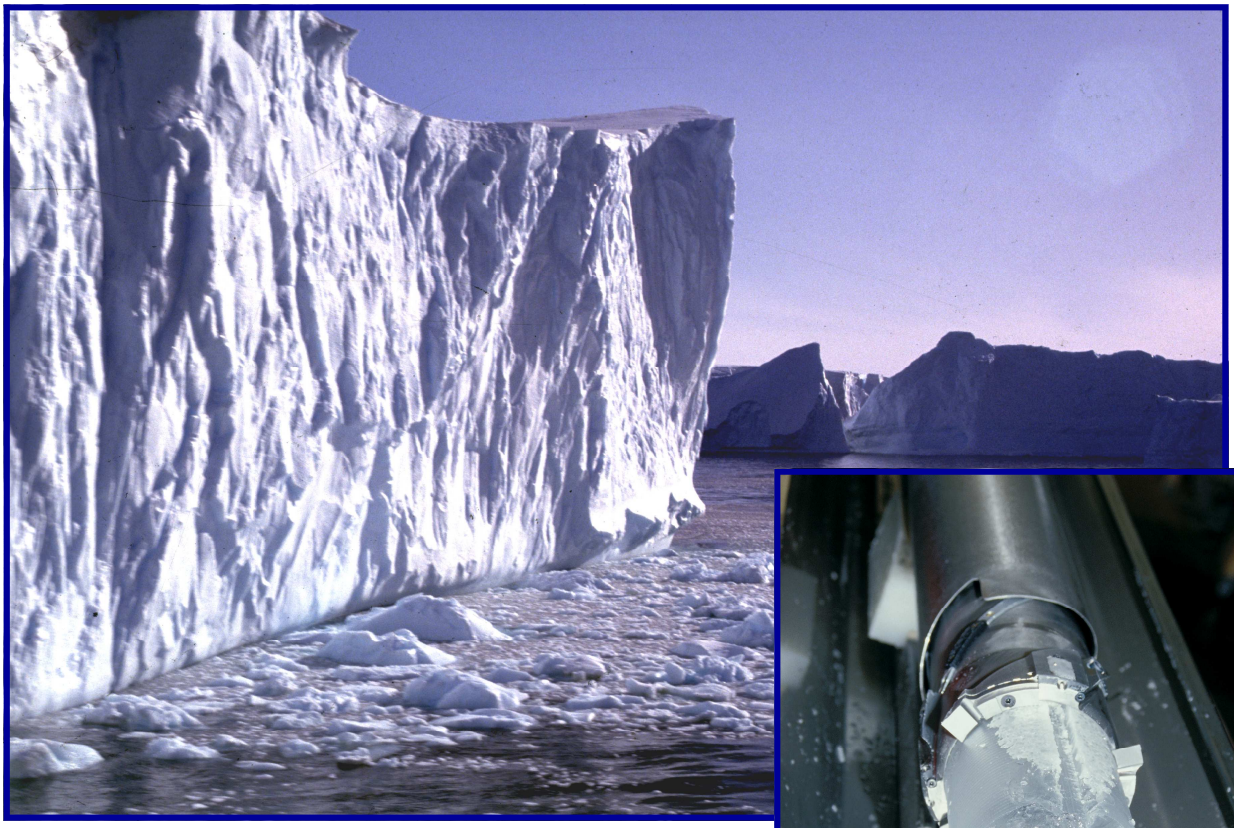
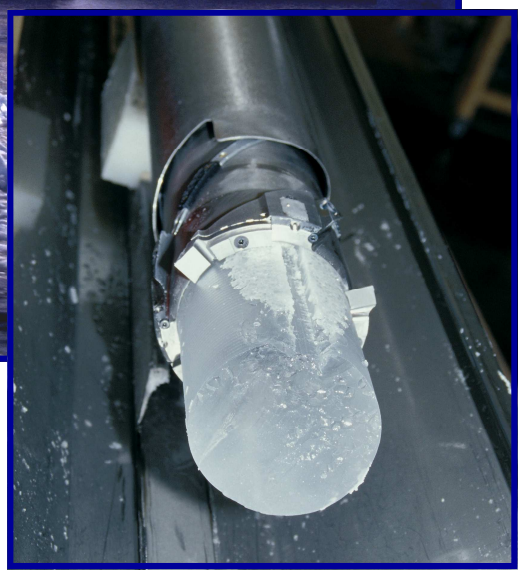
INTERNATIONAL PARTNERSHIPS IN ICE CORE SCIENCES

IPICS II PROGRAMME

Roadmaps and Pathways to Implementation





International Partnerships in Ice Core Sciences
IPICS

European
Polar
Consortium

European Polar Consortium Offices
16—19 October 2005
Brussels, Belgium

NATIONAL REPORTS

EPICA-Europe

Although it is not a national report, in order to avoid too much repetition, we have submitted a single report to update the IPICS community about the multinational EPICA project. EPICA is the European Project for Ice Coring in Antarctica, a joint European Science Foundation/European Commission (EC) scientific programme, funded by the EU (EPICA-MIS) and by national contributions from Belgium, Denmark, France, Germany, Italy, The Netherlands, Norway, Sweden, Switzerland and the UK.

EPICA consists of two ice core drillings. The drilling at Dome C (75° 06′ S, 123° 21′ E, altitude 3,233 m above sea level) was completed in December 2004, at a logged depth of 3259.72 m. Seismic measurements made in the borehole, as well as the temperature profile, lead us to believe that we have terminated the drilling about 10 m above the true bed, and that the ice at the bed is melting. The climate record from the core appears to extend just over 800,000 years (800 kyr). The first results as far as 740 kyr were published during 2004 (EPICA Community Members, Eight glacial cycles from an Antarctic ice core, *Nature*, *429* (6992), 623-628, 2004.). Further papers covering trace gases, chemistry, isotopic and other measurements are in the pipeline and work will be continued on the core throughout the lifetime of the EPICA-MIS EU project (end 2007) and beyond. Archive ice has been left in storage at dome C, under the auspices of the French-Italian Concordia Station. The remaining ice has been returned to Europe.

