDC) in Boulder, Colorado. A monograph-length paper describing the programme's mission, structure, international activities, and results to date was published in early 2002 (Brown et al., 2000). A paper describing results from CALM sites in Alaska is currently in press (Hinkel and Nelson, 2003). The first International CALM workshop was held in Delaware during November 2002.

Spatial Perspective: The advent of global change science has led to the necessity for many elements of earth, biological, and social sciences to integrate their subject matters in an explicitly geographical context. Permafrost science has been no exception in this regard, and it is now commonplace to employ an array of geographical techniques (e.g., remote sensing, GIS, cartography, spatial statistics) in permafrost studies, and to express results in mapped formats (see Usa Basin report as an example). The increase in such studies over the past five years, typified by papers by Smith and Burgess (1999) and Smith and Riseborough (2002), is striking, and will be reported upon at the Zurich conference. Permafrost networks have begun adopting a nested, hierarchical approach to monitoring that facilitates "scaling up" of observations and development of spatial time series covering extensive areas. The GTOS Global Hierarchical Observing Strategy (GHOST) approach has been applied to the PACE borehole transect in Europe (Harris et al. 2001) and active-layer monitoring in northern Alaska (Nelson et al., 1997). A detailed description of GHOST is provided in both Brown et al. (2000) and Harris et al. (2001).

Boreholes: The task of standardizing thermal measurements in boreholes and analysing the resulting data sets is currently undertaken by

the SCDIC's activities and the Global Terrestrial Network-Permafrost. An overview of GTN-P was provided by Burgess et al. (see SCDIC report).

Advocacy to Larger Scientific Community: This WG goal is fulfilled in part through IPCC and ACIA, our input of CALM to the GTOS Terrestrial Ecosystem Monitoring Sites, and numerous publications. A general review of the role of permafrost in global change, targeted to the natural hazards research community, was published in a specialty journal (Nelson et al., 2002a). A shorter paper on the same topic was published in the widely disseminated journal *Nature* (Nelson et al., 2001), and created extensive exposure and examination in popular media. A white paper describing the role of permafrost in the context of climate change and making agency recommendations was prepared for the U.S. Arctic Research Commission (Nelson et al., 2002b). Papers by Osterkamp and Romanovsky (1999), Jorgenson, et al. (2001), among many others, discuss permafrost degradation in a warming climate. The Editorial on Thaw vs. Melt is intended to draw attention to issues of global warming.

WG Meetings: Members of the Global Change WG participated in a number of meetings during its five-year tenure. These ranged from relatively informal discussions to a weeklong workshop.

San Francisco, California, December 1998 and 2000. Formal meetings of the WG were held at the American Geophysical Union Fall meetings to facilitate discussions about the future of CALM, borehole initiatives, data networks, model validation, and location of field sites, and the IPCC report.

Pushchino, Russia, May 2000 and 2002. Discussions were focused on the CALM network, with emphasis on instrumentation and measurement protocols and the proposed workshop, and on GCMs as sources of climate information for forcing permafrost models of future conditions.

Rome, Italy, March 2001. A meeting of the WG was held in conjunction with the First European Conference on Permafrost. Discussions concerned spatially distributed data to be used in model validation, documenting permafrost conditions in marginal areas, particularly the southern fringe of permafrost in the Northern Hemisphere, and stochastic vs. deterministic approaches to

determining permafrost properties. Amsterdam, The Netherlands, July 2001. IGBP Open Session meeting at which Oleg Anisimov presented a plenary session report on climate change impacts in high-latitude regions. Lewes, Delaware, USA, November 2002. A CALM workshop, sponsored by a NSF grant to the University of Delaware, was attended by 33 participants from six countries. The workshop produced a resolution on the future of CALM (see insert box). Interim CDs were produced containing data supplementary to those available on the CALM website and PowerPoint presentations for many of the CALM sites. A workshop report with abstracts of presentations is in preparation. A series of extended abstracts focused on intersite syntheses will be submitted for the Zurich conference. A proposal for a special issue of *Permafrost and Periglacial Processes*, to report on regional synthesis has been approved by the journal's Editor-In-Chief. The tentative publication date is late 2003.

A meeting of the Working Group will be held in Zurich at which time plans for future tasks, changes, and continuation of the Working Group will be discussed.

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Web:

GSC: sts.nrcan.gc.ca/gtnp
 CALM: www.geography.uc.edu/~kenhinke/CALM
 ACIA: www.acia.uaf.edu/

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Periglacial Processes and Environments

The objectives are to evaluate different methodologies and techniques for monitoring periglacial processes, and to publish a manual of techniques. Ole Humlum (Denmark/Norway) and Norikazu Matsuoka (Japan) are the Working Group co-chairs.

CALM Workshop Resolutions

Whereas 33 participants from 6 contributing countries (Canada, Norway, Poland, Russia, Sweden and USA) of the Circumpolar Active Layer Monitoring (CALM) met in Lewes, Delaware, 11-15 November 2002;

- Whereas the IPA plays a leading, coordinating role in the establishment and continued development of the Global Terrestrial Network-Permafrost (GTN-P) and its active layer and permafrost observatories to support the regional and intergovernmental assessments of environmental change and vulnerability;
- Whereas initial results from the first coordinated

phase of CALM (1996-2002) were reviewed in regional syntheses representing many high-latitude regions of the Northern Hemisphere;

- Whereas the CALM website containing both metadata and site data is now a contributing network to the GTOS/TEMS programmes;
- Whereas present and future active layer field methods and modelling requirements were discussed; and
- Whereas a well-established network of spatial and temporal observations is required for present and future development of remotely sensed methods for cryosphere analysis, calibration and validation;

Be it resolved:

- To continue the CALM observations and improve the thematic representativeness of the network;
- To improve linkages with other networks and international programmes such as WCRP (CliC), IGBP and the proposed Circumarctic Environmental Observatories Network (CEON);
- To better understand active layer dynamics through observations of borehole temperatures, subsidence, snow cover, soil properties (moisture, surface organics, texture), topography and vegetation;
- To ensure continued operation, maintenance and enhancement of CALM and borehole temperature databases (GTN-P) and websites;
- To provide input for improvement of permafrost-climate model development, model result comparison, and verification;
- To prepare reports to disseminate results of data analyses beginning with the 8th ICOP and a special journal publication; and
- To develop strategies for remote sensing-based methods of monitoring geocryological parameters over extensive areas, consistent with the GHOST observation scheme.

In order to facilitate measurements of various periglacial processes, the preparation of a field manual was agreed upon by the WG at the 1993 Permafrost Conference in Beijing. The original proposal received additional support at the IPA Council meetings in Berlin (1995) and Bologna (1997). In Yellowknife (1998) it was decided that the main objective of the WG should be production of the handbook, and that this should be available at the permafrost conference in Switzerland in 2003.

In order to facilitate comments from interested persons and institutions, an initial first draft compilation of the manual can be found at the homepage of The University Courses on Svalbard (UNIS, under the research topics of Ole Humlum).

In order to promote this project, the WG

cochairs decided to develop a journal volume that collects papers on a variety of new methodologies and techniques for monitoring periglacial processes. The editors of *'Permafrost and Periglacial Processes'* agreed to publish a special issue, under the general heading 'Monitoring periglacial processes: new methodology and technology', with the two co-chairs of the WG acting as guest editors. A call for papers was issued in late 2002. Some of these contributions will be adapted for the field manual.

Since the Yellowknife conference the following periglacial meetings were held:

- Symposium on 'Periglacial Environments: Past, Present and Future', 27-30 September 1999, Lodz, Poland.
- Periglacial Workshop, 6-7 September 2000, University of St. Andrews, UK.

- Fifth International Conference on Geomorphology, 23-28 August 2001, Chuo University, Tokyo, Japan. The WG co-sponsored an ICG general session on Glacial and Periglacial Geomorphology, a symposium on Glaciation and Periglaciation of Asian High Mountains, and a post-conference field excursion on Alpine Geomorphology in Central Japan.
- International Workshop on Debris-Covered Glaciers, 13-16 September 2001, Seattle, Washington, USA.

The following publications were prepared in conjunction with these meetings:

- *Biuletyn Peryglacjalny*, No. 38, 1999. A special issue from the Lodz symposium.
- *Geomorphology*, a special issue on 'Periglacial geomorphology at the beginning of the 21st century' (in press), based on the general session in the 5th ICG in Tokyo.
- *Zeitschrift für Geomorphologie*, a special issue (in preparation) based on the symposium in the 5th ICG in Tokyo.

Liaison with the IGU Commission on Climate Change and Periglacial Processes (CCPP) has continued since the last WG report. The IGU newsletter is available via e-mail. The CCPP, chaired by Jef Vandenberghe, continues for a second term, enabling the Commission to carry out planned activities. Dr. Julian Murton is secretary for the Commission. The present CCPP Commission is going to be the last one in a series of IGU commissions that have undertaken activities on periglacial research in IGU since 1949.

Web:

Draft Field Manual: www.unis.no
search under Ole Humlum.

IGU newsletter: www.cpes.susx.ac.uk./igu

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Permafrost Engineering

The objectives are to collect information on the practices and procedures of permafrost engineering in various regions of the world, and to facilitate communications with permafrost scientists. Branko Ladanyi (Canada) and Lev Khrestalev (Russia) serve as the co-chairs of this WG.

In addition the WG is pursuing the following more specific objectives:

- Evaluate the effects of climatic changes on infrastructure stability in permafrost regions and assess new geotechnical systems that minimise the introduction of heat into permafrost;
- Develop modern programmes of permafrost engineering training for students.
- Collect information on the practices and procedures of permafrost engineering in various regions of the world, and to facilitate communications with permafrost scientists. Since Yellowknife members of the WG met at a number of international engineering and geotechnical conferences (see previous issues of *Frozen Ground* for details for the following meetings) :
- Ninth International Conference on Cold Regions Engineering, in Duluth, Minnesota, September, 1998.
- Annual International Conferences in Pushchino, in April 1999, May 2000, June 2001, May 2002.
- Tenth International Conference on Cold Regions Engineering in Lincoln, NH, August, 1999.
- International Workshop on Permafrost Engineering at The University Courses on Svalbard (UNIS) in Longyearbyen, Svalbard, June, 2000. The workshop was organized by members of the WG.
- Workshop to Develop a Strategic Plan for Cold Regions Engineering Research in the New Millennium, Anchorage, Alaska, June 2000.
- International Symposium on Ground Freezing and Frost Action in Soils at Université Catholique de Louvain, Louvain-la-Neuve, Belgium, September 2000.
- Second Biennial Workshop on Assessment and Remediation of Contaminated Sites in Arctic and Cold Climates (ARCSACC) in Edmonton on May 2001.
- Second Russian Conference on Geocryology at the Lomonosov Moscow State University, June, 2001.
- International Conference on Estimation of Foundation State in St.-Petersburg May 2001.

During 2002 there were four conferences involving WG members:

- Annual International Conference in Pushchino, 12- 15 May 2002.
- Eleventh International Conference on Cold Regions Engineering in Anchorage, Alaska, 20-22 May 2002 (see USA report).

- 5th International Symposium on Problems of Permafrost Engineering in Yakutsk on 2-4 September 2002 (see Russian report).
- Symposium on Cold Regions Engineering in Lanzhou, 19-21 September 2002 (see Chinese report).

WG member Arne Instanes (Norway) is responsible for the engineering component of the Arctic Climate Impact Assessment (ACIA) project. Lev Khrustalev and Branko Ladanyi are among others contributing to the ACIA report (see *Other News*).

The ASCE Technical Council on Cold Regions Engineering (TCCRE) Committee on Frozen Ground has completed the ASCE Standard on 'Design and Construction of Frost-Protected Shallow Foundations' (available from the American Society of Civil Engineers, 1801 Alexander Bell Drive, Reston, VA 20191-4400, USA).

The principal publication resulting from WG organized activities was the proceedings volume for the International Workshop on Permafrost Engineering held in Longyearbyen, Svalbard.

Some results of the above activities will be presented at the Zurich conference and the future activities of the WG will be discussed.

Web:

ACIA: www.acia.uaf.edu/

ARCSACC: www.merlin.civil.ualberta.ca/ARCSACC

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Cryosol

The objectives were to establish interactions between geocryology and soil science, to prepare a Cryosol book, a global Cryosol classification and a circumpolar soil database, and to organize the Third International Conference on Cryopedology that was held in Denmark in 2001. Charles Tarnocai (Canada) and Sergey Goryachkin (Russia) are the Working Group co-chairs.

Active members include: A. Arnoldussen (Norway), O. Arnalds (Iceland), I. Campbell (New Zealand), L. Beyer (Germany), J. Bockheim (USA), G. Broll (Germany), J. Brown (USA), D. Gilichinsky (Russia), B.H. Jakobsen (Denmark),

J. Kimble (USA), D. Konyushkov (Russia), G. Mazhitova (Russia), E. Naumov (Russia), E.M. Pfeifer (Germany), C.L. Ping (USA), M-L. Raisanen (Finland), S. Smith (Canada), I. Sokolov (Russia), D. Swanson (USA), B. Van Vliet-Lanoe (France), Zhao Lin (China).

Major activities since the Yellowknife Conference focused on preparation of the Northern Circumpolar Soil Database and the Soils of the Northern and Mid Latitudes Database and various soil maps and soil carbon estimates derived from these databases. Preparation and editing of papers to be included in the Cryosol book also formed a major activity. In addition, organizing the Cryosol Symposium held at the 17th World Congress of Soil Science in Bangkok, and preparation of papers for the Congress symposium, the Third International Conference on Cryopedology held in Copenhagen in August 2001, and the 8th International Conference on Permafrost were important activities of the CWG. These activities and other working group related issues were discussed at the CWG meetings, which were held at least twice a year.

The Cryosol Working Group represents both the International Union of Soil Science (IUSS) and the International Permafrost Association (IPA). The CWG is also closely connected with the ITEX and CALM communities, the European Soil Bureau, and the Soil and Terrain Digital Database (SOTER) Project. A soil field data form was developed by the CWG members to be used to record soil data on ITEX and CALM sites. In addition, a number of working group members are involved in active layer monitoring on CALM sites.

During 2002 the papers for the Cryosol book were completed and are now in the final stage of technical editing. The book is expected to be published by Springer Publisher in 2003. The first versions of the Northern Circumpolar Soil Database and the Soils of the Northern and Mid Latitudes Database and the associated soil maps were completed in 2002. The second version of the Northern Circumpolar Soil Database was presented at the World Congress of Soil Science. The databases and associated maps were submitted to GGD for presentation on the CAPS 2 CD-ROM. Future activities of the CWG were discussed at WG meetings in Lincoln, Nebraska, Pushchino, Russia, and Bangkok, Thailand.

Development of the CWG web site was initiated.

During this four-year period, members of the WG carried out soil research activities in Alaska, Arctic Canada, northern Scandinavia and northern Russia; Sergey Goryachkin, as WG co-chair, received financial support from IPA to facilitate electronic communications and develop and maintain the web site. Numerous meetings were organized and/or attended as follows:

- 16th World Congress of Soil Science, Cryosol Symposium, Montpellier, France, August 1998, David Gilichinsky and Brigitte van Vliet-Lanöe (leaders).
- Circumpolar Soil Database workshop, Copenhagen, Denmark, March 1999.
- International Earth Cryosphere conferences, Cryosol section, Pushchino, Russia: April 1999; May 2000; June 2001; May 2002.
- Circumpolar Soil Database workshops: Oslo, Norway, March 2000; Laxenburg, Austria, March 2001.
- Third International Conference on Cryopedology, Copenhagen, Denmark, August 2001.
- Circumpolar Soil Database and SOTER workshop, Lincoln, Nebraska, March 2002.
- 17th World Congress of Soil Science, Cryosol Symposium, Bangkok, Thailand, August 2002, C. Tarnocai (leader).

Publication citations resulting from the CWG activities will appear on the web site. Major publications include the abstract volume for Third International Conference on Cryopedology, a special issue of *Permafrost and Periglacial Processes* published in 1999 based primarily on papers presented at the 1998 16th World Congress of Soil Science, and the Cryosol book (in press).

A CWG meeting is to be held during the Zurich conference. The IPA Council will be requested to continue the Cryosol WG for an additional five years under its current name and in partnership with the IUSS.

Provisional web: <http://igras.geonet.ru/cwg>

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Coastal and Offshore Permafrost

The objective is to encourage the interaction of investigations on the subjects of onshore, transitional and offshore permafrost and hydrates. Hans-W. Hubberten (Germany) and Nikolai Romanovskii (Russia) are co-chairs of the Working Group. Steven Solomon (Canada) chairs the Coastal Erosion Subgroup.

Several field projects have been active along the Russian and North American coasts since the start of the WG in 1998. Under the joint German-Russian project 'System Laptev Sea' five expeditions to the Lena Delta, the coastal lowlands around the Laptev Sea and the New Siberian Islands were performed. COPWG related studies focused on modern processes in permafrost soils and the underlying frozen sequences on Samoylov Island in the central part of the Lena Delta. Major emphasis was on trace gas flux measurements and the characterization of microorganisms involved in the carbon cycle and the identification of older, possibly hydrate-derived methane in the deeper parts of the sequences through drilling. A second goal consisted in the reconstruction of the regional climatic and environmental history since the Early Weichselian with special emphasis on ice-rich permafrost (ice complex) and ground ice bodies. Parallel to these activities, several marine expeditions to the Laptev Sea studied the processes related to sea level change and the position of submarine permafrost. Submarine permafrost was cored in the Laptev Sea using a Russian drilling vessel.

Much effort has been put on the modelling of the evolution of coastal and offshore permafrost and gas hydrates. Initiated by Nikolai Romanovskii, the Moscow State University group in cooperation with the Alfred Wegener Institute (AWI) carried out mathematical simulations of the evolution, distribution and thickness of permafrost from the shelf, coastal and lowland areas of the Laptev and East Siberian Seas for the last 400 kyr. These simulations were made for different geographic, hydrologic and geothermal conditions and included the variation of the gas hydrate stability zone. Since 2001 the modelling of permafrost was continued together with the American group from Fairbanks (Vladimir Romanovsky) with special focus on the thermoerosion of coasts formed by ice-complex,

its partly transformation to relic ice-complex islands and the formation of sandy bars due to thermoerosion of these islands.

Special sessions were organized on the topic of coastal and offshore permafrost and hydrates at various conferences. During the last three international conferences in Pushchino special sessions dealing with "Land-Ocean Interactions in Polar Regions" were chaired by Romanovskii and Hubberten. During the First European Permafrost Conference in Rome (Italy), a special session on "Coastal and Marine Environments" was chaired by Hubberten. At two workshops on the Russian-German Cooperation on the Laptev Sea System held in St. Petersburg in 1999 and 2000 (organized by J. Thiede, AWI, Bremerhaven) and I. Frolov (State Research Center, Arctic and Antarctic Research Institute, St. Petersburg) sessions covered COP topics on onshore and offshore permafrost and terrestrial/marine interactions in coastal zones.

The Russian-German Cooperation Otto Schmidt Laboratory for Polar and Marine Sciences (OSL) established at AARI was officially inaugurated by representatives of the German and Russian ministries of science and technology on 12 October 2000. A fellowship programme was founded for Russians that includes COP-related topics such as the evolution of past and recent state of terrestrial and offshore permafrost, land-ocean interactions, and coastal processes.

Coastal Erosion Subgroup: An international workshop on Arctic Coastal Dynamics was held in November 1999 and funded by the U.S. NSF under the Russian American Initiative on Shelf-Land Environments (RAISE) program. The result was a report and the development of a framework for the Arctic Coastal Dynamics Project. Members of the ACD Steering Committee are Felix Are (Russia), Jerry Brown (USA), George Cherkashov (Russia), Mikhail Grigoriev (Russia), Hans-Wolfgang Hubberten (Germany), Volker Rachold (Germany, Secretariat), Johan-Ludvig Sollid (Norway), and Steve Solomon (Canada, Sub-

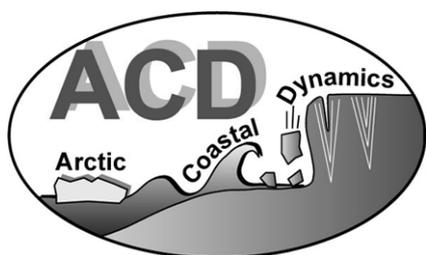
group Chair).

A second, smaller workshop was held in Potsdam in 2000 to develop a Science and Implementation Plan, which was submitted to the International Arctic Science Committee (IASC) for review, approval and advice on future directions. ACD was accepted as an official IASC project under the leadership of Volker Rachold with a secretariat established at AWI (Potsdam) and co-sponsored by the IPA. The project developed a metadata form and database of key monitoring sites, an arctic coastal mapping and classification scheme and held IASC-sponsored workshops in



Participants in the ACD meeting in Oslo, December 2002. Photo: Feliks Rivkin.

November 2001 (Potsdam) and December 2002 (Oslo). Field projects contributing to the ACD programme include annual surveys of the Lena/Laptev coast by a Russian-German team, surveys of the Beaufort Sea and western Canadian Arctic Archipelago by a Canadian team, establishment of key sites along the Alaskan coast, field activities on Spitsbergen by a Norwegian group, and ongoing monitoring activities by Russian investigators. Support for activities comes from various national and international agencies with interests in climate change impacts, storm surge vulnerability, constraints on infrastructure development, and carbon and sediment input from coastal erosion. The International Arctic Research Center, University of Alaska Fairbanks, is supporting a post doc position to analyse circum-Arctic coastal climatology. The Canadian Department of Natural Resources (Department of Foreign Affairs and International Trade and the Climate Change Action Fund), and the EU Northern Dimensions Programme for German-Canadian cooperation provided support for ACD mapping activities and fieldwork. Two new INTAS projects



employing GIS technologies and to develop sediment budgets and carbon fluxes were funded in 2002.

The ACD Steering Committee plans to submit the following to the GGD/CAPS 2 CD: key sites metadata, a photo library of sites, version 1 of the coastal segmentation and classification, and the Russian coastal bibliography.

The following ACD meetings and workshops were held or attended:

- ACD workshops in Woods Hole, MA, November 1999; Potsdam, Germany, October 2000; November 2001; Oslo, Norway, December 2002. The third IASC-sponsored international workshop was held in Oslo, Norway, on 2-5 December 2002. Participants from Canada (3), Germany (3), the Netherlands (1), Norway (5), Russia (11), Switzerland (1), United Kingdom (1) and the United States (2) attended. During the first part of the workshop ca. 30 reports dealing with different aspects of arctic coasts and their dynamics were presented. During the second part regional working groups applied the circum-arctic segmentation and classification for the entire arctic coastline in order to develop the estimates of sediment and organic fluxes from coastal erosion.

