World Data Center A consists of the Coordination Office and the following eight Subcenters:

**COORDINATION OFFICE**
World Data Center A
National Academy of Sciences
2101 Constitution Avenue, NW
Washington, DC 20418 USA
[Telephone: (202) 334-3358]

**GLACIOLOGY** (Snow and Ice)
World Data Center A: Glaciology
(Snow and Ice)
Cooperative Inst. for Research in Environmental Sciences
University of Colorado
Boulder, Colorado 80309 USA
Telephone: (303) 492-9171

**MARINE GEOLOGY AND GEOPHYSICS**
(Gravity, Magnetics, Bathymetry, Seismic Profiles, Marine Sediment, and Rock Analyses)
World Data Center A for Marine Geology and Geophysics
NOAA, E/GC3
325 Broadway
Boulder, Colorado 80303-3328 USA
Telephone: (303) 497-6487

**METEOROLOGY** (and Nuclear Radiation)
World Data Center A: Meteorology
National Climatic Data Center
NOAA, E/CC
Federal Building
Asheville, North Carolina 28801 USA
Telephone: (704) 259-0632

**OCEANOGRAPHY**
World Data Center A: Oceanography
National Oceanographic Data Center
NOAA, E/OC
1825 Connecticut Avenue, NW
Universal Building, Room 406
Washington, DC 20235 USA
Telephone: (202) 675-5594

**ROCKETS AND SATELLITES**
World Data Center A: Rockets and Satellites
NASA/Goddard Space Flight Center
Code 630.2
Greenbelt, Maryland 20771 USA
Telephone: (301) 286-7354

**ROTATION OF THE EARTH**
World Data Center A: Rotation of the Earth
U.S. Naval Observatory
Washington, DC 20392-3100 USA
Telephone: (202) 655-1529 or 1527

**SEISMOLOGY**
World Data Center A: Seismology
U.S. Geological Survey
Branch of Global Seismology and Geomagnetism
Box 25046, Mail Stop 957
Denver Federal Center
Denver, Colorado 80225 USA
Telephone: (303) 236-1500

**SOLAR-TERRESTRIAL PHYSICS** (Solar and Interplanetary Phenomena, Ionospheric Phenomena, Flare-Associated Events, Geomagnetic Variations, Aurora, Cosmic Rays, Airglow)
World Data Center A for Solar-Terrestrial Physics
NOAA, E/GC2
325 Broadway
Boulder, Colorado 80303-3328 USA
Telephone: (303) 497-6354

**SOLID-EARTH GEOPHYSICS** (Seismicity, Earthquake Strong Motion, Tsunamis, Gravimetry, Earth Tides, Recent Movements of the Earth's Crust, Magnetic Measurements, Paleomagnetism and Archeomagnetism, Volcanology, Geochemistry)
World Data Center A for Solid-Earth Geophysics
NOAA, E/GC1
325 Broadway
Boulder, Colorado 80303-3328 USA
Telephone: (303) 497-6521

World Data Centers conduct international exchange of geophysical observations in accordance with the principles set forth by the International Council of Scientific Unions. WDCA is established in the United States under the auspices of the National Academy of Sciences. Communications regarding data interchange matters in general and World Data Center A as a whole should be addressed to World Data Center A, Coordination Office (see address above). Inquiries and communications concerning data in specific disciplines should be addressed to the appropriate subcenter listed above.
DESCRIPTION OF THE WORLD DATA CENTER SYSTEM

The World Data Centers (WDCs) were established in 1957 to provide archives for the observational data resulting from the International Geophysical Year (IGY). In 1958 the WDCs were invoked to deal with the data resulting from the International Geophysical Cooperation 1959, the one-year extension of the IGY. In 1960, the International Council of Scientific Unions (ICSU) Comite International de Geophysique (CIG) invited the scientific community to continue to send to the WDCs similar kinds of data from observations in 1960 and following years, and undertook to provide a revised Guide to International Data Exchange for that purpose. In parallel the CIG inquired of the IGY WDCs whether they were willing to treat the post-IGY data; with few exceptions, the WDCs agreed to do so. Thus the WDCs have been serving the scientific community continuously since the IGY, and many of them archive data for earlier periods.

In November 1987 the International Council of Scientific Unions (ICSU) Panel on World Data Centers prepared a new version of the Guide to International Data Exchange, originally published in 1957, and revised in 1963, 1973 and 1979. The new publication, Guide to the World Data Center System, Part 1, The World Data Centers (General Principles, Locations and Services), was issued by the Secretariat of the ICSU Panel on World Data Centers. This new version of the Guide contains descriptions of each of the twenty-seven currently operating disciplinary centers, with address, telephone, telex, and contact persons listed. The reader is referred to the new Guide for descriptions of the responsibilities of the WDCs, the exchange of data between them, contribution of data to WDCs, and the dissemination of data by them. The WDCs for Glaciology are listed below.