The second drilling is at Kohnen Station, Dronning Maud Land (75° 00′ S, 00° 04′ E, altitude 2,892 m above sea level). The drill depth so far is 2565 m, and it is estimated that the bed is at 2782 m. The remaining 217 m should be drilled during the 2005/06 field season. The ice at the current drill depth is estimated to be close to 200 kyr in age. The time resolution is better than Dome C throughout marine isotope stages 1 and 2; the core will be used especially to define a good relationship between Antarctic and Greenland cores during the last glacial period, and for a climate record from the Atlantic sector of the Antarctic. The ice is mainly stored at the Alfred-Wegener-Institute (AWI) in Bremerhaven, Germany.

Borehole logging measurements will continue to be made at both sites after drilling is completed.

European nations are also involved in several other multinational projects, described in national documents: notably NorthGRIP (Greenland), Berkner Island and Talos Dome (Antarctica). There is no current plan for a further coring by the EPICA nations, but many of them remain interested in the IPICS projects, and the model of international cooperation in EPICA is one that was successful and that we would like to repeat.

National ice core activities and current status for the United Kingdom

Most UK ice core activities continue to be carried out by the British Antarctic Survey (BAS). BAS has been an enthusiastic partner in the EPICA projects (Dome C and Dronning Maud Land drillings), described separately in the EPICA-Europe document.

The main BAS activity in recent years has been the Berkner Island ice core drilling project, carried out jointly by BAS and its French partners from LGGE and IPEV. The location of the drilling is 79° 36′ S, 45°43′ W, altitude 890 m above sea level. In 2002-03, the pilot borehole was drilled and cased to 88 m, the following year 526 m was reached, and in 2004-05, the bed was reached at 948 m. The basal temperature is estimated at -11°C. Clean ice gave way to very sandy material over a length of 0.5 m. Preliminary analysis of the ice suggests that it extends at least to the early part of the last glacial period. The ice is mainly stored at BAS, Cambridge, and is being analysed in BAS, LGGE and other laboratories.

Other ongoing activities include shallow ice coring in the Antarctic Peninsula region: initially cores will be compared with operational meteorological data to understand the origin of the snow. Longer records for comparison with instrumental data and reanalysis data will also be obtained. We continue to work on material from previous Antarctic Peninsula data (up to a few hundred years), looking particularly at chemical proxies in the ice.

Firm plans for the next few years include a bedrock drilling (again in collaboration with French colleagues; Brazil and Canada have also expressed interest in the project) at James Ross Island on the northern end of the Antarctic Peninsula. The aim is to get a full Holocene record, both for a first climate record from this region, and as a template for interpreting earlier studies of the past stability of ice shelves adjacent to the island. Drilling is scheduled for 2007-08. In addition to this project, we will also be minority participants in the Talos Dome project.

We are interested in participating in all 4 IPICS projects. For the long arrays project, we can already offer Berkner Island as a key part of the array, while James Ross Island may also contribute (though probably less than 30 kyr).

National ice core activities and current status for Belgium

General points

Belgium is involved in the study of ice cores from three deep drilling programmes, one in Greenland (NGRIP) and two in Antarctica (EPICA DC and DML) and has representatives in the related Steering Committees (Dr. R. Souchez and Dr. R. Lorrain, both from the Laboratoire de Glaciologie - Université Libre de Bruxelles). Belgium money has been provided in early phases of EPICA and NorthGRIP as well as in the preceding Greenland based programme (GRIP). Three members of the Belgian team (Dr. Lorrain, Dr. Tison and PhD Student Samyn) have worked on the spot of the NorthGRIP drilling site between 2000 and 2003. The contribution of Belgium has been, and is still intended to be, the detailed study of the bottom ice retrieved from these drillings. This bottom ice is generally strongly influenced by the proximity of the substratum. Therefore, the proxy data currently used for climatic reconstruction are generally considerably disturbed and cannot be trusted for this purpose. However, the Belgian scientists involved in these studies have developed special techniques allowing analysis of debris bearing ice and have succeeded, since the middle of the nineties, to show that these data are good indicators of the modifications undergone by basal ice. The latter differs significantly from the ice present above mainly in terms of stable isotopic composition as well as gas content and composition. In certain cases, these compositional characteristics allow to explain how these basal parts of the ice sheets have formed and/or deformed and help to reconstruct the boundary conditions prevailing at the bed. Moreover, modelling of the basal part of the ice sheet have been performed and is still under development by colleagues from the department of Geography of the "Vrije Universiteit Brussel (Dr. F. Pattyn).

The present day situation

1) At present, ice retrieved from the bottom of NGRIP and EPICA DC have been shown to have experienced basal melting and, as a result, typical basal ice is lacking. However the ice reached at the very bottom of these two locations shows distinctive feature in terms of either isotopic values and/or particle content. Gas analyses are planned currently and the expected results are hoped to indicate at least if this ice has kept its climatic recording capacities. The Belgian team is waiting for the basal parts of the drilling EPICA DML still in progress.
Meanwhile, members of the team were involved in the study of deep ice from the Vostok core including the lake ice present at the bottom and have contributed to the understanding of the formation of this ice.

2) Besides, scientists in charge of the Berkner Island drilling programme (Dr. R. Mulvaney and E. Wolff from BAS) have recently proposed that the bottom ice from the very bottom of the latter drilling should be analysed in the Belgian laboratory. In this case the lowest 1 m of the core is clearly composed of particle rich ice visibly different from the situated just above ice. This ice will most probably sent to

Brussels and studied by the Belgian team.

3) Perspectives

Beyond the work already planned (see above), the Belgian team is looking forward to be associated with future programmes involving deep or shallow ice drillings giving access to “interface ice”, i.e. ice formed or deformed at the ice –substratum or at the ice-water (lake or sea water) interfaces.

National ice core activities and current status for Italy

Here is reported the Italian ice core activities since the last report of IPICS in spring 2004. The activities described are directly linked to European ice core project such as EPICA (European Project for Ice Coring in Antarctica) at Dome C and TALDICE (Talos Dome Ice Core Project). In both projects, Italian participation are dedicated to the management of French-Italian Station "Concordia" for and summer field camp at Talos Dome and to drill and log of ice cores activities. In total five drillers/scientist have participated (2 at EPICA, 3 at TALDICE) during the past season.

