

**International Partnerships in Ice Core Sciences (IPICS)**  
2008 Steering Committee meeting  
19-20 April 2008, Vienna



# National reports

## Australia (Tas van Ommen)

### **Australian Antarctic Program - IPICS related activities** **Current projects and plans**

#### **Overview**

Australian activities contribute across the IPICS “2k array”, “40k array” and “oldest ice” themes. The “array” work includes ice core studies on the deep DSS core, and shallower cores from Law Dome and other coastal East Antarctic sites. The Australian Program is participating in efforts to explore potential drilling sites for the oldest ice through significant partnerships in the ICECAP and AGAP airborne survey projects. Also intermediate depth drilling is scheduled for summer 2008/09 at a site (GC41) on the edge of the deeper portion of the Aurora Basin. This will contribute to the 2k array and also provide dating connections to radar work over the Aurora Basin. In addition to its ice core analytical capabilities, the Australian Program is developing airborne radar capabilities and looking to integrate these with a suitable airborne platform. Logistically, the Australian Program has increased its capability to deploy personnel to the continent with the successful implementation of a jet service operating between Hobart and Casey on approximately weekly basis through the summer field season.

#### **2k Array**

Ongoing high resolution analysis of Law Dome cores and calibration of these against instrumental data will provide more records approaching the 2,000 years length and improved characterization of proxies, including deuterium excess and elemental tracers as well as the continued trace ion chemistry and oxygen isotope records. An intermediate depth core is expected from field drilling in 2008/09 at the GC41 site (see following section on oldest ice core). This is a collaborative project with University of Copenhagen and Desert Research Institute (DRI) in Reno. The drill site has an accumulation rate of approximately 10cm ice-equivalent and continuously melted analysis is expected to provide annual dating of this core. This will provide the most continental high-resolution record in East Antarctica and will be useful in exploring transition in climate and deposition processes from coastal sites and high elevation interior sites. Shorter records are also being extracted from shallower cores at Law Dome, and GD17 (another coastal site, some 650km east of Law Dome, drilled in collaboration with I. Goodwin, Macquarie University). These short cores do not directly provide additional 2,000 year records but do provide for better understanding and calibration of proxies. In this vein, additional coring for centennial scale high resolution records is planned for sites west of Law Dome, including Mill Island and the west flank of the Denman Glacier.

#### **40k Array**

The deep DSS core from Law Dome provides a relatively high record of the late glacial period and deglaciation. Further records of trace chemistry and water isotopes are being produced for this period. Current analysis includes atmospheric composition ties (in collaboration with J. Chappellaz, LGGE) using methane to produce better synchronization at selected epochs from the late glacial through to early Holocene.

#### **Oldest Ice Core**

Drilling for a ~400 metre record from GC41 (71°36'10"S 111°15'46"E 2791m elevation) is scheduled in the 2008/09 summer season. This will provide a high resolution record in excess of 2,000 years, as described above. This drill site is located on the coastal edge of the deep portion of the Aurora Basin and will provide a very well-dated tie to radar isochrones in the uppermost part of the ice sheet. These ties will also be extended to the EPICA Dome C record and should provide a useful chronological indicator. While this site is not a candidate for oldest ice, it should contribute to understanding the past dynamics of the ice, especially in conjunction with airborne radar sounding.

The Australian Program is also providing substantial scientific, logistical and financial support in partnership with US (D. Blankenship, University of Texas) and UK (M. Seigert and others) to facilitate airborne surveys of the Aurora Basin region under the ICECAP project. This project will run over the 2008/09 and 2009/10 summer seasons and provide around 42,000 line kilometers of icesheet sounding, bedrock and magnetics. In addition, Australia is assisting the AGAP airborne project in 2008/09, working further west, in the Gamburtsev region, by provision of support for a field camp ("AGAP-North"), and fuel.

**Belgium** (Jean Louis Tison)

Belgium has no plans for independent projects and is therefore not submitting a report. However, it continues to take opportunities to work on basal ice (eg at EPICA sites), and would certainly be interested in this aspect in the oldest ice project. It will also be able to make a continuing contribution to modelling efforts (oldest ice, NEEM,....).

## **Canada** (David Fisher)

**Name and title of person completing report:** David A Fisher, Glaciology Group, Geological Survey of Canada, 601 Booth St, Ottawa Ontario K1A 0E8

### **Ice core drilling and analysis projects that have been active in the last 5 years:**

Geological Survey of Canada : Devon Ice Cap, Mt Logan, POW, Mount Oxford  
University of Alberta , Edmonton, Geography Dept , Martin Sharp, POW  
University of Alberta , Calgary, Shawn Marshal, POW  
University of Ottawa, David Fisher and Ian Clarke, Devon Ice Cap  
\*POW= Prince of Wales ice cap, Ellesmere Island

**Drilling expertise:** The Group presently at the Geological Survey of Canada has done much of Canada's ice coring and analysis to date, but the universities are now partnering up and starting their own programmes along and in conjunction with the GSC. The GSC has two medium depth tipping tower drills (Hilda and Simon) . These drills are close copies of the Danish tipping tower shallow drill and like them have achieved depths down to about 350 m in both dry and partially wet holes. The drill fluid of choice is a type of lamp oil . A third drill a close copy of the Ruffli-Rand drill and was 'inherited' from G Holdsworth, we have used down to 177m .

**Ice core analysis laboratories and their specialties:** At GSC the lab can do major ion chemistry with a Dionex system, and PE AA, both with auto samplers. There is a multi-sizer Coulter Counter for particulates and an ECM rig . There are cold rooms for storage , rough sample prep and one certified class 10 freezer room for preping ultra clean samples. The GSC has a class 100 freezer facility for making up ultra trace metal samples . The GSC in conjunction with the University of Heidelberg has outstanding capabilities for doing trace metal concentrations and isotope ratios (ICPMS). Stable isotope work has been traditionally done by the University of Copenhagen, who are always considered as project collaborators. As part of the POW project the GSC group produced a near exact copy of the University Maine's Autosampler System. We used it to make about 10000 samples from the POW cores. This is a very good and well tried technology and can produce samples with contamination levels as low as 10s of ppt. UMaine was very helpful and I believe NIPR in Japan now also a unit also.

At the *University of Ottawa* , Ian Clarke has good mass spec facilities for stable isotopes of water at the 50 samples per day rate and for gas analysis for O18/O16 and total CO2 for ice cores.

At the *University of Alberta in Edmonton* Martin Sharp's group has 2 ion chromatographs for major ions + & - . On order for a central geo-science lab facility is an ICPMS and a mass spect for stable isotopes. These would be shared instrments.

At the *University of Calgary*, Shawn Marshall and Ann-Lise Norman can do stable isotopes of water and sulfur isotopes in snow and ice samples.

**Future projects:** We put together a "futures" ice coring wish list of sites some time ago. This updated table is available on request and includes all Canadian plans (Columbia pending). David Fisher was the lead contact person in this polling.

**POW = Prince of Wales ice cap project, Ellesmere Island**

The international team drilled two holes (one 177m and the other 150m) for climate history with focus on sea-ice sensitive variables. The history of sea ice over the last 1000 years is the main goal. As part of the project would be the inter-comparison of this record with existing ice core records that could possibly contain a sea ice signature.

The Holocene ECM, melt layer and isotope records have been obtained for the site and a good preliminary time scale produced based on ECM. . Presently the University of Edmonton is analyzing the thousands of major ion chemistry samples and the University of Calgary is working on the sulfur isotope samples plus the deuterium excess record.

Virtually all the ice core players in Canada were 'on' this project and it succeeded in getting funding . The PI was Martin Sharp at the University of Edmonron. The main funding agency was CFCAS ( Canadian Foundation for Climate and Atmospheric Sciences ). The GSC, University of Alberta, and University of Ottawa are all involved with the proposal as was the University of Copenhagen who did the O18 work. There are about 10 research scientists involved and about 6 students in various places. The drilling would be done by the GSC group and the analysis tasks and student opportunities shared out equally. The other funding sources were NSERC and the CRYSYS projects, mainly for student support. The GSC also supports its own people through salary and O&M on the labs it runs.