World Data Center A for Glaciology [Snow and Ice]

Address: WDC-A for Glaciology
          CIRES, Campus Box 449
          University of Colorado
          Boulder, Colorado 80309-0449
          USA

Telephone: (303)492-5171
Telex: 7401426 WDCA UC
Telefax: (303)492-2468
Network Address: [NSIDC/OMNET] MAIL/USA VAX Mail (via SPAN) KRYOS::NSIDC
Director: Dr. R. G. Barry

World Data Center B1

Address: World Data Center B1 for Glaciology
          Molodezhnaya 3
          Moscow 117296
          USSR

Telephone: 130-05-87
Telex: 411478 SGC SU
Director: Dr. V. I. Smirnov
World Data Center C for Glaciology

Address: WDC-C for Glaciology
Scott Polar Research Institute
Lensfield Road
Cambridge CB2 1ER
UNITED KINGDOM

Telephone: (0223)336558
Telex: 81240 CAMSPL G
Network Address: (JANET)ADM13@UK.AC.CAMBRIDGE.PHOENIX
Manager: Mrs. Ailsa D. Macqueen

World Data Center D for Glaciology [Snow and Ice] and Geocryology

Address: Lanzhou Institute of Glaciology and Geocryology
Chinese Academy of Sciences
Lanzhou 730000, China

Telephone: (86)0931-26725, ext. 308
Director: Professor Xie Zichu

The following organization provides international data services including data analyses and preparation of specialized data products. It merges the previous activity of the Permanent Service on the Fluctuations of Glaciers and the Temporary Technical Secretariat for World Glacier Inventory. These activities are not part of the WDC system but the center cooperates with WDCs in the discipline. Users wishing assistance in seeking data or services from this group may contact an appropriate WDC.

World Glacier Monitoring Service (WGMS)

Dr. W. Haeberli
Section of Glaciology
VAW/ETH, ETH Zentrum
8092 Zurich
SWITZERLAND

FOREWORD

In 1979 the WDC undertook an inventory of ice core data and completed a bibliography of selected literature references. In view of the growing interest in the paleoclimatic records contained in ice cores, as expressed in the International Geosphere Biosphere Program plans, this issue provides an updated inventory and bibliography. We are grateful to the National Geophysical Data Center which supported this activity through their Paleoclimate Program.

Climate trends can also be extracted from ground temperature profiles in permafrost areas. The availability of information and data on permafrost, thermal regimes and ground ice was the subject of a workshop organized by WDC-A for Glaciology in August 1988. Summaries of the workshop reports and associated recommendations are also included in this issue.

Roger G. Barry
Director
WDC-A for Glaciology
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ICE CORE INVENTORY

The analysis of ice core data has proven to be one of the most accurate methods to describe past climates. Climate change can be evaluated in terms of air temperature, snow accumulation rate, atmospheric constituents, terrestrial volcanic and cosmic fallout, and human impact. Deep ice cores from polar regions are truly key data sets in paleoclimate studies because they bridge the time-scale gap between instrumental and proxy records with annual resolution (e.g. tree rings) and those data from ocean and lake sediments which have resolutions of hundreds to thousands of years. Global ecosystems are typically affected more by the rate of climate change than by the eventual magnitude of the change. The period of record and time scale resolution of ice core data provide an excellent basis for the study of rapid fluctuations in the global environment over the past 200,000 or more years.

The ice core tables which follow update the inventory which was published in Glaciological Data, Report GD-8, in 1980. They document the ice cores reported in the literature between 1979 and mid-1989.

The tables, listing over 150 individual cores, are grouped into six geographical areas: 1) North America, 2) Greenland, 3) Europe, 4) Asia, 5) Southern Hemisphere, excluding Antarctica, 6) Antarctica. Within areas, the listings are arranged alphabetically by site name. Each core listing includes site name, year core taken, location (lat.-long.), core depth, drill type, drilling and curating agency. The reference column refers the reader to the complete citation in the Author Listing of the Ice Core Bibliography (beginning on p.55) from which the core information was extracted.
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ICE CORE BIBLIOGRAPHY, 1980-1989

This bibliography provides a supplement to "Ice Cores: A Selected Bibliography" published in Glaciological Data, Report GD-8, in 1980. The references are divided into nine subject categories. They are:

- Chemistry
- Physical and Mechanical Properties
- Drill Technology
- Radio Isotopes
- General
- Stable Isotopes
- Miscellaneous Related Topics
- Trapped Gas Composition
- Particulates

An alphabetical list by first author is also provided.

We have attempted to be as comprehensive as possible by searching a variety of data sources and using broad subject categories. The major on-line sources searched are:

- COLD (Bibliography of Cold Regions Science and Technology)
- GEOREF
- GEOARCHIVE
- NTIS (U.S. National Technical Information Service)
- Dissertation Abstracts
- Compendex (Engineering Index)
- Meteorological and Geoastrophysical Abstracts
- CITATION (WDC/NSIDC).

Because we do not have all of the original material in hand, we cannot be certain of the completeness of each citation. However, every effort has been made to ensure accuracy.

We would appreciate your comments on the bibliography - on references we have not included, sources not searched, or subject areas not adequately covered. We plan to keep this bibliography up-to-date and your suggestions are welcome.

Ann M. Brennan
Compiler
CHEMISTRY


CHEMISTRY (Cont.)


CHEMISTRY (Cont.)


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CHEMISTRY (Cont.)


Zanolini, F. (1987) Conductimétrie et chimie de la glace a D57 (Terre Adélie); application a la recherche du paléovolcanisme. (Conductivity and chemical measurements along the ice core from D57 (Adélie Coast); application at the study of the paleovolcanism.) Bulletin - Programme Interdisciplinaire de Recherche sur la Prévision et la Surveillance des Eruptions Volcanique, vo.7, 84p. CNRS-NS 19407.

DRILL TECHNOLOGY


DRILL TECHNOLOGY (Cont.)


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GENERAL


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New York State University, Buffalo. Ice Core Storage Facility and Information Exchange. (1983) Ice Core Samples from Greenland and Antarctica. 49p. WDC No. 83002101.