EPICA at Concordia Station
Detail of this activity is described in EPICA report for IPICS.

TALDICE
The 2004/2005 TALDICE field season started at mid of November 2004 and finished at the mid of January 2005. A field camp (ID1; 159°11'00"E 72°49'40"S) is established at 5-6 km distant from Talos Dome summit (along the SE ice divide), where the bedrock is flat at about 750 m in elevation and covered by 1550 m of ice.

A French and four Italian technicians and scientist (3 Drillers, 1 Scientist, 1 Mechanic) were involved for about 50 days in drill activities and establishment of camp. A temporary field camp (summer camp) was established using the vehicles and modules of IT-ITASE programme plus tents. The drilling camp is designed for approx. 12 scientists and technicians, the camp itself is temporary and will be disassembled at the end of the drilling.

Transport from/to Talos Dome has been performed mainly by Twin Otter, from the Mario Zucchelli Station at Terra Nova Bay (270 km). The drilling equipment and the material necessary for the establishment of a drilling camp has been transported to Antarctica by sea, unloaded at Zucchelli Station, then transported by airplane (1.5 h travel time). A trench for drilling, ice core processing facility and "field laboratory" (40 m long, 4.5 wide, and 4 m high) is excavated using Pisten Bully over which the mechanical drill will be erected.
The trench was lined with a wooden floor comprising approximately 2000 kg of timber and will be covered with a "weatherhaven" shelter during next season. A pilot hole was drilled to a depth of 127 m, reamed and the FRP casing installed using a "shallow" French driller system.
The upper 96 m of the hole was cased to prevent loss of drill fluid in the firn that will be used during the forthcoming season. Drilling will be performed with electromechanical drilling equipments using a drilling fluid to balance the overburden pressure and to prevent ice flow closure of the borehole. Drill fluid (about 40%) and core boxes were acquired and shipped to Mario Zucchelli Station.

During the forthcoming season, from November 2005 to January 2006 for about 80 days, ten technicians and scientists (3 French and 8 Italian) will be involved in

TALDICE activity. The staff will be 7 Drillers, 2 Scientists, a Mechanic. Material (fuel, drill fluid, driller etc.) will be carried to the site with Twin Otter flights. Drilling will continue to approximately 500 m using “Berkner” driller system (French-UK). Ice cores will be cut and processed for physical/electrical properties, and then shipped to European Laboratories. Remaining drill fluid (about 60%) will be acquired and shipped to Mario Zucchelli Station.

National ice core activities and current status for the Netherlands

By Roderik van de Wal

This summary intends to give some insights on work carried out in the Netherlands and ideas for near future. It by no means aims to be a comprehensive overview.

Ice core analysis

Within the EPICA project IMAU has performed the 14C analysis of the Dome C and EDML core. The purpose of this work is to develop a technique to provide an independent time scale for the age of the enclosed air over the last 30 kyr BP. Results of particular the EDML core show the possibility and limitations of application of is technique. Main conclusion is that dating of ice is possible but that the accuracy needs further improvements due to uncertainties in the calculation of additional 4C produced in the snow (Van de Wal et al. in prep).

Dieletrical profile measurements have been performed along firn cores in Dronning Maud Land. Combining these measurements with other cores in the area revealed an accumulation record over the last 1000 years in the area indicating limited variations, no long-term trend though a small barely significant increase during the last century. Variability in Western Dronning Maud Land was shown to be larger than in the eastern parts. (Hofstede et al. 2004)

Interpreting ice core records

A detailed comparison of modeled and observed Antarctic surface mass balance has been made with a regional atmospheric climate model for the period 1980-2004. Large differences are found in the higher coastal zones of East and West Antarctica. Results show 15% more accumulation than previous estimates Van den Berg et al. (in prep.)

In order to assess the climatic influence on the stable isotope concentration of snow a rayleigh-type distillation model in combination with back trajectories has been developed to study the spatial and temporal variability of Antarctic snow. Observed spatial gradients are reproduced with the model and differences in seasonal amplitude identified (Helsen et al. in prep). This work is important for the interpretation of stable isotopes records of ice cores.

Based on combining ice sheet models and marine sediment oxygen isotope records. Temperature and sea level over the past million years has been reconstructed (Bintanja et al. 2005). This work is important for the interpretation of ice cores as it offers a method to combine insight from ice cores and marine cores during the transition from 40 kyr cyclicity before 1Myr towards the 100 kyr cyclicity over the last 500 kyr.

IMAU operates at present four Automatic Weather Stations in Dronning Maud Land.

Results are presented in many publications by Van den Broeke, Reijmer, see EPICA publication list.
In order to understand the local climate conditions on the Antarctic Plateau IMAU carried out a boundary layer experiment near Kohnen station. Combining the measurements with a boundary layer model shows the feedback mechanism responsible for the stability of the boundary layer. Larger wind speeds causes stronger turbulent mixing and hence a stronger cooling forming a temperature deficit which forces stronger katabatic winds (Van As et al. in press.)

Ice core drilling technologies

IMAU has a system for drilling medium long ice cores (<250 m). The system has been used successfully in Antarctica, Sweden and Svalbard.
IMAU has an extensive set of meteorological equipment dedicated for use on glaciers and ice sheets.
CIO, Veining Meinesz centre and IMAU have laboratories for ice core analysis.

New developments

In collaboration with the Centre for Isotope research Groningen and GFI, Copenhagen a project has been started to evaluate the thermal fractionation of 2H and δ17O and δ180. These isotopes show diffusion behaviour that is solely dependent on temperature, but in a different way. As diffusion stops after pore close off the temperature signal is conserved in cores and offers a new independent paleothermometer.

Sources and sinks of methane in the atmosphere are heavily debated nowadays.
At IMAU there is a system in development to measure not only δ13CH4, but also the hydrogen isotopes of methane. The system will be applied to gas extracted from ice cores.

Advance will be taken by the Veining Meinesz research school in collaboration with IMAU of new technologies in the field of solution nebulisation ICP-MS measurements to measure with high precision trace metals including rare earth elements of ice in order to establish a high accuracy temporal picture of these elements and in order to improve dating of older volcanic horizons.