- Roundtables and sessions at the Annual International Permafrost Conferences in Pushchino 1999, 2000, 2001, 2002.

- Arctic Science Summit Week in Cambridge, UK (1999), Iqaluit, Canada (2001), Groningen, The Netherlands 2002.

- LOIRA (Land Ocean Interaction in the Russian Arctic), November, 2002.

In addition to the ACD-IASC collaboration, Solomon and V. Romanovsky are contributing authors to Chapter 5 (Cryosphere) of the Arctic Climate Impact Assessment (ACIA), and the ACD Secretariat maintains communication with the IGBP Land Ocean Interaction in the Coastal Zone (LOICZ) and LOIRA.

Publications: The Working Group, based on the broad-based sponsorship of many related activities, has produced numerous publications. Selected publications are listed below:

ACD Steering Committee, 2001. Arctic Coastal Dynamics Science and Implementation Plan. Submitted to and approved by the International Arctic Science Committee.

Are, F.E., et al., 2002. Comparative shoreface

evolution along the Laptev Sea coast, *Polarforschung* 70:135-150.

Brown, J. and Solomon, S.M., 2000. Arctic Coastal Dynamics: Report of an International Workshop. Geological Survey of Canada Open File #3929.

Deslisle, G., 2000. Temporal variability of subsea permafrost and gas hydrate occurrences as a function of climate change in the Laptev Sea, Siberia. *Polarforschung* 68: 221-225.

Hubberten H.-W. & Romanovski N.N., 2001. Terrestrial and offshore permafrost evolution of the Laptev Sea region during the last Pleistocene-Holocene glacial-eustatic cycle. In: R. Paepe & V. Melnikov (eds): *Permafrost Response on Economic Development, Environmental Security and Natural Resources*. Proc. NATO-ARW, Novosibirsk, 1998. Kluwer, Dordrecht, 43-60.

Meyer, H., et al., 2002. Paleoclimate reconstruction on Big Lyakhovsky Island, North Siberia Hydrogen and oxygen isotopes in ice wedges. *Permafrost and Periglacial Processes* 13: 91-105.

Rachold, V., 2000. Coastal erosion vs. riverine sediment discharge in the Arctic shelf seas. *International Journal of Earth Sciences*. 89: 450-460.

Rachold, V., Brown, J., Solomon, S. (eds), 2002. Arctic Coastal Dynamics, Report of an International Workshop, Potsdam (Germany) 26-30 November 2001, Reports on Polar Research 413, 103 pp.

Rachold, V., Grigoriev, M.N., and Bauch, H.A., 2002. An estimation of the sediment budget of the Laptev Sea during the last 5,000 years. *Polarforschung* 70:151-157.

Rachold, V., et al. Modern terrigenous organic carbon input to the Arctic Ocean, In: Stein, R. and Macdonald, R.W. (Eds.) *Organic Carbon Cycle in the Arctic Ocean: Present and Past*. Springer Verlag, Berlin, in press.

Romanovskii, N.N., et al., 2000. Thermokarst and land-ocean interactions, Laptev Sea region, Russia. *Permafrost and Periglacial Processes* 11:137-152.

Schirrmeister, L., et al., 2002. Paleoenvironmental and paleoclimatic records from permafrost deposits in the Arctic region of Northern Siberia. *Quaternary International* 89:97-118.

There will be a session on coastal permafrost at the Zurich conference. The COPWG

plans to meet and will propose the development of a new subgroup on permafrost modeling and/or hydrates. Based on the ACD Science and Implementation Plan the current project ends in 2005, and therefore the subgroup plans to continue.

Web:

ACD: www.awi-potsdam.de/www-pot/geo/acd.html

IASC: www.iasc.no

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Southern Hemisphere Permafrost and Periglacial Environments

The objectives are to create a scientific platform to stimulate interaction between permafrost and periglacial researchers in the Southern Hemisphere, and to synthesize permafrost and periglacial data and information, including existing IPA initiatives in the region. Jan Boelhouwers (Sweden) and Kevin Hall (Canada) are co-chairs of the Working Group.

Members are Paul Augustinus (New Zealand), Jim Bockheim (USA), Eric Colhoun (Australia), Mauro Guglielmin (Italy), Ian Meiklejohn (South Africa), Jim Peterson (Australia), and Dario Trombotto (Argentina).

Several developments have taken place regarding the advancement of permafrost science in the Antarctic. Following the May 2000 presentation to the Scientific Committee for Antarctic Research (SCAR) programme on Regional Sensitivity to Climate Change (RiSCC) in Antarctic Terrestrial Ecosystems, active layer monitoring was accepted within the RiSCC science plan. Jan Boelhouwers represented IPA at RiSCC meetings in South Africa (2000) and Amsterdam (2001). Mauro Guglielmin participated in Amsterdam (2001) and Hobart (2002). The RiSCC membership has welcomed the contact with IPA and looks forward to permafrost science projects to be submitted through national programmes and to establish active collaboration on the ground.

During the First European Permafrost Conference in Rome the relationship of IPA with the SCAR was further discussed. As the scientific

objectives are unlikely to be accommodated in a separately funded scientific activity, a working relationship with the RiSCC programme was seen as an appropriate approach. This was proposed and accepted at the RiSCC workshop in Amsterdam in September 2001. Temperature monitoring in the active layer and soil disturbance measurements were included in the RiSCC methodology descriptions; protocols are being prepared by Mauro Guglielmin and Jan Boelhouwers, respectively. Where appropriate, geomorphological expert input will be invited for studies at the RiSCC core sites.

A further development was that the SHWG on behalf of the IPA prepared a document for the SCAR 2002 meeting in Shanghai, China, that proposed the establishment of a formal working relationship between the SCAR and IPA. The documentation included information on current and planned permafrost activities by national programmes in the Antarctic.

Objectives for Antarctic permafrost science were formulated as follows:

- Monitoring of the permafrost spatial distribution, temperature and active layer thickness (GTN-P, CALM).
- Monitoring and analysis of environmental parameters (especially temperature, radiation, moisture) that act as controls on permafrost and periglacial processes.
- Field-based monitoring of permafrost and periglacial processes in soil/rock, and the rates at which these operate.
- Field-based analysis of the physical/chemical manifestations/morphology that result from these processes.
- Past climate reconstructions using permafrost indicators.
- Permafrost and periglacial process interactions with other abiotic (hydrological, pedological) and biotic components of ecosystems.

In response to the IPA proposal presented by Wayne Pollard (Canadian SCAR representative), the SCAR Standing Scientific Group on Geosciences appointed a Permafrost Action Group (PAG) to convene a meeting at Zurich and a workshop at the forthcoming International Symposium on Antarctic Earth Sciences in September 2003 in Potsdam, and to prepare a report for the next SCAR meeting in 2004. IPA is represented on the PAG that is chaired

by Pollard.

South American colleagues led by Dario Trombotta convened a cold climate environment session at the International Geological Congress 2000 in Rio de Janeiro, accompanied by a pre-congress field trip in southeast Brazil organized by May C. Modenesi-Gauttieri. A mid-term WG meeting at the IAG conference in Tokyo 2001 discussed progress on the bibliography, website and SCAR-related activities. Members of the WG compiled a set of regional reviews including all areas of present and past permafrost and periglacial conditions in the Southern hemisphere. The reviews were presented at the XVth INQUA Congress in Durban, 1999 and were subsequently published in the *South African Journal of Science*, 2002, volume 98, issues 1 and 2. As part of the XVth INQUA Congress a post-conference excursion was held in the Lesotho highlands debating the southern African Quaternary periglacial record. To further improve access to Southern Hemisphere permafrost studies a bibliography of over 1000 references was compiled for final release at the Zurich conference.

A WG website was developed. It provides a first information access point to SH permafrost studies for the specialist and non-specialists alike. The site offers the review papers, INQUA excursion field guide and the provisional bibliography for downloading. The WG will provide the review papers and the bibliography for the GGD CAPS 2 CD.

Financial support from the IPA was received to compile and publish the bibliography and establish the website. Both activities also received support from Uppsala University and University of Northern British Columbia. IPA also supported attendance of Jan Boelhouwers to the South African RiSCC workshop, 2000.

A paper session and workshop on Antarctic permafrost session are planned for the Zurich conference. The Southern Hemisphere WG will consider to have fulfilled its aims by 2003 and it is not recommended to be continued in its present form. The Antarctic workshop in Zurich could form the basis for a new Antarctic Permafrost WG. This could, amongst other objectives, provide continuation in collaboration with the SCAR organized RiSCC and PAG activities.

Web:

SHWG: www.natgeog.geo.uu.se/shwg/

SCAR: www.scar-ggi.org.au/actiongroupspemafrostindex.htm

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Kevin Hall (hall@unbc.ca)

Task Forces

Rock Glacier Dynamics and Permafrost Creep

The objectives of the Task Force are to establish the basis for and initiate numerical modelling concerning flow of ice/rock mixtures on slope. Wilfried Haeberli (Switzerland) is the TF chair assisted by Bernard Hallet (USA). The activities are jointly organized by IPA and the International Commission on Snow and Ice (ICSI).

As a follow-up of the workshop and meeting during the First European Permafrost Conference at Rome in 2001, the main efforts of the TF members now concentrate on the preparation of a final report, which is most likely to consist in a special contribution to *Permafrost and Periglacial Processes*, hopefully available for the ICOP 2003.

The text contains a brief introduction and formulation of the main tasks (W. Haeberli, B. Hallet), overviews concerning composition (rock, ice: N. Matsuoka, M. Elconin), thermal conditions (surface, boreholes: O. Humlum, D. Vonder Mühl), geometry and kinematics (A. Kääb, V. Kaufmann), rheology (S. Springman, B. Ladanyi) and a final discussion on future research perspectives (all members). The last section especially outlines needs and requirements for integrated numerical modelling. Such quantitative treatment must be based on data available from photogrammetry, data loggers, borehole observations and laboratory experiments. It should include and combine partial models for:

- (a) rock weathering and rock fall with grain-size sorting on scree slopes,
- (b) freezing processes and ice formation in negative-temperature scree with abundant fine material but also coarse blocks,
- (c) rheology of damped creep in structured and ice-saturated coarse blocks as well as of steady-state creep in fine-grained materials containing excess or even massive ice, and
- (d) kinematics of non-isotropic, heterogeneous

and layered, ice-rich permafrost on slopes with transportation of coarse surface material to the front and following re-incorporation into the creeping body causing corresponding age inversion at depth.

It was the clear goal of the Task Force to concentrate on purely periglacial features and processes. As a next step, however, interactions and feedbacks between snow, glaciers and frozen scree on mountain slopes should be considered in order to understand additional complications in nature and more complex landforms.

Wilfried Haeberli (haeberli@geo.unizh.ch)
Bernard Hallet (hallet@u.washington.edu)

Mapping and Distribution Modelling of Mountain Permafrost

The objective of the Task Force is to develop systematic strategies for mapping and modelling distribution of mountain permafrost at different scales. The TF builds on the accomplishments of the former WG on Mountain Permafrost. Bernd Etzelmüller (Norway) and Martin Hoelzle (Switzerland) are cochairs of the TF.

Mountain permafrost mapping and distribution modelling is a research field of high interest, because of its linkage to climate change and hazard assessment. The TF was founded during the IPA Yellowknife meeting in 1998. An email list of about 50 interested colleagues is maintained at the University of Oslo. Participation is open to all interested persons.

In Europe, mapping and modelling permafrost distribution is carried out in several countries, until 2001 within the EU-funded project PACE (Permafrost and Climate in Europe). Recent modelling activities are concentrated mainly in areas where boreholes are now available in mountain permafrost environments. At these borehole sites the distribution models could be well tested and/or calibrated and coupled to climate models.

The mapping of permafrost in the Asian and Eurasian mountains has intensified during this period. Permafrost mapping activities are carried out in the Altai, Tien Shan and Pamir mountains through cooperation among Russian, Mongolian, Kazakh and Chinese scientists.

Permafrost distribution in the Southern Hemisphere and particularly the Antarctic has been identified as an issue within the IPA/SHWG and SCAR. Members of the Southern Hemisphere Working Group are compiling an inventory of permafrost maps.

The TF organized meetings and sessions during the First European Conference on Permafrost in Rome, 26-28 March 2001 (see Frozen Ground 25 for report of the Conference; the abstract volume is available from Charles Harris). During the Task Force session, 10 oral presentations and 15 poster presentations were given. All participants were invited to give a paper in a special issue in the *Norwegian Journal of Geography* about 'Mountain permafrost mapping and distribution modelling' (Volume 55, issue 4, 2001). The objective of this special issue was to develop a state-of-the-art report for high-mountain mapping and modelling of permafrost, together with recent studies within this field. The contributions in this special issue are in three major fields. The *process studies* describe interactions between permafrost occurrence and external factors, such as glaciers or snow. The *modelling methods* papers show different approaches of modelling past and present permafrost distribution. The *regional studies* focus on fieldwork and apply modelling to delineate the permafrost occurrence in certain regions.

The TF was represented at the International Symposium on Arid Land Permafrost, in Ulaanbataar, Mongolia, in September 2001 (see Frozen Ground 25). The focus of the symposium was the permafrost distribution mapping and modelling of the central-Asian mountain permafrost. In 2002 permafrost scientist from the University of Oslo, Norway, the University of Zurich, Switzerland, and the University of Alaska, U.S., in co-operation with the Mongolian Academy of Science, carried out permafrost investigations on the east shore of the Hövsgöl lake, northern Mongolia (see following detailed report).

With the TF meeting in Rome and the publication of the special issue on mapping and modelling of mountain permafrost, the official status of the TF officially ended. A report of the TF will be given in Zurich ICOP, there will be an opportunity to discuss the future continuation of these efforts, and we anticipate many contributions

regarding TF-related activities.

Web: www.geografi.uio.no/ipa/

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Martin Hoelzle (hoelzle@geo.unizh.ch)

Isotope/Geochemistry of Permafrost

The objectives of the Task Force are to promote application of isotope geochemical methods in permafrost research, to identify the main gaps in knowledge for successful application of isotopic methods in permafrost studies, and to develop an internationally accepted protocol for a WG. Rein Vaikmae (Estonia) is the TF chair assisted by Hans-W. Hubberten (Germany).

Several informal TF meetings concerning the scope of activities took place during the last years among Rein Vaikmae, Hans Hubberten, Jerry Brown and Yuri Vasilchuk. These discussions led to the establishment of a TF Secretariat at the Alfred Wegener Institute for Polar and Marine Research, Potsdam, Germany, with Hanno Meyer as the responsible person. During a meeting in Tallinn in June 2002 Vaikmae, Hubberten and Meyer agreed to prepare a TF homepage at AWI and to start with a questionnaire in order to obtain information on scientists interested and active in Circum-Arctic and Circum-Antarctic isotope/geochemistry studies in permafrost (see below). Based on the results and responses to this questionnaire either a formal application for a new working group on Isotope/geochemistry of Permafrost would be prepared for the IPA Council meeting in Zurich, or a recommendation to end the activities of the TF after five years would be made.

A large number of activities related to isotope geochemistry in permafrost took place during the past years, particularly under the umbrella of the joint German-Russian projects (see COP report for some details). The textbook 'Principles of Isotopic Geocryology and Glaciology' by Yu. K. Vasilchuk and V. M. Kotlyakov was published in 2000 by Moscow University Press. Vasilchuk has entered into bilateral agreements related to isotope analyses with Austria and South Korea.

The following questionnaire on isotope/geochemistry of permafrost is available upon request from Hanne Meyer ([\[potsdam.de\]\(http://potsdam.de\)\), or simply respond to the following questions and return to Meyer.](mailto:hmeyer@awi-</p></div><div data-bbox=)

Investigator's Name:

Institution:

- Are you interested in and/or active in isotope/geochemistry of permafrost?
- Which isotopes are you studying (H, O, C, N, S, others)?
- What analytical facilities do you use?
- Are you using other geochemical tracers (elements, radio-isotopes, etc.)
- In which areas of the Arctic/Antarctic are you working (give coordinates, height above sea level)?
- What type of material are you studying (ice, water, soil etc.)
- What types of archives are your studies related to? (Ground ice, glaciers, active layer, etc.)?
- What is the main interest of your isotope/geochemistry research? (E.g. climate reconstruction, provenance studies, genesis, etc.)
- Which is your interest to participate in the TF?
- Do you have recommendations for activities of the TF (e.g. isotope bibliography of permafrost, Circum-Arctic isotope maps, methodological exchange between labs, etc.)?
- Where do you see the main gaps in knowledge of isotopic methods in permafrost studies?
- Do you have publications related to isotope/geochemistry of permafrost? Provide citations.

Hans-W. Hubberten (hubbert@AWI-Potsdam.de)

Rein Vaikmae (vaikmae@gi.ee)

News from Members

Canada

In 2002 funding for permafrost research at Centre d'études nordiques, Université Laval was obtained from the Government of Québec to support the networks of automated meteorological stations and permafrost temperature cables across Nunavik (Northern Québec) as well as to update the database. A recent and rapid warming trend causing concern for the safety of existing infrastructure was the main cause of the renewed interest and funding of the permafrost monitoring activity. Data on the recent change from a cooling trend between 1945 and 1995 to the ongoing warming was presented at the permafrost session of the American Geophysical Union in December 2002.

A new research project began in summer 2002 in the community of Salluit to address the difficulties created by permafrost warming in Nunavik. The project is supported by the Ministry of Public Safety of Québec and the local indigenous governments. Salluit is located in the continuous permafrost zone on the southern shore of Hudson Strait (62°N). The village lies in the bottom of a narrow valley and is mostly built on frozen saline and ice-rich marine silty clay. In order to satisfy the needs of the increasing population for land development, a high accuracy assessment (mapping scale of 1:2000) of permafrost conditions is being done. The aim is to build a 3D geological and thermal model that will support decision making for land management. The Geological Survey of Canada is providing logistical support and participating in geophysical surveys. Thermistor cables and dataloggers were installed in some of the many new drillholes. Fieldwork in summer 2003 will be mainly directed to measurements of geotechnical properties.

Collaboration with Germany's BGR (See Germany report) continued near Umiujaq where instrumented palsas and lithalsas are being monitored. Work begun in 1999 on Bylot island in the high Canadian Arctic (see last year's report) also continued. Contacts: Michel Allard/Richard Fortier.

There is a record amount of development activity occurring in the Northwest Territories, all of which consider the impact of permafrost conditions. Developments include production

and expansion of the Ekati (BHP) Diamond Mine, development of the new Diavik diamond mine, and oil and gas exploration in the Beaufort Delta, Sahtu and Fort Liard regions. In addition, the Mackenzie Valley Producers Group earlier this year filed a letter of intent related to the future development of a Mackenzie Valley gas pipeline. In support of all these activities, transportation systems and municipal infrastructure must continue to be upgraded and expanded to meet the increased demands resulting from the activity. All of this development points to significant future construction in permafrost areas.

Several studies by the Geological Survey of Canada (GSC) continued in the western Arctic, supported by the federal Panel on Energy Research and Development (PERD). The outputs will support evaluation of resource development, pipeline routing options, geotechnical engineering, land-use decisions and environmental assessments of northern development in the Mackenzie Delta, Mackenzie Valley corridor and southern Yukon. Monitoring of creep of permafrost slopes continues at the new warm permafrost site near Wrigley, central Mackenzie Valley, and at 3 sites in cold permafrost in the Mackenzie Delta area. The establishment of a second site for study of warm permafrost slope creep is planned for Yukon in 2003. A report on deep seated rotational failures in ice-bonded permafrost, based on GSC field work conducted in the latter part of the 1990s, is underway and will discuss rotational failures in frozen and thawing Cretaceous shales, active-layer detachments triggered by forest fire, rotational failures in glacial sediments along the banks of the Mackenzie River, and climate-induced failures as recorded by tree disturbance.

Digital, GIS compatible, geotechnical, geothermal and related, data base development and analysis continued for the western Arctic. Investigations at permafrost-pipeline interaction study sites installed in the mid 1980s and expanded in 1990s continues, as do those at the network of active-layer and permafrost monitoring sites throughout the Mackenzie Valley and Delta. Contacts: S. Smith, L Dyke, M. Burgess, F. Wright and M. Nixon.

During March 2002 a capacitive-coupled electrical resistivity survey was conducted on Richards Island, Mackenzie Delta, Northwest Territories by the Canadian Geological Survey.

In this new geophysical technique, an electric current is applied to the ground via a transmitter dipole and the resulting potential is measured at a receiver dipole using capacitive coupling rather than direct electrical contact. This method has an advantage over galvanic resistivity methods in areas where surface resistivity is extremely high and electrode contact would be problematic. Since direct contact with the soil is not required, a capacitive-coupled system can be moved continuously across a snow-covered surface. Measurements were made at 1 metre intervals along a 3800 m long traverse by towing the system behind a snowmobile at a speed of 7 km/hr. Dipole spacings were varied from 10 to 100 m to produce an image of subsurface electrical resistivity to depths of up to 30 metres. Using two-dimensional inversion software, an electrical resistivity section was obtained from which ice content could be interpreted. The method was found to be very effective in mapping ice-bearing sediments, especially zones of massive ice where electrical resistivity is extremely high. Excellent correlation was found with the results of a ground-penetrating radar survey and with ice content that has been measured in drill cores. Contact: T. Calvert.



Capacitive-coupled resistivity survey conducted in Mackenzie Delta, March 2002 by the Canadian Geological Survey.

Field surveys were undertaken by the Geological Survey of Canada in 2002 to investigate coastal stability and vertical ground motion west from the Mackenzie Delta, Northwest Territories to Kugluktuk, Nunavut. Onshore and nearshore coastal profiles were measured at four communities and in a waterfowl nesting area.

GPS receivers were installed at Holman, Sachs Harbour and Kugluktuk to measure vertical motions across the boundary from submergence in the west to emergence in the east. These surveys were augmented by acquisition of high-resolution (< 1m) satellite imagery. The research is being funded by the GSC, the federal Panel on Energy Research and Development (PERD), and the Canadian Space Agency with partners in the Canadian Wildlife Service and the Canada Centre for Remote Sensing. Contact: S. Solomon.

Wayne Pollard, McGill University and his students have been studying saline springs in the Canadian High Arctic in order to better understand the nature of permafrost hydrology and as analogues for environments which may host life on Mars. He has also been investigating the use of remotely sensed imagery for understanding permafrost stability and active-layer processes.