The POW work continues in the lab and in the write up. The GSC supervised PhD student is nearing completion of his PhD on the pan-Arctic sea-ice proxy analysis.

### **International Polar Year**

Using Canadian IPY funds the GSC group is involved in two drilling projects. One is the Danish lead NEEM project in Greenland, which has been endorsed by IPICS and the other the Mt Oxford project in Northern Ellesmere Island, Canada.

The NEEM project itself is well described in other documents within IPICS. The GSC is to do the pollen and some of the trace/noble metal analysis . Participation in the drilling/field work and monetary support are also planned from the GSC side. The NEEM project is underway and their report will fill in the details.

The Mt Oxford drilling would be done by an international group led by the University of Mass. The GSC part would be to do high resolution (20m pit/auger) metals (in situ Hg in particular) and pollen at Mt. Oxford and eventually do melt layer stratigraphy on the core. The lead institution is still hunting for its core funding for this. The Mt Oxford work gets kicked off in April/May 08 with recon work on site by the GSC.

The IPY (government) gave the GSC group about \$350,000 Cdn over 5 years to carry out their part in the two drill projects. The GSC supports it people through salary and infrastructure.

### **Drilling on Svalbard with GSC help**

John Moore and the Finish group will be drilling in 2008 on Svalbard using one of our tipping tower drills (Simon). They provided all the money from EU sources and we provided the drill . Chris Zdanowicz of GSC will be going over there, and 'our' contract driller will be running the rig.

This project is funded by the Finns and EU money. We will participate in the science and help in interpretation. Samples will be collected from the site(s) for our IPY activities also. GSC contributes also a visit from Zdanowicz and the loan of one of

our drills. The drilled has been prepared and shipped and the driller will join them soon in Svalbard .

### **Mars drilling**

Fisher in the GSC group is very interested in the idea of getting a record from the North Ice Cap of Mars and has been pursuing the goal for some time. Presently there is one funded project (Kuklos) that aims to extend and develop the technology of drilling on other planets ice. Kuklos is JPL (Mike Hecht) lead and is US funded.

Another related project SUBLIME has been proposed to the ASTEP programme and is in review. It would aim at integrating and using a complete drilling , sampling and measurement system . It is also JPL lead (Mike Hecht PI). Sublime intends to use the “rig” to drill and analyze on Terrestrial sites also and show the potential of such “in situ“ systems. They could be the way for getting much faster and denser coverage, which is a goal of IPICS. Fisher is in both these projects .

Kuklos is funded and SUBLIME is in review. One gets the feeling that the idea of drilling the North Cap is beginning to “catch on”. One reason for this is that the North Caps  $\delta(D)$  record could be very long indeed (at least 10 Ma) and should reflect the strength of the solar wind (ie solar system weather).

Also the Phoenix mission, which will land close to the ice cap has thrown a lot of light and interest on the ice cap itself, because the ground ice (Phoenix main research target) is intimately related to the ice cap. Fisher is a member of the Phoenix team. The Phoenix lands on May 25 2008.

**Columbia Drilling:** information pending

**Funding agencies:** as in earlier reports, with addition of:

IPY – Canada The International Polar Year agency parceled money to Universities and government groups for the study of the polar (Arctic) regions . They gave the GSC group money to carry out its part in two international drilling projects. A third GSC non-drilling IPY project involves surface sampling through the North.

*Investigators who have been involved in ice coring projects in the last 5 years:*

*GSC, NRCan, Glaciology D Fisher, R Koerner, C Zdanowicz, J Bourgeois, M Demuth, J Zheng. Christophe Kinnard Produce and measure cores from Arctic(POW) ,Mt Logan, Yukon, NEEM and Mt Oxford.*

*University of Alberta , Edmonton, Geography Dept. Martin Sharp, Melissa Lafrenier, measure shallow cores they obtain from Ellesmere Island, POW.*

*University of Calgary , Calgary, Geography & Geomatics, Shawn Marshall, Vivian Wasiuta , Dept Physics and Astronomy Roy Krouse , Ann-Lise Norman, Bernhard Meyer. Obtain and measure cores from POW, Ellesmere Island.*

*University of Ottawa , Geology, Ian Clarke, Raphaelle Cardyn. Uses GSC cores from Arctic and Logan.*

*University of Victoria, Earth & Ocean Science . Hinrich Schaefer Methane analysis, isotopes. Uses GSC cores from Arctic and Logan.*

*UBC Oceanography, Curtis Suttle, viruses. Uses GSC cores from Arctic.*

## Denmark (Dorthe Dahl-Jensen)

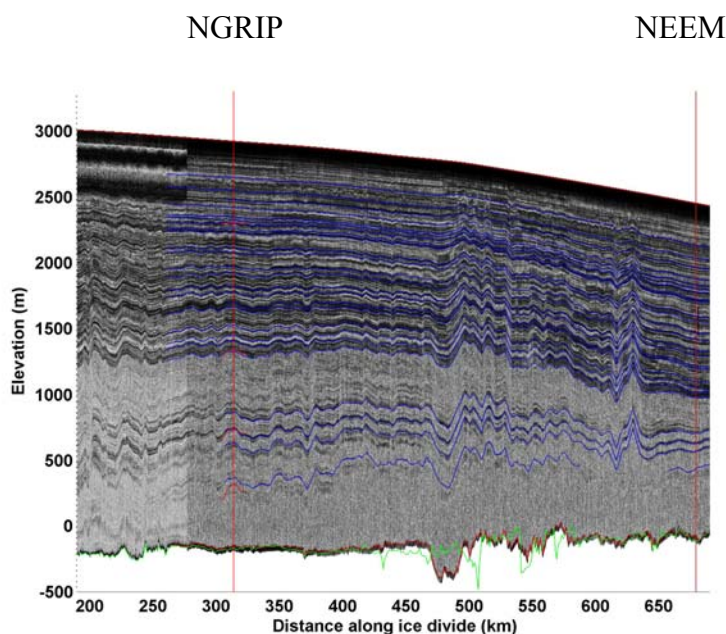
### **Ice core activities in Denmark**

#### **Centre of Ice and Climate**

The Copenhagen group has formed a Centre of Excellence for Ice and Climate and have expanded the ice core group significantly. Major activities are stable oxygen isotopes, gas measurements, cfa methods, stratigraphy and dating, tephra, laser techniques for gas and isotope measurements, ice sheet modelling, atmosphere and climate modelling and carbon cycle modelling. Research will be focused on interglacial ice, both Holocene and Eemian.

#### **NEEM**

The Centre for Ice and Climate, Niels Bohr Institute, Denmark also form the coordination and logistic centre for the IPY deep ice core drilling program, NEEM in North Greenland. The program started in 2007 as a 14 nation program (Belgium, Canada, China, Denmark, France, Germany, Iceland, Japan, Korea, Netherlands, Sweden, Switzerland, UK, US) and will continue until 2011. During the 2007 season we logged the NGRIP borehole with the DK logger, moved equipment from NGRIP to NEEM, drilled three 60-80m cores along the ice-ridge flow line connecting NGRIP and NEEM, placed GPS strain nets and performed radar measurements with AWI and CreSIS radars.



*Figure: New radar measurements of the ice ridge flow line Between NGRIP and NEEM (CreSIS)*

At the NEEM site further radar measurements were performed in a net around the selected drill site. Finally a ski way for US C130 was made.

In 2008 the camp structures will be built and the drill and science trench made. After shallow drilling, reaming and casing the deep drill will be installed. Our ambition is to drill to 400 m during the 2008 season. During the seasons 2009 and 2010 we hope to penetrate the 2550 m deep ice and 2011 should be the final season at NEEM. The 2008 field season report can soon be downloaded from the site [www.iceandclimate.dk](http://www.iceandclimate.dk)

#### **EPICA**

The researchers at the Centre of Ice and Climate are part of the EPICA program. The group participates in the stable oxygen isotopes measurements, the chemistry and dust programs, the dating and borehole measurements.

#### **AURORA-BASIN**



In collaboration with the ice core group from Hobart, Australia we will use the DK Hans Tausen drill to drill 400 m at the Aurora-basin site. The ice core will be drilled during the 2008/2009 season with participation of DK drillers/scientists. The aim of the project is to get a detailed record of the last 2000 years.

