NEWSLETTER OF THE NATIONAL ICE CORE LABORATORY — SCIENCE MANAGEMENT OFFICE

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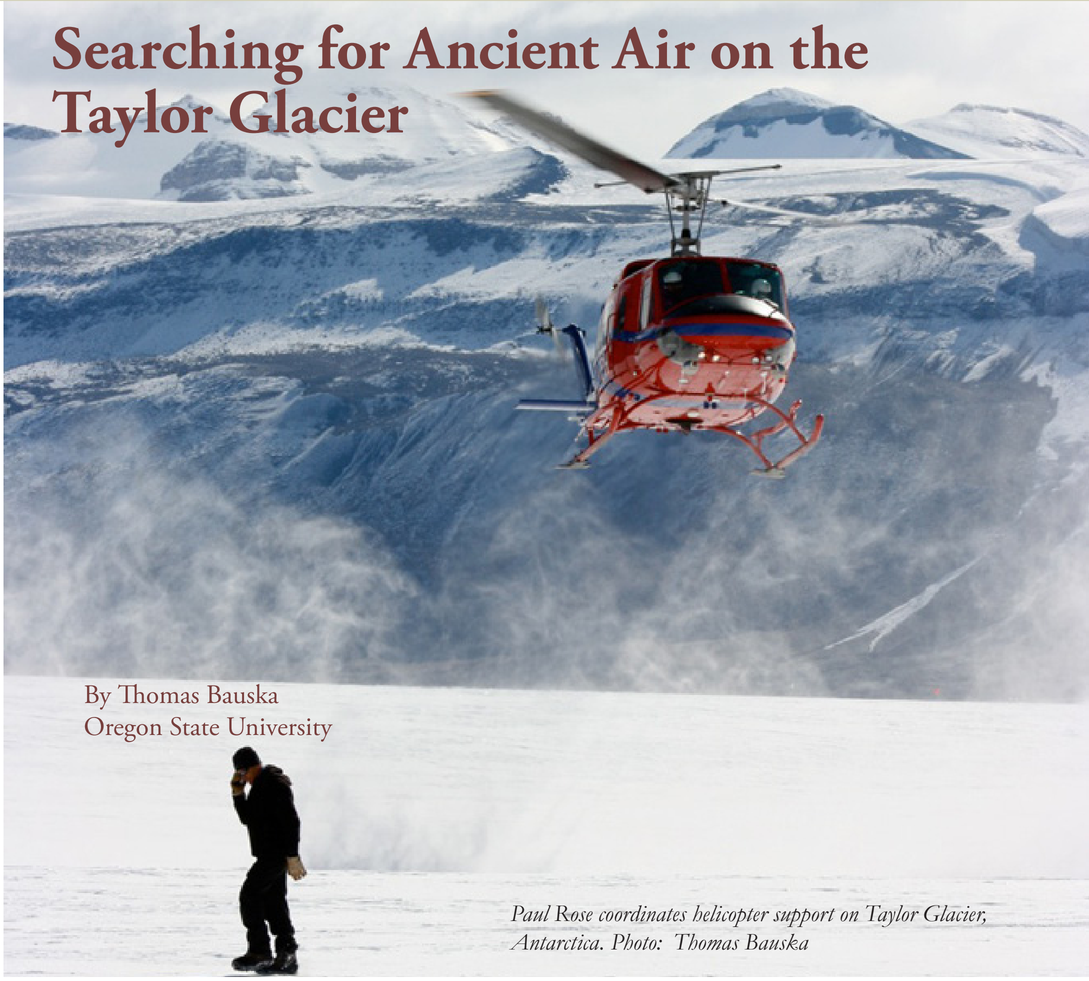
Searching for Ancient Air on the Taylor Glacier



By Thomas Bauska
Oregon State University

Paul Rose coordinates helicopter support on Taylor Glacier, Antarctica. Photo: Thomas Bauska

AROUND 11,500 YEARS AGO the methane content of the atmosphere increased by about 50% in as little as 200 years. Scientists who study the natural variability of methane are especially interested in this event because it coincides with a period of rapid climate reorganization known as the Younger Dryas to Preboreal transition (YD-PB).

In order to study the YD-PB and other events like it, scientists have used deep ice cores from Greenland and Antarctica. Because these cores are only about 5 inches in diameter, the amount of ice available to make measurements of extremely rare gases or special isotopic tracers is limited. These difficult measurements are important because they can tell scientists why gases such as methane have varied in the past.

For reference, the YD-PB transition in methane in the Dome C ice core in East Antarctica is at about 400 meters below the surface. At WAIS Divide, West Antarctica, the transition will likely be at ~2000 meters depth. For most other ice cores ice from this time period occurs somewhere between these two depths. The total amount of YD-PB ice ever recovered by all deep ice cores is approximately 2,000 kg.

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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*.

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Masthead photos courtesy of Lonnie Thompson and Michael Morrison.

Message from the Director

Dedication. Commitment. Diligence. Those words come to mind when watching the WAIS Divide ice core processing at NICL this summer. Staff, interns and students spend hours every day in the freezer at -24C measuring, cutting and repackaging the core for archiving and shipping to institutions for a multitude of analysis. They go about their work carefully and safely day after day. The enthusiasm of the group is remarkable and training of the next generation of scientists is taking place. Also helping spark the willingness of the group to endure the harsh working conditions, are ice core researchers visiting NICL and giving science talks to inspire the crew.