In March 2002, a collaborative project between the Geological Survey of Canada and Hanne H. Christiansen of the Danish Technical University (ARTEK) received support from the Canadian Department of Foreign Affairs and International Trade, under the Northern Dimension of Canada's Foreign Policy (NDFP). The project involves the rescue and compilation of permafrost thermal data from Greenland for submission to the Global Terrestrial Network Permafrost, and documentation and comparative analysis of recent trends in permafrost conditions in Greenland and the adjacent Canadian Arctic. Environment Canada is also a partner in the analysis. Contact: S. Smith.

A web site is currently being developed for the Canadian Permafrost Monitoring Network by the GSC and will be eventually available through the GSC's permafrost web site. The web site provides information on the monitoring network and will act as a data submission and dissemination node. A request for site metadata has been sent to Canadian permafrost researchers and metadata currently available may be accessed through the web site.

The GSC is collaborating with Environment Canada, with support from the Government of Canada's Action Plan 2000, to establish snow depth monitoring stations at selected GSC permafrost monitoring sites. In summer 2002, three snow stations were installed at CFS Alert,

Nunavut and one station was installed at both Baker Lake, Nunavut and near Wrigley, NWT. An additional five to seven stations will be installed in summer 2003. Contact S. Smith.

In early April 2002, the Government of Canada announced it would contribute \$6.1 million over five years to expand research efforts in Canada's North, through six new Natural Sciences and Engineering Research Council (NSERC) university research Chairs. As one of the new chairs, Dr. Christopher Burn (Carleton University) will research the stability of the permafrost regions of northwest Canada, examining, among other things, effects of variable winter weather in valleys, forest fires, as well as the re-freezing of ground in the vicinity of tailing ponds. Supporters and partners of Dr. Burn include the Village of Mayo and First Nation of Na Cho Nyak Dun, Yukon Parks and the Water Resources Division, Indian and Northern Affairs Canada, Aurora Research Institute, and Yukon College.

Discussions were held at the Canadian Geotechnical Society's Annual Conference, in the Cold Regions Division, over the need for research and for training of 'permafrost' scientists and engineers, in connection with the major geotechnical developments in the North. Gas pipeline construction and treatment of ground contamination in cold regions are two areas of particular concern. The incoming President of the Society, Suzanne Lacasse (Executive Director, Norwegian Geotechnical Institute), spoke of the need for multinational, multidisciplinary approaches to research and education, with more effective collaboration between all concerned with major projects.

The Cold Regions Division of the Canadian Geotechnical Society was pleased to recently present Dr. Peter Williams with the 2003 Roger Brown Award. The award honours him for his excellence in the field of permafrost throughout his long career. Early in his career Dr. Williams began working at the Division of Building Research at the National Research Council, alongside Roger Browne. Dr. Williams then became a professor at Carleton University where he carried out extensive research on the freezing of soils. Peter also developed and directed the field-scale experiment on frost heave around pipelines that were conducted at Caen,

Normandy, in a joint France-Canada partnership. Significant publications include his textbook "The Frozen Earth: Fundamentals of Geocryology", co-authored with Michael Smith, and his popular short book "Pipelines and Permafrost". His landmark paper, "Hydraulic conductivity of frozen soils" by Burt and Williams, demonstrated the movement of water through frozen soils. These results contributed to assessment of the feasibility of operating chilled gas pipelines in the Mackenzie Valley in the 1970's. Peter now divides his time between the Scott Polar Research Institute at the University of Cambridge and Carleton University, where he is active in bringing to English publication; Russian books, journal articles, and maps that would be otherwise inaccessible to westerners.

We would like to thank Michel Allard for serving as the Chair of the Canadian National Committee for the IPA (CNC-IPA) for the past 2.5 years. In mid 2002 we welcomed Brian Moorman as the new Chair.

Web:

GSC permafrost: sts.gsc.nrcan.gc.ca/permafrost
Canadian Permafrost Monitoring Network:
iss.gsc.nrcan.gc.ca/canpfnetwork/index.htm

Margo Burgess (mburgess@nrcan.gc.ca)

China

Construction of the longest railway in the world at elevations over 4000 m presents unique opportunities and challenges to our country. The railway traverses the famous Qinghai-Tibet Plateau and covers a distance of 1118 km, from Golmud in Qinghai Province to Lhasa, the capital city of the Tibet Autonomous Region. The Qinghai-Tibet railway travels over a 632-km permafrost zone, 550 km of which is in continuous permafrost. The Plateau permafrost has a relatively high temperature, compared with permafrost temperatures in Siberia and the Arctic, and it is therefore more susceptible to thermal disturbance. Because the plateau is both an 'initiator' and a 'magnifier' of global change, it will most likely respond early to climatic changes, and the temperature increase on the Qinghai-Tibet Plateau will be larger than the global average. Thus, permafrost in this particular condition will

bring great difficulties to design, construction and maintenance of the railway. Counter-measures to protect the permafrost and cool the subsoil must be taken because of the relatively high-temperature permafrost and the global warming. To monitor the situation, several different engineering tests are conducted based on principles of controlling radiation, conduction and convection. The tests for example concern shading the sun, using insulation material, changing the height of embankments, using heat semi-conductors, increasing ventilation, using thermopiles, using crushed stone embankment etc. So far, the idea of protecting the permafrost and cooling the subsoil has been applied widely to design and construction of the Qinghai-Tibet railway. Meanwhile, research on the following topics are conducted: How does the climate change? How is permafrost responsible for climate change? How is permafrost changed during engineering action? How is permafrost changed with both climate change and engineering action?

The Sixth Chinese Conference on Glaciology and Geocryology and International Symposium on Permafrost Engineering was held in Lanzhou, 19-22 September 2002. It was sponsored by the Chinese Society of Glaciology and Geocryology, the State Key Laboratory of Frozen Soil Engineering and Ice Core and Cold Regions Environment Laboratory of the Cold and Arid Regions Environmental and Engineering Research Institute, Chinese Academic Sciences, and co-organized by the Civil Engineering School of Lanzhou Railway University. About 130 representatives from thirty-three universities and research institutes in China, USA, Canada and Germany attended the conference.

The symposium had three main topics: Cryosphere and the change of global climate; Engineering in cold regions and the Qinghai-Tibet railway; Basic physical and mechanical properties of ice, snow and permafrost. Post-conference field excursions took place 23-30 September. The first trip went from Lanzhou to Golmud with a stop at Dunhuang city. The second trip went from Golmud to Lhasa city along Qinghai-Tibet roadway, and studied permafrost-related and geotechnical problems in the construction of the Qinghai-Tibet railway.

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Denmark

Bo Elberling and co-workers, Institute of Geography, University of Copenhagen are currently studying the environmental impact resulting from oxidizing sulfidic mine tailings as well as soil organic degradation in the High Arctic. Presently, the focus is on below-zero reaction kinetics, gas trapping in frozen ground, microbial adaptation to low temperatures and the role of winter activity in permafrost regions. The Danish Natural Science Research Council funds the project.

In the Ammassalik area in SE Greenland, a project registering temperatures, snow cover and geomorphic activity was terminated in summer 2002. This project was run by Ole Humlum, The University Courses at Svalbard, since 2000, and investigated the possible occurrence of permafrost. Presumably, near sea level, permafrost is absent but present above c. 400-500 m asl. By this, the Ammassalik area represents a region with high permafrost sensitivity towards climate change.

Below the Copenhagen city centre at the Nørreport station permafrost was established artificially by the Comet consortium to excavate a link tunnel between different train stations, connecting the new Copenhagen metro with the other trains. The freezing was done to prevent water from entering during the excavation.

Hanne H. Christiansen, Institute of Geography, University of Oslo, Norway has as a guest researcher at the Center for Arctic Technology, ARTEK, Danish Technical University, carried out a cooperation project with Canadian permafrost scientists on the collection of permafrost thermal data from boreholes in Greenland for inclusion in the global terrestrial network on permafrost (GTN-P) (see also the Canadian report).

The Danish National Adhering Body to the IPA, the Danish Society of Arctic Technology, SAT, organised the symposium 'Identification of permafrost data from Greenland' 2 May 2002, to obtain more information on existing permafrost data from Greenland. Twenty-four persons participated, many of whom had worked with permafrost in Greenland themselves as engineers earlier on. Also several students, presently working with permafrost conditions in Greenland, attended the symposium.

It was decided to collect old and new data from Greenland for the next Circumpolar Active-layer Permafrost System (CAPS) CD-ROM.

Hanne H. Christiansen (hhc@unis.no)

France

Since the last French report, a number of new projects related to permafrost have emerged with three main subjects: geomorphological studies, modelling permafrost and periglacial processes and extraterrestrial permafrost studies.

Current geomorphological studies carried out by the GEOLAB team in Clermont-Ferrand by M.-F. André, S. Etienne, D. Mercier and D. Sellier deal mainly with past and present dynamics of periglacial areas. Special attention is paid at Spitsbergen to paraglacial runoff processes reshaping or destroying landforms and deposits generated by frost-related processes, which slowed down since the Little Ice Age. Bioweathering, chemical processes, salt weathering and frost shattering in combination with rock weathering processes is tentatively evaluated in Iceland, Spitsbergen, Antarctica, Scotland and continental Norway, based on high resolution microclimate monitoring, SEM examinations, *in vitro* experiments and XRD analyses. The Spitsbergen programme is supported by the French Polar Institute and the Antarctic programme by the British Antarctic Survey through a collaboration with Kevin Hall, University of British Columbia, Canada.

A. Decaulne, University B. Pascal, Clermont Ferrand completed a field study on snow avalanches and debris-flows in northwestern Iceland. Snow avalanches only impact slopes in a few areas, where avalanches boulder tongues accumulate by mobilizing rock fall material, and cause accumulation of debris cones. On the contrary, debris-flows always have a high geomorphologic impact on slopes, by transporting from 500 to 3500 m³ of debris from moraines or from periglacial material located in numerous chutes at the mountain tops.

The last years V. Jomelli, Laboratoire de Géographie Physique, Meudon, observed permafrost (rock glaciers) and periglacial processes (snow avalanches, rock fall, sorted stripes and debris flows) in the Andes of Bolivia, Peru, and Equator and in the French Alps, to

study the response of these landforms to recent and Little Ice Age climatic change. In the Bolivian Andes measurements on the Caquilla rock glacier show symptoms of degradation. Debris flow frequency in the Massif des Ecrins, France shows decreasing recurrence time since the 1980s and a shift of the triggering to higher altitudes.

T. Brossard and D Joly, University of French-Comté, continued their studies at the Kongsfjord area at Svalbard on vegetation responses to global change. They focus on a description of the modern distribution of plants and temperature, on a validation of vegetation and temperature models and on studying the potential influences of land cover changes on climate change.

The extent of permafrost at the Last Glacial Maximum (LGM) in Hungary were studied by B. Van Vliet Lanoe, University of Lille, in cooperation with the Geology Department of the Eötvös University in Hungary. Periglacial features can be differentiated from neotectonism and seismic deformation. The study shows that permafrost existed in the main Pannonian basin at the LGM. The relationship between ice cap dynamics, geothermal gradient and permafrost during the Last Glaciation in Northern Iceland was studied in the programme IPEV in collaboration with A. Gudmunsson, Icelandic Geological Survey.

Investigations of fluvial thermal erosional processes along the Lena River was continued by F. Costard and L. Dupeyrat, Orsay University, in collaboration with E. Gautier, Laboratoire de Géographie Physique, Meudon. Various laboratory simulations within a cold chamber demonstrate the validity of the previous mathematical model for the range of laboratory conditions. A hierarchy of parameters (Reynolds number, water and ground ice temperature) is proposed to explain the present efficiency of thermal erosion along the Siberian rivers.

Since 1998 the camera of the Mars Global Surveyor space probe has provided thousands of high-resolution images (2-5 m/pixel) showing close-up over striking geomorphic features like recent gullies. These unexpected landforms are interpreted by the camera team as debris flows due to subsurface seepage. F. Costard, N. Mangold and J.P. Peulvast, Orsay University, together with F. Forget, Laboratoire de Météorologie Dynamique, Jussieu proposed that these debris flows are

produced by the seasonal thaw of near-surface ground ice like in cold regions on Earth (Costard et al., Science, 2002). This is possible especially in periods of higher obliquity of 40° predicted by astronomers compared to the current 25°. The gullies are distributed poleward of 30° latitude and over poleward-facing slopes preferentially in agreement with a process triggered by obliquity. On the other hand, the surface of Mars is also covered by patterned ground, like polygons and striated soils, at various scales from several tens to hundreds of meters. The final goal is thus the understanding of the climatic evolution and the water cycle of Mars.

Costard, F., Forget, F., Mongold, N. And Peulvast, J.P. 2002. Formation of Recent Martian Debris Flows by Melting of Near-Surface Ground Ice at High Obliquity. Science, 295, 110-113.

François Costard (fcostard@geol.u-psud.fr)

Germany

The Potsdam Research Unit of the Alfred Wegener Institute for Polar and Marine research (Hans-W. Hubberten) organised expeditions with 15 German and 15 Russian scientists and technicians to the Lena Delta and the New Siberian Islands in the German-Russian project 'System Laptev Sea' from June to September 2002 (team leaders: E.-M. Pfeiffer, L. Schirrmeister, V. Rachold and M.N. Grigoriev). One team focused on modern processes in permafrost. Major emphasis was put on trace gas flux measurements and characterising microorganisms in the carbon cycle. Eddy-correlation tower measurements, providing high-resolution data on methane, carbon dioxide and micro-climatic parameters integrated over a larger area, were carried out during the entire active period, including the transition phases spring-summer and summer-autumn. Additional to microbiological and molecular ecological studies of the micro-flora actively participating in the carbon turnover, Holocene and Pleistocene permafrost soil sequences were characterised to estimate the effect of climate change on permafrost landscapes. A second team concentrated on the reconstruction of periglacial processes and landscape development during the late Quaternary in the surroundings of Tiksi, emphasising snow patch processes in the

marginal zone of the Kharaulakh mountains and their foreland. A third team studied the coastal dynamics of the New Siberian Islands. Apart from geodetic measurements comparing the actual coastline with older aerial photographs, shore-face profiles were measured down to the 10-m isobaths and sediment samples were taken. Of special interest were frozen terrestrial and marine deposits that probably date back to 400-500 ka BP, as well as the large sand areas of 'Bunge-Land'. Another topic was related to the IPA-IASC project ACD (Arctic Coastal Dynamics, V. Rachold, see the Coastal and Offshore Permafrost report). Another expedition carried out geomorphological, palaeopedological and geocryological studies in the Verkhoyan Mountains and their piedmont plain (Central Yakutia), team leaders: B. Diekmann and I. Belolyubsky.

The Bundesanstalt für Geowissenschaften und Rohstoffe, Hannover, G. Delisle, and the Centre d'Études Nordiques, Université Laval, Ste-Foy, Québec, M. Allard, continue their monitoring programme of the temperature and pressure field within a palsa east of Umiujaq, eastern shore of Hudson Bay, in Northern Quebec. The data analysis reveal episodic cracking of the permafrost at its base, injection of limited quantities of ground water, followed by refreezing. For the last 24 months slow, but steady warming at rates between 0.03K to 0.05K per year have been recorded within the palsa.

At the Department of Soil Mechanics and Foundation Engineering, University of Kaiserslautern, H. Meissner continues research on 'Behaviour of frozen soils' to describe a viscous potential for frozen soils depending on variables such as case history, tension level, temperature, water content, pore numbers etc. Experiments are carried out with cubic samples in a 'True Tri-axial Apparatus'.

At the Department of Geography, University of Bonn, R. Dikau continues the programme 'Landform – a structured and variable boundary layer'. Research is carried out in the periglacial belt of high mountain geosystems in the Turtmanntal, Valais, Switzerland. Several PhD-theses concentrate on geomorphometric analysis of landforms on different spatial scales (Rasemann), the structure and activity of talus cones (Schreiner), permafrost distribution and sediment budgets (Nyenhuis) and on kinematics

of periglacial features (Roer). In addition to geophysical measurements and observations of ground temperatures the monitoring programme was extended by the installation of a weather station and an automatic camera. Recent developments in airborne data acquisition (High Resolution Stereo Camera) lead to the creation of digital terrain models with a resolution of one meter. This facilitates the analysis of fine scale periglacial objects on meso and micro spatial scales.

In the framework of PACE21, permafrost temperature monitoring in the 100 m borehole at Stockhorn plateau is continued by the Institute for Geography, Giessen University by L. King. A meteorological station was installed in June 2002 in co-operation with the Physical Geography Department of the Zurich University, M. Hoelzle. Shallow ground temperature measurement sites were established in the Gornergrat area to monitor the influence of substrate character on the ground thermal regime (S. Philippi). First data of the 30-m deep Ritigraben borehole, Grächen-Seetalhorn area, confirm the existence of more than 30-m deep permafrost. As the subsurface consists of unconsolidated sediments, advective processes play a significant role in the ground thermal regime. Several sensors monitoring rock and air temperatures in the block cover were installed by T. Herz.

At the Institute of Geography, University of Heidelberg, A. Schulte analysed alluvial fans formed by slush torrents in northwestern Spitsbergen. Two of these fans, Kvikkåa and Beinbekken, were formed exclusively by the sediment of slush torrents and can therefore be studied as monogenetic geo-archives. A maximum accumulation of 1.5 to 2 m of sediment is assumed to have built up in approximately 11000 years. The low overall sedimentation rates confirm the large recurrence intervals for slush torrents in Spitsbergen.

The Institute of Physical Geography, Freiburg University, H. Gossmann and S. Vogt, continues to host the SCAR Working Group on Geography and Geographic Information project King George Island GIS (KGIS). The KGIS project provides a spatial database for King George Island, South Shetland Islands, Antarctica, with a focus on high-resolution data sets for the periglacial areas of the island.

Permafrost distribution and thermal conditions in the German Alps and in non-alpine Central Europe are investigated by M. Gude, University of Jena. Studies on alpine permafrost at the Zugspitze were started within the PACE project, and continue with the analysis of distribution, thermal conditions and geo-technical implications. Non-alpine permafrost conditions are investigated in numerous highland scree slopes in Germany, Czech Republic and France, based on an interdisciplinary research programme covering biology, geophysics, geomorphology, and micrometeorology.

At the Institute for Meteorology and Climate Research, University of Karlsruhe, C. Hauck has initiated geophysical and meteorological monitoring to study energy exchange processes between atmosphere and frozen ground.

In 2001 the Department of Physical Geography, University of Regensburg, J. Völkel, finished the project 'Changes of the Geo-Biosphere during the last 15.000 years – Continental Sediments as Geo-archives', focused on periglacial processes forming widespread slope sediments during the Younger Dryas. In the study areas of the Harz, Rhön, Fichtelgebirge and Bayerischer Wald, geomorphodynamic activity on the slopes reported in the literature could not be proved for the Younger Dryas. Another project discusses the means and the dating of the late glacial deglaciation at high altitudes of the Interior Plateaus of British Columbia, Canada.

At the Department of Physical Geography, University of Stuttgart, S. Sander continues the investigations on geomorphic processes in Nordenskiöldland at Svalbard to verify the potential link between climatic change and geomorphic features such as mass movement, debris flows and thermal erosion.

C. Kneisel at the Department of Physical Geography, University of Trier is maintaining the monitoring of ground temperatures at a site with sporadic permafrost below the timberline in the Upper Engadine, eastern Swiss Alps, to investigate the interaction of the permafrost with the environment.

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Italy

Italian permafrost and periglacial research continues in both in the Alps and in the Southern Hemisphere. A new project entitled 'Permafrost and Global Change in Antarctica II (PGCAII)' was recently funded by the Italian National Antarctic Research Programme for two years. The main goals in PGCAII are to study the impacts of Global Change in Antarctica, and to reconstruct the palaeoclimatic evolution of Victoria Land through permafrost analysis. The Global Change studies will include active-layer monitoring and analysis of the relationships between climate, vegetation cover and active layer, along a transect from the Antarctica Peninsula to South America and in Victoria Land in Antarctica. Relevant sites for the transect will be identified such as Signy at Orchards Islands, Jubany at South Shetland Islands, and Edmonson Point, this last site is also included in the SCAR-RiSCC project. Palaeoclimatic reconstructions will be achieved through the analysis of ground thermal profiles, to study the relationships among climate, vegetation cover and active layer, and the cryostratigraphy of ground ice. Also new methods, such as phylogenetic analysis of bacteria and the study of weathering processes of cryotic rocks, will be used reaching a potential time period of 10 million years.

The existing cooperation with the Instituto Antartico Argentino (L. Jorge Strelin, Cadic) continues with a new international agreement between Insubria University and the British Antarctic Survey (BAS). As part of this agreement a new long-term, active-layer monitoring site will be installed in the climatically very sensitive area of Signy Island. Next year Cynan Ellis Evans (BAS), Andrew Hodgson (University of Sheffield), Nicoletta Cannone (University of Ferrara) and Mauro Guglielmin (University of Insubria) will carry out a SCAR-RiSCC campaign to set up the permafrost monitoring site and a new CALM grid at Signy Island.

At the SCAR-RiSCC meeting in Hobart, Australia, Mauro Guglielmin proposed a specific protocol for monitoring permafrost thermal regimes and active-layer thickness through the Southern Hemisphere Working Group of the IPA.

In the framework of the LTER project cooperation between M. Guglielmin and M.

Balks, Waikato University, New Zealand, will be formalised to start joint research next year. In a new project funded by the Italian Mountain Research Institute three new 18-m deep boreholes were drilled in the Foscagno Rock Glacier in the Italian Alps. The boreholes will be instrumented to monitor ground thermal regime. The cores from these boreholes showed different types of ice that, hopefully, will allow reconstruction of the palaeoclimatic history of this rock glacier. New geophysical investigations (electric tomography and radar investigations), experiments with markers and automatic monitoring of spring water flow at the foot of the rock glacier ramp, should allow reconstruction of the hydrogeology of this alpine permafrost aquifer.

A doctoral thesis on the analysis of the ancient periglacial features such as block streams and block fields in the Ligurian Alps was started at the University of Genova. The Italian Association of Physical Geography and Geomorphology sponsored two Working Groups, one on the study of ancient periglacial features and one on the study of permafrost and active periglacial processes. In November 2001 a workshop on the 'Relationships between permafrost degradation and slope instability' was held in Milano organised by ARPA Lombardia.