References

An incomplete overview of the most recent publications of ice core activities can be found at http://www.phys.uu.nl/~wwwimau/research/ice_climate/epica/home.html, which contains 17 publications with Dutch researchers involved.
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National ice core activities and current status for Sweden

Past

The Swedish engagement in ice core research started in 1987-1998 together with Denmark and Iceland in the Nordic Renland project[1] on the east coast of Greenland. The first Northern Hemisphere record of atmospheric aerosol composition covering the entire last glacial period was extracted from this 325 m long ice core[2,3,4]. During following years Sweden performed shallow and intermediate depth ice core drilling in the Dronning Maud Land (DML) area, Antarctica[5,6,7], during several expeditions within the frame of ITASE and pre-site surveys for EPICA-DML, as well as on glaciers in Sweden[8] and Svalbard[9]. The drillings in Svalbard were performed in cooperation with Norway, the Netherlands, Finland, UK and Estonia. The purpose was spatial and temporal variability in physical and chemical character.

Present

Sweden is one of the nine nations cooperating in the latest deep drilling on Greenland, North-GRIP[10]. The main focus from the Swedish side is the ion chemistry. Sweden is one of ten nations cooperating within the European Project for Ice Coring in Antarctica, EPICA, at Dome C[11,12] and in DML. Also here the main effort is within the ion chemistry consortium. Swedish drillers/drill helpers have participated in the three different deep drillings.

Future

Sweden is planning for three different activities during IPY 2007/2008 involving ice core drilling and surface snow sampling programmes.

1. The start of a new international Greenland deep drilling, the so called NEEM-project. The IPICS document describing this proposal has the title; **The last interglacial and beyond: A northwest Greenland deep ice core drilling project.**
2. The Japanese-Swedish IPY Traverse 2007/2008, a traverse between the two deep drilling sites EPICA-DML and Dome F with end points at the Swedish station Wasa and the Japanese station Syowa. The scientific activities will contribute to the IPICS proposal with the title; **The IPICS 2k Array: a network of ice core climate records for the last millennia.**
3. Nordaustlandet, Svalbard. Ice coring on the Vestfonna Ice Cap to study last millennia climatic variability at an annual resolution in cooperation with Norway, the Netherlands, Finland and Estonia. This project will also contribute to **the IPICS 2k Array: a network of ice core climate records for the last millennia.**

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National ice core activities and current status for Switzerland

Name and title of person completing report:
T. Stocker, J. Schwander, M. Schwikowski (2004) T . Stocker (update 2005)

Names of ice core drilling and analysis projects that have been active in the last 5 years

Greenland Ice Coring Project (GRIP): ongoing analysis
European Project for Ice Coring in Antarctica (EPICA Dome C) : Drilling, onsite and lab. analysis
European Project for Ice Coring in Antarctica (EPICA DML) : Drilling, onsite and lab. analysis
North Greenland Ice Coring Project (NGRIP): Drilling, onsite and lab. analysis
Talos Dome (Antarctica)
Paleoclimate of the Central Andes
Reconstruction of air pollution levels and climate in the Altai region of Central Eurasia from high-altitude glacier ice core records
Paleo climate from Andean ice cores and lake sediments
Past climate changes derived from a high-altitude ice-core in Patagonia

Please briefly describe what drilling expertise this nation has.

Shallow and intermediate depth drilling in dry holes.
Manufacturing of precision drill heads.
Echo sounding in deep holes to determine location of bedrock.
Expertise in retrieval of ice cores from high-mountain glaciers, above the range of helicopter operation.

Please list the ice core analysis laboratories and their specialties in this nation.

Climate and Environmental Physics, Physics Institute, University of Bern: Greenhouse gas mixing ratios (GC and IR absorption spectroscopy), Continuous flow analysis (Ca, Na, NH4, HCHO, H2O2, NO3, conductivity, [dust, SO4: in cooperation with DK, IT]), ECM, mass-spectrometric analysis of isotopes of water, and elemental and isotopic ratios and air, low level radioactive measurements, firn air extraction..

Swiss Federal Institute for Environmental Science and Technology , CH-8600 Dübendorf: 10Be and 36Cl with AMS (In collaboration with Heidelberg)

Laboratory of radio and environmental chemistry, Paul Scherrer Institut and University of Bern: Analyses of major ions, trace elements, radioisotopes, stable oxygen and hydrogen isotopes, carbonaceous particles, 14C in carbonaceous particles

Please list the name(s) of agencies and a contact person(s) that might fund future ice coring activities.

Swiss National Science Foundation
Swiss Office of Education and Research
Swiss Office of Energy
European Commission

Please list investigators in this nation who have been involved in ice coring projects in the last 5 years.

B. Stauffer (Greehouse gases, logistics)
T. Stocker (Greenhouse gases, Climate modelling)
J. Schwander (Firn gases, drilling, chronology, logistics)
M. Leuenberger (Isotopes)
T. Blunier (Greenhause gases, synchronisation, Isotopes)
H. Gäggeler (Alpine drilling, major ions, trace elements, radioactive isotopes)
M. Schwikowski (Alpine drilling, major ions, trace elements, radioactive isotopes)
J. Beer (10Be, 36Cl, solar activity)

National ice core activities and current status for Australia

Australian ice core research has for a number of years concentrated on Law Dome where we have a special interest in high resolution studies that make use of the high accumulation at the dome summit site. Accumulation in the summit area is 0.7m IE which leads to clear seasonal layers down to a depth of about 1000m (80% of the total ice thickness, age ~4400 years). Work on the DSS ((Law) Dome Summit South) 1200m core is on-going and is expected to be continued for several years.
Recently, a number of other sites have been investigated. One aspect of this is to try to find other high resolution (sub-seasonal resolution) sites to compare with records from Law Dome. The other aspect is to obtain records from sites in different accumulation regimes. These projects were generally designed to fit under the ITASE umbrella. Some will also contribute to the IPICS 2k array project.