### **ROOSEVELT ISLAND**

A project is under construction to drill a 750 m deep ice core on the Roosevelt Island. The ice core will be drilled with the DK Hans Tausen drill hopefully during the 2009/2010 season. The aim of the project is to reconstruct the evolution of the West Antarctic Ice Sheet by use of radio echo sounding layers, a dated ice core and reference horizons to other palaeo data. Stable oxygen isotope measurements, ecm, dep, chemistry and gasses will be measured on the ice core.

### **West Antarctic Ice Sheet (WAIS) deep drilling.**

The group participates in the US WAIS deep ice coring with field personnel and hopes to contribute scientifically on issues such as dating, N-S synchronisation, stable isotopes and gases.

On behalf of the Copenhagen Group

Dorthe Dahl-Jensen  
Professor, NBI, University of Copenhagen

## **Estonia** (Rein Vaikmäe)

### **Estonian recent and planned activities in ice core research**

Estonia has been involved in ice-core research starting from late 70-es through the collaboration with the Institute of Geography RAS, Moscow (V.Kotlyakov) and with AARI, St.Petersburg (L.Savatyugin, V.Lipenkov). Stable isotope records of ice cores from Svalbard (Lomonosovfonna, Austfonna, Westfonna), from Severnaya Zemlya (Vavilov Ice Dome) and from Antarctica (Dome B in collaboration with the Grenoble group, Shacleton Shelf Ice) were extracted.

During the last 10 years we have been working together with Norwegian Polar Research Institute (NPI) on Svalbard to investigate the present and past 800 years of climate by means of shallow ice core records. Estonian contribution has been:  $\delta^{18}\text{O}$  and  $\delta\text{D}$  analysis, interpretation and participation in field work + sampling.

#### **Investigated ice cores:**

Core site	Core taken	Elevation	Depth	Dating	Sampling
Lomonosovfonna	1997	1230 m.a.s.l.	126 m	1200-present	1.5-5 cm
Austfonna	1998	600 m.a.s.l.	118 m	1750-present	25 cm
Austfonna	1999	600 m.a.s.l.	289 m	1200-present	2-25 cm
Holtedahlfonna	2005	1150 m.a.s.l.	125 m	1600-present	2-5 cm

#### **Planned activities:**

Estonia has no plans for independent drilling projects but will be interested in participating in IPICS projects in collaboration with other countries. We are particularly interested in 2kyr array, but also in 40 kyr and oldist ice core (including shallow coring traverses during site identifying survey).

Currently Estonia participates in the Norwegian Polar Institute SVICECLIM project, working with the last drilled ice core from Holtedahlfonna. Planned activities on Svalbard involve participating in ice coring programme on Nordaustlandet in cooperation with Norway (project leader), Sweden and the Netherlands.

Estonia is among the 16 European countries, having official agreement with European Science Foundation for participation in ESF PolarCLIMATE programme which will be launched in May 2008. The main interest is to participate in consortium oriented on ice-core shallow arrays.

We shall also continue our research on subglacial meltwater drainage and groundwater formation in glaciated areas. Therefore we shall look for opportunities to work on basal ice.

Estonia is also interested in training the new generation of ice core scientists through the participation in IPICS.

### Analytical capacity available for ice core research:

Estonia can mainly contribute to the IPICS through the ice-core stable isotope analyses. The Laboratory of Isotope-paleoclimatology (Institute of Geology at Tallinn University of Technology) has a Thermo Electron Corporation IRMS Delta V Advantage with peripherals which include GasBench II ( $\delta^{13}\text{C}$  and  $\delta^{18}\text{O}$  in carbonates and  $\delta\text{D}$  and  $\delta^{18}\text{O}$  in water), TC/EA with liquid injector ( $\delta\text{D}$  and  $\delta^{18}\text{O}$ ) and with autosampler for organic samples ( $\delta\text{D}$  and  $\delta^{18}\text{O}$ ), Flash EA 1112 ( $\delta^{13}\text{C}$  and  $\delta^{15}\text{N}$  from organic samples) and interface ConFlow III. We also have a Finnigan MAT Delta E IRMS with water samples equilibration line and an ultra low-level spectrometer Quantulus 1220 for radiocarbon dating.

### Agences that might fund future ice coring activities.

Research Competence Council (Estonian Ministry of Education and Research)  
Estonian Science Foundation  
European Commission  
European Science Foundation

### Scientists active in ice coring projects in the last 5 years.

Rein Vaikmäe (water isotopes, paleoclimate, subglacial meltwater drainage), Tallinn University of Technology (TUT), ([rein.vaikmae@ttu.ee](mailto:rein.vaikmae@ttu.ee))  
Tõnu Martma (stable isotope mass-spectrometry, drilling), TUT, [tonu.martma@gi.ee](mailto:tonu.martma@gi.ee)  
Jüri Ivask (ion-chromatography, ice chemistry), TUT, [jyri.ivask@gi.ee](mailto:jyri.ivask@gi.ee)

## **Europe** (Eric Wolff)

Although individual European nations will report separately, it has become traditional for us to also supply a joint European report, covering activities involving many nations.

Since the last meeting, all EPICA field activities at Dome C and Dronning Maud Land (EDML) have been completed, although borehole logging is still planned. A large number of publications from Dome C (back to 800 ka) and EDML (covering especially the last glacial cycle) have appeared. Although funding directly for EPICA is nearly complete, many people continue to work on EPICA ice and data. There will be a “final” EPICA open science meeting in Venice in November 2008 (see <http://www.epica2008.eu/>).

Several other projects involving various combinations of European nations have been carried on, and will be reported in national reports, e.g. Talos Dome, Berkner Island, James Ross Island, and of course NEEM. In addition, several activities that will contribute to site selection for IPICS projects have taken place (eg TASTE-IDEA traverses).

With the completion of EPICA, the nations involved and others in the European Polar Board have agreed to form a new structure, Europics, to pursue future European ice core goals, mainly related to IPICS. Europics will have held its first formal meeting in Vienna in April 2008, and we will be able to report on that during the IPICS SC meeting.

**France** (Jérôme Chappellaz)

**National Ice Coring Activities and current status for France**

**2008 update**

Name and title of person completing report: Jérôme Chappellaz

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

Participation at the EPICA project with emphasis on the DC drilling  
Participation at the NGRIP project  
Participation at the Berkner drilling project  
Participation at the Vostok drilling project  
Participation at the Talos Dome drilling project (with Berkner drill)  
Participation at the James Ross drilling project (with James Ross drill)

Andean ice cores with IRD (San Valentin, Coropuna, Illimani)  
Alpine ice cores (Mt Blanc summit, Col du Dome, Monte Rosa, Colle Gnifetti)

France is providing analysis for all these projects (ice isotopes, gases, dust, chemistry, Beryllium 10, heavy metals, physical properties,.....), as well as specific analyses for the Australian project on Law Dome, and the Chinese projects at Dome A and the Himalayas (East Rongbuk, Dasuopu). Contributions also to ice flow modelling and dating.

Please briefly describe what drilling expertise this nation has :

Hot water drilling:  
down to 300m depth, French Alps, 1980-1985.  
Thermal drilling:  
dry hole, down to 905m, Antarctica, 1978.  
liquid filled hole, down to 800m, Antarctica, 1987-1989.  
Electro mechanical drilling:  
dry hole, down to 300m, Antarctica, Greenland, continuously.  
liquid filled hole, down to 3270m, Antarctica , Greenland, since 1990.  
Hole logging:  
0.5 mK precision temperature, pressure, diameter, inclination, orientation.

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

LGGE (Grenoble): gas, dust, physical properties, chemistry, heavy metals

LSCE (Saclay): ice and gas isotopes

CEREGE (Aix en Provence): 10 Be

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

IPEV, Gerard Jugie, director

INSU/CNRS, Patrick Monfray, director for ocean/atmosphere science

ANR (National Research Agency)

European Commission

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

There are about 50 scientists involved in this country. Here are 4 contact scientists: Valérie Masson-Delmotte (IPICS member) and Jean Jouzel at LSCE

Jérôme Chappellaz (IPICS member) and Dominique Raynaud at LGGE  
Edouard Bard at CEREGE

The contact person for ice core drilling and logging technology is Olivier Alemany (LGGE).