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Japan

The Mountain Permafrost Research Group of the Association of Japanese Geographers completed a four-year research project. The research areas covered were: Japanese mountains including Hokkaido (M. Ishikawa, Y. Sawada, T. Sone, H. Matsumoto, N. Takahashi, K. Hirakawa and Y. Ono) and Japanese Alps (K. Fukui, M. Aoyama, A. Ikeda, S. Iwata and N. Matsuoka); other Asian mountains including Kamchatka (T. Sone and K. Yamagata) and Himalaya (T. Watanabe, M. Ishikawa, S. Iwata and C. Narama); Swiss Alps (N. Matsuoka, A. Ikeda, K. Hirakawa and T. Watanabe); and Antarctica (T. Sone, J. Mori, K. Fukui and H. Miura). The research topics focused on internal structure of rock glaciers, block slopes, frost mounds and other terrain underlain by permafrost, modelling of local and

regional permafrost distribution, climatic and rock controls on rock glacier dynamics, various weathering and slope processes associated with permafrost or seasonal frost and recognition of permafrost indicators and reconstruction of palaeo-periglacial environments. The activities also involved annual meetings in Tokyo and field excursions in Hokkaido and the Japanese Alps. In addition, a co-sponsoring symposium 'Glaciation and periglaciation of Asian high mountains' took place during the 5th International Conference on Geomorphology in Tokyo 2001. A special issue *Mountain glaciation and mountain permafrost in Asia* was published in the *Journal of Geography*, Vol. 111, August 2002, Tokyo Geographical Society, in association with the Study Group on Quaternary Glaciation in Japan. Seven papers (in Japanese) from this issue highlighted mountain permafrost. Papers in English will soon be available in another special issue to be published at the end of 2002 in *Zeitschrift für Geomorphologie*, which contains papers from the 5th ICG symposia: six papers concern the research group activities. The outcomes from the research group also involved a doctoral thesis by M. Ishikawa, December 2001, Hokkaido University, entitled 'Distribution of mountain permafrost in the Daisetsu Mountains, Hokkaido, Northern Japan'. Several other doctoral theses will be completed in the coming years.

The ice-fire experiment group (M. Fukuda) conducts post-boreal forest fire research in Eastern Siberia along the Lena River. The research focused on the thermal impact to the permafrost after forest fire as well as the effect on greenhouse gases such as methane.

The Yukon River Watershed Water and Energy Exchange group (N. Ishikawa) completed year two of a three-year research project in Alaska. Y. Kodama and Y. Ishii, Hokkaido University, measured CO₂ flux and runoff discharge from a permafrost-dominated watershed at Caribou-Poker Creeks Research Watershed north of Fairbanks. They also joined field research on open-system pingo drilling by K. Yoshikawa, University of Alaska in the same watershed. Pingo ice was observed 7.5 m below a surface layer of retransported silt deposits. Massive ice extended to bedrock, 23.5 m deep. A one-inch PVC casing was installed in one of the boreholes to measure temperature. T. Sato of the National Research Institute for Earth Science and Disaster

Prevention and T. Ozeki, Hokkaido University, studied the impact of snow on permafrost also at Caribou-Poker Creeks Research Watershed. Sato maintains a meteorological tower and extensive snow surveys at this site.

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Kazakhstan

The Kazakhstan Alpine Permafrost Laboratory continued monitoring of the thermal regime of permafrost, active layer (CALM programme), seasonally frozen ground and dynamics of rock glaciers in the Northern Tien Shan.

During summer 2002 the geodetic observation net registering the rate of movement of Gorodetsky rock glacier was extended. N. Palgov started the geodetic net in 1923. Over a 79-year period, mean displacement of the central part of the frontal lobe of the rock glacier was 72 m or 0,91 m/yr. Some parts of the rock glacier reached a maximum surface movement velocity of 2.0-2.2 m/yr during the few last years.



Rock glacier 'Gorodetsky' in the Northern Tien Shan.
Photo: Sergei Marchenko.

Investigations of anthropogenic landscape modification and associated natural processes in permafrost areas were continued. An example is the construction of a road from Almaty to the south shore of Issyk Kul Lake triggering natural processes. The 100-kilometer road crosses two mountain ranges, the Transili Alatau and the Kungei Alatau, and rises to the continuous permafrost belt at an elevation of 3800 m asl. At one location the road cut the front of a rock glacier initiating slope processes. As a result, material from the rock glacier fell on the road in the first

year after construction.

Geomorphologic studies were carried out in the Talgar, Asy and Turgen valleys, Northern Tien Shan, together with German scientists led by T. Bolch, Department of Geography, University of Erlangen-Nurnberg. The studies focussed on mapping the distribution of cryogenic landforms and mudflow deposits, relief evolution and comparison of periglacial environments of different valleys depending on microclimatic, and topographic factors.

Collection of spatial data on the distribution of mountain permafrost in the Northern Tien Shan continued. The lower permafrost boundary on south-facing slopes in the Transili Alatau Range, 43° N, was found at 3250 m asl in coarse blocky materials.

At the international permafrost workshop in Mongolia, September 2001, an international team (China, Mongolia, Russia and Kazakhstan) decided to prepare a permafrost map of Central Asia. Therefore a meeting was held 2-7 April at the Cold and Arid Regions Environmental and Engineering Research Institute, CAREERI, Lanzhou, China on the compilation of the Central Asian Map of Permafrost and Ground Ice Conditions. The participants of the meeting, Guo Dongxin, Li Shuxun, Li Shude, Tong Boliang, Zhao Lin, Nan Zuotong and Sergei Marchenko, discussed the regionalisation and classification of permafrost areas in Central Asia, mountain and high plateau permafrost distribution, permafrost temperatures, ice content and the distribution of periglacial phenomena. At the meeting the existing mountain permafrost mapping were reviewed. Partial financial support for the meeting in China were provided by grants from the National Snow and Ice Data Center, Boulder, USA, and from CAREERI, Chinese Academy of Sciences, Lanzhou.

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Mongolia

In the Global Environmental Facility project 'Dynamics of biodiversity loss and permafrost melt in Lake Hövsgöl National Park', led by Clyde Goulden, USA, Bernd Etzelmüller, University of Oslo, Norway and Vlad Romanovski, University

of Fairbanks, USA, conducted geophysical (electric) and thermal measurements in seven 4-10 m deep shallow boreholes to monitor and map the permafrost. To study the dynamics of pingo, thermokarst, solifluction and icing, it is planned to drill additional several shallow boreholes (see also separate report on this project).

N. Sharkhuu each year expands the permafrost monitoring. This year he drilled three 15-m deep boreholes in Terkh, Chuluut and Sharga valleys in the Khangai mountains. The boreholes were located where former deep boreholes were drilled and investigated by him in 1969. He installed temperature data loggers in the soil surface and in the 1.3-m deep CALM borehole at 2950m asl.

N. Sharkhuu collaborated with M. Ishikawa and Y. Zhang taking part in field surveys in the Joint Japanese and Mongolian FRONTIER project, headed by T. Ohata and T. Kadota. As part of this project, in the Nalaikh depression near Ulaanbaatar, automatic weather stations were operated at the same sites as the permafrost thermal monitoring 30 m deep borehole. In addition numerous temperature and water moisture data loggers were installed.

Jambaljav and coworkers conducted short-term visual field observations of changes in some permafrost phenomenon in the Darkhad depression, Hövsgöl mountain region, to compare with old photographs and other materials.

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Norway

The Department of Physical Geography, University of Oslo, mapped the lower limit of the permafrost at Sølen. In the eastern part of southern Norway, the limit is as low as about 1100 m asl. in east and north-facing slopes (H. Juliussen, E. S. F. Heggem and B. Etzelmüller). In Dovrefjell and at Jotunheimen at the Juvvasshøe PACE borehole areas, in central southern Norway, collection of data from 13 boreholes continued (K. Isaksen, T. Eiken, R. Ødegård and J. L. Sollid). The drilling operations on Dovrefjell were financed by Forsvarsbygg (O.-E. Martinsen) and the Norwegian Geological Survey (B. Follestad).

On Svalbard data from the Janssonhaugen PACE borehole site were collected (K. Isaksen, O. Humlum and J. L. Sollid). In the Møre and

Romsdal area of western Norway, and in the Troms and Finnmark areas of northern Norway, ground temperature monitoring were established at selected sites to map the lower limit of the permafrost, and study its influence on rock falls (K. Isaksen, L. Blikra and J. L. Sollid).

In Kongsfjorden on Spitsbergen, four coastal erosion monitoring sites were established as part of the IASC ACD (Arctic Coastal Dynamics) project (B. Wangensteen, T. Eiken, R. Ødegård and J. L. Sollid). The Department, in co-operation with the Department of Geography, University of Zurich, carried out three weeks of field work mapping the permafrost distribution in northern Mongolia, Hövsgöl region, collaborating with the IPA (J. Brown), the Long-term biodiversity and ecological monitoring in northern Mongolia project (C. Goulden) and the Mongolian Academy of Science (N. Sharkuu). The field work was funded by the Global Environmental Facility (see also separate report on this project).



Drilling a 9 m deep borehole in permafrost on Dovrefjell, October 2001. Photo: Ketil Isaksen

The Norwegian Geotechnical Institute (NGI) runs a programme on how permafrost responds to industrial activity and terrestrial pollution. Micro- biological studies in the field and laboratory are combined with thermal field experiments and numerical studies to develop methods and knowledge leading industrial activity in Arctic to sustainable development. An automatic measuring system for microbiological activity in permafrost gives information about changes in bio-production in soil due to pollution and it will also be used for terrestrial monitoring of oil contamination.

The project will provide advice and methods for cleaning terrestrial pollution

in permafrost, reducing oil pollution and predicting possible consequences of different levels of oil pollution. The project also focuses on geotechnical design for thermal loads. In recent years NGI has adjusted the calculation of frost depth methodology to new numerical tools. With field tests, measurements and with numerical models, the project studies thermal effects of contaminated and not-contaminated soil. A frost susceptibility cell is presently being designed at the NGI laboratory to quantitatively measure frost susceptibility of soil, contaminated and not contaminated.

Based at the University Courses on Svalbard, UNIS, in Longyearbyen at 78°N, investigations on a range of geomorphic activities, initiated in 1999, have been continued throughout 2002 as described also on the UNIS webpage.

Investigations on ice-wedge dynamics, loess formation and snow cover control on ground temperatures were initiated in 2002 by Hanne H. Christiansen, Department of Physical Geography, University of Oslo, using automatic digital cameras and miniature dataloggers. S. Korsgaard, UNIS/Institute of Geography, University of Copenhagen, finished a master thesis investigating the evolution of an ice-cored rock glacier, the local meteorological environment and the associated Holocene oxygen isotope stratigraphy in spring 2002.

A research project on cold-climatic bedrock weathering, initiated in 2001, was carried out by Angelique Prick (UNIS/EU). This project, which involves daily monitoring, will continue until summer 2003.

Ole Humlum, UNIS has continued measurements of precipitation and temperature at different sites in the landscape, using miniature dataloggers. Two standard meteorological stations measuring air temperature, air humidity and wind speed are operated to obtain information on the effect of altitude and the distance to the sea. One of these stations is located at the PACE borehole on Janssonhaugen. A precipitation-sampling scheme was continued in 2002 by Ole Humlum. This project relates the oxygen isotope signal to air temperature and providing background for interpreting the oxygen isotope content in ice sampled from rock glaciers, ice wedges and glaciers in the Svalbard region.

J. Jeppesen, UNIS/Institute of Geography,

University of Copenhagen, finished a master thesis on Svalbard ice-wedges and their isotope variations in spring 2002. Hanne H. Christiansen and Ole Humlum operates two CALM sites near Longyearbyen and Ny Ålesund, representing dry and humid climatic settings, both equipped with data loggers measuring active-layer temperatures.

Web:

UNIS: <http://www.unis.no>
 Physical Geography, University of Oslo:
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Poland

For many years Polish scientists have been conducting interdisciplinary research on geosystems in Arctic and Antarctica. Poland operates two polar stations open all year, the Polish Polar Station, Hornsund, Spitsbergen, Svalbard Archipelago and the Polish Antarctic Station H. Arctowski, King George Island, South Shetlands, West Antarctica. In winter 2001/2002 the Kaffioyra station, Spitsbergen, of the Nicholas Copernicus University, Torun, was also open. Research also takes place in few other bases on the west coast of Spitsbergen only open during the polar summer.

During the year 2002 research expeditions to Spitsbergen were undertaken by the Maria Curie Sklodowska University, Lublin, the Nicholas Copernicus University, Torun, the University of Silesia, Sosnowiec and the Adam Mickiewicz University, Poznan. The research focused on continuing programmes begun within the last years on the operation of periglacial geosystems under the influence of climate and



Sorted circles. Calypsostranda, Bellsund Region, Spitsbergen, Svalbard. Photo: Kazimierz Pékala.

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human impacts. Research results were published in the volume of *Polish Polar Studies* entitled *The operating and monitoring of geosystems of polar areas* issued at the XXVIII International Polar Symposium, in Poznan in March 2002. In the same volume the basic rules of the international CALM programme, in which Poland takes part (Site P1) at Calypsostranda, Spitsbergen, were presented. The new multi-disciplinary programme of the Committee on Polar Research of the Polish Academy of Sciences was presented to the participants of the XXV Antarctic Treaty Consultative Meeting, in Warsaw, September 2002. This programme called 'Arctic and Antarctic research programme of Poland' is planned to be realised in 2002-2010. Research concerning permafrost, active layer and periglacial processes are included in this programme.

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Russia

During the past year research was conducted in all branches of modern permafrost science and engineering.

In the context of global change the Institute of the Earth Cryosphere, SB RAS, performed mathematical analysis of geothermal measurements in the upper horizons of permafrost for the entire Russian territory (A.V. Pavlov). The trend of the Arctic permafrost development was established by V.N. Konishchev's method for palaeoenvironmental reconstructions and the different time intervals were estimated for the soils of the Kola Peninsula, Bolshezemelskaya tundra and the Lower Amur watershed (Moscow

State University, Department of Geography).

The lithosphere's temperatures were generalised to a depth of 3000 m for the main geological structures of the southeastern part of the Siberian Platform. The influence of the deep heat flux on the permafrost thickness and as applied to the different geomorphologic elements was estimated (V.T. Balobaev, M.N. Gelezniak, Permafrost Institute SB RAS).

Long-term theoretical and experimental research devoted to the physics of cryogenic processes in the soils and their mathematical description were completed (J.B. Gorelik, V.S. Kolunin, Institute of the Earth Cryosphere SB RAS).

Under the leadership of E.D. Ershov and I.A. Komarov (Moscow State University, Department of Geology) a comparative analysis was performed on the surface polygonal relief of Earth and Mars. This work included the laboratory testing of the thermal and mechanical properties of the frozen soils at temperatures as low as -125°C .

Studies on the dynamics of geocryological conditions under the impact of human activities continued at several institutions. At the Research Institute of Bases and Underground Structures new approaches were offered for the causes of topographic relief. Among other measures ground-ice barriers are considered to regulate runoff and groundwater flows. Year-round thermo-electric cooling devices were designed and tested under industrial conditions (Fundamentproject). Thermal and seismic-acoustic properties of so-called 'oil-ground' were studied (E.D. Ershov, Y.D. Zikov, Moscow State University, Department of Geology).

The investigation of the interaction between ocean and coastal permafrost continued by the German-Russian group of researchers from the Alfred Wegener Institute (Potsdam), the Permafrost Institute (Yakutsk) and Moscow State University (Division of Geocryology). Based on the observational data, the balance of mineral and organic sediments for the Laptev and Eastern Siberian seas were evaluated as was the impact of the coastal cryogenic processes on the carbon system of the Eastern Siberian Sea. Some regularities were established in relation to thermokarst dynamics on the Laptev Sea shelf and coastline during the Late Pleistocene and

Holocene (H. Hubberten, N. Romanovskii et al.).

The Production and Research Institute for Engineering Construction Survey, Moscow State University, and the Fundamentproject conducted widespread engineering-geocryological and ecological investigations in the territories of the oil and gas fields and along roadways and pipelines. As a result, the series of engineering-geocryological maps were developed and the geocryological prognoses prepared taking into account technogenic impact and climate changes.

The first issue of 'Basic sources of information in the area of engineering-geocryology, glaciology and ice-techniques' was prepared. This project consists of a compilation of more than 1600 sources: monographs, textbooks, articles, maps, dissertations and standard-normative documents. An electronic version is under development.

Publication of the journal 'Earth Cryosphere' continued in Russian as the main source for current publication of Russian permafrost research. The first issue in English is in preparation.

The International Conference on Extreme Cryosphere Phenomena: Theoretical and Applied Aspects was held in Pushchino, 13-15 May, 2002. A total of 137 reports were submitted by researchers from Canada, China, Finland, Germany, Japan, Kazakhstan, Mongolia, Norway, Russia, Switzerland, United Kingdom, United States and several other countries with 160 scientists and engineers present. Reports were presented and discussed in the following sessions: geocryological mapping and forecasting (co-chairs: V. Baulin, D. Drozdov, E. Melnikov), coastal dynamics of Arctic Seas (co-chairs: F. Are, A. Vasil'ev, V. Rachold, N. Romanovsky), cryogenic physical-geological processes and phenomena (co-chairs: V. Konishchev, V. Solomatin), natural and technogenic hazards in the cryolithozone (co-chairs: M. Minkin, L. Khrustalev), response of the cryolithozone to climate changes and anthropogenic impact (co-chairs: A. Pavlov, V. Romanovsky) and physics and mechanics of extreme phenomena in the cryolithozone (co-chairs: S. Grechishchev, V. Romanovsky). Round-table discussions were held to review the current activities under the international monitoring programmes CALM and GTN-P. The number of the attendees and presentations set a new level of participation with an increased involvement of

the young researchers.

The Fifth International Symposium on Permafrost Engineering was held in Yakutsk, 2-5 September. It was sponsored by the Siberian Branch of the Russian Academy of Sciences, the Russian Fund of Basic Research, the Government of Sakha Republic, the companies 'Yakutia Railroads' and 'Geotechnology'. Participants from China, Japan, Norway, Russia and United States presented 87 papers that were discussed in the following sessions: physics and mechanics of the frozen ground, problems of building and maintaining construction in the cryolithozone, geocryological aspects of mining, road construction. Following the symposium a five-day excursion took place to observe local features of mining operations, building and maintenance of the roads, and other engineering structures under permafrost conditions. During the meetings it frequently was emphasized that permafrost engineering must be consistent with the priorities of geocryology, as well as the activities of the IPA.

The following monographs were published during the past year (all in Russian):

- Dubikov G.I. 2002. Composition and cryogenic structures of permafrost in Western Siberia. Moscow, GEOS, 246 p.
- Gorelik J.B. and Kolunin V.S. 2002. Physics and modeling of cryogenic processes in lithosphere. SB RAS, GEOS, 262 p.
- Kuzmin G.P. 2002. Underground constructions in the cryolithozone. Novosibirsk, Nauka, 176 p.
- Shepelev V.V., Boytsov A.V. and Oberman N.G. 2002. Monitoring groundwater of the cryolithozone. Permafrost Institute, SB RAS, Yakutsk, 172 p.

Makarov V.N. 2002. Lead in the biosphere of Yakutiya. Permafrost Institute, SB RAS, Yakutsk, 114 p.

Melnikov, E.S and Grechishchev, S.E. (eds.) 2002. Permafrost and oil & gas development. Moscow GEOS. (Available from Russian Scientific Council of Earth Cryology, 200 rubles).

Roman L.T. 2002. Frozen soils mechanics. Moscow, Nauka/Interperiodika, 426.

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Southern Africa

At Marion Island a project was initiated by Steve Holness, Western Cape University, South Africa and Jan Boelhouwers, Uppsala University, Sweden, continuing an earlier 5-year project in the Maritime Sub-Antarctic. The 290-km large Marion Island (46° 54'S, 37° 45'E) rises 1230 m asl, in the southern Indian Ocean, north of the Antarctic Polar Convergence. The climate is dominated by strong westerly winds, high relative humidity, a small temperature range, relative low temperature, and high precipitation. The study area is the peak of a shield volcano. Marion Island comprises typical sub-Antarctic biota with a scarcity of species. Coastal areas are characterised by bogs and mires in tussock grassland. The objectives of the project are to assess responses of geomorphic processes to climate changes, to analyse and describe Holocene sedimentological records, to explore and generate proxy-climate data and to integrate this with data and modelling from other researchers in palaeolimnology and



Participants in the Pushchino conference, May 2002.

climate modeling, to examine possible Northern and Southern Hemisphere teleconnections/interhemispheric relationships between climate change, and to do detailed morphological and sedimentological analysis of key landforms (e.g. patterned ground, slope failures, blockfields) in order to assess palaeoenvironmental implications of these landforms. Investigation techniques include: organic sedimentary records from peat bogs, testate amoebae activity, peat humification, ground microclimates, surface sediment activity, morphology and relative ages of relict glacial and periglacial features (including evidence of rapidly degrading permafrost for high altitude areas of the island) and weathering processes and rates. A Ph.D. thesis and a M.Sc. thesis and at least six peer-reviewed publications from recent periglacial research on Marion Island have either been published or are in press.

A key issue in the southern African periglacial research is the nature of Quaternary palaeoenvironments. Recent publications continue to suggest evidence for localised glaciation, while the counter arguments suggest a relatively inactive geomorphological environment during the Last Glacial Maximum, with somewhat drier conditions than present with deep, seasonal ground freezing. It is clear that landforms used to argue for niche glaciation during the Quaternary have been misinterpreted and that considerable research is required to clarify and resolve the discrepancies. Contemporary climatic data are scarce and extrapolating Quaternary palaeoenvironments is, thus, exceptionally difficult. Current research by Paul Sumner and Werner Nel, Pretoria, South Africa, using automated logging equipment is aimed at gathering data regarding contemporary climatic and ground microclimate in the High Drakensberg/Lesotho area. Further investigations are being conducted on openwork block accumulations, sorted patterned ground and colluvial mantles to establish both current and past environmental conditions.

A session of the International Geographical Union (IGU) Commission on Climate Change and Periglacial Environments was held at the IGU Regional Conference in Durban from 4-7 August 2002. Paper topics ranged from periglacial climates during the Last Glacial in Europe to climate change issues in the maritime Sub-Antarctic and a review of current debates on Quaternary

palaeoenvironments of the High Drakensberg in southern Africa. It was clear from discussion that quantitative approaches using modern analytical techniques and modelling are needed to resolve the periglacial and glacial questions for southern Africa.

