NEWSLETTER OF THE NATIONAL ICE CORE LABORATORY — SCIENCE MANAGEMENT OFFICE

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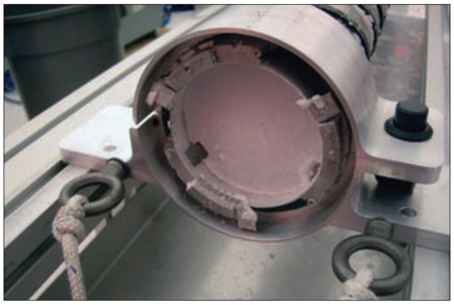

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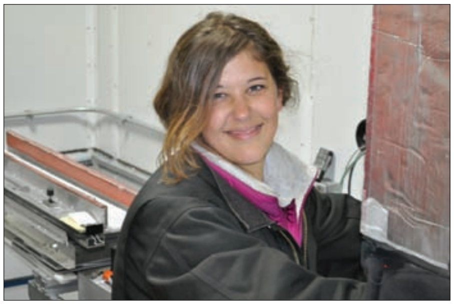

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NICL Long Range Sustainability Plan

The National Science Foundation (NSF) has supported U.S. ice core facilities for storing, curating, and studying meteoric ice cores recovered from the glaciated regions of the world for over four decades. These facilities provide scientists with the capability to conduct examinations and measurements on ice cores, and preserve the integrity of these ice cores, in a long-term repository for current and future investigations.

The current U.S. ice core facility is the National Ice Core Laboratory (NICL). NICL was established in 1993 and is located in Building 810 of the Denver Federal Center in Lakewood, Colorado. NICL is funded by the NSF and housed administratively within the U.S. Geological Survey, Core Science Systems Mission Area, which is responsible for all operational aspects of the facility.

The NICL's most important responsibility is for the safe and secure storage and curation of ice cores that are collected primarily by NSF-sponsored projects. The facility also provides a venue for scientists to examine ice cores without having to travel to remote field sites. The main archive freezer is 55,000 cubic feet in size and is held at a temperature of -36°C. The exam room, held at -24°C, is 12,000 cubic feet in size, contiguous with the archive area, and contains a filtered cold air room and a +3°C loading dock. The NICL also consists of space outside the freezer facility for material fabrication, storage, changing areas, offices, and visiting scientist workspace.

NICL currently uses the hydrochlorofluorocarbon (HCFC) HCFC-22, commonly referred to as R-22, as the refrigerant to keep the freezer cold. Under the U.S. Clean Air Act and the Montreal Protocol on Substances that Deplete the Ozone Layer, the U.S. is phasing out the production and import of HCFCs in order to protect the stratospheric ozone layer. Starting on January 1, 2020, U.S. production and import of HCFC-22 will end. While the use of HCFC-22

The main archive freezer at the National Ice Core Laboratory. –Credit: National Ice Core Laboratory

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NICL Long Range Sustainability Plan

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can still continue after January 1, 2020, the supply of HCFC-22 will be extremely low and its cost will be extremely high.

In late 2013, the NSF Division of Polar Programs asked Dr. Robert W. Corell to develop a study team to review and develop recommendations and options for the future of NICL that meet existing and future national and international refrigeration system policies mandated by the U.S. as a signatory of the Montreal Protocol. The central mandate of the *NICL Long Range Sustainability Plan* study is to assess the current NICL refrigeration system, and to recommend options for the future of NICL that meet the refrigeration requirements of the Montreal Protocol.

The *NICL Long Range Sustainability Plan* contains three sections:

Section 1: A detailed analysis of the science projected for the decades ahead that will require support by the NICL facility.

Section 2: An analysis of the NICL facility science requirements, and an engineering study of a proposed upgrade to NICL's refrigeration system. The engineering study will address the design, costs, projected time schedules, and other technical and engineering details of the facility.

There are three scenarios under consideration regarding the refrigeration upgrade:

1. Temporarily move NICL's cores to a commercial storage facility, update the refrigeration in the current NICL facility, and return the cores to the updated NICL facility;
2. Build an additional storage freezer at NICL, move the cores to the new storage freezer, update the refrigeration in the current NICL facility, and then return appropriate cores to updated NICL facility;
3. Build a new ice core facility at a location to-be-determined, move the cores at NICL to the new facility, and decommission NICL.