#### Future

France will be interested in participating in all four IPICS projects, in collaboration with other countries. It will contribute to the ice core drilling technology group.

Currently planned projects include a contribution to NEEM, a bilateral reconnaissance drilling at Dome A (with China), a contribution to ITASE traverses (with Italians and Russians), the latter including probable drillings for firm air analyses. On non-polar glaciers, there are plans to develop a series of new drillings at high altitude, for long-term storage of an archive currently in danger, as it gets more and more affected by the warming.

In addition, France contributes to the study of fast ice stream glaciers, with a specific project on the Astrolabe glacier nearby Dumont d'Urville station. It also carries on glacier mass balance survey along the DDU / Concordia line, with shallow drillings.

**Germany** (Heinz Miller, Hubertus Fischer)

National ice core activities and current status for Germany

*Name and title of persons completing report:*

Heinz Miller, Hubertus Fischer

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

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)

Akademik Nauk Ice core (Arctic): Drilling, onsite and lab analysis

***New projects (planned or envisaged)***

NorthEEM, Drilling, onsite and lab analysis (started 2007)

PREIPICS: coastal core reconnaissance (shallow and intermediate drilling completed) lab analysis (started 2006/07)

PREIPICS: deep drilling (envisaged)

***Please briefly describe what drilling expertise this nation has.***

Shallow and intermediate depth drilling in dry holes.

Deep drilling

Drill electronics

Borehole geophysics

Hot water drilling

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

*Alfred-Wegener-Institute for Polar and Marine Research, Bremerhaven*

Continuous dust analysis

Mass-spectrometric analysis of water isotopes

Discrete analysis of major and trace ions on ice and atmospheric aerosol

Isotopic ratios in greenhouse gases

Multielement analysis

Physical properties

Line scan

DEP

Modeling and measurements of air entrapment processes in firn

*Institute of environmental physics, University of Heidelberg*

10Be

TOC

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

German Research foundation  
Federal Ministry for Education and Research  
Alfred-Wegener-Institute  
European Commission

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

H. Miller (geophysics, logistics), AWI  
J. Kipfstuhl (physical properties), AWI  
J. Freitag (Firn gases), AWI  
H. Oerter (water isotopes), AWI  
H. Fischer (Greenhouse gases, synchronisation, Isotopes, chemistry), AWI  
U. Ruth (CFA, Dust) , AWI  
F. Wilhelms (Drilling, DEP), AWI  
O. Eisen (Radar, accumulation), AWI  
D. Steinhage (Radar), AWI  
D. Fritzsche (Drilling, water isotopes), AWI  
H. Meyer (water isotopes), AWI  
A. Wegner (mineral dust), AWI  
J. Schmitt (isotopes in greenhouse gases), AWI  
  
D. Wagenbach ( $^{10}\text{Be}$ , TOC), University of Heidelberg



## **India** (Thamban Meloth)

### **PROGRESS OF INDIAN ICE CORE PROGRAMME (2006-08)**

India had initiated a shallow ice core drilling program in the central Dronning Maud Land (cDML) as a long-term mission project of the Indian Scientific Expedition to Antarctica (InSEA). It is a joint collaborative project between the National Centre for Antarctic and Ocean Research (NCAOR), Goa and the Antarctic Division of the Geological Survey of India (GSI), Faridabad. The major scientific objectives of the project are:

- i. To study spatial variability in the snow/ice accumulation rates and its characteristics to understand the environmental variability along coastal to inland transect in the coastal Antarctica during past few centuries.
- ii. To study the influence of biogeochemical cycling on the atmospheric distribution of chemical species as recorded in the coastal Antarctic snow.
- iii. To understand the influence of internal / external climate forcing mechanisms on the Antarctic environment and climate in the recent past.

The project forms part of ITASE (International Trans Antarctic Expedition) program of the SCAR. As part of this project, three shallow ice cores were collected during the 25<sup>th</sup> InSEA (2005-06) and 26<sup>th</sup> InSEA (2006-07) field campaigns. Details of the samples are as follows:

Core No.	Location	Core Length (m)	Proxy parameters studied
IND 25/B5	71° 20' 38" S & 11° 35' 38" E	65 m	Isotopes ( $\delta^{18}\text{O}$ , $\delta\text{D}$ ), Cations ( $\text{Na}^+$ , $\text{K}^+$ , $\text{Ca}^{2+}$ , $\text{Mg}^{2+}$ , $\text{NH}_4^+$ ), Anions ( $\text{SO}_4^{2-}$ , $\text{Cl}^-$ , $\text{MSA}$ , $\text{NO}_3^-$ ), trace metals, micro-tephra, bacteria, etc.
IND 26/B6	70° 11' 57" S & 12° 27' 25" E	75 m	
IND 26/B7	70° 13' 48" S & 11° 55' 44" E	56 m	

In order to achieve the objectives of the above project, more shallow ice core drilling will be conducted during the future expeditions along the proposed Indian ITASE transect in the cDML region.

### **LOGISTIC & SCIENTIFIC CAPABILITIES:**

1. *Presently India has capabilities to carry out shallow (~100 m) dry drilling using electromechanical facilities within the logistic reaches of the Indian station.*
2. *India has also established its dedicated Antarctic Ice Core Laboratory with necessary archival, processing and analytical facilities at the National Centre for Antarctic and Ocean Research (NCAOR), Goa. The archival facility includes two walk-in freezer*

*rooms maintained at -20°C with custom-made EPP boxes for storage of ice cores; Ice core processing facility maintained at a -15°C freezer room fitted with necessary worktables, bandsaw machines and electrical conductivity measurement (ECM) facility; Clean room facilities for sample melting and analyses. The analytical facilities include: 1). Isotope Ratio Mass Spectrometer (IRMS) with capabilities to carry out automated, high-precision measurements of stable isotopes of oxygen and hydrogen; 2). Glacio-chemistry Lab equipped with a fully automated, reagent-free, Ion Chromatograph system; 3). Inductively Coupled Plasma Mass Spectrometer (ICP-MS) for trace metal analysis; SEM-EDS facility for studying the micro-particles and particle-bound microbes within the ice cores.*

3. *In order to sustain the high-quality research, capacity building is also being undertaken in various field of ice core research. Some level of indigenization is also being initiated in the field of ice core technology in close co-operation with industry.*

#### ***FUTURE PLAN:***

In collaboration with other IPICS partners, India would like to initiate a deeper depth ice core program to recover ice sequences that permits a high-resolution study of the Antarctic climate evolution since the last deglaciation. Some of the major scientific themes of the proposed study would be:

- *Role and response of Antarctica in the last glacial to interglacial climate evolution*
- *Role of northern hemisphere on Antarctic climate during the last deglaciation*
- *Role of internal and external forcing mechanisms on Antarctic climate*
- *Role of Southern Hemisphere in the Asian monsoons and climatic teleconnections*

*Considering the large-scale scientific, logistic and financial requirements of the proposal and to achieve the set objectives in a limited time frame, it would be highly beneficial to have collaborations with the leading international ice core community. If a new program is not in favour with other IPICS members, then India is keen to join the ongoing/ recommended projects of IPICS.*

The proposed Indian project would be very much part of the IPICS 40,000 year plans. As per the IPICS document, “although the drilling projects within the IPICS 40k array is primarily organized and coordinated independently, the IPICS frame work provides an ideal stage for an overarching coordination of logistics and drilling activities”.

**Italy** (Massimo Frezzotti)

NATIONAL ICE CORE ACTIVITIES (2006-2007) AND CURRENT STATUS FOR ITALY

Here is reported the Italian ice core activities since the last report of IPICS in fall 2005.