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Spain

In 2002 the Spanish IPA Group in collaboration with University of Valladolid published the book '*Mountain and High-Altitude Periglaciation*' in Spanish, containing papers presented at the Group's last workshop in Potes, 27-29 June, 2001, (see Spanish report in *Frozen Ground* 25). The next workshop is scheduled for 25-27 June, 2003 in San Ildefonso-La Granja, a small, historical town, associated with the Spanish royalty and located 90 km from Madrid, in the mountains with Peñalara at 2429 m asl. as the highest peak. Javier Pedraza (javierp@geo.ucm.es), from University of Complutense Madrid is organizing the workshop, which will focus on the relationship between periglacial features and other processes. The workshop is open to the international community, see Spanish IPA-Group webpage.

In the Pyrenees University of Barcelona coordinated the RISKINAT project on periglacial processes and their effect on rock fall hazards in the central Pyrenees (Val de Nuria and Andorra). Researchers from the Universities of Zaragoza and Huesca are experimenting with geoelectric soundings for permafrost prospecting in Sierra Telera, and also operates temperature monitoring for studies on temporal soil freezing in Sierra de Guara. Researchers from University of Valladolid, together with teams from other Spanish and Swiss universities, are studying permafrost distribution in the central Pyrenees (Postes) and continue to monitor the flow of several rock glaciers (Argualas Peak Area).

In the Cantabrica Range researchers from the University of Leon are analyzing the relationship between inactive rock glaciers in the mountains of Catoute and Gistredo and rock fracture networks, using present ground temperatures to extrapolate the effective climatic conditions during the formation of these rock glaciers. University of Valladolid recently launched an initiative to investigate how glacial

and periglacial landforms in the Picos de Europa were effected by the Little Ice Age cooling.

In the Northwest Region projects of the University of Santiago focus on the northeast region of Spain and have produced interesting results on the location of glacial, periglacial and nival landforms at very low altitudes and even in coastal areas.

In the Central mountain range ground temperature conditions and ground mobility are compared to snow cover duration in a study conducted by University of Complutense, Madrid.

In southern Spain, at the Sierra Nevada Mountains teams from the Universities of Barcelona, Complutense and Alcala de Henares continue monitoring temperature changes and movement of the southernmost rock glacier in Europe at Veleta Peak. Monitoring of ground temperature in the 114-m deep PACE borehole continues, after reparation of the data logger.

Outside Spain members of the Spanish IPA Group are involved in international projects such as the Antarctic effort of the University of Alcala de Henares on Livingston Island (South Shetland), where data on ground temperatures in areas of discontinuous permafrost (max. 2.4-m deep) at 25-m altitude and continuous permafrost (max. 1.1-m deep) at 275 m altitude are recorded and related to local periglacial processes. University of Complutense is working on a comparative study of permafrost distribution in the active Popocatepetl and inactive Ixtacihualt volcanoes in Mexico, where ground temperature monitoring down to 1.8 m at altitudes between 4000-4950 m is carried out. Finally, teams from the Institute Xeologico de Laxe are using cosmogenic dating on periglacial landform in several massifs in Galicia (Spain) and Andringitra (Madagascar).

Serrano, E. and García de Celis, A. (eds.) 2002. Periglaciario en montaña y Altas latitudes. Universidad de Valladolid, Valladolid, Spain, 296 pp.

Web:

Spanish IPA Group: www.ucm.es/info/IPAesp

RISKINAT project: www.ub.es/xarxariscosna

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Sweden

The Swedish Academy of Sciences now acts as the Swedish Adhering Body to the IPA. The Abisko Research Station director Terry Callaghan, who is a board member of the Academy, is the formal link with the Academy. The permafrost group of the Swedish Geomorphological Research Group elects the Swedish representative to the IPA at its annual meeting. H. Jonas Åkerman, Lund University, is the Swedish representative to the IPA Council.

At the Department of Physical Geography and Ecosystems Analysis, Lund University, Torben Christensen has since April 2000 coordinated ecosystem-atmosphere carbon flux measurements at Stordalen, in northern Sweden (68°20' N, 19°02' E), where mixed mire is underlain by discontinuous permafrost. Both advanced eddy correlation and automated chamber systems measuring CO₂, H₂O, CH₄ were installed in collaboration with Terry Callaghan, Abisko Scientific Research Station, Thomas Friberg, Institute of Geography, Copenhagen University, Bo Svensson, Linköping University and Patrick Crill, University of New Hampshire, as part of the EU funded CONGAS project, now an integrated part of the EU-funded CARBOMONT project, also funded by national Swedish sources. Also carbon translocation and turnover experiments using ¹⁴C labelling and soil chemistry analyses including detailed studies of organic acids are carried out. Soil and air temperature, radiation, precipitation, water table position, soil moisture content and active layer thickness are all systematically monitored. A CALM grid will be established in 2003 by Torbjörn Johansson, in cooperation with the continuation of the long-term, active-layer monitoring conducted by Jonas Åkerman in the same region. In cooperation with The Abisko Research station J. Åkerman maintains the 80 km east-west Abisko/Torneträsk area active-layer transect, with eleven active layer sites monitored since 1978. Annual data is included in the CALM database. J.O. Mattsson continues the editing responsibilities of *Geografiska Annaler*.

At the Kapp Linne area at Svalbard active-layer monitoring was started in 1972, and now continues in co-operation with Ole Humlum, The University Courses at Svalbard. J. Åkerman maintains a limited monitoring programme of

active periglacial processes and their climatic significance in the area, including vegetation mapping and digital elevation model analyses of the vertical and horizontal distribution of vegetation and geomorphological forms and processes.

Else Kolstrup, Jan Boelhouwers, Phil Wookey and Göran Possnert at the Department of Earth Sciences, Physical Geography, Uppsala University continue their research on boundary constraints of geomorphological forms and processes in past and present periglacial environments in Swedish Lapland, Finnish Lapland, the Subantarctic Islands and in Iceland.

At the Department of Earth Sciences, University of Karlstad, R. Nyberg maintains projects in the Abisko area on the dynamics of the Kårsa glacier, permafrost and slope processes in the Pallenvagge and Nissunvagge valleys, and on the assessment of the importance of extreme erosional events as geomorphological hazards and as climatic indicators.

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Switzerland

The local organising committee is busy with the preparation of the 8th International Conference on Permafrost to be held in 2003 in Zurich. We are looking forward to welcome the permafrost community next July in Switzerland.

The 'Permafrost Monitoring Switzerland', PERMOS, continued its activities within the pilot phase 2001-2003. The first annual report was published. Two working groups, one for the 12 boreholes and one for the 10 BTS areas, were established to coordinate and standardise data sets. A second report is being edited and data will be published according to suggestions of the working groups.

In 2002 three permafrost-related Ph.D. theses were finished: Catherine Stocker-Mittaz, University of Zurich 'Permafrost distribution modelling based on energy-balance data', Martin Musil, ETH Zurich, 'Inverting seismic and georadar data with applications to the Muragl rock glacier' and Lukas Arenson, ETH Zurich 'Unstable Alpine permafrost: A potentially important natural hazard. Variations of geotechnical behaviour with time and temperature'.

At the Swiss Federal Institute for Snow and Avalanche Research Marcia Phillips is investigating low-lying permafrost sites located below the limit of alpine permafrost, in collaboration with several other research institutes. The sites are scree slopes at the base of high cliffs and are characterised by having exceptionally cold ground temperatures. Trees growing on these slopes are highly stunted. Soil and tree-ring analyses and ground temperature measurements are carried out to investigate the reasons for the reduced growth of the trees. The stability of avalanche defence structures on steep slopes in alpine permafrost terrain continues to be monitored. The structures at three experimental sites are creeping downslope at rates exceeding those approved by the Swiss Federal Guidelines and various types of foundations are increasingly being put to the test. Two, 20-m deep boreholes were drilled in the avalanche slope at Flüelapass, behind lake Schotten, in the project 'Snow cover and permafrost' by Martina Lütschg and Veronika Stöckli, aiming at a numerical study of the interaction processes between snow cover and permafrost.

Avalanche defence structures on a strongly creeping permafrost slope.

Photo:

Marcia Phillips.



New projects of the Glaciology and Geomorphodynamics Group at the Geography Department, University of Zurich focus on energy flux processes in the active layer (Susanne Hanson, Martin Hoelzle), quantitative remote sensing for spatial permafrost modelling (Stephan Gruber, Daniel Schläpfer) and parameterization of rock-wall temperatures (Stephan Gruber, Wilfried Haerberli). Five, 5-m deep boreholes at sites with different surface characteristics were drilled in the Murtèl-Corvatsch area. The use of hyperspectral remote sensing in high-mountain permafrost has been pioneered by a successful flight of DAIS7915 in the Murtèl-Corvatsch test area. A set of 22 miniature temperature dataloggers has been installed in near-vertical rock faces of different aspect between 2000 and 4500 m asl.

In collaboration with the Institute for Meteorology and Climate Research, University of Karlsruhe, Germany (Christian Hauck), the Glaciology and Geomorphodynamics Group at the Geography Department, University of Zurich (Lars Schudel, Martin Hoelzle) continues permafrost monitoring on Schilthorn with combined geophysical and meteorological measurements. This work started during the PACE project and aims to quantify the energy exchange processes between the atmosphere and the shallow subsurface related to ground freezing and thawing. Permanently installed electrodes for electrical resistivity monitoring (determining the unfrozen water content), an energy balance station and instrumented PACE boreholes for temperature measurements are used. In addition, the data serve as input and validation variables for 1-dimensional modelling of energy and water fluxes in frozen soil.

The investigations on the two rock glaciers Muragl and Murtèl-Corvatsch within the ETH-Mini-Poly project (Sarah Springman, Hansruedi Maurer, Daniel Vonder Mühl, Lukas Arenson, Martin Musil) were completed except for ongoing temperature monitoring within five boreholes and borehole deformation measurements at the second location. The geophysical cross-hole georadar experiments at Muragl showed very good consistency with the internal structure from the drillings and it was possible to estimate the location of the shear zone. The laboratory investigations, triaxial creep and shear tests on permafrost samples, revealed new information concerning the behaviour of ice-rich frozen soil with high volumetric air content under various loading conditions. Together with the field observations, these results were used to develop general statements about the stability of rock glaciers. In addition, thermal anomalies have been measured within both rock glaciers, revealing air and water circulation at the base but also through open channels within the permafrost, which may result in accelerated permafrost degradation.

The Institutes of Geography of the Universities of Lausanne (Christophe Lambiel, Emmanuel Reynard) and Fribourg (Reynald Delaloye, Alain Turatti, Sébastien Métrailler) continue their collaboration mainly in the Valais Alps. Frozen scree slopes at very different altitudinal ranges are the subject of thermal and

geolectrical measurements. Glacier forefields are investigated to understand the glacier-permafrost relationships in the Verbier area. In the Réchy/Lona region, electrical soundings and BTS measurements in two small glacier forefields carried out in 1990 are compared with modern data in collaboration with the University Institute Kurt Bösch at Sion (R. Lugon). Rock glaciers movement have been measured with a differential GPS. First results show velocities up to 125 cm/year in a rock glacier with low resistivity ice, whereas an adjacent rock glacier containing high resistivity ice only moved 30 cm/year.

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United Kingdom

A new research programme on 'Bedrock fracture by ice segregation', funded by the Natural Environmental Research Council, has commenced in the cold laboratories at the CNRS Centre de Géomorphologie, Caen, France. Four sets of experiments, each running for a year, will monitor the effects of different thermal regimes, moisture conditions and material properties on rock fracture, ice segregation and frost heave in large blocks of limestone and sandstone. Experimentally-formed fractures and segregated ice will be compared with predictions from two theoretical models of rock fracture and frost heave, and the observed rock fractures compared with contemporary and relict weathering profiles. The research is led by Julian Murton (University of Sussex) and Jean-Claude Ozouf (CRNS Caen), in collaboration with Jean-Pierre Coutard, Jean-Pierre Lautridou and Gerard Guillemet (CNRS Caen), David Robinson and Rendel Williams (Sussex) and Rorik Peterson (University of Alaska, Fairbanks).

The UK radioactive waste management company Nirex is involved in an international collaborative project, PERMA, to study the characteristics of a permafrost field site that might be of relevance to safety assessments for northern European deep geological radioactive waste disposal. The investigations are being carried out at a gold mine in northern Canada together with partners from Finland (POSIVA and GTK), Sweden (SKB) and Canada (OPG and University of Waterloo). The partners are aiming to improve

the understanding of the subsurface hydraulic and chemical processes and the behaviour of crystalline bedrock under permafrost conditions. Thermal and mechanical processes are also of interest. Activities carried out to date include electromagnetic SAMPO soundings in the vicinity of the mine, to provide information on the permafrost depth, fracture zone characteristics and possible talik structures, and surface and subsurface water sampling. The project continues into 2003.

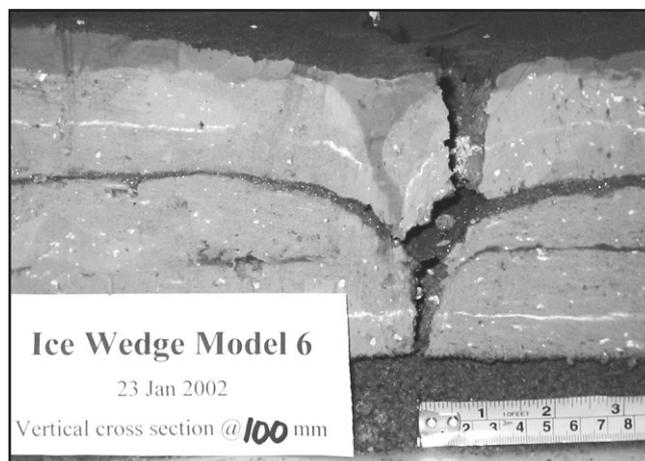
Nirex have recently commissioned a report on 'Middle and Late Quaternary Permafrost and Periglacial Environments in the UK: A Review of Geological Evidence, by Professor Charles Harris, Cardiff University: UK Nirex Ltd (code KSGE050), May 2002. This report is in the public domain.



The Cardiff Geotechnical Centrifuge. The facility consists of a 2.8 m radius beam centrifuge capable of accelerating a load of 1 tonne to up to 100 gravities.

Development of scaled physical modelling of cryogenic processes was continued under the direction of Charles Harris, at the Cardiff University School of Engineering Geotechnical Centrifuge Centre. The research is funded by the UK Natural Environment Research Council and the Royal Society. Work in progress includes investigation of the significance of soil properties and slope geometry on solifluction processes and shallow periglacial landsliding with James Smith, Cardiff University, and an investigation of the significance of host sediments (geotechnical properties and ice content) during the thawing of ice wedges and the formation of ice-wedge casts with Julian Murton, Sussex University.

Experiments are performed at scales of between 1/10 and 1/30, under elevated gravity fields ranging from 10 gravities to 30 gravities. The technique allows full-scale, self-weight stresses to be replicated within the scaled model, so that pore pressures and soil stress/strain relationships can be accurately modelled. Centrifuge modelling is also in progress at the University of Dundee under the direction of Michael Davies, where the interaction between engineering structures and thawing soils, and the significance of warming temperatures to the stability of frozen rock slopes are under investigation.



1/30 - scale model ice wedge cast formed by thawing a model ice wedge within ice-rich frozen silty clay host sediment. The cover soil (active-layer) consists of silt.

A two-day conference organised by the British Geomorphological Research Group and the Quaternary Research Association will be held on 13-14 January 2003 at the Geological Society, Burlington House, London London entitled *Cryospheric Systems*. The conference will focus on glacial and periglacial systems and in particular their interactions, in terms of processes, landforms and sediment associations, in the context of climate change. Conference convenors, Charles Harris, Julian Murton and David Evans.

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United States of America

The U.S. Permafrost Association (USPA) was officially established in 2001 to better enable U.S. scientists to contribute to the International Permafrost Association and to promote permafrost science and engineering in the U.S. During the

past year membership has grown to over 130 individual, corporate, and institutional members, the constitution and bylaws were approved, and elections were held. Douglas Kane was elected as the Association's first president. The annual meeting was held at the AGU Fall meeting in San Francisco in December 2002. Discussions included U.S. participation in the Zurich conference, and how best to promote permafrost activities in the U.S. The following contains individual reports of many USPA members and organizations

The American Society of Civil Engineers (ASCE) Technical Council on Cold Regions Engineering (TCCRE) held the 11th International Conference on Cold Regions Engineering in Anchorage, Alaska, 20-22 May, 2002. There were over 230 attendees participating in 32 technical sessions. Seventy papers were published in the conference proceedings. The theme of the conference was "Cold Regions Impacts on Transportation and Infrastructure". Eleven papers and 4 technical sessions focused on the performance of the Trans Alaska Pipeline System (TAPS) after 28 years of operation. During the conference awards luncheon, Jim Rooney delivered the Eb Rice Memorial Lecture, Bucky Tart received Harold R. Peyton Award for Cold Regions Engineering, and Norbert Morgenstern was awarded the CAN-AM Amity Award. The Peyton recipient was also recognized during the 150th anniversary celebration of the ASCE that was held in Washington, DC, 3-7 November, 2002. The 12th International Conference on Cold Regions Engineering will be held 16-19 May, 2004 in Edmonton, Alberta, Canada, and will be co-sponsored by TCCRE and the Cold Regions Engineering Division of the Canadian Society of Civil Engineering. The 13th International Conference on Cold Regions Engineering is being planned for Bangor, Maine in June or July 2006.

During 2002 the U.S. Arctic Research Commission (US ARC) organized a task force on *Climate Change, Permafrost and Infrastructure Impacts*. The objective was to identify key issues and research needs to foster an understanding of global change impacts on permafrost in the Arctic and their relevance to natural and human systems. The task force findings include: requirements for a dedicated, visible U.S. permafrost research programme, data management needs, baseline permafrost mapping requirements in Alaska,

basic permafrost research focused on process studies and modeling, and, applied permafrost research on design criteria and contaminants in permafrost environments. The report will be available from the Commission in Spring 2003.

The U.S. National Science Foundation supports several programmes and numerous projects that examine permafrost dynamics and influence on ecosystem processes and their response to climatic variability. Larry Hinzman (University of Alaska Fairbanks) reports on the organization and funding of a new NSF program that has a substantial permafrost-oriented involvement: The Hydrologic Cycle and its Role in Arctic and Global Environmental Change: A Rationale and Strategy for Synthesis Study (CHAMP). The primary aim of CHAMP is to catalyze and coordinate interdisciplinary research with the goal of constructing a holistic understanding of arctic hydrology through integration of routine observations, process-based field studies, and modeling. A number of projects were funded starting in summer 2002. The CHAMP strategy is available on the internet (see address at end of report). F. Stuart Chapin (University of Alaska Fairbanks) reports that the NSF-funded Arctic Transitions in the Land-Atmosphere System (ATLAS), a coordinated programme to examine the geographical patterns and controls over climate-land surface exchange and develop reasonable scenarios of future change in the Arctic, is in its final synthesis stage.

News from individual projects include the following highlights with details available on the USPA web site:

NSF-LTER studies by Tom Osterkamp, Vladimir Romanovsky and Kenji Yoshikawa (University of Alaska Fairbanks) at the Bonanza Creek Experimental Forest and Caribou Poker Creeks Research Watershed (CPCRW) documented warming and degradation of permafrost over the last 20 to 80 years. Larry Hinzman, Douglas Kane and Kenji Yoshikawa continued their investigations in CPCRW and on the Seward Peninsula that relate changes in hydrologic processes and permafrost to climatic dynamics. Graduate dissertations by Kevin Petrone and William Bolton demonstrated the strong controls of permafrost extent upon hydrologic processes (baseflow, peak discharge, recession rates) and chemical exports (NO₃,

DOC, and essential cations). Kane and Hinzman have upgraded the remote meteorological and hydrological stations operated by the UAF Water and Environmental Research Center to provide near-real time continuous monitoring of field conditions via the internet.

Several NSF-sponsored projects led by Kenneth Hinkel (University of Cincinnati) and Frederick Nelson and Nikolai Shiklomanov (University of Delaware) in northern Alaska include observations on the influence of enhanced snow accumulation on seasonal thaw, assessment of an urban heat island at Barrow, measurements of regional active layer thicknesses as part of the CALM network, and seasonal and long-term measurements of heave and settlement using DGPS. In 2002, average thaw depth at Foothills sites were substantially reduced compared to the period of record (1995-present) and sites on the coastal plain although low, were slightly higher than in 2001. An international CALM workshop was held in Lewes, Delaware in November 2002, to develop a synthesis of the five-year programme. A special issue of *Polar Geography* contains data and information on over 100 CALM sites from the 15 investigating countries. Several papers were published with Oleg Anisimov (Russia) concerned with the possible effects of thawing permafrost on human infrastructure, and on demonstrating the utility of stochastic modeling as an alternative method of mapping geocryological parameters. A joint project with Ron Paetzold, USDA Natural Resources Conservation Service, is investigating the variability of the surface energy balance and shallow ground thermal regime in different landscape units at Prudhoe Bay.

Wendy Eisner (University of Cincinnati) and Jim Bockheim (University of Wisconsin) continued a programme of intensive spring and summer coring and survey of drained thaw-lake basins from Barrow inland to Atqasuk.

Tom Osterkamp (Geophysical Institute), reports that this year marks the twenty-fifth anniversary of the beginning of a series of 25-station permafrost observatory along the north-south transect of Alaska stretching some 1200 km between Prudhoe Bay and Glenallen.

These observations continue as part of the project to investigate the influence of climate and environmental factors on the thermal and moisture regimes of the active layer and permafrost in

Alaska. Additional sites have been established in outlying areas to help create a statewide picture of permafrost conditions and their changes.

In April 2002, Vladimir Romanovsky and Kenji Yoshikawa (University of Alaska Fairbanks), and Jerry Brown, added two, 45-meter boreholes to the Barrow Permafrost Observatory, and in August installed two 1-meter thermistor probes (see web site). Initial results of this IARC-supported borehole programme appeared in *Eos*. Vladimir Romanovsky with colleagues Tatiana Sazonova, Dmitrii Sergueev, and Gennadii Tipenko at the Geophysical Institute have produced a synthesis of environmental data along an east Siberian transect and a comparison of active layer and permafrost conditions with an Alaskan transect.



Drilling operations at Barrow April 2002.

A report by Brown and Torre Jorgenson (ABR, Inc) on the carbon loss due to coastal erosion was presented at the Arctic Coastal Dynamic (ACD) workshop in Oslo. The estimates of carbon loss were developed from the two key ACD sites on the U.S. Beaufort Sea coast. The 14 erosion transects from the Barrow Elson Lagoon key site were remeasured in August and only minor changes were noted since summer 2001 (project led by Brown and Orson Smith, University of Alaska Anchorage).