GENERAL (Cont.)


MISCELLANEOUS RELATED TOPICS


PARTICULATES


PARTICULATES (Cont.)


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PHYSICAL AND MECHANICAL PROPERTIES


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PHYSICAL AND MECHANICAL PROPERTIES (Cont.)


Physical and Mechanical Properties (Cont.)


Radio isotopes


RADIO ISOTOPES (Cont.)


RADIO ISOTOPES (Cont.)


RADIO ISOTOPES (Cont.)


STABLE ISOTOPES


STABLE ISOTOPES (Cont.)


STABLE ISOTOPES (Cont.)


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Thompson, L.G. (1979) Glaciology of the Peruvian Quelccaya Ice Cap. Sociedad Geologica del Peru. Bolitin, 63, p.149-158. WDC No. 85000998.


STABLE ISOTOPES (Cont.)


TRAPPED GAS COMPOSITION


TRAPPED GAS COMPOSITION (Cont.)


TRAPPED GAS COMPOSITION (Cont.)


TRAPPED GAS COMPOSITION (Cont.)


AUTHOR LISTING


New York, State University, Buffalo. Ice Core Storage Facility and Information Exchange. (1983) Ice core samples from Greenland and Antarctica. 49p. WDC No. 83002101.


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Samoilov, O.IU.; Zagorodnov, V.S. (1985) Raspredelenie raditsionnykh kerok v ledianom kerne iz skvazhini na Starstii Komosemol'skii kak pokazatel' paleoklimaticheskih uslovi. (Distribution of radiation crusts in ice cores from the Komosemol'skaya Station well as indication of paleoclimatic conditions.) Akademiia Nauk SSSR. Institut Geografi. Materialy Gliatiologicheskih Issledovanii, no.54, p.204-208. WDC No. 86001466. CRREL No. 40003930.


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Zanolini, F. (1987) Conductimétrie et chimie de la glace a D57 (Terre Adélie); application a la recherche du paleovolcanisme. (Conductivity and chemical measurements along the ice core from D57 (Adélie Coast); application at the study of the paleovolcanism.) Bulletin - Programme Interdisciplinaire de Recherche sur la Prévision et la Surveillance des Eruptions Volcanique, vol.76, 84p. CNRS-RS 19497.


GREENLAND ICE SHEET PROJECT (GISP2)

The National Snow and Ice Data Center (NSIDC) has received a small grant from the National Science Foundation Division of Polar Programs to provide data management services for the Greenland Ice Sheet Project (GISP2). GISP2 represents the renewal of the seven year GISP1 program which ended in 1983 and produced a 2037 m deep ice core (70,000 year record) at the location Dye 3 in southeastern Greenland. The GISP2 drill site is located in central Greenland where the depth to bedrock is estimated to be 3100 m which could provide a stratigraphic record of 200,000 or more years. The first field season for GISP2 was successfully completed during the summer of 1989.

THE STUDY OF NATURAL CLIMATE VARIABILITY: A NOAA PROGRAM IN PALEOClimATOLOGY

The National Oceanic and Atmospheric Administration (NOAA)/National Geophysical Data Center (NGDC) program has two components (1) establish and build the global paleoclimate database, and (2) carry on a research program to use the developing data base for the study of global climate change. NGDC has already made significant progress on the first component. To date numerous data sets of paleoclimate information have been assembled from ice cores, lake and marine sediments, tree rings, and historical information. Building the global database will continue to be important during the life of the program. The task of intercomparing and merging these various data sets for global climate reconstructions is just beginning and will become an increasing focus of the program during FY90 and FY91. In cooperation with other NOAA line offices and U.S. academia, within 3-5 years we expect to achieve significant improvements in the global description of the effects of annual- to century-scale climate change; to identify and better understand the causes of the climate change; and to do a significantly better job of separating man-induced climate change from the natural variability.
The FY90 program will achieve its objectives by: recruiting a senior paleoclimatologist; a visiting scientist program; sponsoring one or more relevant workshops; establishment of a newsletter and a publications series; and sponsoring an extramural program. NGDC proposes to implement a data management system and facility that will allow the rapid retrieval and superposition of data sets of various kinds, and provide a much needed resource to the paleoclimate research community.

The FY90 program provides resources to the university community to encourage them to "clean up" data sets collected over the years under various projects so that the data can be made available to the whole community through NGDC. Most of these proposed activities are leveraged and several are combined with "good science" focused primarily on the study of climate fluctuations of the Holocene of North America. Working with the National Science Foundation and other agencies, NOAA will complement activities funded by those agencies by supporting more applied research, and data validation and documentation tasks, so as to benefit the whole community, and help the overall mission of the NOAA Climate and Global Change Program.
ICE CORE DATA

DATA ANNOUNCEMENT

ICE CORE DIGITAL DATA SETS

1. Dye 3 $\Delta^1^H^O$.

$\Delta^1^H^O$ versus depth data are available for the 2000-meter ice core drilled at Dye 3 in Southern Greenland during 1979-1981. In this data set, produced by the Geophysical Institute at the University of Copenhagen, $\Delta^1^H^O$ values recorded are the mean of all samples between a given depth and the previous data point, towards the surface of the ice sheet. All depths are measured along the core according to the main core log; depths are not corrected for topographic effects upstream.

The data are archived on one IBM PC-type double-sided, double-density diskette, in one file containing 16770 ASCII characters. The data format is five columns of depth - $\Delta^1^H^O$ pairs, with a physical record length of 100 characters. The data are available on one diskette, on one computer-compatible magnetic tape, or as a paper listing.