The activities described are mainly linked to European (Italy, France, Germany, Swiss, UK) ice core project TALDICE (TALos Dome Ice CorE project). The location of the drilling is 159°11'E 72°50'S, altitude of 2310 m above sea level, with a surface mean temperature of -41 °C and snow accumulation of about 80 kg m<sup>2</sup> yr<sup>-1</sup>. TALDICE project is a part of IPICS scientific objectives "40,000 year network: a bipolar record of climate forcing and response". Italian effort in Antarctica was dedicated to the management of summer field camp, drilling and logging activities of TALDICE project.

Since the second IPICS meeting, in fall 2005, TALDICE teams have drilled for three season: from 127 to 607 m during 2005-2006 season; from 607 to 1300 m during 2006-2007 season and reaching the 1620.20 m depth on December 23, 2007.

Unfortunately without reach the bedrock, estimate to be 1560 m +/-25 m. Italian, French, British and German technicians and scientist were involved for about 50 days for season in drilling (using French-British "Berkner drill system") and logging activities. Ice core down to 1620 m have been retrograde to Europe, drill trench and field camp have been cleaned and the borehole access from surface has been set up for future measurements. The processing of TALDICE ice core (cutting, sampling, CFA-FIC, DEP and Line scanner) has been performed at AWI Bremerhaven ice core facility. Ice samples have been shared and are being analysed in several European Laboratories. The archive ice is stored at University Milano Bicocca.

The others activities in Italy have mainly been focused on analyses of the EPICA (EDC and EDML) and ITASE ice cores.

Italian ice core community are interested in all 3 IPICS projects proposed for Antarctica, in particular for 2kyr and oldest ice core projects.

**Japan** (Hideaki Motoyama)

*Name of Country:* **Japan**

*Name and title of person completing report:* Hideaki Motoyama

*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

Phase 3: Interdisciplinary study

Cosmogenic nuclide study (Geomagnetic field, solar activity), Micro-biology study, Micro-meteorite study, basal ice study

Study on Japanese ITASE shallow cores

H72(73m), YM85(105m), MD364(80m), DFS(56m)

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. A deep ice core drilling down to 3,035.22 m in depth was successfully finished in January 2007.

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, electric properties, microorganisms and micro-meteorite.

Institute of Low Temperature Science, Hokkaido University: Physical properties such as clathrate hydrate, Raman spectral N<sub>2</sub>/O<sub>2</sub> 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 CO<sub>2</sub>, CH<sub>4</sub> and N<sub>2</sub>O concentrations, isotopic ratios of CO<sub>2</sub>, O<sub>2</sub> and N<sub>2</sub>, and O<sub>2</sub>/N<sub>2</sub> ratio.

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. A deep ice core drilling down to 3,035.22 m in depth was successfully finished in January 2007. It will be expected to conduct the borehole measurement again into several years later.

We plan to conduct the firm air sampling and shallow ice core drilling at Dome Fuji station in 2009/2010 and 2010/2011.

We take part in NEEM from 2008.

*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 8 contact scientists.

Shuji Aoki (Tohoku University) [aoki@mail.tains.tohoku.ac.jp](mailto:aoki@mail.tains.tohoku.ac.jp)

Nobuhiko Azuma (Nagaoka University of Technology) [azuma@mech.nagaokaut.ac.jp](mailto:azuma@mech.nagaokaut.ac.jp)

Yoshiyuki Fujii (NIPR) [fujii@nipr.ac.jp](mailto:fujii@nipr.ac.jp)

Hideaki Motoyama (NIPR) [motoyama@pmg.nipr.ac.jp](mailto:motoyama@pmg.nipr.ac.jp)

Kumiko Azuma (NIPR) [kumiko@pmg.nipr.ac.jp](mailto:kumiko@pmg.nipr.ac.jp)

Shuji Fujita (NIPR) [sfujita@pmg.nipr.ac.jp](mailto:sfujita@pmg.nipr.ac.jp)

Takeo Hondoh (Hokkaido University) [hnd@lowtem.hokudai.ac.jp](mailto:hnd@lowtem.hokudai.ac.jp)

Takao Kameda (Kitami Institute of Technology) [kameda@mail.kitami-it.ac.jp](mailto:kameda@mail.kitami-it.ac.jp)

**Korea** (Soon Do Hur and Sungmin Hong)

*Name of Country:* **Korea**

*Name and title of person completing report:*

Sungmin Hong  
Director, Center of Polar Climate Sciences, Korea Polar Research Institute  
Songdo Techno Park 7-50, Songdo-dong, Yeonsu-gu,  
Incheon 406-840, KOREA

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

- High mountain glacier ice core drilling at Quilian Mt., China in 2007 (38°42'18.5"N, 97°16'14.1"E, 5,350 a.s.l.)
- Analysis of trace metals in Vostok Antarctic ice and Sajama ice in Boliva
- Trace metals, water soluble ions and Pb isotope analysis in snow and ice from Mt. Everest of the Himalayas

*Drilling expertise this nation has.*

- Shallow ice coring was carried out at Quilian Mt., China in 2007 through cooperation with State Key Laboratory of Cryospheric Science, China

*Ice core analysis laboratories and their specialties in this nation.*

- Korea Polar Research Institute:
  - . Ultra Clean rooms (Class 1000 and 10) for sample preparation and analysis
  - . Cold room for ice core decontamination
  - . Micro particle size analyzer
  - . Ion Chromatography
  - . Graphite Furnace Atomic Absorption Spectrometry
  - . Inductively Coupled Plasma Mass Spectrometry

*Current and future known ice core project.*

- A shallow ice core drilling at high mountain area in western Mongolia in 2008 (contribute to 2k arrays)
- Participation in Greenland NEEM deep ice core drilling project from 2008 to 2010

*New equipment or logistic capacity.*

- High Resolution magnetic Sector Inductively Coupled Mass Spectrometry (HR-MC-ICP-MS) and Thermal Ionization Mass Spectrometry (TIMS) will be installed at Korea Polar Research Institute for determining ultra-low trace metals, REE and Rb, Sr, Sm, Nd and Pb isotopes in high mountains and polar snow and ice.
- Korea is planning to construct the second research station on Antarctic continent until 2012. In this context, KOPRI is searching for the most suitable location which will be decided soon. It is expected that Korea will more contribute to IPICS for supporting the logistics and developing various ice coring programs in Antarctica.

**Netherlands** (Roderik van de Wal)

\*In terms of presite activities: two weather stations are installed. One is located at the former Plateau station, 79.25°S, 40.5°E, 3625 m a.s.l. the other one is installed at the pole of inaccessibility, 82.12°S, 55.1°E, 3724 m a.s.l. The weather stations are installed during the Norwegian-US traverse from Troll to South-Pole and back. They measure wind speed, wind direction, snow height, temperature, humidity, air pressure, solar and terrestrial radiation as well as snow temperatures. There are no plans for firn core drilling at present.

\*A second activity is related to modelling firn air in order to predict better where the oldest firn air can be retrieved.

\*In collaboration with Niels Bohr (Copenhagen) the use of  $^{17}\text{O}$  as additional proxy is tested.

\*Not explicitly mentioned in your request is the NEEM program (the 4th IPICS issue). For completeness our activities in the NEEM project are stable isotopes from methane  $\delta^{13}\text{C}$  and  $\delta\text{D}$  and secondly ice sheet and regional atmospheric modelling of Greenland during the Eemian.

## **New Zealand** (Nancy Bertler)

In the last two years, the NZ programme has:

\* Opened a new, state of the art ice core facility. The freezer facility is designed to hold 2,000m of ice cores at -35C. An adjacent working freezer operates at -20C. The facility also has an ultra clean laboratory, continuous melting system, and a gas extraction (cheese grater) device

\* We currently hold 800 m of ice cores from coastal Antarctic sites and 80m of New Zealand ice cores which we analyse in collaboration with University of Maine and the Alfred Wegener Institute

\* Available analytical facilities include: water isotopes, ICP-MS water and dust chemistry, gas concentration and isotopic ratios, radioactive isotopes (10Be, 32Si, T)

\* We are currently developing in collaboration with Dorte Dahl-Jensen's group a new ice core drill with a drilling capacity of 1,000 m depth to be completed and tested for the 09/10 Antarctic field season

\* During the 2006/07 field season we recovered in collaboration with the Alfred Wegener Institute one 100m ice core from N-Victoria Land in the vicinity of Cape Hallett and a 200m core from Mt Erebus Saddle

\* During the 2007/08 field season we successfully conducted a site survey for two new drilling sites in the Byrd Glacier region with over 150km of high resolution radar profiling, shallow ice coring, and establishment of a new AWS.