In order to proceed with the three scenarios above, NICL-SMO has worked with the ice core science community to develop science requirements for a U.S. Ice Core Facility (see below).

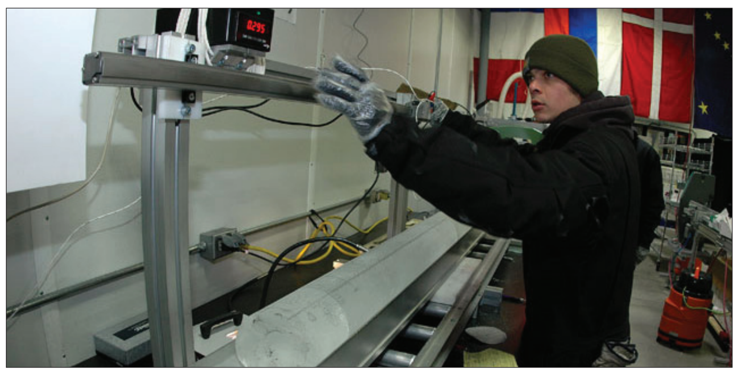
Section 3: A review of NICL's existing management and organizational plan, and a recommendation on how to run the facility in the coming years.

It is envisioned that the recommendations and options outlined in the *NICL Long Range Sustainability Plan* will serve as the basis for the NSF to develop the necessary program and budgetary needs to upgrade NICL's refrigeration and accompanying NICL facilities for the decades ahead.

Science Requirements for a U.S. Ice Core Facility

General Requirements

- Geographically located in an area easily accessible by commercial aircraft and not more than 1 hour (or 60 miles) from the airport.
- The Facility should be dedicated to only the storage of meteoric ice samples.
- Redundant cooling/freezing system components (e.g., 100% redundancy in compressors, evaporators and condensers).
- Dedicated alarm system for power, temperature, mechanical systems and air monitoring with back-up power generation, preferably natural gas fueled.
- Metered power supply.
- Constructed or updated using the latest in energy efficient technology (including interior lighting and under-floor heating using waste heat generated by the cooling system).
- Facility should be inside an envelope building to provide additional security and safety.



Inside NICL's exam room during a core processing line. –Credit: Peter Rejcek, NSF

Main Archive Freezer

- Provide for long-term archive storage of meteoric ice cores and is sustained for at least the next 25 years.
- Ability to accommodate an additional 15,000 meters of ice cores (nominally 4 inches in diameter) over the next 25 years.
- Maintain temperatures to minimize sublimation and to preserve the integrity of compounds in ice cores. NICL currently maintains -36°C in the archive freezer.
- Provide access to all ice cores in the main archive freezer (i.e. individual ice cores can be directly accessed).

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Development of Intermediate Drill set to produce Antarctic ice cores from 1,500 meters

By Rachel Walker, freelance writer
Courtesy: *Field Notes,* Polar Field Services

The coring head of the IDD drill showing the three cutting teeth and bottom of the ice core. –Credit: Mark Twickler

In Mark Twickler's world, "small" is relative. When it comes to a new ice core drill that's being developed and tested by a team of specialized engineers from the Ice Drilling Design and Operations group (IDDO), small means about 20,000 pounds. This new drill recently underwent field-testing at Summit Station in Greenland prior to its deployment at South Pole.

"We need to limit the drill's logistic footprint and get the cores we need," says Twickler, a project manager at the University of New Hampshire for large, multi-institutional projects.

Intermediate Depth Drill (IDD)

The types of cores he's talking about are those up to 1,500 meters deep. These ice cores are believed to contain climate records from 40,000 years ago. The new drill, which is an "intermediate depth drill (IDD)," will allow them to mine the depths of Antarctica and Greenland for cores that will help reconstruct regional patterns of climate variability in order to provide greater insight into the mechanisms that drive climate change.

Access to previously inaccessible ice cores

More, the drill will enable the obtainment of a wide range of ice cores, which will contribute to the growing knowledge of climate history and events. This data can be used in present day models to better predict climate and ice sheet stability on long time scales.

"The ice at South Pole is very clean, which means it will be good for measuring trace amounts of atmospheric gases trapped in the ice core," says Twickler.

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Development of Intermediate Drill

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However, before the drill heads south, it first traveled north to Summit Station in May, where a team of engineers put it through a series of tests, which it passed.