References:


2. Ice Core Microparticle Analysis.

Microparticle analyses were performed on ice samples obtained by core drilling at locations in Peru, on Mount Kenya, in Antarctica, and in Greenland. Data include number of particles in each of 15 size ranges. Each file contains data for a different ice core: Quelccaya Ice Cap 1976; Quelccaya Ice Cap 1977; Lewis Glacier, Mount Kenya; Byrd Station 2164-meter core; Camp Century 1387-meter core.

Data are archived on one reel of computer-compatible tape.

References:


January 1987 (rev. 10/89)

World Data Center-A for Glaciology [Snow and Ice]/National Snow and Ice Data Center
National Geophysical Data Center, NOAA
Boulder, Colorado 80303


3. Svalbard (Spitsbergen) Cores: Chemical Analyses and Stratigraphy.

Svalbard ice core data received from the Institute of Geography, Soviet Academy of Sciences, are now available on IBM PC-compatible diskette. The data are stored in three text (ASCII) files and contain annual layer thickness and chemical analysis data.

A. Lomonosovfonna Ice Core, West Spitsbergen

Borehole location: 78° 44′ N, 17° 34′ E
Surface elevation: 1020 m a.s.l.

This file contains the annual layer thicknesses measured in Lomonosovfonna ice core (West Spitsbergen) in 1982. The borehole drilled by V. Zagorodnov reached bedrock at 135 meters. Annual layers were determined by the stratigraphic method; all thicknesses are in centimeters of ice (0.90 g/cc). The second column contains the original values measured in the ice core. The third column contains values corrected for thinning with depth and density changes, smoothed to a three-year mean.

B. Austfonna Ice Core, Nordaustlandet, Svalbard

Borehole location: 78° 51′ N, 24° 08′ E
Surface elevation: 750 m a.s.l.

The borehole was drilled by V. Zagorodnov at the summit of the Austfonna at Nordaustlandet, Svalbard, in July 1987. Bedrock was reached at 566.7 meters. The first column contains depths by one meter steps. The second column contains ice age calculated by measurements of thinning of infiltration ice layers with depth. The third contains percentage of infiltration ice content, that correlates well with mean summer (June - August) temperature. The lowermost 60 meters of the core consist of 100% infiltration ice.

C. Austfonna Ice Core Chemical Data, Nordaustlandet, Svalbard

This file contains data on chemical composition of ice samples from the 1987 Austfonna core (566 meters from surface to bottom), drilled by V. Zagorodnov and processed by S. Arkhipov (both from Institute of Geography). All concentrations are in milligrams per liter of water. Values given are depth (meters), pH, HCO₃, and Cl.

References


DISTRIBUTION AND COST

Computer tapes are available at a cost of $60.00 per reel. Tapes are 9-track, unlabelled, and may be requested as 1600 or 6250 bpi, ASCII or EBCDIC. IBM-PC compatible diskettes containing ASCII files are available at a cost of $25.00 per diskette. Paper listings of the Dye 3 Δ18O data are available for $25.00 each.

To Order Data

Prices shown are effective through September 30, 1990; please inquire for a current price quote. Prepayment, or a written purchase order, is required. Please make check or money order, in U.S. dollars, payable to University of Colorado, WDC/NSIDC. Telephone orders are accepted with written confirmation.

For further information, or to place an order for data, call or write:

World Data Center-A for Glaciology (Snow and Ice)
National Snow and Ice Data Center
CIRES, Box 449
University of Colorado
Boulder, Colorado 80309
U.S.A.
Telephone: (303) 492-1834 or (303) 492-5171
Telex: 7401426 WDCA UC
Telemail: [NSIDC/CMNRT] MAIL/USA (Attn: Data Request Services)
VAX Mail KRYOS: NSIDC via SPAN
FAX: (303) 492-2468
1. OVERVIEW

Information on permafrost phenomena is collected for a wide range of purposes by many different groups of specialists. The vast extent of the published literature — 4400 entries appear in the 1973-82 bibliography compiled for the Fourth International Conference on Permafrost and an additional 4000 citations in the update prepared for the Fifth — is illustrative of the potential magnitude of the related data sets. Measurements range from field observations of permafrost-related features, to surface and borehole data on physical properties of frozen ground and geophysical surveys, and laboratory experiments or tests. Remote sensing is now adding new types of data on frozen ground conditions.

Up to now, there are only isolated examples of organized national programs to collect, standardize and archive permafrost-related data. Planning for new international activities such as the International Geosphere Biosphere Programme (IGBP) calls for monitoring global change in areas sensitive to climatic or anthropogenic disturbances. The sensitivity of permafrost conditions to such changes is well recognized. However, the IGBP requirements imply a need to develop integrated global archives of permafrost-related variables suitable for use in multi-disciplinary research. In an attempt to assess the current status of bibliographic and numerical data bases on permafrost, ground ice, and thermal regimes, a Workshop on Permafrost Data and Information was organized by the World Data Center-A for Glaciology (Snow and Ice) in conjunction with the Fifth International Conference on Permafrost held in Trondheim, Norway. Approximately 50 participants from nine countries discussed the availability of, and needs for, inventories and catalogs of existing data sets and developed recommendations for future activities in these areas. A summary of the reports contributed to the Workshop and the list of recommendations is presented here.