Recent field work (ice core drilling)
November 2004. Law Dome, DSSW19k. 66°46'34"S, 112°22'7"E. Depth 120m, age ~600 years. Drilled on the lower accumulation side of Law Dome, 19km west of the Law Dome deep core and the dome summit. The record is primarily for comparisons with the high accumulation deep core with respect to MSA-sea ice extent and Little Ice Age-to-present studies. PI Mark Curran, Australian Antarctic Division and ACE-CRC

January 2004. Eastern Wilkes Land, site GC17, 67°51'S, 127°02'E, elevation 1520m, core depth 140m, age ~300 years. The aim is to produce a 200-300 year history of circum-antarctic circulation associated with the ACW, ENSO and SAM of climate variability. PI Ian Goodwin, University of Newcastle.

November/December 2005. Law Dome, near DSS. A ~250m deep large diameter (200mm) thermal core. For:

1. Pre-industrial methane – sources and sinks. Measurement of isotope ratios (13C, 14C) PI Andrew Smith, ANSTO. Collaboration with Jim White, INSTAAR; David Lowe, NIWA (New Zealand National Institute of Water and Atmospheric Research), David Etheridge, CSIRO-AR.
2. Lead, lead isotopes, tin, tin isotopes, barium and indium concentrations as indicators of sources, pollution, transport mechanisms in the time period 1850-1920. PI Kevin J.R. Rosman, Department of Applied Physics, Curtin University of Technology; collaboration between Curtin University of Technology, ACE CRC (Hobart), LGGE (Grenoble, Fr), University Ca'Foscari of Venice (Venice, It) and KOPRI (Seoul, Korea).
3. High resolution 10Be studies. Seasonal cycle of deposited 10Be, variation over solar cycle. Vin Morgan, Tas van Ommen, Joel Pedro (AAD), Andrew Smith, David Fink, (ANSTO)

Future field work

2006/07 Intermediate depth drilling at GF12, 68°30'S, 97°0'E, elevation 2200 m. At this site the accumulation rate is about 30cm ice eq. and annual layering is preserved. The aims are to develop a 200-300 year paleoenvironmental history, including annual records of snow accumulation, and sub annual proxy records of climate; surface temperature; maritime cyclone incursions into Wilkes Land; fluctuations in the katabatic wind field; and midtropospheric ridging over the Southern Ocean and Wilkes Land. PI Ian Goodwin, University of Newcastle.

2007/08 or 2008/09 Reconnaissance ice core drilling in the Aurora Deep Basin. The objective is to drill a ~400m deep core at a site over the Aurora Sub-Glacial Basin where the ice thickness is ~4000m. There are two principal research aims. The first is to investigate the site as a possible location where a very long (> 1,000,000 year) record could be obtained, the second is to obtain an East Antarctic ice core/climate record at a location intermediate between the high inland site of EPICA Dome C and the coastal Law Dome site. Local radio echo sounding and borehole temperature data will be collected. This project fits into both the IPICS 1.2M year record project and the 2k Array project.

Future. High quality DSS Transition and Glacial ice. The Law Dome site with its high accumulation – small ice age/gas age difference and its coastal location can potentially contribute to questions of N-S timing and the sequence of events in the Glacial and Transition (and hence the IPICS project Processes of Climate Change). However, the Law Dome deep core is practically all from the brittle zone and core quality imposes limits on some measurements. We propose to obtain better quality Transition and Glacial material either in another deep drilling project or by using a rapid access drill to a depth of ~900m and the coring the next 300m. The problem of core quality needs to be addressed, however we believe thermal coring in the warm ice might be the solution.

Future. Coring at high accumulation coastal sites. The aim is to locate sites where annual layers are preserved for precise dating and for comparison with the Law Dome records. The initial work would be to obtain shallow cores by hand augering on an opportunity basis. This would be followed by intermediate depth drilling at likely locations. Potential sites include: Mill Island, Cape Darnley and Mt. Brown or the U5 site in Wilhelm II Land.

National ice core activities and current status for Canada

Three ice cores were retrieved from Prince of Wales Icefield (Ellesmere Island), Nunavut, Canada in 2005 (funded by The Canadian Foundation for Climate and Atmospheric Sciences -CFCAS). One of them reached bedrock (179.2 meters from Surface), while the other two were 44.0 meters (covering over 100 years) and 153 meters from surface (covering about 1000 years).

The purpose for drilling those cores was to investigate the interactions between Arctic climate, sea ice, and ice cap mass balance over the past millennium. This study is expected to help us understand the response of sea ice to climate forcing and its role in mediating the response of glaciers to climate change. This study is being carried out the Universities of Alberta, Calgary and Ottawa together with the Geological Survey of Canada (GSC).

Five 20-m cores were collected from Devon Ice Cap in the 2004-2005 field seasons and have been analysed for anions, ice layers and net accumulations. The goal for collecting these short cores is to eventually build an archipelago-wide network of short core records that can be used to investigate the spatial structure among ice core records, and its relationship to atmospheric and sea ice variability. (University of Alberta).