Jay Johnson, drilling engineer for Ice Drilling Design and Operations group at the University of Wisconsin-Madison (right) discussing the drill operations with Steffen Bo Hansen from the Centre for Ice and Climate, Copenhagen. –Credit: Mark Twickler

Modeled after a Danish Template

The drill was developed by the Ice Drilling Design and Operations group from the University of Wisconsin and is modeled after a Danish drill that was already in operation. It consists of a core barrel with teeth that rotate and drill into the ice. It also comes equipped with a cable to suspend and power the drill, a control box and a winch for the cable. Finally, the drill has the capacity to pump fluid into the drill hole, which is essential once the drilling exceeds a couple hundred meters. Below that depth, the hole is under more pressure and will close if fluid is not injected to counteract the pressure of the ice.

Testing specifics

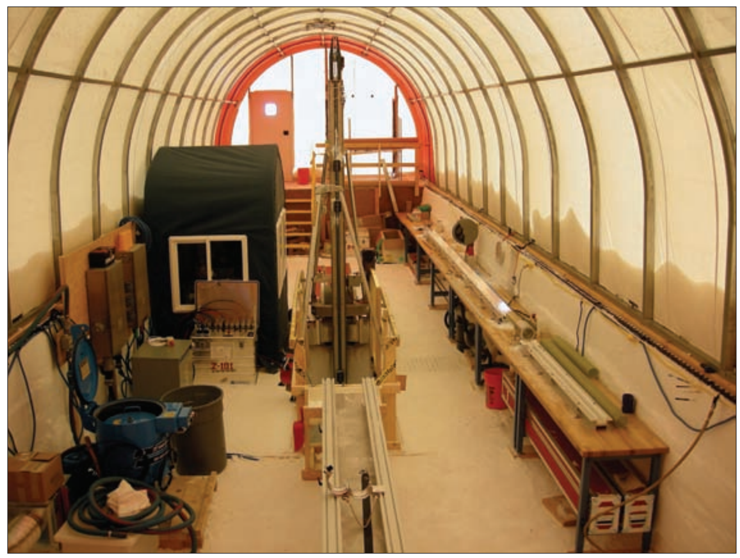
Twickler says various fluids with different components are available, and the Greenland tests for the IDD experimented with a new, previously tested fluid that complies with all environmental regulations. While it worked well, it has an unpleasant aroma, which the team is working to mitigate in order to, make the drilling environment enjoyable, he said.

South Pole Bound

Once the drill is fine-tuned and completed, it will ship to South Pole Station in Antarctica. Science proposals to analyze the core were submitted to NSF in April and the South Pole Ice Core project is coordinated by investigators from University's of California-Irvine, Washington and New Hampshire.

Stationing it at the South Pole makes sense, given the pristine cores that are expected to be retrieved and the fact that a research station is already there.

"That's big," says Twickler. "We can go in, get our core, and get out in two field seasons."



Inside the drill tent showing the control room (left), drill (center) and ice core processing area (right). –Credit: Mark Twickler

Ice Cores 101

More, the drill is expected to produce ice cores of excellent quality. These are perfectly intact cores that are two meters in length, says Twickler.

When drilling for ice cores, technicians first dig a five-foot deep trench that is then covered with a weather port to shield the workers from inclement weather. Then they use the drill to "core into the ice sheet vertically, but pull the core out horizontally." Once harvested, ice cores are cut into one-meter lengths for shipping convenience,

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Upcoming Meetings

Arctic Change 2014
8-12 December 2014
Ottowa, Canada
http://www.arcticnetmeetings.ca/ac2014/

2014 Fall AGU Meeting
15-19 December 2014
San Francisco, CA, USA
http://fallmeeting.agu.org/2014/

International Symposium on High-Mountain Asia
2-6 March 2015
Kathmandu, Nepal
http://www.igsoc.org/symposia/2015/kathmandu/

EGU General Assembly 2015
12-17 April 2015
Vienna, Austria
http://www.egu2015.eu/

Arctic Science Summit Week 2015
23-30 April 2015
Toyama, Japan
http://www.assw2015.org/

26th Union of Geodesy and Geophysics (IUGG) General Assembly
22 June - 2 July 2015
Prague, Czech Republic
http://www.iugg2015prague.com/

IPICS 2nd Open Science Conference
7-11 March 2016
Hobart, Australia
http://pages-igbp.org/workinggroups/endorsed-and-affiliated/ipics/meetings

NICL Long Range Sustainability Plan

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- Adjustable shelving to accommodate different sized core tubes.
- Accommodate long-term archival storage of ice cores up to 14 cm diameter in the main archive freezer and up to 24 cm diameter for short term storage.
- Allow for de-accession of ice cores from the main archive freezer.