R. G. Barry
### 2. PARTICIPANTS

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3. REPORT SUMMARIES

3.1 Permafrost Research and Global Change
A. Lachenbruch, USGS, Menlo Park

Data are collected with regard to a problem: A key problem is "Global Change". Study of changing permafrost regimes involves:

1) observation of the thermal regime in permafrost — various data types,
2) extraction of information to develop models,
3) prediction.

The necessary observations are air, surface interface, ground temperatures and heat fluxes across the boundaries. Data are required with approximately 50 km spacing. Measurements should include:

1) 20 m temperature ($\Theta_{20}$) record. Below 15 m there is no annual cycle, therefore, this indicates long-term trends and approximates the mean annual air temperature. The 20 m temperature record contains lags due to past climatic events. A precision of 0.1°C is required in the measurements of $\Theta_{20}$.

2) Depth $\Delta Z$ to bottom of permafrost = 0°C depth ($\Theta_0$). This is required to obtain a linear approximation to surface temperature, $T_s$ ($\Delta 0.1°C = 3$ m depth of permafrost). A precision of 0.1°C in $\Theta_0$ is required. i.e., three measurements $\Theta_0$, $\Theta_{20m}$, and $\Delta Z$ are essential.

For climatic change determinations, temperature observations at 10 m intervals are needed to get $\Delta T/\Delta t$. Note that a borehole takes time to drill, and attainment of the equilibrium temperature requires time = $\ln (1 + 1/\tau)$, where $\tau$ = time in years.

Water content of materials provides information on thermal properties and is easier to measure; thermal conductivity is very important for heat flux.

For monitoring purposes: borehole temperatures are required at successive times to 0.01°C precision.

Reference

3.2 Permafrost Studies in China
Dr. Qui, Lanzhou

Recent activities in permafrost research in China include:

1. Current research involves field observations, airphotos, and Landsat images. On this basis, a map of snow, ice and permafrost in China (1:4 m scale) has just been published.
2. A new station has been established in Xinghai Xizang (Western foot of Kunlun Mountains); its program will involve: monitoring frozen ground trends related to environmental factors, frozen ground dynamics and periglacial features, and engineering problems.
3. A new Laboratory of Frozen Soils and Engineering is to be established by 1992; it will be open to all scientists. Research will address heat/mass transfer, frost heave, strength, rheology of permafrost, and engineering models.
4. A data library will be established at the Station and in the Laboratory.
5. The Chinese Society of Glaciology and Cryopedology held conferences in 1978 and 1981 in Lanzhou and 1986 in Harbin; approximately 450 papers were presented of which approximately 200 were published; the 4th Congress at Lanzhou was held in Fall 1988.

The Journal of Glaciology/Cryopedology has to date published 600 papers of which approximately 300 are permafrost-related.

Future Plans:

1. Establishment of a National Permafrost Data Center*;
2. Standardization of data collection, processing, and terminology;
3. Organization of data banks;
4. Enlargement of international cooperation.

*Editor's note: World Data Center-D for Glaciology (Snow & Ice) and Geocryology, directed by Professor Xie Zichu, has been formed at the Lanzhou Institute of Glaciology and Geocryology.
3.3 Permafrost Studies in the USSR
Dr. N. Grave

Research in the USSR includes preparation of permafrost maps and collection of geotechnical data. Seasonal layer temperatures are being used to determine heat balance on site.

The difficulty presented by the publication of data and information in many languages is recognized. The USSR plans to publish a new Geocryology quarterly journal, in English, part of which will be devoted to data aspects.

The lack of a common system of data collection is also a concern. Soviet workers will be glad to participate in such a system when it is established. They are already cooperating with WDC-A for Glaciology in bibliographic activities on permafrost literature.

3.4 A review of permafrost data in Canada
A. Heginbottom, Geological Survey of Canada

It is important to understand the distribution of permafrost and ground ice with regard to geology, geography and other environmental factors. How do we map permafrost? This task is less amenable to the direct application of numerical data, since it requires interpretation. These are problems of access to information — especially for the USSR and China.

Issues: 1. a data base - comprises a machine-compatible spatial collation (latitude, longitude, altitude) - retrievable by computer searches.

2. data collection - typically paper records; labor intensive and less well indexed - but the technology does not run the risk of becoming outdated.

Examples for Canada: A summary is presented in Table 1. Several points may be noted.

Temperature data: Are held in a data bank at Geological Survey of Canada. Data up to 1983 (published as lists also) are in the public domain.

Geotechnical data: Archived (in 1970s) but not well indexed. Published, then withdrawn, and not re-issued.

Canadian Private Sector: Geotechnical data, most in CCT format. These are largely proprietary systems, ("Corporate Gold"); ownership of the data may be crucial for future resource exploitation
needs. These collections include seismic data, EM sounding, georadar profiles, acoustic data, and
geology/geomorphology information, not easily handled, or distributed.

Site Specific Data — for routes, sites. Often proprietary and different systems, so data cannot be readily exchanged.

Defunct Projects - For example, the Mackenzie Valley pipeline consortium collapsed. In theory the data are held by the Arctic Institute of North America (AINA) but are not well indexed.

Individual researchers - Some data are held by Atmospheric Environment Service (AES), and could be made accessible.

Adequacy of Bibliographic Information

Permafrost Conference - The Conference volumes are valuable sources because they include papers not just proceedings; there is a problem of locating thematic information across the different volumes - Heginbottom provided an index to 1983 but this needs extending as there are now many other national conferences.

*RECOMMENDATION - Prepare a listing of current Permafrost reports (on a worldwide basis).