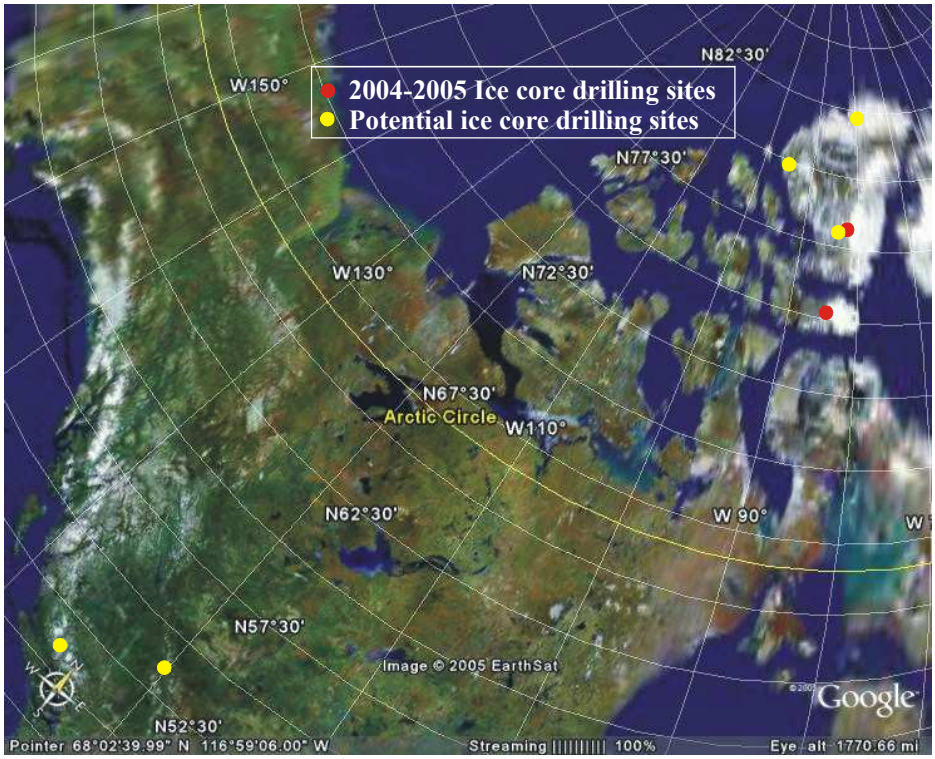
Two 20-m cores have been collected from Prince of Wales Icefield for cation analyses (in progress). These cores are dated by 18-O results, anion stratigraphy and accumulation records from 1965 to 2001 and will be used to investigate links between changed in atmospheric circulation, sea ice extent and concentration, ice core chemistry and ice cap accumulation during the period of instrumental/satellite records. (University of Alberta).

Wish list for the future years Including IPY:

1. One ice core down to about 2000 years for Hg pollution study from Ellesmere Island, where precipitation is relatively high (more than 20 cm ice equivalent annually). (David Fisher et al., GSC);
2. One or more cores for CFCAS Western Cryosphere Network, if funded, on Mount Waddington (South Coast Mountains). (Eric Steig, University of Washington, USA and Brain Menunous, University of Northern British Columbia, Prince George, B.C.);
3. Cores at the Wapta (ca. Peyto) and Columbia Icefields (ca. Athabasca), both of which have excellent instrumental records, historical photography, geobotanical and morphological perspectives as well as infrastructure. Trial coring at Peyto and other related data suggests good decadal averages could be possible. (Mike Demuth et al., GSC);
4. Cooperative drilling on Mt Oxford, Northern Ellesmere, with Ray Bradley and Lonnie Thompson. (David Fisher et al., GSC, Ray Bradley, University of Massachusetts and Lonnie Thompson, Ohio State University);
5. Possible participation in NEEN drilling though this is a deep drilling project with

its own IPICS white paper. (David Fisher et al., GSC and colleagues in a variety of countries)

6. Extend shallow ice core network to Axel Heiberg Island and northern Ellesmere island – eventually hoping for a long core from Axel which should give a better record of climate and sea ice variability in the Arctic Ocean sector of the QEI. (Martin Sharp, University of Alberta).



National ice core activities and current status for China

By Li, Yuansheng

General

The national ice core research in China has focused on two areas: Antarctic ice sheet and Tibetan mountain glaciers. In Antarctic ice sheet, Chinese Antarctic Research Expedition Party (CHINARE) collected 6 shallow ice cores on the profile from Zhongshan Station to Dome A during past 10 years, as well as a 300m shelf ice core at the Amery Ice Shelf and a 108m ice core at the summit of Dome A, East Antarctica. In last season, Chinese inland traverse team arrived at the summit of Dome A and retrieved a 108m ice core there, which may contain 2000-2500 years climatic records. The analysis and processing for these ice cores have been completed, except 300m Amery Ice Shelf core and 108m Dome A ice core. In Tibetan mountain glacier area, more than 10 ice cores were collected during past 15 years. There are several research groups which study on the mountain glacier in Chinese Academy of Sciences.

Future plan for Antarctic ice core program

Chinese Antarctic Research Expedition Party plan to establish an inland station at a site of the Dome A area in next 5 years. The main purpose of the new station will be a base for deep ice core drilling at the summit of Dome A. For this purpose, we carried out the Dome A traverse and reached the summit of Dome A in last season. An automatic weather station, which can work in -90 degrees Celsius, was installed at the summit of Dome A and the ice thickness of some sites at the top of Dome A was measured, one of the sites is more than 3000m by surface ice radar observation. This indicates that the oldest ice in Antarctic ice sheet may be found in the summit of Dome A. So we plan to carry out a new Dome A traverse in 2007/2008 season to investigate ice thickness in more detail and magnitude around the summit of Dome A, to set up buildings there and to take a 350-500m ice core at the summit of Dome A. To get experience on deep ice core drilling and logistic operation, we will send a scientist to participate Japanese Dome F deep ice core drilling program at Dome Fuji in the coming Antarctic season and a scientist to take part in the US west Antarctic deep ice core drilling program in the summer of 2006/2007. Hopefully, the deep ice core drilling at Dome A may start in 2010.

National ice core activities and current status for Japan

Name of Country: **Japan**
Name and title of person completing report: Nobuhiko Azuma

Names of ice core drilling and analysis projects that have been active in the last 5 years:

Study on deep ice core from Dome Fuji, Antarctica
Phase 1: Basic analysis
Phase 2: High time-resolution analysis
Second deep ice coring project at Dome Fuji, Antarctica
Study on Japanese ITASE shallow cores
Study on Arctic shallow ice cores from Svalbard, Mt. Logan, Greenland, Kamchatka, and Mt. Wrangell, Alaska.
Study on high mountain ice cores from Altai Mts and Qilian Mt.

Please briefly describe what drilling expertise this nation has.
Deep ice coring: Deep ice core drilling was carried out to a depth of 2503 m at Dome Fuji, Antarctica in 1995-1996 with a JARE-type mechanical drill. Second deep ice coring project at Dome Fuji aiming to drill to the bedrock started 2003/2004 using the improved drill.
Intermediate depth coring: A 700 m deep ice coring was carried out at Mizuho Station, Antarctica in 1983-1984.
Shallow ice coring: First shallow ice coring was done to a depth of 70 m at Mizuho Station, Antarctica in 1971 with a primitive mechanical drill. Shallow drill has been improved and has been used at Antarctica, Greenland, Svalbard, Patagonia, Himalaya, Kunlun, Altai, Kamchatka, western Siberia, Mt. Logan and Alaska.