Exam Room

- Maintain temperatures to minimize sublimation and to preserve the integrity of compounds in the ice cores. NICL currently maintains a temperature of -24°C in the exam room.
- Provide flexible work area that can be adjusted to accommodate the needs of the investigator or multiple investigators sub-sampling ice core.
- Exam room contiguous to main archive freezer.
- Exam room should have pre-chilled makeup air so that the room has a continuous supply of cold fresh air; exhausted air should be discharged to outside the envelope building.

Loading Dock

- Maintain cool loading dock for large shipments of ice cores and preparing shipment of individual shipments.

Physical Space Outside Freezer Facility

- Availability of adequate space for material fabrication, storage, changing areas, offices, and visiting scientist workspace.

Staff

- Provide curators with experience in organizing and assisting core processing sessions, sampling, database maintenance, and training of investigators and students.
- Provide Internet access to the digital archive sample availability database.

Facility Desires

- Hi-density roller racking to maximize storage.
- Ability to bring the dock area temperature down to -20°C for temporary storage of large shipments of ice.

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Development of Intermediate Drill

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packaged so as to preserve their integrity, and shipped to the U.S. National Ice Core Lab in Lakewood, Colorado.

Increased efficiency, lower costs

Once the drill is in use, it will allow scientists to drill for ice cores with increased efficiency and lower costs, says Twickler.

"If you're trying to do a deep ice core drill project like the recent Antarctic WAIS Divide it requires a lot of resources to bring in large drills," he says. "With a smaller drill and a lighter logistic footprint, we can go to more places and get ice cores that we wouldn't otherwise be able to collect."

For more information on the South Pole Ice Core project, visit http://spicecore.org.

This article originally appeared in Field Notes, the online newsletter blog from Polar Field Services. We thank Kip Rithner and Rachel Walker for permission to re-publish the article.

For information about Polar Field Services visit http://polarfield.com

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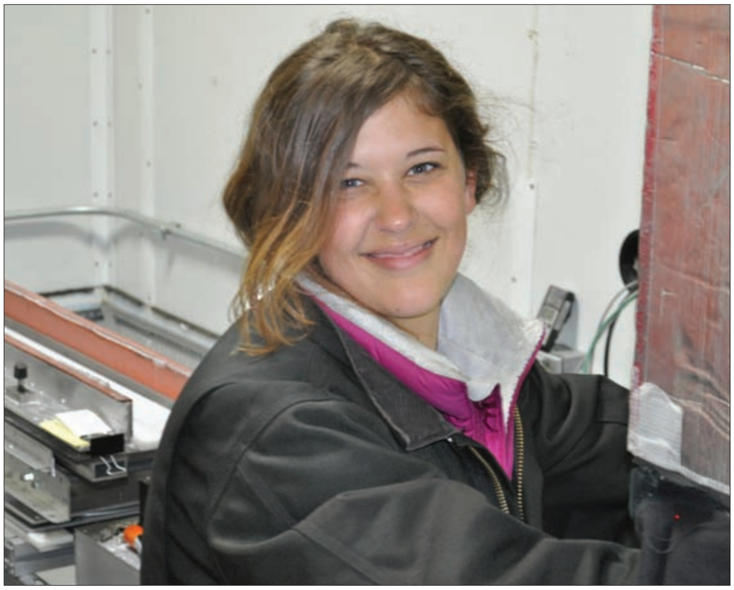
NICL EXPERIENCE INSPIRES PATH FORWARD