Bibliographies are provided by Glaciological Data, GD 14 & 21, and earlier by the Arctic/Antarctic Bibliographies, but GD 14 (1983) was not very conveniently indexed and a similar system was used for GD 21; specifically, the user has to identify the correct key-word or search by author. The GDs and other publications should provide a regional index, but will this effort be cost effective. Is this a possible role for the International Permafrost Association?

Translations - In Canada this is an increasing problem. Funds/staff have dried-up except for the private sector. The former National Research Council (NRC) staff Technical Translator retired. As a result, North American papers cite few Russian/Chinese references - or only old pre-WWII ones. There is a need for better indexing, and storing of permafrost information and data, both national and international, for the major languages; there is also a need to develop protocols for data and information formats.

Reference

<table>
<thead>
<tr>
<th>Type of Data Collected</th>
<th>Bibliographic; Terminological; Geographical; Geological; Field; Geothermal; Mechanical; Chemical; Laboratory; etc.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Purpose of Data Collection</td>
<td>Design/Construction Planning; Environmental Assessment; Research; Reference; Combinations of the above.</td>
</tr>
<tr>
<td>Ownership of Data Collections</td>
<td>Federal Government; Department/Agricultures; Provincial/Territorial Government Agencies; Universities; Consultants: commercial/university; Oil Companies; Mining Companies.</td>
</tr>
<tr>
<td>Availability of or Access to Data</td>
<td>Published; Public Domain; Proprietary: available at a price or not available; inactive: available or not available.</td>
</tr>
<tr>
<td>Form of Data Storage</td>
<td>Machine Readable: magnetic tape or disks/diskettes; Paper Copies.</td>
</tr>
<tr>
<td>Specifications of Data Collections</td>
<td>Format; Content; Age; Currentness; Indexing; Reliability.</td>
</tr>
<tr>
<td></td>
<td>Variable: to be assessed case by case.</td>
</tr>
</tbody>
</table>
3.5 Permafrost data at the U.S. Geological Survey
B. Molnia, USGS, Reston, VA

The USGS is clearing house in order to systematize and make available data from its various divisions. It is also spearheading the Arctic Environmental Data Directory project.

The USGS was established in 1880. Today there are approximately 200 personnel involved in Arctic research, but only 70-100 active in Arctic fieldwork. Where are the results of this 100 years of data collection? - most have disappeared!

Each of the major Divisions of USGS: Geologic, National Mapping, Water Resources - has its own philosophy and system for data handling. The National Mapping Division operates the National Digital Cartographic Data Base and the National Cartographic Information Center for topographic and geologic maps. Water Resources Division provides annual reports for drainage basins, etc. that are incorporated in a digital data base called WATSTORE. The Geological Division - has most data, including hundreds of holdings, but these are least well identified. Data Levels are defined as 0 = Rock Samples, up to level 4 = digital spatial arrays.

**ACTIVITIES:**

1. USGS is compiling a Data Directory, the Earth Science Data Directory (ESDD). The contents will include type, time of collection, number of records, contact person and telephone number.

2. There is a parallel activity by the Interagency Policy Group. A plan is in effect to use the Earth Science Data Directory (ESDD) and NOAA/NEDRES as components of a Directory for all Arctic environmental information (Laughlin, 1988). It will provide interactive access to the Directory; PC-compatible software is available for the ESDD.

**Reference**

3.6 Permafrost data at the Cold Regions Research and Engineering Laboratory (CRREL)
V. Lunardini, U.S. Army, CRREL

There is not only a data explosion from many recent laboratory and field strides but also a data implosion into archives. Once deposited in the archives the data are often virtually useless. CRREL permafrost data are buried in files— which would require a huge effort to locate and to interpret.

Engineering aspects. We need: 1. measurements; and, 2. theory on the thermal conductivity (K)— in contrast to metals, and other engineering materials permafrost is hard to characterize. We need a comprehensive data base of K as functions of temperature and soil systems incorporating the known data and highlighting the gaps. The value of thermal conductivity near the freezing point is particularly sensitive to temperature and difficult to characterize for purposes of design or calculation.

Statistics have been compiled on the CRREL bibliography which contains 160,000 (160 K) titles (80 K English, 46 K Russian, 5 K German, 3 K French, 1 K Spanish, 1 K Chinese). Of these, Permafrost accounts for 13 K items (8.5 K Russian, 4.5 K English). For major subtopics, the total numbers are as follows: temperature, 1545; thermal properties, 878; climate, 300; area, 555; depth, 928; frozen ground, 4986.
3.7 Field Measurements
T. Osterkamp, Geophysical Institute, University of Alaska

A number of questions need to be addressed.

1. We need to determine how permafrost has responded, and is responding, to climate change. In relation to this question, what are the rates of change of the permafrost thickness, areal extent, etc. in places where permafrost is actively changing? Numerous factors are involved: a) climate; b) ecology; c) hydrology; d) oceanography; e) others. How are they coupled? e.g., sea level change affects subsea permafrost; thawing affects tundra lakes, anthropogenic - resource extraction modifies permafrost. An evaluation of available data is required, e.g., Alaskan data exist from late 19th Century. We need to determine rates of change of permafrost thickness and areal extent, in places undergoing active change.

2. What are the fluxes of heat, moisture, nutrients and other chemicals, and gases in the active layer and permafrost? How are these fluxes coupled?

3. New methods will be required for in situ measurements of unfrozen water content, salt content, and thermal properties in drillholes.