Please list the ice core analysis laboratories and their specialties in this nation.
National Institute of Polar Research, Tokyo: Chemistry, oxygen and hydrogen isotopes, microparticles, tephra and electric properties.
Institute of Low Temperature Science, Hokkaido University: Physical properties such as clathrate hydrate, Raman spectral N2/O2 ratio, bulk density by X-ray transmission, and total air content.
Nagaoka University of Technology: Physical and mechanical properties of ice cores.
Center for Atmospheric and Ocean Studies, Tohoku university: Atmospheric compositions such as CO2, CH4 and N2O, and the isotopic ratios of 13C and 15N.
Kitami Institute of Technology: Mechanical properties and total gas content.
Yamagata University: Dust component.
Shinshu University: Chemistry.
Tokyo Institute of Technology: Hydrogen isotope and d-excess and microorganisms.
Nagoya University: Organic chemistry, pollen and oxygen isotope.

Highest priority project: Second deep ice coring project at Dome Fuji, Antarctica

Number of investigators: about 60 investigators.

Degree of readiness for participation in the project: The ice coring started in 2003/2004 after five-year preparation of improvement of drill, transportation of fuel and building new drilling site. Present drilling depth is 1850m,

Please list the name(s) of agencies and a contact person(s) that might fund future ice coring activities.

National Institute of Polar Research, Yoshiyuki Fujii (Director)
MEXT and JSPS***:*** Grant in Aid for Scientific Research

Please list investigators in this nation who have been involved in ice coring projects in the last 5 years.

There are about 60 scientists involved in ice core science. Here are 6 contact scientists.

Shuji Aoki (Tohoku University) aoki@mail.tains.tohoku.ac.jp
Nobuhiko Azuma (Nagaoka University of Technology)
azuma@mech.nagaokaut.ac.jp
Yoshiyuki Fujii (NIPR) fujii@pmg.nipr.ac.jp
Koukichi Kamiyama (NIPR) kamiyama@pmg.nipr.ac.jp
Takeo Hondoh (Hokkaido University) hnd@lowtem.hokudai.ac.jp
Hitoshi Shoji (Kitami Institute of Technology) shojihts@mail.kitami-it.ac.jp

National ice core activities and current status for Russia

Name of Country: Russia

Name and title of person completing report:
Vladimir Lipenkov, Leading researcher at the Arctic and Antarctic Research institute, St. Petersburg, Chief scientist of the national project entitled "Deep ice coring, paleoclimate research and subglacial Lake Vostok exploration in Antarctica".

Names of ice core drilling and analysis projects that have been active in the last 5 years:
VOSTOK. The drilling of 5G hole has been performed in collaboration with French and US scientists. The drilling stopped in 1998 at 3623 mbs, 130 m above Lake Vostok, the ice core analyses are in progress.
Deep ice coring on Academy of Science ice cap, archipelago Severnaya Zemlya (Russian-German project implemented in 1999-2001, the drilling reached bedrock at 724 mbs, the ice core analyses are in progress.
Participation in the EPICA DC ice core analyses.
Participation in the Berkner ice core analyses.
Participation in the NGRIP ice core analyses.

Please briefly describe what drilling expertise this nation has.
For the past 25 years deep ice coring has been performed in East Antarctica at Vostok Station (3G, 4G, and 5G holes, the deepest 5G hole reaches 3623 mbs), Dome B (780 m), Komsomolskaya (870 m), at 73 km from Mirny (750 m), and at 105 km from Mirny (720 m); the shallow drilling down to 150 m has been done along the route Mirny-Vostok at 60 km , 140 km, 200 km, 240 km, 340 km and 400 km from the station of Mirny. A number of holes down to the bedrock (400-724 m) have been drilled in ice caps of archipelago Severnaya Zemlya. Both thermal and electromechanical drills of different designs and capacity, and the special equipment for enlarging the hole diameter, as well as for directional drilling (for making a branch-hole from a desired depth in the main hole to obtain extra ice core) have been used in these projects. The drill units employed to drill these holes were designed and built at St. Petersburg Mining Institute, and also at the AARI.

Please list the ice core analysis laboratories and their specialties in this nation.
1. Arctic and Antarctic Research Institute (AARI Roshydromet), St. Petersburg – physical properties of ice, water isotopes (in collaboration with Center of Isotopic Research of All-Russian Geological Research Institute), mass balance;
2. Laboratory of Microbiology and Biogeochemistry of Water Reservoirs, Institute of Microbiology (IM RAS), Moscow – microbiology of polar ice cores;
3. Division of Molecular and Radiation Biophysics, Petersburg Nuclear Physics Institute (PNPI RAS), Gatchina – molecular biology of polar ice cores;
4. All-Russia Research Institute for Geology and Mineral Resources of the World Ocean (VNIIOkeangeologia) – bedrock microparticles in ice cores;
5. Kazan State University (KSU), Kazan – mathematical modeling of physical

processes in polar ice, data interpretation;

If there is a written plan for future ice core projects please provide the citation for the plan and explain how a copy of it can be obtained. Also, please provide four copies of the document.

The ice core projects in Russia are implemented in the frame of the long-term Federal Targeted Program "World Ocean", subprogram "Antarctica", project 4 "Deep ice coring, paleoclimate research and subglacial Lake Vostok exploration in Antarctica". The tentative plans for this program covers the period from present to 2012 (available only in Russian at http://www.aari.nw.ru/projects/Antarctic/default_en.asp).

In particular, project 4 is aimed at paleoclimate research through deep and shallow ice coring, and exploring subglacial Lake Vostok and surrounding areas by means of remote (radio-echo and seismic) surveys, as well as sampling and studying the accreted ice, lake water and bottom sediments. The document describing the program contains overarching scientific objectives rather than implementation plans for which it provides general guidance. Annual plans are being elaborated based on actually available funding and current scientific priorities as indicated by events and progress. For 2005/06 field seasons, the continuation of coring of accretion (Lake Vostok) ice in hole 5G down to 3680-3700 m has been put forward as the first priority. If we succeed in this step, the next will be a penetration into Lake Vostok, which is currently planned for 2006/07 and 2006/07 field seasons.