Torre Jorgenson and Erik Pullman (ABR, Inc.) with Yuri Shur (University of Alaska) are conducting studies in the eastern portion of the NPR-A supported by Conoco Phillips Alaska. The project is designed to (1) determine the nature, magnitude, and distribution of ground ice in relation to terrain units, (2) evaluate potential thaw settlement from surface disturbance, and (3)

develop a conceptual model of how ground ice develops in relation to lake basin development. Data are collected on soil carbon stores within the upper 2.5 m of the permafrost.

Skip Walker (University of Alaska Fairbanks) is leading an interdisciplinary team of researchers in field observations and experiments to validate a model of frost-boil formation and its relevance to climate change. Twelve Alaskan sites are located along a climate gradient from Happy Valley in the Arctic Foothills to Howe Island in the Delta of the Sagavanirktok River on the Beaufort Sea coast. Site visits along a transect from Inuvik on the Mackenzie River to Satellite Bay on Prince Patrick Island (Canada) and along the Kolyma River (Northeast Russia) were conducted in summer 2002. The project is also linked to the Circumpolar Arctic Vegetation Mapping project.

A number of activities are on-going at the National Snow and Ice Data Center / WDC for Glaciology, University of Colorado. Mark Parsons and Tingjun Zhang, are leading the IARC-funded Global Geocryological Database (GGD) activity to produce Version II of the CAPS CD-ROM in cooperation with the IPA. The IARC-supported Frozen Ground Data Center has been established to improve access to existing data through online searching, ordering, and availability in the Global Change Master Directory. Christoph Oekle, in collaboration with Zhang, Mark Serreze, and Richard Armstrong, has developed a regional model of soil freeze/thaw at a 25 x 25 km resolution and daily time steps for the period September 1998 through December 2000. Feng Ling and Zhang have developed a numerical simulation to model the permafrost thermal regime and talik formation under shallow thaw lakes in the Alaskan Arctic. Zhang with Serreze, Roger Barry, and David Gilichinsky (Russia) are continuing their analysis of the historical soil temperature measurements in the Russian Arctic and Subarctic.

Ron Sletten and Bernard Hallet (University of Washington) are currently involved in projects in both the Arctic and Antarctic and include: the biocomplexity of carbon cycling (Thule, Greenland); weathering studies (Zackenberglund and sites in southwest Greenland); and diffusion of heavy metals contaminants at study sites in Alaska. In the Dry Valleys of Antarctica, they are examining the dynamics and evolution of

contraction crack polygons, the motion of rock glaciers, the formation of inflational soils, and other geomorphic processes. Surface velocities along the centerline of the rock glacier of 20 to 40 mm/yr, are based on differential GPS and Synthetic Aperture Radar Interferometry measurements. This research is focussed in Beacon Valley where the oldest ice on Earth has been reported, and where there are some of the best terrestrial analogs for investigating the stability of subsurface ice and periglacial processes on Mars.

Nicole Mölders and John E. Walsh (University of Alaska Fairbanks), supported by IARC, are investigating the roles of high-latitude terrestrial variables and processes (e.g., permafrost, soil freezing and thawing, snow, interaction of soil moisture and soil temperature states) in the context of numerical weather prediction (NWP) models. Simulations with and without consideration of soil frost processes are being performed to examine the influence of permafrost on the regional weather in Alaska. The inclusion of soil frost processes leads to altered fluxes of heat and water to the atmosphere, which modify the cloud and precipitation formation on the local scale.

Gary Clow, USGS, relogged a number of deep boreholes in northern Alaska and downloaded data measuring active layer temperatures, air temperatures, snow depth, and solar radiation. These deep drill holes showed significant warming during the 1990s.

Tim Collett (USGS) reports that the multi-national 2002 Mallik gas hydrate research programme, located in the Mackenzie Delta region, resulted in the recovery of a large number of gas hydrate samples from below the 640 m deep permafrost section at depths of between 890 m and 1150 m. Other aspects of the Geological Survey of Canada lead project consisted of well logging, obtaining down-hole temperature profiles, microbiologic studies, seismic cross-hole tomography, and the first modern production tests of a gas hydrate reservoir involving both pressure draw down and thermal stimulation.

Kathleen A. McCarthy (USGS) has been investigating the movement of free-phase petroleum hydrocarbons in the subsurface at a site near Barrow, Alaska. Hydrocarbons from surface spills have migrated well below the permafrost table, most likely through fractures in the frozen

sandy gravel.

Erk Reimnitz (retired USGS) is analyzing the shape of shorefaces from the arctic coastlines of North America and Siberia. The shape may be controlled by the action of floating ice ranging in size or extent from continuous sheets down to small floes and even individual ice crystals; processes that differ from those in lower latitude, ice-free coastlines.

Matthew Sturm (Cold Regions Research and Engineering Laboratory) has developed a statistical model that can be used to predict the temperature of the snow-ground interface over a large region. The model, based on measurements made in the Kuparuk Basin, is simple and emphasizes the importance of snow in controlling permafrost temperatures and active layer thickness.

H.J. Walker reported on the history of the Louisiana University arctic coastal and permafrost research in the Spring 2002 issue of *Witness the Arctic*. An unabridged version of this overview is available on the ARCUS web site. Also, just published in the book *Landscapes of Transition*, edited by K. Hewitt et al. and published by Kluwer in 2002, is the paper "Landform development in an arctic delta: the roles of snow, ice and permafrost".

Alexandre Tsapin and G. McDonald (Jet Propulsion Laboratory) are using amino acid racemization and radiocarbon dating to investigate the metabolic activity of "dormant" microorganisms in northern Siberian permafrost. Viable bacteria have been cultured from million-year-old Siberian permafrost, but the relationship between the age of the bacteria and the age of the sediments remains uncertain.

Bucky Tart reports that Golder Associates, Anchorage, has been involved in numerous permafrost engineering projects throughout Alaska and in the Former Soviet Union. The major project has been the permafrost geotechnical consultation for the Trans Alaska Pipeline (TAPS) during and since pipeline construction. Other projects involve frost heave concerns for pavements in Anchorage, and slope stability issues in permafrost for various pipeline locations, highways, and mines.

Buzz Scher and Charlie Riddle, R&M Consultants, Anchorage, report on two rural airport projects. The Tetlin runway involves

a thermal design to avoid settlement of the aggregate surfaced runway that is built over variable ice-rich and ice-poor permafrost. The Kotzebue airport design requires removal of a hill composed of ice-rich silt without sedimentation into the adjacent lagoon.



Winter drilling on permafrost slope. Photo: Bucky Tart.

Dave Norton, an Anchorage-based consulting engineer working for the owners of the Trans Alaska pipeline, reports that permafrost engineering was a focus of interest during the process to renew the Trans Alaska Pipeline rights-of-way (ROW). The pipeline began operation in 1977. In 2002 the Bureau of Land Management prepared an Environmental Impact Statement (EIS) that evaluated renewal of the ROW for an additional 30 years. Changing conditions along the ROW, primarily permafrost degradation, were among the key points of investigation. The EIS determined that the pipeline and the permafrost regime near it had reached thermal equilibrium in most cases. Areas that exhibit continued permafrost degradation are addressed by built-in support adjustments and normal maintenance.

Thomas Berglin and Ed Clarke (Soils Alaska PC, Fairbanks) report that they are undertaking a testing programme on the thaw stability and sampling procedures for both fine-grained (micaceous silt) and coarse-grained (very sandy gravel) soils of interior Alaska. Clarke attended the Fifth International Symposium on Permafrost Engineering in Yakutsk, Russia, and exchanged experiences with Russian and Chinese researchers on foundation construction techniques on frozen granular soils.

Hannele Zubeck and He Liu (University of Alaska Anchorage) are modeling the use of helical piles to increase pile capacity in permafrost soils.

Several groups lead by Vladimir Aizen (University of Idaho), are monitoring watersheds in the Salmon River basin (Rocky Mountains, U.S.A.) and Narin River basin (Akshiyarak Mt. Massif, Kyrgyzstan) by measuring meteorological, hydrological, borehole temperatures, heat balance and snow pack parameters, and aqueous geochemistry within nested watersheds to evaluate the role and long-term changes of water balance components.

William J. Wayne, University of Nebraska, reports on his continuing studies of periglacial sand wedges and sheet sand in Nebraska, and on relict patterned ground in the Snowy Range, Wyoming.

The American Society of Mechanical Engineers (ASME) supports two technical areas that are of interest to cold regions engineers – the Heat Transfer Division's K-18 Committee that focuses on low temperature heat transfer and the Ocean, Offshore, and Arctic Engineering Division (OOAE) that sponsors the annual Offshore Mechanics and Arctic Engineering (OMAE) conference. The 22nd Conference (OMAE 2003) will be held in Cancun, Mexico, from June 8 to 13, 2003, and includes the Polar & Arctic Sciences & Technology Symposium.

Finally, we regret to note the death of Duwayne M. Anderson in October; a pioneer in the research on unfrozen water and ice segregation.

Web:

ARCSS: www.nsf.gov/od/opp/arctic/system.htm

ARCUS: www.arcus.org

ATLAS: www.laii.uaf.edu/ATLAS/atlas.cfm.Barrow

Obs: iarc.uaf.edu/barrow_permafrost.html

CALM: www.geography.uc.edu/~kenhinke/CALM/

CHAMP: www.arcus.org/ARCSS/hydro/index.html

EIS: www.tapsrenewal.jpo.doi.gov/

Frost boils: www.geobotany.uaf.edu/cryoturbation.index.html

Frozen Ground: nsidc.org/frozenground/

HARC: www.arcus.org/HARC/index.html

ITEX: www.systbot.gu.se/research/itex/itex.html

Met network: www.uaf.edu/water/projects/

NorthSlope/northslope.html

RAISE: www.raise.uaf.edu/

Siberia transect: www.gi.alaska.edu/snowice/

Permafrost-lab/proj_trans/pr_trans.html

US ARC: www.arctic.gov

USPA: www.uspermafrost.org

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Lake Hövsgöl Permafrost Project, Mongolia

The primary goal of the Hövsgöl Project is to study the impacts of nomadic pasture use and climate change on watershed biodiversity and permafrost of the taiga (boreal) forest and steppe of northern Mongolia. The project is funded by a five-year grant from the Global Environment Facility (GEF) to the Mongolian Academy of Sciences (MAS), implemented by the World Bank and a foundation of the Mongolian Long-Term Ecological Research Program at Lake Hövsgöl. This region at the southern edge of Siberia is a zone of biogeographic and ecological transition from forest to forest-steppe and steppe. Lake Hövsgöl, the sixteenth largest lake on Earth, lies in a graben and is part of the Baikal Rift System. The surface of Lake Hövsgöl is at 1642 m a.s.l., and the north-south aligned basin is surrounded by mountains with peak elevations from 2400 to almost 3500 m, and with mountain tundra above 2200 m.

The Siberian larch (*Larix sibirica*) covers north-facing mountain slopes and ridge tops; the vegetation of valley bottoms and south-facing slopes are primarily steppe grasses; both vegetation zones have a ground cover of mosses and lichens. Analysis of temperature data from the meteorological station at Hatgal at the southern end of the Lake indicates that annual temperatures have warmed by about 1.5° C over the last 40 years.



Project manager Clyde Golden instructing permafrost to Mongolian students at the project campsite in Borsog valley, Hövsgöl, northern Mongolia. Photo: Bernd Etzelmüller.

The study area includes six river valleys entering the Lake on the eastern shore that form a gradient of nomadic pasture use in the steppe

valley bottoms and south-facing slopes, extending from Borsog gol (50°58'24.5"N, 100°44'54.1"E) in the south with no nomadic pasture use, to Turag gol (51° 17'46.0" N, 100° 47'51.5"E) in the north with the most nomadic pasture use. The study is designed to define the impacts along this gradient of use while also monitoring meteorological conditions. Permafrost exists close to the lake shore in valley bottoms and in the mountains, except on south-facing slopes. Above approximately 2200 masl permafrost seems to be continuous, even on south-facing slopes. Permafrost thickness near the lake is some tens of meters, increasing to more than 200 m in the high mountains. Besides topography, permafrost distribution and thickness is highly dependent on snow distribution and the vegetation/wetness pattern in the area.

The goal of the permafrost studies is to define the distribution and temperature of permafrost and the depth of the active layer, and to initiate a monitoring programme of soil and permafrost temperatures in each of the valleys. During June 2002, N. Sharkhuu drilled six boreholes to six meters depth at different topographic locations in the Borsog and Dalbay valleys. During the period August 23 to September 2, 2002 detailed field studies of permafrost were conducted by an international team lead by Sharkhuu (Mongolia), Etzelmüller (Norway), and Romanovsky (USA). The methods used during the first field studies included (a) field measurements of soil temperature, (b) analyses of geophysical parameters, and (c) the generation and analyses of digital elevation models and satellite imagery. The field measurements provided the basis for the later development of statistical/empirical and physical models of the permafrost distribution in the Hövsgöl area.

Ground surface temperature are being monitored at twenty locations using UTL-1 miniature temperature loggers, buried in the ground at five to ten cm depth. The loggers are programmed to record temperatures every 90 minutes throughout one year. At the borehole sites drilled by Sharkhuu, surface and subsurface temperature is monitored using UTL1 and Hobo loggers. Additionally, one active-layer site to a depth of 1.6 m was established at the Borsog camp site near the meteorological station.

Two MRC soil temperature probes were

installed at the two new locations as a part of automatic meteorological stations. One of these locations is a north-facing slope in the Dalbay River valley, and another at the Hatgal meteorological station. These temperature probes will provide year-round hourly soil temperature data at eleven depths from the ground surface and down to one meter (approximately every 10 cm). These data, together with temperature data from the deeper boreholes, will be used for calibration of our numerical thermal model. The site-specific calibrated models will be applied to the entire period of available meteorological data from this region to reconstruct the permafrost temperature dynamics within different landscape units. Based on long-term past or future climate change scenarios, the same models can be used to investigate long-term permafrost dynamics.



Active-layer temperature monitoring started in Borsog Valley by Regula Frauenfelder, Zürich University and Vlad Romanovsky, Fairbanks University. Photo Bernd Etzelmüller.

Ten, two D-resistivity tomography profiles were measured at various locations in the field, including the northernmost Turag and Shagnuul valley, which are heavily grazed by nomadic

live stock. One-D-resistivity measurements were carried out at four field sites. A 50-m digital elevation model (DEM) was generated based on digitised contour lines (with 20-m equidistance) derived from analogue Russian maps dating from the 1940s. A second DEM with 25-m resolution and an orthophoto over the study area was generated by Dr. A. Käab (University of Zurich) based on satellite imagery. He used the ASTER sensor (Advanced Space-borne Thermal Emission and Reflection Radiometer, on board the TERRA spacecraft), which contains along-track stereo channels, usable for the generation of simultaneous stereo pictures and thus enabling the generation of DEMs utilizing photogrammetric techniques. The generated DEMs were the basis for the calculation of a set of topographic variables for the study area, which are useful both in permafrost modeling and land use classification. The potential incoming radiation is estimated based on the DEM using the software SRAD.

It is planned to continue these investigations during 2003 in order to obtain a sound basis for deriving relationships between permafrost occurrence, permafrost temperature, topographic characteristics and land cover. Energy balance models will be applied to simulate permafrost temperature response to climate changes in the area. The development of the mapping and modeling activities and related international field activities were conceptualised during the field excursion in September 2001 following the Symposium on Mountain and Arid Land Permafrost held in Ulaan Baatar (see *Frozen Ground* 25). Coordination for the international team is provided by Clyde E. Goulden, Hövsgöl GEF Project and Director, Institute for Mongolian Biodiversity and Ecological Studies, Academy of Natural Sciences, Philadelphia, PA.

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Bernd Etzelmüller, Eva S.F. Heggem,

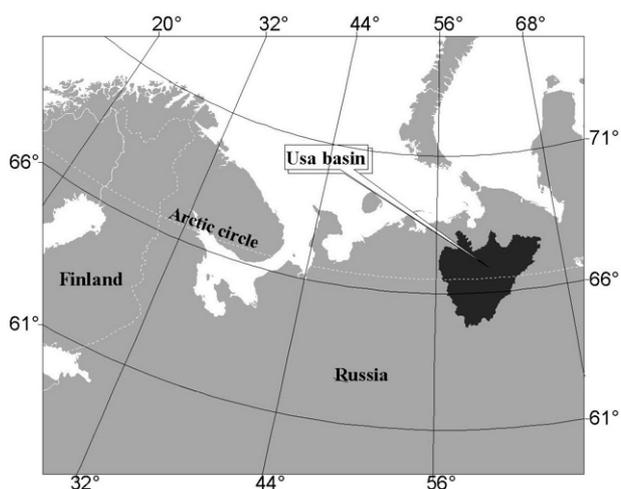
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Permafrost and Infrastructure in European Russia

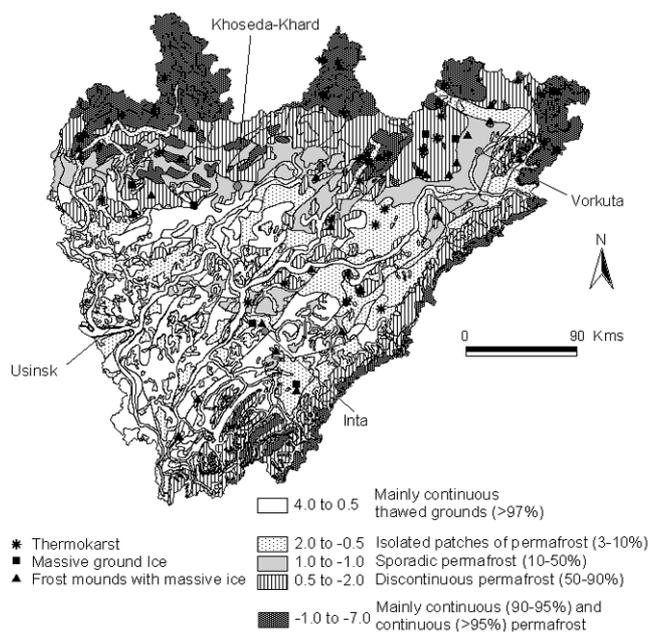
The PERUSA project (Permafrost in the Usa Basin: distribution, characterization, dynamics and effects on infrastructure), funded by the INTAS programme of the European Commission was carried out by five partner institutions from Russia, Finland, the Netherlands and the United States. The objectives of PERUSA were to map permafrost conditions, to investigate the sensitivity of permafrost to climate change, to assess the present relationship between distribution of permafrost and urban/industrial infrastructure, and to evaluate where future permafrost degradation due to anticipated global warming might affect infrastructure.

The research in the PERUSA project was carried out in the Usa Basin, which is the largest tributary of the Pechora River (Northeast European Russia). The region is unique in continental Europe because of its extensive lowland tundra and permafrost. The total area of the Usa Basin is approximately 94000 km². The northern part is tundra and forest-tundra accounting for 60 % of its total surface; mostly pristine taiga forests occupy 30% of the area in the south; the remaining 10% are alpine areas in the Ural Mountains to the east. The region is rich in non-renewable resources (minerals, coal, oil and gas). Vorkuta and Inta are coalmining towns. Oil fields are located mainly north of the town of Usinsk. Because of the remoteness of these areas, fossil fuels have to be transported by an extensive network of railroads and pipelines.



The location of the Usa Basin (map by Kari Mikkola)

The PERUSA project was carried out in close cooperation with the EU 4th Framework funded 'Tundra Degradation in the Russian Arctic' TUNDRA project. The TUNDRA project



Permafrost map of the Usa Basin, with temperatures and location of the main industrial towns and the Khoseda-Khard meteorological station.

assessed feedbacks from the Usa Basin to the global climate system through changes in greenhouse gas emissions and freshwater runoff. A present-day regional climate model developed in the framework of the TUNDRA project was applied to simulate permafrost conditions. The Pechora and adjacent regions were used as a case study to test the ability of the 15-year long (1979-1993), 16-km horizontal resolution, climate simulation with the regional climate model HIRHAM4 to predict the distribution and temperatures of permafrost (Christensen and Kuhry, 2000). A frost index applied to the deep soil layer in the model was able to reproduce the distribution of permafrost at regional scales, including the more southern distribution of permafrost at high elevation in the Ural Mountains and in the West Siberian lowlands.

The GIS 'Permafrost of the Usa Basin' developed in the framework of the PERUSA project shows that about 75% of its area is occupied by permafrost terrain. Of the total permafrost area about 75% is isolated, sporadic and discontinuous permafrost. Permafrost temperatures in these zones are in the order of 0 to -2°C. Therefore, most of the Usa Basin (nearly 60%) is underlain by 'warm' and 'more discontinuous' permafrost (Mazhitova and Oberman, 2002; Oberman and Mazhitova, in press). We defined these zones of isolated, sporadic and discontinuous permafrost

as 'high risk' areas very sensitive to even moderate temperature increases under future global warming.

The GIS 'Permafrost of the Usa Basin' is based on data of the distribution and temperature of permafrost calibrated for the period of recent warming between 1970 and 1995 (Oberman and Mazhitova, 2001). The recent warming trend, however, should be put into context of the longer term meteorological records in the study area. Although mean annual temperatures increased by almost 1°C per decade between 1970 and 1995, the values reached in the mid-1990 are not exceptionally high compared to previous warm periods of the 20th century (e.g. the 1930-1940's). Since the warm mid-1990's, mean annual temperatures have declined, with 1998 being the coldest year on record (Khoseda-Khard and Vorkuta meteorological stations). Therefore, there is no clear fingerprint of global warming yet in this part of the Arctic. This also implies that the mapping and observations made within the framework of the PERUSA project fall within the range of natural variability observed over most of the 20th century.

The sensitivity of permafrost to climatic change was examined at different time scales. Permafrost dynamics over thousand of years was traced in peat plateaus and palsas using detailed palaeobotanical and radiocarbon analyses. Permafrost aggradation as recorded in eight investigated permafrost peatlands in the Pechora region has occurred at c. 4800 yr BP (Väliranta et al., submitted). Oksanen et al. (2001) report phases at c. 3100, c. 2200 and < 600 BP as important for permafrost development in peatlands. These ages fall within periods of climatic cooling suggesting that relatively minor fluctuations (-2 to +1°C) did have an effect on permafrost over the long periods of time considered in this analysis.