4. We still need to develop analytical and numerical methods for interpreting temperature and other flux measurements in the active layer and permafrost.

Equipment needs include a reliable continuous field logger, plus long-term automatic measurements (ideally, we should be able to service instruments 1/year in July). Remote plus in situ methods for borehole observations; properties - water, salt content. Can we get active layer thickness remotely; date of freezing, etc?

Problems:

1. Cooling observed 1983-87 at Prudhoe Bay dock is possibly a result of temperatures declining from the 1981 high. The change in temperature profile in degrading permafrost is because of the latent heat effects associated with the presence of unfrozen water. Current analytical models are inadequate.

2. Shallow permafrost - appears to be thawing from the top down. Societal effects include the effects of thaw on roads and buildings - research is needed to minimize such effects.
3. Soil salinities in Alaska are 5-10 times greater than expected. Offshore permafrost in particular is more complex due to salt effects. Active layer may be 2-3 m thick, in contrast to adjacent land locations. What is the role of salt fingers?

3.8 Engineering Aspects
T. Vinson, School of Engineering, Oregon State University, Corvallis

Climate related aspects involve: boundary conditions of site, snow depth, vegetation, and hydrology.

Engineering-related aspects involve particularly density and ice content. Mechanics - We need a classification for N. America and elsewhere concerning chemistry of pore ice, fluid, thermal characteristics and creep characteristics [a standard test procedure is required], creep strength. One test procedure has been standardized - but previous measurements may not reflect that standard, therefore it is difficult to use them from an engineering point of view; active layer - frost - heave, thaw imply weakening of soil strength.

Researchers need:

1. a recognized classification system;
2. test procedure standards (recognized/referenced);
3. collection/transmission of data - (costs aspect needs to be resolved);
4. information on the statistical significance of measurements.
3.9 Data Design Questions
M. J. Clark, Department of Geography, University of Southampton

There are several data analysis issues. Post-acquisition processing and analysis often incorporates a model. Calibration is a concern; we need to know the representativity of any data collected. Sampling design questions have received little attention.

Possible solutions:

1. Ideally, we desire instrumental observations as they give better data archives.

2. We need to create an interest in methodology and aim for realistic targets.

3. Existing data sets must be assembled - codify and amplify how collected; Can IPA "standards'/guidelines be developed?

4. For data assembly - WDC-A for Glaciology should play an important role. It is preferable to leaving the task to individual agencies with their own special interests.

5. Finally, as a personal concern, IPA/WDC should record ideas of 'classical' workers who laid the foundations of permafrost research by collecting audio/video records of their methods, sites, etc.
4. RECOMMENDATIONS

The International Permafrost Association (IPA), through its working groups should seek:

1. to define the key variables needed for:
   a) global baseline information on current permafrost conditions,
   b) monitoring of global change in the geosphere-biosphere system,
   c) understanding the thermophysical and mechanical properties of ground and permafrost.

   An associated task will be to determine the appropriate minimum set of variables and boundary conditions, and sampling strategies to ensure representative observations.

2. to ensure security of all key historical information and data records by:
   a) depositing in national archives, aural and/or written records of senior scientists who have made significant or unrepeatable studies,
   b) re-recording of observations and data onto new media as technologies change,
   c) duplication of valuable data sets at more than one centre, or off-site, to avoid catastrophic data loss.

3. to play a coordination role for data standards in collaboration with the appropriate FAGS and WDCs of International Council of Scientific Unions, and to encourage scientists and national agencies to support data archiving (management) activities through recognized data centres.

4. to identify standardized procedures for testing and measurement of physical properties and classification of permafrost for the archiving of fully documented quality controlled data sets. Such documentation should specify the observational and analytical procedures applied to the data.

5. to facilitate the development of user-friendly hardware/software data systems in the form of:
   a) data directories with interactive remote access and cross-referenced guidance to permafrost-related data and information,
   b) hardware independent access-software to data sets.
In addition, a proposal was submitted to the Council of the International Permafrost Association to form a Working Group on Permafrost Data. Formation of this Working Group has since been approved. See Appendix 1.
Appendix 1.

WORKING GROUP ON PERMAFROST DATA

PURPOSE: To improve and standardize the collection, archiving, documentation and dissemination of permafrost data.

The Working Group will collaborate with the Working Group on Permafrost Terminology and with other national and international committees and agencies concerned with relevant data.

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Appendix 2.

ENVIRONMENTAL DATA DIRECTORY—DEEP GROUND TEMPERATURES, MEAN ANNUAL GROUND SURFACE TEMPERATURES AND PERMAFROST THICKNESS DETERMINATIONS NORTHERN AND ARCTIC CANADA

Alan Judge
Energy, Mines and Resources, Canada

For over twenty years the Permafrost Research Section, Terrain Sciences Division of the Geological Survey of Canada, has acquired ground temperature measurements and related data for northern Canada through in-house projects, cooperation with the hydrocarbon and mineral industry and contracted research to Canadian consulting companies. The total data collection consists of 6 individual data files with differing levels of sophistication. Here I will describe each file individually.

1. Precise (0.01 - 0.1K) ground temperatures, from surface to depths of hundreds to a thousand metres or so, at 140 petroleum and mining exploration holes in Arctic Canada. Temperatures are measured sequentially so as to assess the drilling disturbance and determine equilibrium values. Estimates of permafrost thickness to accuracies of several metres are made at these wells. This data set has formed the basis of a series of reports published regularly as Canadian Geothermal Data Collection — Northern Wells and the data is separately available in a computer-compatible form on a CDC Cyber with EMR.