\* We have created two new graduate student scholarships to work within our ice core programme (PhD and MSc) and are currently advertising for a new postdoctoral position

\* In collaboration with Howard Conway, Dorte Dahl-Jensen, Ed Waddington, Ed Brook, Erik Steig, and Paul Mayewski we are currently preparing for a drilling season at Roosevelt Island, possibly for 09/10 field season.



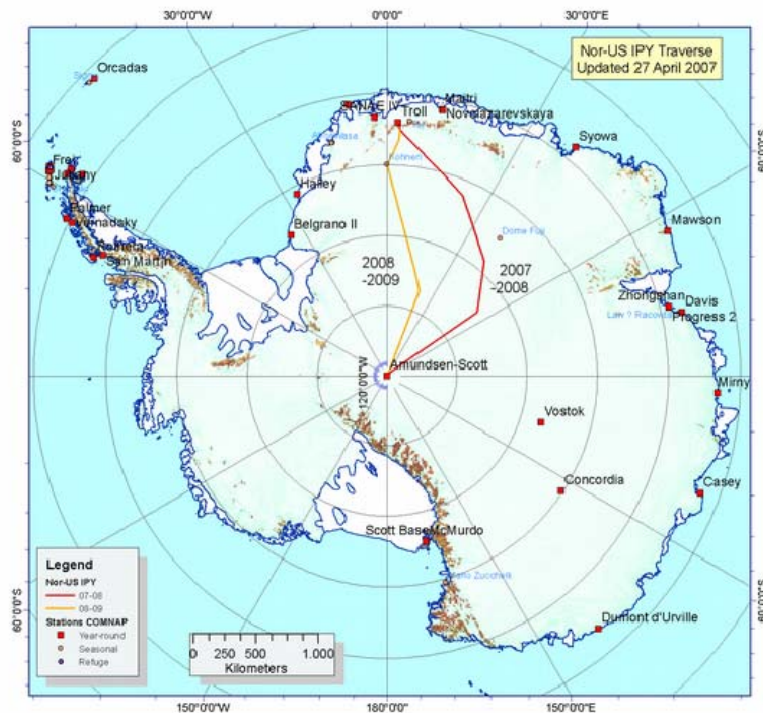
Norway (Elisabeth Isaksson)

## IPICS related Norwegian ice core activities

### Antarctica

#### Norwegian – US Scientific Traverse of East Antarctica

The field expedition for this international partnership involves scientific investigations along two overland traverses in East Antarctica: one going from the Norwegian Troll Station to the United States South Pole Station in 2007-2008; and a return traverse by a different route in 2008-2009 (see Figure below). This project will investigate accumulation variability and climate change in East Antarctica with focus on the last 1000 years. The first about 500 km of the traverse was visited during the EPICA pre-site surveying both in 1996-97 and 2000-01.



*Figure with the traverse route included.*

The first year of this 2-leg traverse has now been completed. Due to technical problems the vehicles were left at 86.80033 deg S, 54.45187 deg E where the traverse will start again in November 2009. Three cores of 90m depth each were retrieved on

different locations on the East Antarctic plateau, including historic stations like Plateau Station and Pole of Inaccessibility. These cores are estimated to cover the last 1000 years. Four different sites firn cores with a depth between 20-25m have been obtained. Those shallow cores will be analyzed for dielectric parameters (DEP) in order to identify volcanic horizons and thus provide accumulation rates.

Along the entire traverse route several radar devices have been in operation, with frequencies of 5, 400, and 500 MHz as well as 5.3 GHz. The radar data will be used to link firn cores and determine accumulation rates. The low frequency radar should yield information about the bedrock topography but due to technical problems it is currently unclear if the data reveal the actual bedrock reflection.

Because this traverse has visited areas where very little field data exist from before the information collected will be valuable in the search for the oldest ice. Some of the ice core records drilled may have annually resolved data (will be analyzed in Joe McConnells laboratory) and thus can contribute to the 2k array programme.

More information on the traverse can be found at <http://traverse.npolar.no>

**Future plans:** During the 2009/10 we will start a 4-year year long oceanographic-glaciological project on Fimbulisen ice shelf and we will try to drill one coastal core in this area during this time period.

## **Svalbard**

In the last decade we have drilled several ice cores on Svalbard. In collaboration with Japan we drilled on Austfonna in 1998 and 1999, with the Netherlands, Estonia, Finland and Sweden on Lomonosovfonna in 1997 and on Holtedahlfonna in 2005. The cores cover the last 800 years and have annually resolved records for at least 300 years and decadal for the rest. These cores can contribute to the 2k array programme.

**Future plans:** Within the next 5-years we would like to drill to the bedrock of the 600 m deep ice cap on Austfonna.

## Russia (Vladimir Lipenkov)

### Current projects and plans related to ice core activity for Russia

After an eight-year break, Russian Antarctic Expedition (RAE) resumed deep drilling project at Vostok Station in 2005/06 Antarctic season. Ice coring at Vostok continues with electromechanical drill and encounters difficulties typical for drilling in “warm ice” under high pressure. At the time of writing the depth of hole 5G-1 is 3666 mbs and the thickness of ice separating bottom of the hole from the ice-water interface is about 90 m. Isotope, chemical and biological analyses carried out on the newly obtained accretion ice samples (frozen lake water) and related modelling efforts provide important pre-entry information about the extraordinary environmental conditions in subglacial Lake Vostok. If no indication for a shallower depth of the ice-water interface is obtained in the course of ice coring, drilling with electromechanical drill will continue to about 3720 m depth. Access to the lake from the bottom of 5G-1 will be completed with the coreless electrothermal drill system designed in St. Petersburg Mining Institute. First entry into Lake Vostok and extraction of sub-ice water in the hole are currently planned for season 2009/10.

In parallel with ongoing drilling project at Vostok, RAE has started glaciological and geophysical surveys on the new route for logistic tractor traverse from Progress to Vostok Station and along the two selected ice-flow lines originating from Ridge B and passing: one through the Vostok drilling site, and another through northern part of Lake Vostok (see figure).

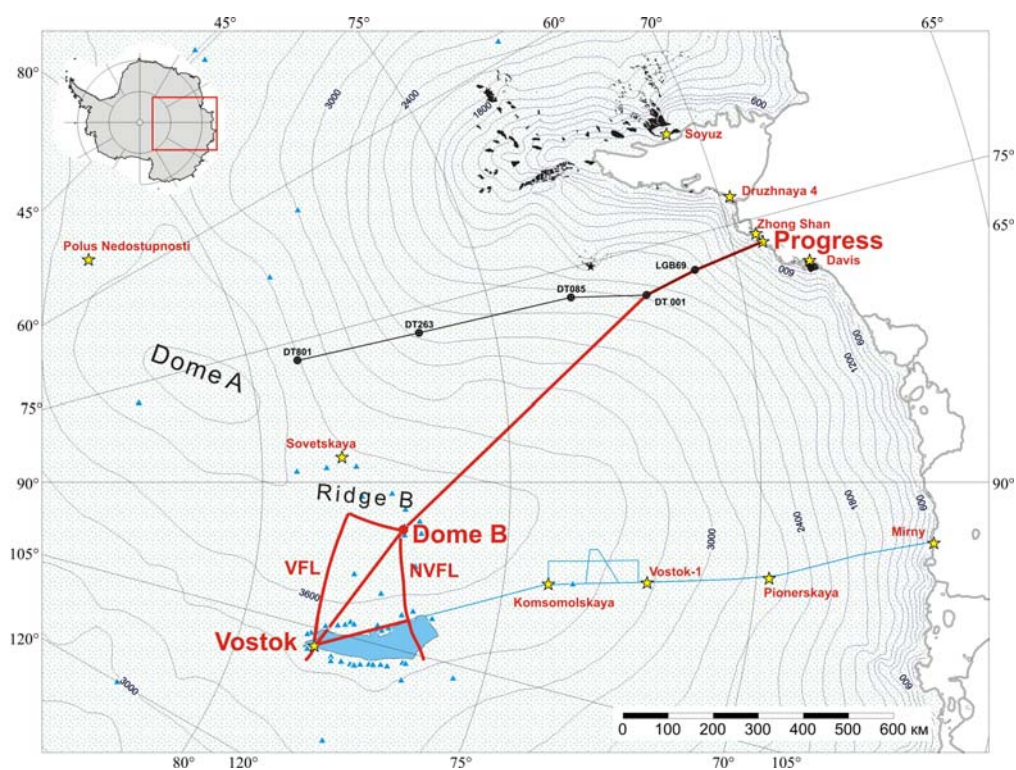


Figure 1. Scientific traverses planned by Russian Antarctic Expedition between Vostok and Progress stations in 2008-2011 (red lines). VFL – Vostok ice-flow line, NVFL – North Vostok ice-flow line