Long-term monitoring data shows how different sites have responded to the recent warming (1970-1995), in terms of active layer/seasonal freezing depths and permafrost temperatures. The active layer thickened, but by different degrees depending on geomorphic position, parent material and changes in snow cover (Oberman and Mazhitova, 2001). Permafrost temperatures at the depth of zero annual amplitude generally increased by 1.2 °C (peat plateau) to 0.7 °C (upland in loam deposits). Permafrost profiles dis-

play gradual increases in temperature with depth during the warming trend with deeper layers first still showing cooling inherited from the cold decades of the 1950's and 1960's.

The response of permafrost to climate change over the next 85 years was provided by a transient, one-dimensional model for two sites near Vorkuta that represent opposite ends of the temperature range in the discontinuous permafrost zone of the study area (pers. comm., Romanovsky). One is an upland site in loamy sediments (with 'warm' permafrost), the other a peat plateau (with 'cold' permafrost). Permafrost at the loamy site reacts very quickly to the transient warming of up to 3 °C with talik formation within 5-15 years, but progressive thawing is slow due to energy consumed by the phase transition to liquid water. The 'peat' site reacts more slowly. The active-layer depth increases, but first signs of talik formation only appear in the 2080's. The conclusion is that even under moderate conditions of global warming most of the permafrost in the 'high risk' area of the Usa Basin is likely to start thawing within a decade to a century, but talik depth will increase only gradually.

To evaluate how permafrost dynamics will affect urban/industrial infrastructure in the region, GIS-overlays were prepared of permafrost conditions and infrastructure in the Usa Basin (Mazhitova et al., in prep.). These layers reflect conditions from the 1980's, however, average climatic conditions have not changed substantially since that period. Because of the economic downturn in Russia new infrastructure in the study area is limited, with some possible exceptions near Usinsk due to the expanding oil activities. Results show that between 37 and 62% of the different types of industrial/transport infrastructure in the Usa Basin are located in the zones of isolated, sporadic and discontinuous permafrost. A considerable proportion of the infrastructure is located on peaty grounds, especially roads and pipelines. The temperature of the permafrost in the 'high risk' area is between 0 and -2°C. Therefore, this permafrost would be sensitive to even moderate climatic warming. In most landforms, permafrost will start to thaw and ground to subside within the 21st century. The response will be differential depending on permafrost terrain. The risk of damage to infrastructure is not only restricted to progressive vertical thawing of permafrost, but

also lateral expansion of thermokarst lakes can seriously threaten existing and future infrastructure. The northern section of the Vorkuta railroad and the northern section of the (present and future) pipeline system face the most serious problems.

The Pechora region is experiencing a sharp increase in oil/gas activities (exploration and exploitation) due to greater demands on the international markets. Permafrost degradation due to global warming would represent a significant challenge to permafrost engineers in the 21st century. Our recommendations are to continue with existing long-term permafrost monitoring near the town of Vorkuta and to expand the monitoring in the tundra north of Usinsk and around the town of Narjan-Mar (Pechora Delta). In addition, sound investments in good materials and construction techniques are necessary to cope with the differential response of various permafrost terrains to anticipated global warming. These responses would create entirely different conditions than those experienced in the recent past.

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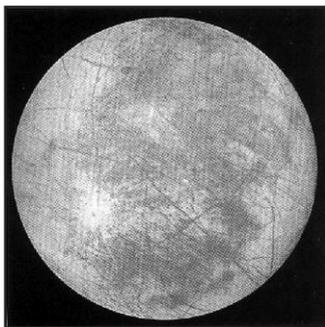
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Oil field and pipeline installations in a peat plateau/thermokarst complex in the tundra north of Usinsk. Photo: Peter Kuhry.

Planetary Permafrost and Astrobiology

Many significant results and developments related to the planetary permafrost and extraterrestrial Life are now available. In this year alone two new journals were published: *Astrobiology* and *International Journal of Astrobiology*. In February 2002 the monograph *Astrobiology* reported several chapters related to permafrost and active layer models. In March in St. Petersburg the workshop 'Field expeditions in Russia regarding astrobiological interest' was organized by NASA. In April both the EGS meeting (Nice) and the conference 'Water in the upper Martian layers' (Potsdam) focused on Mars as a 'water-rich planet'. In May four papers in *Science* (297) reported the first year's discoveries based on the satellite 'Odyssey' observations that found water in the subsurface Martian layers (1-2 m depth) using the High Energy Resolution Neutron Detector and other methods. Future plans include the mapping of this layer over the entire planet. In September the European conference on Exo/Astrobiology (Graz) included the session 'Permafrost Astrobiology'. Finally in October at the World Space Congress (Houston) plans for the project 'Mars Express-2003' were developed to explore the subsurface structure at km-scale down to the permafrost. Also discussed was the priority for the future space mission: Mars or Europa (the ice-covered moon of Jupiter).



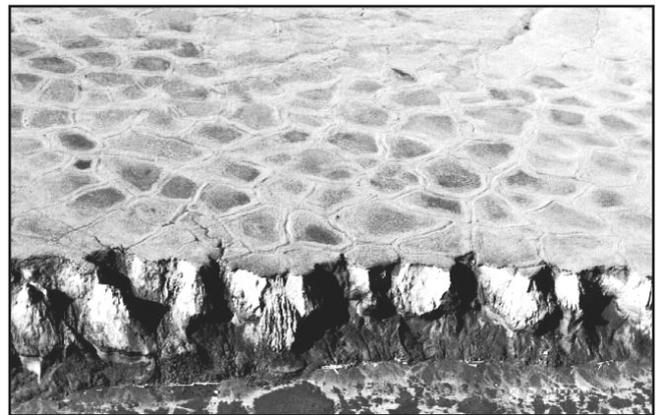
The ice-covered moon Europa (Photo NASA).

One of the main goals of the space research is the search for life. After the Viking mission (1975) officials became sceptical about the possibility of extraterrestrial life, but scientists continue their studies. Results from images of Europa returned by the Galileo spacecraft indicated the possibility of liquid water under its cracked, icy surface. David McKay (Johnson Space Center) discovered evidences of existed life (even if arguable) within the Martian meteorite found in Antarctica. As a result interest in exobiology increased in the last

five years, and in 1998 the NASA Astrobiological Institute (NAI) was established, and in 2001 the European Exo/ Astrobiology Network Association (EANA) was formalized.

Since life requires water, different theories and models are attempting to explain the mechanisms for the existence of water on the other planets. One such mechanism in regard to Mars would be through subsurface volcanism with the interactions of water at shallow depths within the ice or the permafrost.

Due to the subzero temperatures, water occurs in a frozen state. The Odyssey data shows the presence of H₂O-ice or permafrost close to the Martian surface rather than at depths up to 200-300 m (traditional view). The terms 'ice' and 'permafrost' became the key words in both NASA and European Space Agency's astrobiological discussions. Comparison of photos of Martian polygons (front cover photo) with those on terrestrial permafrost and ice cracks on Europa with ice sheets has become popular.



Terrestrial polygons at the Russian arctic coastline. Photo: David Gilichinsky.

The search for extraterrestrial life is based on the most probable environments on Earth. Since most planets of the Solar System and their moons are of the cryogenic type, the Earth cryosphere serves as a model for these Space objects. The subzero terrestrial environments has proven stable habitats for maintaining viable microorganisms. Significant numbers of ancient viable microorganisms are known to be present down to 3600 m within Antarctic Ice Sheet, where ice ages reach 420,000 years (Abyzov 1993; Petit et al. 1999; Price 2000), and in permafrost of both hemispheres, where estimated ages of the permafrost vary from thousand to several million

years (Gilichinsky 2002a,b). These organisms probably possess unique mechanisms that allow them to survive during geological time. Upon thawing the microorganisms resumes their physiological and biogeochemical activity. These phenomena are of great significance for research in the newly emerging field of 'exo/astrobiology'.

The terrestrial microbial communities that inhabited the cryosphere may serve as analogues of possible extraterrestrial ecosystems on the Earth-like planets. Therefore, planetary cryospheres represent one of the environments where the probability of finding life is the highest. Cameron and Morelli (1974) first proposed concepts for solving the biological problems of Mars using the terrestrial models. Even when the estimated age of the permafrost for Mars is 3.5 Gyr, the cells might be preserved here within the subsurface frozen material. It could be hypothesized that Martian permafrost might contain the genetic resources of pre-existing life that vanished due the catastrophic events on the planet.

The constructive metabolism and methane generation were observed in the native permafrost samples at temperatures as low as -17°C (Rivkina et al. 2000, 2002), as well as low rates of bacterial DNA and protein synthesis in South Pole snow (Carpenter et al. 2000). These findings confirmed not only the presence of the viable microorganisms, but also their metabolic activity that provides repair of DNA damages and maintenance of the cell's viability. Therefore, it is reasonable to conclude that potential life forms within Martian permafrost, as a planet free of oxygen, might be represented by anaerobic chemolithotrophic bacteria with their specific mechanisms to assimilate CO₂ and other compounds.

During the past 20 years geocryologists and glaciologists as a community have been relatively uninvolved in investigations of planetary permafrost, even though it was one of them who first described the Martian permafrost (Kuzmin 1983, and others). The remote sensing experience in glaciology may be used to estimate the thickness of ice on Europa, as was the case when I. Zotikov predicted the existence of the Lake Vostok beneath the Antarctic Ice Sheet. In the early days of IPA a great deal of attention was given to planetary permafrost. Today the

permafrost experience should be used again to explore the close analogues represented by cryopegs, active volcanoes, meteorite craters, and in layers with extremely low pH and extremely high levels of ground radiation that occurs in permafrost and glaciated regions. For example, liquid water also may occur on Mars as overcooled brine lenses within permafrost, formed when the planet became dry and cold. Advances in satellite interpretation of physical terrestrial data and imagery can provide new knowledge for analysis of planetary features, their origin and assess sites for landings and sampling.

The space-related studies of such natural repository as the cryosphere can help develop modern technologies. The cryosphere as a natural repository can answer the fundamental question: how long can life be preserved, as well as solving basic and applied geocryological problems; such as the development of molecular-biological clock and direct dating of permafrost ages including the Antarctic permafrost. For the future space missions and the education of young scientists and students, the 'positive role of negative temperatures' has to be demonstrated. Such training and research has begun in the recently established Laboratory of Planetary Cryology, Geocryology Department of Moscow State University.

The former IPA President T. Péwé (1975) first published a brief review of the microorganisms in permafrost, and once again today, permafrost is considered as a microbial habitat (Gilichinsky 2002a,b). The 8th International Conference on Permafrost in Zurich offers the opportunity for the IPA to resume its interests and leadership in the studies of periglacial planetary features and frozen physicochemical complexes; the latter are most favourable for the long-term preservation of life as compared with any other environments.

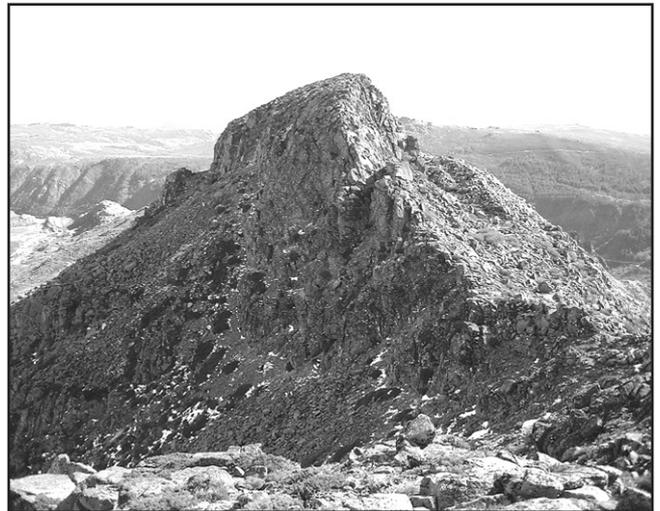
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Other News

Portugal

Research on relict and present-day periglacial processes by G. Vieira (University of Lisbon) continues in the Serra da Estrela Mountains. A geomorphological map of the area at 1:25000 showing the main glacial and periglacial features will be finished by the end of 2002. Monitoring of shallow ground and rock temperatures is providing new results with respect to the characterization of the daily and seasonal freeze-thaw regimes of the areas above 1600 m asl. C. Mora (University of Lisbon) is studying the local climate of the same mountain, with focus on monitoring air temperatures at different topographic positions. The air temperature data will be compared with the ground and rock temperatures for geocryological research.



Cântaro Gordo, Serra da Estrela, Portugal at 1,875 m asl. Test site for monitoring of ground and air temperatures (summit) and rock temperatures at the south (right) and north (left) free faces. Daily and seasonal freeze-thaw cycles occur. Photo: G. Vieira.

A joint project between M. Ramos, University of Alcalá de Henares, Spain and G. Vieira, University of Lisbon, studying the active layer and permafrost in Livingston Island (Antarctica) was recently approved by the Programa Nacional de Investigaciones Antárticas (Spain). It supports the ongoing monitoring of the temperatures in two shallow boreholes drilled in Hurd Peninsula in 2000.

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David Gilichinsky (gilichin@issp.serpukhov.su)

Romania

Permafrost research in Romania is conducted by universities and individuals. Over the last two years, the main cold region research activities were undertaken by a team (P. Urdea, M. Voiculescu, M. Török-Oance, M. Ardelean and F. Vuia) from the Department of Geography, West University of Timisoara, in two research projects entitled 'Study of the present-day morphodynamic processes in alpine areas of the Southern Carpathians, from a sustainable perspective of mountainous area' (1999-2001) and 'Present-day geomorphological processes in the alpine domain of the Southern Carpathians in global climatic change perspectives' (2002-2004). Both projects are funded by the Romanian National Council for Superior Education and Scientific Research. Part of the work focused on establishing relationships between permafrost development, including sporadic, extrazonal permafrost situated at low altitude (1100 m asl.) in the Detunata Goală Area, the Apuseni Mountains and the dynamics of rock glaciers, solifluction, frost heaving, debris-flows and climatic warming tendencies. For future activities digital terrain models of the Fagaras Mountains, Parang Mountains and Muntele Mic were prepared.



Rock glaciers and late glacial moraines in the Netis Cirque, Tarcu Mountains, Southern Carpathians, Romania. Photo: Petru Urdea.

During the 5th International Conference on Geographic Research in the Carpathian-Danube region that took place in Timisoara, 17-19 May, 2002, a round-table discussion on the tendencies of the morphodynamic processes in alpine areas of the Carpathians was organised.

Glacial and periglacial relief and relict permafrost indicators were studied by the Timisoara team in Muntele Mic, by P. Urdea in, the Bihor Mountains, by P. Urdea and D. Gureanu, in the Cernei Mountains, by F. Vuia, in the Parang Mountains, by M. Ardelean in the Piule-Iorgovanu Mountains, by A. Andra and A. Nedelea (Bucharest University) in the Topolog and Capra Basin in the Fagaras Mountains, and by M. Mandrescu (Stefan cel Mare University of Suceava) in the Rodnei and Calimani Mountains in the Eastern Carpathians.

Petru E. Urdea (urdea@cbg.uvt.ro)



PACE 21

Permafrost and Climate in the 21st Century (PACE21)

Notification has recently been received from the European Science Foundation in Brussels that the PACE21 Networking Programme will be funded for three years, starting in January 2003. This programme seeks to promote research on:

- The geothermal response of permafrost to climate change, and resulting feedback to the geomorphic and environmental systems, and
- Assessment of impacts in terms of geo-environmental hazards to engineering structures and human activities.

This will be achieved through research meetings and workshops, coordination and promotion of publications in research journals, publication of a major edited -state-of-the-art review, and a web-based information service. The existing European Permafrost Monitoring Network, established under the EU 4th Framework PACE project, provides mountain permafrost thermal data from seven 100 m deep instrumented boreholes in a transect from Svalbard, through Scandinavia, to the Alps and Sierra Nevada, but there remains a critical need for this network to be extended both to high latitude arctic sites and other high

altitude mountain permafrost regions. Impacts of warming in permafrost at high latitude and high altitude regions include thaw subsidence and increased slope instability, and the PACE21 network will provide a multidisciplinary forum for development of new research initiatives. The project will be international in outlook, and seek to integrate European permafrost research with that of North American and Russian scientists and engineers.

Networking focus on

- Monitoring and numerical modelling of permafrost geothermal regime
- Climatic impacts on permafrost geomorphic and environmental systems
- Impacts of permafrost degradation on human activities

The PACE21 Network has a list of provisional meetings:

In July 2003 the First PACE21 Workshop and First Coordination Committee Meeting will take place at the 8th International Conference on Permafrost at the University of Zurich, Switzerland. Coordinator: Martin Hoelzle (University of Zurich). Workshop Theme: Permafrost-climate interactions, temporal-spatial modelling and monitoring. Analysis of permafrost thermal data and progress in numerical modelling approaches will be reviewed.

In May 2004 the Second PACE21 Coordination Meeting will take place at the Russian Academy of Sciences, Pushchino, Russia. Link-person David Gilichinsky (Russian Academy of Sciences, Pushchino). The meeting will include Russian observers, and will focus on developing research opportunities and research links with Russian scientists. Key issues will include the establishment and development of permafrost monitoring networks in Russia (arctic sites and mountain permafrost in the Urals), geocryological process, and impact studies in the Russian arctic.

In August 2004 the Second PACE21 Field Workshop and Third Coordination Committee Meeting will take place at the University Courses on Svalbard (UNIS). Coordinators: Johan-Ludvig Sollid (University of Oslo) and Ole Humlum (UNIS). Theme: Permafrost geomorphological systems. Svalbard provides a critical combination of arctic permafrost within a mountain environment, and therefore offers

participants the opportunity to study at first hand geomorphological and geotechnical processes with both Arctic and Alpine contexts. A workshop will also be held at UNIS, with papers selected for publication.

In March 2005 the third PACE21 Workshop and Fourth Coordination Committee Meeting will take place at the Alfred Wegener Institute Potsdam, Germany. Coordinator: Hans Hubberten (AWI, Potsdam). Workshop Themes: Climate-permafrost interactions, including climate reconstruction, slope instability, coastal dynamics, methanogenesis in permafrost terrain and release of greenhouse gases.

Finally in September 2005 the Fifth PACE21 Coordination Committee Meeting will take place at Cardiff University, UK. Coordinator: Charles Harris. This meeting will provide a focus for final reporting of the PACE21 Network, and publication of research outcomes. The meeting will confirm the on-going data archiving strategy for permafrost monitoring in Europe and review realisation of objectives, including bilateral and multilateral research initiatives arising from PACE21.

The Network Convenor is Charles Harris, Cardiff University. The Coordinating Committee is: Michael Davies, University of Dundee, UK; Bernd Etzelmüller, University of Oslo, Norway; Mauro Guglielmin, University of Insubria, Italy; Wilfried Haeberli, University of Zurich, Switzerland; Ketil Isaksen, Norwegian Meteorological Institute; Hans Hubberten, Alfred Wegener Institute, Potsdam, Germany; Ole Humlum, UNIS, Svalbard; Matti Seppala, Helsinki, Finland; and Sarah Springman, ETH, Switzerland.

To register interest, and join the mailing list, please e-mail Charles Harris.

Charles Harris (harrisc@cardiff.ac.uk)

International Commission on Snow and Ice

The Bureau of the International Commission on Snow and Ice (ICSI) met in Paris, France, 11-12 March 2002. An important aspect relating to IPA concerns an expressed desire for the Commission to change its status within the International Union of Geodesy and Geophysics (IUGG). Among

the options studied is the possibility that ICSI becomes an Association on its own, rather than remain as a Commission within the International Association of Hydrological Sciences (IAHS).

IPA President Hugh French had previously met with ICSI President Gerry Jones in January of 2002 to discuss issues of mutual interest. During the summer of 2002, the EC approved the creation of a joint IPA-ICSI working group consisting of Roger Barry (USA), Jon Ove Hagen (Norway) and Wilfried Haeberli (Switzerland and representative of IPA within ICSI). The objective was to outline some background information and future directions for ICSI.

The roots of ICSI go back to glacier monitoring and snow research in the late 19th and early 20th century, i.e., to the visible surface components of the cryosphere rather than the less directly-observable subsurface ice in areas of daily, seasonally or perennially negative ground temperatures. The establishment of IPA in 1983 within IUGS changed the claim of ICSI and IUGG to embrace all aspects of the cryosphere. The corresponding separation into two organizations treating 'surface' and 'subsurface' ice at different structural levels and in different unions of ICSU can be seen by some as a drawback to the integrity of the science of ice. International efforts concerning serious global problems such as climate change (e.g. the Intergovernmental Panel on Climate Change, IPCC) or global environment-related observation (e.g. the Global Terrestrial Observing System, GTOS) increasingly call upon an integrated view of the various cryosphere components and their related processes within the earth system. Hence, there are many good reasons to develop initiatives to promote such integration. Climate-cryosphere models and impact studies, global terrestrial observation, natural-hazard assessments in cold mountains or deep hydraulic / geothermal effects from ice sheets and permafrost in connection with radioactive waste disposal are among the more obvious topics in the immediate future. Combined efforts in such fields could bring ICSI and IPA closer together and prepare the basis for increased cooperation.

The draft report of the working group was discussed by the IPA EC at its recent meeting in the UK in November. Three possibilities can be considered: 1) ICSI remains as a Commission within IAHS, 2) ICSI and IPA join together as

one body and 3) ICSI initiates actions to become a stand-alone Association involved with the interactions between snow, ice and permafrost. It was felt that the IPA permafrost community includes important engineering components and, hence, is broader than that involving just scientific research of snow and ice. At the same time, the IPA wishes to cooperate with ICSI in areas of mutual interest. The creation at Zurich in 2003 of a joint IPA-ICSI Working Group on glacier-permafrost interactions was one possibility raised in discussion. The idea of forming - in the more distant future - either an International Association of Cryospheric Sciences (IACS) or an International Association of Snow, Ice and Permafrost (IASIP) should be discussed and evaluated only in close contact with IPA. Such potential future evolution needs time and patience, because it involves complex strategic considerations and a difficult learning process about inter- and transdisciplinary science.

The EC recommends that the IPA maintains close links with ICSI. The IPA should attempt to strengthen cooperative efforts in the field of integrated cryosphere research and assessment, while promoting at the same time the identification of the scientific and engineering frozen-ground community within IPA. The IPA could take this opportunity to demonstrate its true international character by helping to find a practicable international administrative framework for all the snow, ice and permafrost components of the cryosphere. Appropriate steps are being discussed in the IPA EC and the issue will be further discussed by the IPA Council in July in Zurich.