By Jen Lennon, Antarctic Support Contract

As an undergraduate, I switched universities more than once in my search for the perfect major and program. I had plenty of enthusiasm for science, but very little focus – I had no idea what I wanted to study. As I finished up my sophomore year, I started looking for summer geology internships, and I found the National Ice Core Laboratory (NICL). Of the three universities I had already attended, none of them were involved in any sort of ice core research. Most of the programs were focused on rocks that were millions to billions of years old, and worked in time scales that I had trouble relating to. At the NICL I was introduced to scientists working in time frames hundreds to thousands of years long. Their research picked out patterns in the ice on yearly and seasonal scales- time scales I could relate to. The following summer, I returned to the NICL to work on the West Antarctic Ice Sheet (WAIS) Divide core processing line, where the WAIS Divide Science Coordination Office had organized weekly talks by the principal investigators working with the ice cores. Through these talks, I was able to become even more familiar with climate science and its research community – climate and ice research were presented to me as attainable goals that I could make a reality if I chose. Thanks to the inspirational group of researchers and staff I was able to interact with at the NICL, I have now completed a MS with the Climate Change Institute at the University of Maine, and am employed as a laboratory manager on the Antarctic research vessel the *Laurence M. Gould* – a future that would not have been likely if I hadn't been given an opportunity to intern at the NICL.



Jen Lennon during the 2011 WAIS Divide core processing line at the NICL. –Credit: Mark Twickler, UNH

IPICS 2nd Open Science Conference

International Partnerships in Ice Core Sciences (IPICS) is the principal planning group for international ice core science. Established in 2005, IPICS now includes scientists from 22 nations.

IPICS' First Open Science conference was held in 2012 in Giens, France, and was a huge success, with 230 scientists from 23 nations in attendance. A good overview of the science that was presented at the conference is contained in the joint *Climate of the Past/The Cryosphere* special issue that emerged from the conference:
http://www.clim-past.net/special_issue55.html

SAVE THE DATE!
The second IPICS Open Science conference will be held in Hobart, Australia from 7-11 March 2016.

For information about IPICS and the 2nd Open Science conference, visit
http://pages-igbp.org/workinggroups/endorsed-and-affiliated/ipics/

In-Depth is published semi-annually by the **National Ice Core Laboratory - Science Management Office (NICL-SMO)**.

We are interested in project stories and news from the ice coring community. Please contact us if you are interested in submitting a story or news item to *In-Depth*.

***In-Depth* Newsletter**

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Masthead photos courtesy of Lonnie Thompson and Michael Morrison

National Science Foundation Projects Related to

Ice Cores or Ice Core Data

The table below shows projects related to ice core research that have been funded by the National Science Foundation (NSF) since the last issue of In-Depth was published. To learn more about any of the projects listed below, go to the NSF Award Search page (http://www.nsf.gov/awardsearch/) and type in the NSF Award Number. If you have a newly-funded NSF project that was omitted from this listing, please let us know and we will add it to the next issue of In-Depth.

Title of the Funded Project	Investigator	Award Number
Collaborative Research: Investigating Geochemical Signatures in Greenland ice of a Possible Extraterrestrial Impact During the Younger Dryas Climate Event	Mayewski, Paul Sharma, Mukul	1417476 1417395
Collaborative Research: P2C2--Pleistocene/Holocene Climate Reconstruction from a Pamir High Resolution Deep Ice-Core	Aizen, Vladimir Mayewski, Paul	1401826 1401899
Collaborative Research: Reconstruction of Carbon Monoxide in the Pre-Industrial Arctic Atmosphere from Ice Cores at Summit, Greenland	Mak, John McConnell, Joe Petrenko, Vasilii Tsigaridis, Konstantinos	1405817 1406219 1406236 1404158
Collaborative Research: The Greenland Firn Aquifer Impacts on Ice Sheet Hydrology: Characterizing Volume, Flow, and Discharge	Forster, Richard Schmerr, Nicholas	1417987 1417993
Dust transport and deposition in the American West: a record of climate and land-use change from the Upper Fremont Glacier, Wind River Range, Wyoming	Aciego, Sarah	1422473
EAPSI: Evaluating the Impact of an Unusual Meteorite at the Onset of Younger Dryas Using a Greenland Ice Core	Seo, Ji-Hye	1414985
EAPSI: Investigating the Alaskan Black Carbon Deposition During the Last Millennium from the Mt. Hunter Ice Core	Winski, Dominic	1414610
Looking for Evidence of Stratospheric Ozone Depletion in Ice at South Pole	Alexander, Becky	1446904
MRI: Acquisition of a Frequency Quadrupled Titanium Sapphire Laser	Williams, William	1428112

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