The main scientific objectives of the project are: to determine spatial and temporal (over the past 200 years) variability of accumulation and isotopic composition of snow and to map the ice-sheet thickness, bottom conditions, subglacial topography and the internal layers along the traverse routes. Glaciological investigations include shallow firn coring (to 20-30 m) and 10 m temperature measurements at 50-150 km interval. The geophysical program includes deep radio-echo sounding and determination of ice flow vectors based on the precise GPS measurements.

First investigations on the Vostok flow line (VFL) were performed in 2005/06 season. They were completed to 110 km upstream and 30 km downstream of Vostok Station. In 2006/07 preliminary survey started along the North Vostok flow line (NVFL), in 2007/08 it was extended to Ridge B and continued along the new logistic route from Progress to Vostok. Also within this season, RAE mostly completed the long-term program for geophysical survey (radar and seismic sounding) of the Lake Vostok area. The newly obtained data on snow accumulation, internal layering and bottom topography of ice sheet have been used to constrain the ice-flow line models for both VFL and NVFL, to refine the Vostok ice core chronology and to predict the ice age distribution in the northern part of Lake Vostok.

The field works along the ice-flow lines and on the route to Progress Station will continue during 3 coming seasons. It is also envisaged that in 2009/10 and 2010/11 Russian researchers will join Italian/French/Russian traverse on its legs from Vostok to Dome A (via Dome B) and from Dome A to Komsomolskaya Station. The additional information from radar survey and shallow coring will be used to further refine local ice-flow models and finally to produce a reliable prediction of the ice age-depth distribution in the vast region that encompasses Lake Vostok, Ridge B and the area to the west and north-west of Ridge B. We consider this large-scale field works as a contribution to the site selection stage of "IPICS oldest ice" project.

In the European ice core community we are currently involved in performing gas content measurements on the EDC, DML and Berkner ice cores and in developing gas content as a new tool for absolute dating of old Antarctic ice. We hope that our potential to contribute to the analyses of the ice cores planned under the IPICS projects will increase with developing facilities for gas and isotope measurements in AARI, St. Petersburg and with creation of a laboratory dedicated to Antarctic snow and ice chemistry in Limnological Institute in Irkutsk. These developments are now envisaged in the framework of International associated laboratory (LIA) for Antarctic ice core studies which is to be established between Russia and France.

Sweden (Margareta Hansson)

## **Short summary of Swedish ice core research activities**

### *Past*

The Swedish engagement in ice core research started in 1987-1998 together with Denmark and Iceland in the Nordic Renland project<sup>1</sup> 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<sup>2,3,4</sup>. During following years Sweden performed shallow and intermediate depth ice core drilling in the Dronning Maud Land (DML) area, Antarctica<sup>5,6,7</sup>, during several expeditions within the frame of ITASE and pre-site surveys for EPICA-DML, as well as on glaciers in Sweden<sup>8</sup> and Svalbard<sup>9</sup>. 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. Sweden was one of the nine nations cooperating in the North-GRIP<sup>10</sup> deep drilling on Greenland. The main focus from the Swedish side is the ion chemistry. Sweden was also one of ten nations cooperating within the European Project for Ice Coring in Antarctica, EPICA, at Dome C<sup>11</sup> and in DML<sup>12</sup>. Also here the main effort is within the ion chemistry consortium. Swedish drillers/drill helpers have participated in the three different deep drillings.

### *Present and Future*

Swedish activities during IPY 2007/2008 involving ice core drilling and surface snow sampling programmes are:

1. The start of the new international Greenland deep drilling, the NEEM-project. The Swedish scientific contribution will be radionuclide measurements, tephra analyses and ion and stable sulphur isotope studies. The IPICS document describing this project has the title; **The last interglacial and beyond: A northwest Greenland deep ice core drilling project.**
2. The Japanese-Swedish Antarctic Expedition JASE 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, including radar measurements, aerosol measurements, surface snow sampling and shallow coring (10m), contribute to **the IPICS 2k Array: a network of ice core climate records for the last millennia.**

## **Switzerland** (Thomas Stocker)

National Activity Report 2007/2008

T. Stocker (U Bern)

J. Beer (EAWAG, Zürich)

M. Schwikowski (PSI, Villigen)

### **Active Ice Coring Projects:**

- EPICA
- Talos Dome
- NEEM
- Coring in the European Alps, Patagonia, Andes and Mongolian Altai

### **Gas Measurements on Ice Cores (U Bern):**

- Completion of CO<sub>2</sub> and CH<sub>4</sub> measurements from 650 to 800 kyr on EPICA Dome C ice and related papers are in press [*Loulergue et al., 2008; Lüthi et al., 2008*]
- High-resolution CO<sub>2</sub> measurements on EPICA DML ice for MIS 3 and 4 (Lüthi et al., in preparation)
- Millennial natural variability of N<sub>2</sub>O concentrations during the Holocene (Schilt et al., in preparation)

### **Continuous Flow Analysis (U Bern):**

- Completion of new CFA unit in preparation of NEEM [*Kaufmann et al., 2008*]
- Completion of 800 kyr dust record from EPICA Dome C [*Lambert et al., 2008*]
- Development of modules for air extraction module and CH<sub>4</sub> measurements (Schüpbach et al., in preparation)
- Completion of new DOC module for CFA (Federer et al., in preparation)

### **Firn Gas Measurements (U Bern):**

- Preparation of firn sampling during NEEM field season 2008

### **Radionuclide Measurements (EAWAG Zürich, PSI Villigen):**

- ca. 500 <sup>10</sup>Be measurements, Holocene part of EDML completed [*Muscheler et al., 2007; Ruth et al., 2007; Willerslev et al., 2007*]
- Radiocarbon measurements [*Jenk et al., 2007*]

### **Drilling Technology:**

- Drill cutters for TALOS Dome, Implementation of CAD Programme for drill cutters (U Bern)
- construction of tower components for NEEM (U Bern)
- Shallow and intermediate depth drilling in dry holes (PSI, Villigen)
- Expertise in retrieval of ice cores from high-mountain glaciers, above the range of helicopter operation (PSI Villigen)