2. As subsets to the above files and also available on the EMR Cyber and through Open-File Reports, precise ground surface temperature is collected for 100 drillholes to 20m depth along the 800km Norman Wells pipeline in discontinuous permafrost. The majority of the sites both in the disturbed right-of-way and in adjacent undisturbed terrain are read at monthly intervals although at six sites automated data loggers have increased frequency to 4X daily. One site is operated jointly at which Atmospheric Environment Service is collecting automatic meteorological data.

3. Deep ground temperatures at sub-permafrost depths to 4km were derived from bottom hole temperatures and drill stem test data for most of the 500 petroleum exploration wells in Arctic Canada. Generally, the precision is to several degrees. The data set extends that of file 1. above to a larger area and a larger number of wells to greater depths but with much lower
precision. The data collection has been acquired through contracted studies and data are released through Open-File Reports. Some data are available on magnetic tape but not in easily accessed formats or routines at present. The data set is useful in establishing the deep boundary conditions including ground water circulation in permafrost growth.

4. Thickness of ice-bonded permafrost and occurrence of gas-hydrates has been derived from downhole geophysical logs collected for 700 petroleum exploration wells in Arctic Canada. Precise temperatures collected (file 1. above) have been used to calibrate the geophysical responses. This data set expands in volume and region the permafrost thickness determination in 1. above, although generally with a lesser precision of 1 to 10m. The results are published as Open-File Reports and some preliminary maps have been prepared.

5. Permafrost thicknesses totalling 1000 values have been assembled for Canada using published sources and 1. and 4. above. The data have been assembled as a research tool and are available on floppy discs using Lotus 1-2-3 format on an IBM-PC.

6. Mean annual ground surface temperature data have been collected for Northern Canada. The collection gathers together mean annual ground surface temperature, as determined by frequent readings on short cables or from surface intercepts of deeper temperature data, from 305 locations. The reports are available as Open-Files and the basic numeric data were assembled as a research tool and are available on floppy discs using Lotus 1-2-3 format on an IBM-PC.
Appendix 3.

CANADIAN GEOTHERMAL DATA BIBLIOGRAPHY

1. Canadian Geothermal Data Collection


2. Sources of other deep temperature data


Hardy and Assoc., Ltd. 1984. Study of well logs in the Arctic Islands to outline permafrost thickness and/or gas hydrate occurrence. Earth Physics Branch Open File 84-8, 215 + 169p.

Hardy and Assoc., Ltd. 1984. A study of well logs in the Western Northwest Territories and Yukon to outline permafrost thickness and/or gas hydrate occurrence. Earth Physics Branch Open File 84-27, 290p.
BOOK NOTES


This five volume set is a detailed study of the geocryology of the Soviet Union. Each volume focuses on a broad geographic region: 1) European USSR, 2) Western Siberia, 3) Central Siberia, 4) Eastern Siberia and the Far East, 5) Mountain regions.

Each of these volumes has three major divisions with regionally-based information and data:

1. Principles of frozen ground formation and current geocryological conditions;
2. Geocryological characteristics - by more localized regions with data;
3. Geocryological forecasting and use and preservation of the natural environment.

Each volume offers an extensive list of references and includes many figures, maps and tables.


This glossary is "a list of definitions related to permafrost science and permafrost engineering. The primary objective is to present terms that enjoy common usage in the current literature, with special reference to Canada and Canadian conditions."

The volume contains definitions for 201 terms, numerous cross references and indications of terms not recommended. One third of the volume is given over to material that supplements the Glossary. An extensive reference list provides sources for more detailed information on specific topics. Diagrams and photographs are provided to illustrate various permafrost phenomena.
GLACIOLOGICAL DATA SERIES

Glaciological Data, which supersedes Glaciological Notes, is published by the World Data Center-A for Glaciology (Snow and Ice) several times per year. It contains bibliographies, inventories, and survey reports relating to snow and ice data, specially prepared by the Center, as well as invited articles and brief, unsolicited statements on data sets, data collection and storage, methodology, and terminology in glaciology. Contributions are edited, but not refereed or copyrighted. There is a $5 shelf stock charge for back copies.

Scientific Editor: Roger G. Barry
Technical Editor: Alan M. Brennan

The following issues have been published to date:

GD-1,  Avalanches, 1977
GD-2,  Arctic Sea Ice, 1978
GD-3,  World Data Center Activities, 1978
GD-4,  Glaciological Field Stations, 1978, Out of Print
GD-5,  Workshop on Snow Cover and Sea Ice Data, 1979
GD-6,  Snow Cover, 1979
GD-7,  Inventory of Snow Cover and Sea Ice Data, 1979
GD-8,  Ice Cores, 1980, Out of Print
GD-9,  Great Lakes Ice, 1980, Out of Print
GD-10, Glaciology in China, 1981
GD-11, Snow Watch 1980, 1981
GD-12, Glacial Hydrology, 1982
GD-13, Workshop Proceedings: Radio Glaciology; Ice Sheet Modeling, 1982
GD-15, Workshop on Antarctic Climate Data, 1984
GD-17, Marginal Ice Zone Bibliography, 1985 Out of Print (Microfiche available)
GD-18, Snow Watch '85, 1986
GD-19, Tenth Anniversary Seminar; Passive Microwave Users Workshop; Microwave Radiometry Bibliography, 1987
GD-22, Northern Libraries Colloquy, August 1988

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