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Hugh French (hfrench@science.uottawa.ca)

Climate Observing Systems

Renewed emphasis was made on the significance of cryospheric observations in the preparations for the Second Adequacy Report of the Global Climate Observing System (GCOS) Committee to the United Nations Framework Convention on Climate Change for the 2003 meeting of the Subsidiary Body for Scientific and Technical Advice, Conference of the Parties. These contributions were organized under the GCOS/

GTOS and its Terrestrial Observations Panel for Climate (TOPC).

Members Roger Barry and Wilfried Haerberli participated in several activities of the Terrestrial Observation Panel for Climate (TOPC). Wilfried Haerberli organised and presented the revisions to the snow, ice and permafrost variables at the TOPC meeting in Ispra, Italy, 25-27 June, 2002. Roger Barry and A Belward (TOPCs Chair) participated in the GCOS Experts meeting in Boulder, Colorado, 12-14 August, 2002. The broad objectives at these meetings as relating to the GCOS were to: support GCOS in the preparation of the Second Adequacy Report and to review and revise the TOPC Terms of Reference.

Efforts in Ispra concentrated on compiling a reduced list of key variables for monitoring the climate system. Clarity of scientific concepts as well as feasibility of adequate observational networks on time scales over the next decade played a primary role in the selection of variables. Snow, glaciers and permafrost received top ranking in the first round and corresponding written material was prepared for the Boulder meeting. The report on 'Glaciers and ice caps, Snow cover, and Permafrost,' prepared by W. Haerberli, R. Barry, J. Brown, S. Smith and M. Burgess, respectively, will be included in Annex 1 to the Second Adequacy Report on atmospheric, oceanic and terrestrial observing networks.

The Boulder meeting of IPCC and GCOS experts also stressed the importance of data exchange and of assembling historical data and updating archives with new observations. These activities can also make an important contribution to capacity building in the underdeveloped countries. The need for agreed standards for geophysical data collection, processing and products, as well as their documentation was emphasized. The final list of parameters and priorities assigned will feed into the terms of reference and long-term activities of the TOPC and GCOS/GTOS programmes.

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Wilfried Haerberli (haerberli@geo.unizh.ch)

Arctic Climate Impact Assessment Update

The Arctic Climate Impact Assessment (ACIA) is

an international project of the Arctic Council and the International Arctic Science Committee (IASC). The goal of ACIA is to evaluate and synthesise knowledge on climate variability, climate change, and increased ultraviolet radiation and their consequences. The aim is to provide useful and reliable information to the governments, organisations and peoples of the Arctic on policy options to meet such changes. Climate variability and change, and more recently, notable increases in UV radiation, have become important issues in the Arctic over the past few decades. The ACIA will examine possible future impacts on the environment and its living resources, on human health, and on buildings, roads and other infrastructure. Such an assessment is expected to lead to the development of fundamental and useful information for the nations of the Arctic region, their economy, resources, and peoples.

Members of IPA Working Groups are participating in preparation of several ACIA chapters. Steven Solomon (Canada) and Vladimir Romanovsky (USA) are contributing to Chapter 5: Cryosphere and Hydrologic Variability. Their assessment summarises the impacts of climate change on onshore, coastal and offshore permafrost, and the processes, which control the development and stability of permafrost. Included is a brief discussion of permafrost-related hydrate stability zone. Arne Instanes (Norway) is lead author for Chapter 15: Infrastructure, including Business/Industry, with input from Lev Khroustalev (Russia) and Branko Ladanyi (Canada) of the Engineering Working Group. Oleg Anisimov (Russia) of the Working Group on Global Change and Permafrost is contributing to the assessment as well as to the IPCC.

The following is a brief status report based on an ACIA Integration Team (AIT) meeting in Copenhagen 20-22 November 2002. The AIT was formed to oversee the integration process between the ACIA chapters and the members of this small group include the ACIA Executive, two lead authors, and the editor and graphics expert hired by the ACIA Secretariat. The Arctic Monitoring and Assessment Programme (AMAP), the Conservation of Arctic Flora and Fauna (CAFF), IASC and indigenous representatives were also at the meeting for a total of 18 persons.

Chapter drafts received from the lead authors underwent an initial internal review by

the AIT. This included a quick first review of all the chapters by the editor (Susan Hassol), and a more detailed technical review in which each AIT member reviewed one or more of the ACIA chapters. While there are still gaps in many of the chapters and there is some overlap between chapters, they are generally in good shape. Most of the chapters are between 60-100 single-space typewritten pages long, and in addition they have numerous illustrations. We expect the scientific report to be about 1,000 printed pages long.

A list of key findings from each chapter has been compiled and will form the basis of the overview or summary document, to be written by the editor and graphics expert. The policy document and the procedures leading up to them are the responsibilities of AMAP and CAFF. The next major steps for the scientific report are as follows:

By December 2002 all ACIA lead authors will have received review comments from the AIT reviewer assigned to each chapter.

January 13, 2003: The revised chapters are due at the ACIA Secretariat, to be put on the protected ACIA website and on a CD for distribution to all lead and co-authors.

March 24-28, 2003: A synthesis meeting will take place in the U.S., with the main purpose of interaction between the chapter authors (identifying remaining gaps, eliminating overlap, checking on consistency etc.)

July 4, 2003: The scientific report will be distributed by CD for external review.

Web: <http://www.acia.uaf.edu/>

*Gunter Weller, ACIA Secretariat
(gunter@gi.alaska.edu)*

SCANNET

The Scandinavian – North European Network of Terrestrial Field Bases (SCANNET) consists of field site leaders, research station managers and users groups in northern Scandinavia and Europe that are collaborating to improve comparative observations and access to information on environmental change in the North. SCANNET facilitates comparative, regional science activities seeking to identify, record and understand environmental changes around the North Atlantic.

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one internal meeting in Copenhagen in June and the second Annual Meeting in Iceland in October. At the Annual Meeting representatives from CAFF, CEON and IPS were present. An application for a circumpolar network of snow monitoring using automatic digital cameras was developed by SCANNET together with the IASC Tundra Taiga Initiative and submitted to AMAP. The circumpolar snow-monitoring network will also involve the Russian Indigenous Peoples organisation RAIPON. Climate Change scenarios for the SCANNET region were finished, and will be available soon on the SCANNET web page.

Web: www.scannet.nu

Hanne H. Christiansen (hhc@unis.no)

Circumarctic Environmental Observatories Network

The concept of a terrestrial Circumarctic Environmental Observatories Network (CEON) was introduced at Arctic Science Summit Week (ASSW) in 2000 at a meeting of the Forum of Arctic Research Operators (FARO). FARO members supported the CEON concept to promote the measurement of environmental observations and their dissemination to Arctic researchers whilst encompassing and building on the strengths of existing stations and environmental observatory networks within the Arctic. Since 2000, the CEON concept has received increasing support, including endorsement by the International Arctic Science Committee (IASC).

To date, CEON presentations have been made at various network meetings, research meetings, and polar boards in Europe, Russia and

the US in order to establish contact and obtain feedback from potential CEON stakeholder and user groups, and to scope and develop the CEON concept as an international initiative. Presentations have focused on the necessity for the CEON initiative to meet the needs of the participating research community, science administrators, policy makers, industry, education and indigenous communities whilst providing linkages between disciplines and existing networks and to provide connectivity from regional to circumarctic and global scales. Deliberately, presentations of the CEON concept have made no mention or suggestion of measurements or processes that should or could be made. Instead, audiences have been asked to introduce their own bias into the development of CEON by providing feedback to the following question: *"What would you do if you had the opportunity to conduct standardised long-term, integrated measurements across all research stations and networks in the Arctic?"* It is hoped that such an approach will facilitate the development and scope of CEON based on the experience, needs and future directions envisaged by a broad range of potential CEON stakeholder and user groups.

Excellent feedback and suggestions for the development of CEON have been provided to date. Suggested tasks that could be facilitated by CEON include:

- Organizing a common annual meeting and venue for participating stakeholder and user groups.
- Bulk acquisition and dispersion of standardized instrumentation (that promotes near-real time availability of data).
- Development of an Internet accessible methods manual, which could offer a central archive for various sampling, instrumental and operational methods practiced in the Arctic by different networks, collaborations and stations.
- Support for cross disciplinary/network/site education and knowledge exchange via the sponsoring of scholarships and research fellowships.

The scoping and development of the CEON initiative will continue throughout 2003, including production of a web page that will host generic CEON power point and poster presentations translated into different languages of the Arctic. It is also hoped that there will be an international workshop late in 2003 to formalize the CEON

initiative by drafting a science plan and creating a road map for its inception. The involvement of young people will play a significant role in this meeting. Preliminary planning for this workshop will take place at ASSW at Kiruna, Sweden in late March-April 2003.

The CEON initiative should not be seen as duplicating prior or ongoing research effort, but an international endeavor that aims at forming a logistic and research framework within which ongoing and future research can be oriented to cumulatively form and facilitate long-term research endeavors in the Arctic. For more information on CEON and to express your interest in CEON contact Patrick Webber (webber@msu.edu) or Craig Tweedie (tweedie@msu.edu).

Web:

ASSW 2003: www.polar.se/assw

FARO: www.faro-arctic.org

IASC: www.iasc.no.

Craig Tweedie (tweedie@msu.edu)

Third International Conference on Contaminants in Freezing Ground

Held in Hobart, Australia, in April, 2002, the Third Conference had 104 registrants - nearly twice that for the second (Cambridge, 2000) Conference. In association with the Conference, the Australian Government announced expenditures of AUS\$ 102 million for Antarctic conservation and science, which includes a significant increase for research and clean-up of contaminated Antarctic sites. The Canadian Department of Foreign Affairs and International Trade provided funds for all registrants to receive free copies of the three-part set of the Proceedings of the Second Conference.

Developments in technologies for remediation were discussed as well as striking microbacteriological research likely to prove of great significance for more effective bioremedial procedures. Also considered was the contribution to be made by Australian companies and research establishments, based on their Antarctic practical and research experience, to the extensive and costly contaminant problems in the Northern Hemisphere.

Peter Williams (peterjwilliams@lineone.net)

Publications

Earth Cryosphere

This multidisciplinary journal publishes papers and reviews within all aspects of the Earth Cryosphere. Chief editor, Academician the Russian Academy of Sciences, Vladimir P. Melnikov. Annual subscription is available for \$60 USD directly from the Editorial Board of the 'Earth Cryosphere' Russia, 117312, Moscow, Fersman street, 11, 2, 68. Fax: (095) 135-65-82. E-mail: kriozem@online.ru or for \$96 at: info@periodicals.ru, see also www.periodicals.ru.

Russian Permafrost Information Exchange

The Scott Polar Research Institute, Cambridge, UK, in collaboration with various Russian and other institutions has formally established its Russian Information Transfer Programme (www.spri.cam.ac.uk/resources/russian/). The Programme which operates on a cost-recovery basis, can also provide custom searches and analyses. Available works include: Yershov: General Geocryology (Cambridge University Press); the 16-sheet 'permafrost' atlas of Russia and Neighbouring Republics (includes English language explanatory folio volume, shortly to

appear in 2nd Edn.); and others relating especially to oil and gas transport and geotechnical issue generally (enquires: Isabella Warren, imtw1@cam.ac.uk). Articles from the Russian journal of permafrost studies, *Earth Cryosphere*, have been prepared for an English language trial issue of the journal.

CRYOFRONT

The electronic Journal of Cold Region Technology can be viewed at: www.members.shaw.ca/cryofront/cryofront.htm, where you find both recent and past issues and a compilation of cold region technology conference abstracts. Cryofront is an award winning electronic journal of cold region technology. Ken Johnson, M.A.Sc., P.Eng. is the publisher and editor of the journal, and may be reached at cryofront@shaw.ca. CRYOFRONT is published occasionally (and more if time permits), and distributed to an audience of over 700 cold regions technology practitioners around the world. Cryofront has been in publication since 1997. To subscribe to Cryofront, send an e-mail to cryofront@shaw.ca. Contributions and feedback are welcome, and the information has no copyright.

PERMAFROST AND PERIGLACIAL PROCESSES

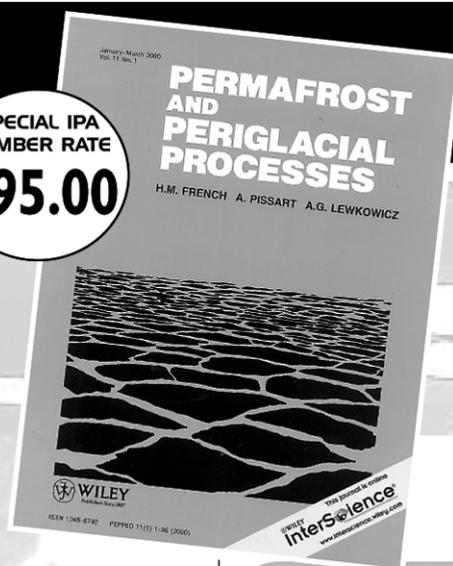
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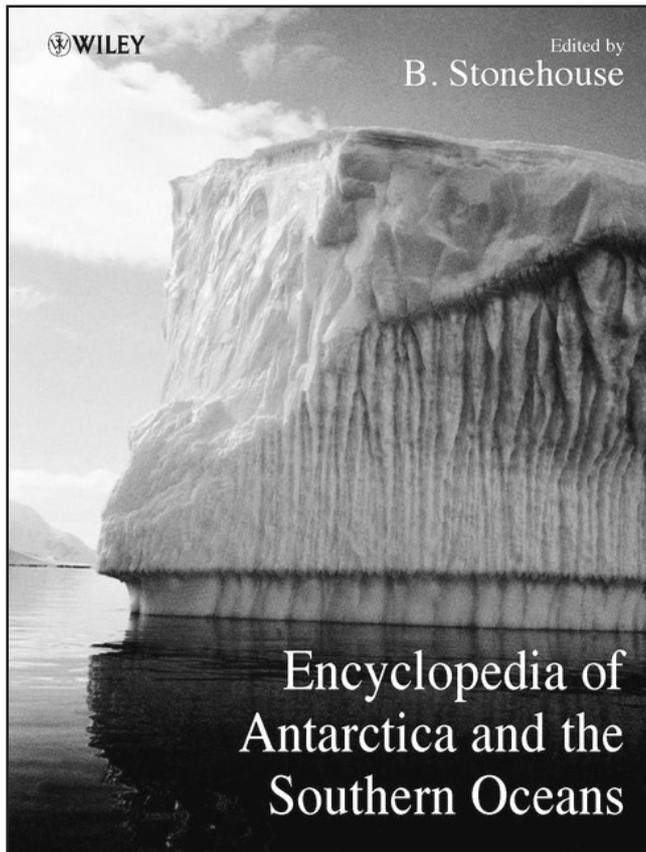
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Edited by B Stonehouse, Scott Polar Institute, UK. It has comprehensive coverage (over 1300 articles) on the history, geography and politics of Antarctica, compiled by a team of 28 international researchers who have worked in the area. John Wiley & Sons, 0471 986658, 360 pages, August 2002, £225.00/\$350.00.

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Forthcoming meetings

2003

Cryospheric Systems

13-14 January, Geological Society, London, U.K. Joint meeting of the British Geomorphological Research Group and the Quaternary Research Association. Contact: Charles Harris, harrisc@cardiff.ac.uk

Arctic-Alpine Ecosystems and People in a Changing Environment

24 February - 1 March, Tromsø, Norway. More information: www.npolar.no/arcticalpine2003/

Northern Contaminants Program Symposium: Canadian Arctic Contaminants Assessment

4-7 March, Ottawa, Canada. Contact information: www.inac.gc.ca/ncp

7th International Symposium on Mining in the Arctic

28 March - 4 April, Iqaluit, Nunavut, Canada. Contact: John E. Udd: judd@nrca.gc.ca

Arctic Summit Week

31 March - 4 April, Kiruna, Sweden. More information: www.iasc.no

33rd International Arctic Workshop

2-4 April, Norwegian Polar Institute, Tromsø, Norway. Contact information: www.npolar.no

Agriculture in Northern Ecosystems – Effects of Global Change on Soil Ecological Processes

2-4 April, University of Vechta, Germany. Contact information: gbroll@ispa.uni-vechta.de

European Geophysical Society-American Geophysical Union-European Union of Geosciences Joint Assembly

6-11 April 2003, Nice, France. Several sessions on cryospheric sciences including permafrost. More information: www.copernicus.org/egsagueug/index.htm

3rd Biannual Conference on Assessment and Remediation of Contaminated Sites in Arctic and Cold Climates

4-6 May, Edmonton, Alberta, Canada. More information: www.civil.ualberta.ca/arcsacc

Earth Cryosphere as a Habitat and an Object for Nature Management

19-21 May, Pushchino, Russia. Contact: David Gilichinsky: gilichin@issp.serpukhov.su

13th International Offshore and Polar Engineering Conference

25-30 May, Honolulu, Hawaii, USA. More information: www.isopec.org.

22nd International Conference on Offshore Mechanics and Arctic Engineering

8-13 June, Cancun, Mexico. Contact: Dr. W. L. Kuehnlein, Tel: 494069203240

Spanish Periglacial Workshop

25-27 June, San Ildefonso-La Granja, Spain. More information: www.ucm.es/info/IPAesp

Cryosphere-Climate Interaction Symposium at the IUGG 2003

7-8 July, Sapporo, Japan. More information: www.jamstec.go.jp/jamstec-e/iugg/index.html

8th International Conference on Permafrost

21-25 July, University of Zurich, Switzerland. See inside back cover for further information or www.geo.unizh.ch/ICOP2003/

XVI INQUA Congress

23-31 July, Reno, Nevada, USA. More information: www.dri.edu/DEESINQUA2003/inqua_home.htm

2nd Global Mountain Biodiversity Assessment Symposium on Linking mountain diversity with fire, grazing and erosion.

20-23 August, La Paz, Bolivia. More information: www.unibas.ch/gmba

7th International Symposium on Antarctic Glaciology

25-29 August, Milano, Italy. More information: www.disat.unimib.it/isag7

International Symposium on Antarctic Earth Science

8-12 September, Potsdam, Germany. More information: www.awi-potsdam.de/ISAES

Fourth International Conference on Arctic Margins

30 September – 3 October, Dartmouth, Nova Scotia, Canada. Contact: Ruth Jackson: rujackson@nrcan.gs.ca

Arctic Climate System Study (ACSYS) Final Conference

11-14 November 2003, St. Petersburg, Russia. More information: acsys.npolar.no/meetings/final/conf.htm

2004

4th International Conference on Contaminants in Freezing Ground

31 May – 4 June, Fairbanks, Alaska. More information: www.Freezingground.org/conference

32nd International Geological Congress

20-28 August, Florence, Italy. More information: www.32igc.org/default1.htm

International Symposium on Arctic Glaciology

23-27 August, Geilo, Norway. More information www.igsog.org

2005

Sixth International Conference on Geomorphology

7-11 September, Zaragoza, Spain. More information: wzar.unizar.es/actos/SEG

International Permafrost Association Council

December 2002

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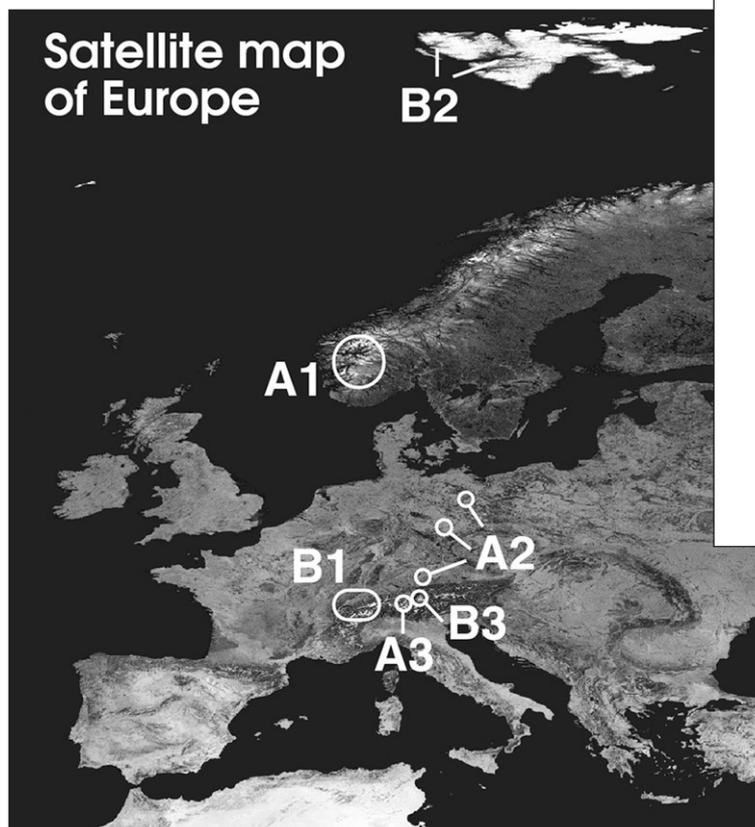
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8th International Conference on Permafrost. Zurich, Switzerland, 21 - 25 July, 2003

	Sunday 20 July	Monday 21 July	Tuesday 22 July	Wednesday 23 July	Thursday 24 July	Friday 25 July	
8.30 - 10.00		Registration	Oral sessions (3 parallel)	Oral sessions (3 parallel)	Oral sessions (3 parallel)	Oral sessions (3 parallel)	
9.00		Opening					
		Coffee 30 min.					
10.30 - 12.00		Plenary talks	Oral sessions (3 parallel)	Poster sessions	Plenary talks	Poster sessions	
		90 min. L U N C H					
13.30 - 15.00			Oral sessions (3 parallel)	Poster sessions	Excursion 'zurich by Ice'	Poster sessions	3 Reviews and discussions Plenary
	Coffee 30 min.		Coffee 30 min.				
15.30 - 17.00	IPA Executive committee meeting	IPA Council meeting	3 Reviews and discussions Plenary		3 Reviews and discussions Plenary	Closing ceremony IPA Council meet- ing, preparation field excursions	
17.30 - 19.00		Working group	Working group		Working group		
20.00 - 22.00	Ice breaker reception		Public lecture	Barbecue	Banquet		

Location of field trips:



Web page: www.geo.unizh.ch/ICOP2003/



IPA web site:

www.geodata.soton.ac.uk/ipa

Global Geocryological Database (GGD) and CAPS CD-ROM:

[nsidc.org/frozen ground/](http://nsidc.org/frozen%20ground/)

Global Terrestrial Network on Permafrost (GTN-P):

sts.gsc.nrcan.gc.ca/gtnp

Circumpolar Active Layer Monitoring (CALM):

www.geography.uc.edu/~kenhinke/CALM

Arctic Coastal Dynamics(ACD) Initiative:

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