### **Selected Publications:**

- Jenk, T.M., S. Szidat, M. Schwikowski, H.W. Gäggeler, D. Bolius, L. Wacker, H.-A. Synal, and M. Saurer, Microgram level radiocarbon ( $^{14}\text{C}$ ) determination on carbonaceous particles in ice, *Nucl. Instr. Meth. Phys. Res., B* 259, 518-525, 2007.
- Kaufmann, P.R., U. Federer, M.A. Hutterli, M. Bigler, S. Schüpbach, U. Ruth, and T.F. Stocker, A new Continuous Flow Analysis (CFA) system for high-resolution field measurements on ice cores, *Envir. Sci. Tech.*, submitted, 2008.
- Lambert, F., B. Delmonte, J.R. Petit, M. Bigler, P.R. Kaufmann, M.A. Hutterli, T.F. Stocker, U. Ruth, J.P. Steffensen, and V. Maggi, Dust-climate couplings over the past 800,000 years from the EPICA Dome C ice core, *Nature*, 452, 616-619, 2008.
- Loulergue, L., A. Schilt, R. Spahni, V. Masson-Delmotte, T. Blunier, B. Lemieux, J.-M. Barnola, D. Raynaud, T.F. Stocker, and J. Chappellaz, Orbital and millennial-scale features of atmospheric  $\text{CH}_4$  over the last 800,000 years, *Nature*, in press, 2008.
- Lüthi, D., M. Le Floch, B. Bereiter, T. Blunier, J.-M. Barnola, U. Siegenthaler, D. Raynaud, J. Jouzel, H. Fischer, K. Kawamura, and T.F. Stocker, Lower carbon dioxide concentrations in Dome C ice 650,000 - 800,000 years before present, *Nature*, in press, 2008.
- Muscheler, R., F. Joos, J. Berr, S.A. Müller, M. Vonmoos, and I. Snowball, Solar activity during the last 1000 yr inferred from radionuclide records, *Quat. Sci. Rev.*, 26, 82-97, 2007.
- Ruth, U., J.-M. Barnola, J. Beer, M. Bigler, T. Blunier, E. Castellano, H. Fischer, F. Fundel, P. Huybrechts, P. Kaufmann, J. Kipfstuhl, A. Lambrecht, A. Morganti, H. Oerter, F. Parrenin, O. Rybak, M. Severi, R. Udisti, F. Wilhelms, and E. Wolff, "EDML1": a chronology for the EPICA deep ice core from Dronning Maud Land, Antarctica, over the last 150 000 years, *Clim. Past*, 3, 475-484, 2007.
- Willerslev, E., E. Cappellini, W. Boomsma, R. Nielsen, M.B. Hebsgaard, T.B. Brand, M. Hofreiter, M. Bunce, H.N. Poinar, D. Dahl-Jensen, S. Johnsen, J.P. Steffensen, O. Bennike, J.-L. Schwenninger, R. Nathan, S. Armitage, C.-J. de Hoog, V. Alfimov, M. Christl, J. Beer, R. Muscheler, J. Barker, M. Sharp, K.E.H. Penkman, J. Haile, P. Taberlet, M.T.P. Gilbert, A. Casoli, E. Campani, and M.J. Collins, Ancient biomolecules from deep ice cores reveal a forested Southern Greenland, *Science*, 317, 111-114, 2007.

## UK (Robert Mulvaney)

Activity since the last IPICS meeting:

Berkner Island (UK/French project) – although the ice core drilling (S79° 32.9', W045°40.7', 880m altitude, 950m depth, 130 kg m<sup>-2</sup>a<sup>-1</sup>, -26°) was completed in January 2005, when the sandy bed was reached, we had been unable to penetrate more than a few cm into the bed. We returned to the site in early 2006 to attempt to drill further into the bed, and were successful in penetrating a further 50 cm, obtaining several kg of the sand, but unfortunately without catching a sediment core. At the same time, we obtained an accurate borehole temperature profile (using a LGGE/France logger), and tested a prototype borehole camera system. Following this the site was cleared completely of all infrastructures, though the borehole remains accessible. Currently, we have profiles of stable isotopes and gases spanning about ¾ of the 950m core plus chemistry, gas isotopes and cosmogenic isotopes on a more limited range of samples, and analysis continues.

James Ross Island – in January and February 2008, an ice core drilling project (again involving collaboration with LGGE/France) reached the bed at 364 m in a single season of activity, using a UK Naval ship and helicopters to access the site close to Mount Haddington (S64°11.5', W057°40.7', 1540 m altitude, ~500 kg m<sup>-2</sup>a<sup>-1</sup>, -14.7°). Much of the infrastructure for the drilling was similar to the Berkner Island drilling operation, though the actual drill used was produced specifically for the project, employing a booster pump rather than piston fluid pump, and a shortened barrel giving an average core length of only 1.1 m. Drilling was carried out in an unlined borehole, using pure D60 as a drilling fluid. A unique aspect of this project was that following measurement of the temperature profile and borehole photography, all the drilling fluid was recovered from the borehole using a baler, and removed from the field. The ice will return to the UK in May 2008 for analysis - from modelling, we expect the age of the ice at the bottom to date from the LGM.

Future plans (5-year horizon):

Oldest ice – in 2008/09, BAS will fly its survey Twin Otter (radar, magnetometer, gravimeter) over the Dome A/Gamburtsev region in a joint project with the USA (Robin Bell). Flight lines will specifically target obtaining data (ice thickness, internal horizons) to help define the best site for drilling an 'oldest ice' core. In addition, during the same season, BAS will supply part of the Berkner/James Ross drilling infrastructure to a joint Chinese/French project to drill a medium depth core at Dome A itself as part of the oldest ice pre-site work, and will collaborate in the chemical analysis of this core.

NEEM: the UK is part of NEEM, with interests in chemistry (especially possible sea ice proxies), as well as tephra, firn air, ....

40k – we expect to continue our interest in the climate of the Weddell Sea/Peninsula region and the withdrawal of the Weddell Sea ice sheet during the deglaciation with a new bedrock ice core. Target sites could include the Fowler Peninsula and the Fletcher Promontory (both ~600m ice depth) and the Sky Train Ice Rise (~500m) to the south west of the Ronne Ice Shelf.



2k – one possibility is to recover a shallow core (150 to 200m) from the Pine Island Basin, targeting specifically a putative thick volcanic layer at around 2000 years BP. Other Antarctic Peninsula sites are also possible 2K targets.

Robert Mulvaney and Eric Wolff (British Antarctic Survey, IPICS SC members from the UK.)

## USA (Ed Brook)

### **Summary of United States Current Ice Coring Activity for IPICS SC Meeting, Vienna, April 19-20, 2008 Prepared by Ed Brook (Oregon State University)**

- 1) WAIS Divide. The WAIS Divide drilling in West Antarctica in 2007-2008 went very well, reaching 580 m in the first main drilling season. Core quality was excellent, core handling went smoothly, and overall drill performance was excellent. The recovered core will be processed at the National Ice Core laboratory in summer 2008. Completion of drilling to the bed is projected for 2010/2011. Borehole logging and possible replicate coring would follow in later years. Principle Investigator is Kendrick Taylor, with participation from a majority of the U.S. ice core community. A science management office is maintained at the University of New Hampshire, managed by Mark Twickler ([www.waisdivide.unh.edu](http://www.waisdivide.unh.edu)). The first science meeting was held in Lake Tahoe, CA, in October, 2007, and a second meeting is scheduled for on Oct. 2-3, 2008.
- 2) Norway-US IPY Traverse in East Antarctica. This project was partially completed in 2007/2008, and collected several shallow cores and geophysical data. Fieldwork will continue in 2008/2009. US PI's include Mary Albert, Tom Neumann, Joe McConnell, Ross Edwards, Ted Scambos, and Gordon Hamilton.
- 3) NEEM. The US NSF is supporting logistics for NEEM (approx. \$1.3M) through a grant to the University of Colorado (Jim White). The University of Kansas is also funded for radar work in the NEEM region. A proposal for NEEM science funding is pending at US NSF (approx \$2.7M, PI's White, Sowers, Severinghaus, Brook, Baker, Albert). The proposal requests funds for work on abrupt climate change, firm processes, the Eemian section, and ice near the base of the core.
- 4) Denali. Karl Kreutz at University of Maine, Cameron Wake at University of New Hampshire, and colleagues are starting a project at Mt. McKinley (Denali) in Alaska with the ultimate goal of recovering ice core records that would be relevant to the IPICS 2K project. Eric Steig and colleagues at UW are proposing coring in British Columbia for records on similar time scales.
- 5) Roosevelt Island. Plans for drilling on Roosevelt Island (Ross Sea, Antarctica) have been developed by a US/New Zealand/Denmark team (Howard Conway, Ed Waddington, Eric Steig, Ed Brook, Nancy Bertler, Dorthe-Dahl Jensen). The Roosevelt Island core will be a contribution to the IPICS 40 ka project but also has ice dynamics and the glacial history of the Ross Sea region as major foci. A proposal to US NSF will be submitted in June 2008.
- 6) Oldest Ice. Radar survey work in the AGAP/GAMBIT project conducted by Robin Bell is being supported by US NSF and will contribute to site selection information for the oldest ice project.