Please provide a description of ice coring activities your nation has a strong interest in approaching as part of an international effort.

Longest ice core record is of particular interest (see description of the suggested international project of deep ice coring in a site located about 200 km north from Vostok Station in the melting area of subglacial Lake Vostok).

An indication of the level of interest in the project by the science community and funding agencies.

The level of interest is high. During IPY, it is planned to continue geophysical (radio-echo and seismic sounding) and glaciological (shallow drilling to 30 m for accumulation, snow stratigraphy, isotope measurements) traverse works and associated modeling efforts to identify sites for a > 1Ma ice core record around northern part of Lake Vostok. Funding agency will be the Federal Service of Hydrometeorology and Environmental Monitoring of Russia (Roshydromet), as well as Russian Antarctic Expedition. The decision to initiate and fund the deep drilling in the northern part of Lake Vostok will strongly depend on the level of interest in this project shown by other nations.

Degree of readiness for participation in the project

In what year would this nation be able to make a substantial field effort to initiate the project?

The beginning of deep drilling in the northern part of Lake Vostok can be expected after 2010

Please list investigators in this nation who have been involved in ice coring projects in the last 5 years. (Names and email addresses are requested. If possible, please provide a few key words describing the investigator's expertise).

Sabit S. ABYZOV	abyzov@inmi.host.ru	microbiology
Irina A. ALEKHINA	alekhina@omrb.pnpi.spb.ru	molecular biology
Sergey A. BULAT	bulat@omrb.pnpi.spb.ru	molecular biology
Alexey A. EKAYKIN	ekaykin@aari.nw.ru	water isotopes
Vladimir N. GOLUBEV	golubev@geol.msu.ru	physical properties, water isotopes
Vladimir M. KOTLYAKOV	direct@igras.geonet.ru	water isotopes
German L. LEITCHENKOV	german_leitchenkov@hotmail.com	microparticles
Vladimir Ya. LIPENKOV	lipenkov@aari.nw.ru	physical properties
Valery N. MASOLOV	masolov@polarex.spb.ru	seismic and radio-echo sounding
Sergey V. POPOV	spopov@peterlink.ru	radio-echo sounding
Andrey N. SALAMATIN	Andrey.Salamatin@ksu.ru	mathematical modeling
Sergey A. SOKRATOV	socratov@geol.msu.ru	physical properties, water isotopes
Nikolay I. VASILIEV	vasilev_n@mail.ru	drilling technology, borehole geophysics

National ice core activities and current status for the United States

Prepared by Ed Brook (Oregon State University) and Jeff Severinghaus (Scripps Institution of Oceanography, University of California)

1. This year's Antarctic field season (2005-2006) will see the start of the field component of the WAIS Divide ice core project. This ice core has been in the planning stages for over a decade and the community is anticipating new and exciting insights to climate research from the analysis of the core. WAIS Divide will recover a high-resolution 3000+ meter ice core covering ~100,000 years, from a site in inland west Antarctica. The project is scheduled to run through 2011, with most of the deep core returned to the US in 2008 through 2010. A trial of replicate coring from the main borehole is planned for the 2010-2011 season. A drill test is planned for Greenland in 2006. Principle Investigator: Kendrick Taylor, with participation from a majority of the U.S. ice core community.

2. US ITASE (http://www.ume.maine.edu/USITASE/) is supported by OPP-NSF to traverse from Taylor Dome to South Pole with a possible extension from South Pole to Dome A during the 2006-2008 field seasons. US ITASE is part of a 20 nation SCAR ITASE (http://www.ume.maine.edu/itase/) effort under the SCAR AGCS Scientific Research Project. It is dedicated to reconstructing the last 200+ years of climate and environmental change over Antarctica and the Southern Ocean that will assess the role of Antarctica in the global climate system. US ITASE phase 1 (throughout West Antarctica and to South Pole) covered >5000km, sampled from the bed of the ice sheet through the lower atmosphere, and collected >3000m of ice core. US ITASE Phase 2 (2006-2008) will contribute to IPY under a multi-national effort dedicated to the investigation of East Antarctica (TASTE-IDEA). Science management: Paul Mayewski, PI's: Paul Mayewski, Gordon Hamilton, Eric Steig, Steve Arcone, Bob Jacobel and Brian Welch.

3. A U.S./Danish collaboration has successfully obtained very large samples of ancient air from an ice margin site at Pakitsoq, in west Greenland and mapped the stratigraphy of ice from the end of the last ice age. A main objective is to measure ^{14}C of CH_4 and use it as a tracer of methane sources. Principle Investigators: Jeff Severinghaus, Ed Brook, Niels Reeh.

4. Megadunes project. This central Antarctic project explores the effects of extreme firn metamorphism on ice core gas- and ice-isotopes, due to very low or zero accumulation rate, in a region of snow megadunes (80.78 S, 124.50 E). Initial findings include a deep zone of air convection in the firn due to enhanced permeability, and anomalous ice-isotopes due to post-depositional recrystallization from vapor. Principal Investigators: Jeff Severinghaus, Mary Albert, Mark Fahnestock, Ted Scambos, Chris Shuman.

5. A variety of geochemical and meterological experiments are ongoing at the

Greenland Summit Observatory, oriented towards better understanding of air-snow transfer processes, particularly for volatile species such as nitric acid. There is shallow drilling in support of this work, to examine recent changes not represented in the deep core, and to provide sample volume for new measurements. A 100 m core was obtained in 2005; other shallow cores may be obtained in the next few years. Principle Investigators: Eric Steig, Jack Dibb, Michael Bergin.

6. Ice cores to 100+ meters depth were recovered from two glacier sites (Clark and Commonwealth Glaciers) in the Dry Valleys during the 2004/05 Antarctic season, and cores to ~200 meters depth are planned this season from the Clark and Upper Victoria Glaciers. The main project objective is to reconstruct local/regional scale climate dynamics and atmospheric chemistry during the last 2000 years, and link to other ongoing Antarctic ice core/paleoclimate research. Principle Investigators: Karl Kreutz and Paul Mayewski.