-MST ■

The Ultimate Classroom

Fieldwork at Allan Hills, Antarctica provides lifetime of learning

By Nicole Spaulding, University of Maine

(L to R) John Higgins, Nicole Spaulding and Andrei Kurbatov approach a shallow drill site in the Allan Hills during the 2009-2010 field season. Photo: Mike Waszkiewicz

WHEN I WAS ASKED to write about my experience working in the Allan Hills, I could scarcely think of where to begin: the beauty? the wind? In the end I kept coming back to the skills I had gained working there. I believe that the Allan Hills of Antarctica are the ultimate classroom.

They may contain ice as old as 2.5 million years, so they could provide answers to questions about climate conditions for time intervals that even the deepest ice cores in Antarctica have not unveiled to date. More so, those answers are physically sitting right at the surface just waiting to be collected (see *In-Depth* Vol. 4, Issue 2 - Fall 2009). Like most problems that appear simple at first glance, the development of an environmental record from Allan Hills requires a broad set of skills. In my two seasons working in the Allan Hills as a PhD student I learned how to use survey grade GPS and radar equipment, worked as ice-core handler, weather observer, and camp manager among other roles.

When the Twin Otter drops off our team of five, we are greeted only by ice, snow and wind. Before scientific operations can begin we have to erect tents, start melting snow and make first radio contact with McMurdo. Our camp is established on a snowfield that resembles a runway– it is a perfect location for a camp- but our drill sites are as far as 10km away. Our commute, which is approximately 40 minutes on a "good day", involves 2 snowmobiles with attached sleds and a circuitous route around sastrugi, flagged at least every 100 meters for safety. We make this commute daily after observing the weather, chatting with McMurdo forecasters, eating breakfast, and packing lunch.

Our first working days are consumed with the set-up of our drill site. The high winds of the Allan Hills (~30 mph average during our 2010/2011 field season) mean that this operation must be conducted with care – a single errant gust of wind could end our season if the drill becomes damaged! We build a wind barrier from tarps tied to a metal frame with climbing ropes and anchored in place with ice screws. Once drilling commences cores are measured, all visual observations are recorded and they are packed securely for the long journey back to the United States.

Within the lee of the shelter there is relative calm; just an inch outside of it drifting snow

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The Ultimate Classroom

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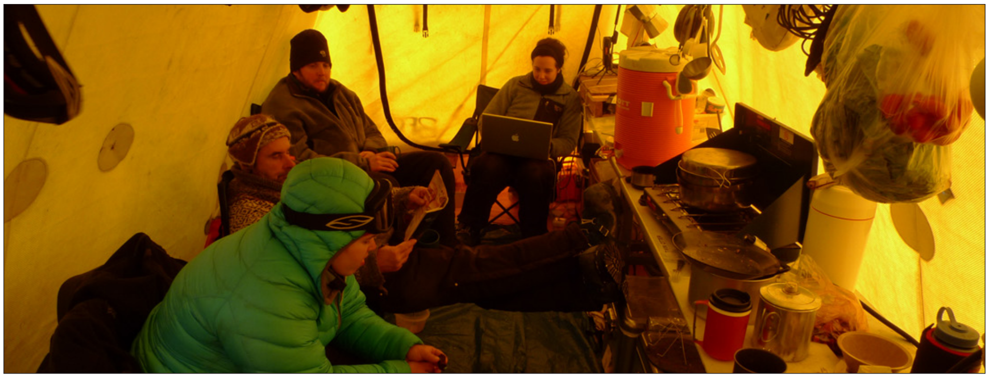

(Front to Back) Nicole Spaulding, Mike Waszkiewicz, John Higgins and Melissa Rohde relax in the kitchen tent at the end of a hard day's work. Photo: Andrei Kurbatov

dances ferociously across the sloped and rippled blue ice surface. Crampons are a must when trenching, collecting ice samples or wandering around GPS survey sites. All of these activities are necessary in order to develop this record. GPS surveys show how the ice is flowing through the area. Near surface sampling will show how the environmental signal varies along that flow path and trenched samples will bring us closer to answers for those nagging climate questions.

During lunch all five of us pile into a tiny mountain tent that we keep at the drill site for emergencies to pass around thermoses of hot water and bags of snacks. At the end of a day the cores are loaded onto sleds, tied in place and slowly driven back to camp. This is a nerve-racking haul; these cores are so important. Dating the gas they contain is our primary mechanism for establishing the chronostratigraphy of ice flowing through the Allan Hills and I don't want to be the one that rolls the sled!

(L to R) John Higgins, Melissa Rohde and Mike Waszkiewicz work at a drill site from the 2010-2011 field season. Photo: Melissa Rohde

Once back at camp while some members lower the ice cores into a snow-pit where they will await transport back to McMurdo, others get to work in the kitchen. With the smell of dinner wafting through the tent, each day's data are transferred to back-up notebooks, USB drives and computers. Progress is discussed and plans are made. As we thaw out, we sink lower into our chairs satisfied with a hard day's work.

In a field camp of five, in a place like Allan Hills, there is no division between science and logistics – both types of work are interwoven and it's not possible to define where one begins and the other ends. For me, it is the perfect place to learn the lessons I will apply throughout what I plan to be a lifetime of scientific fieldwork.

For more information about the Allan Hills project, visit:
http://cci.um.maine.edu/2MBIA/

This work is funded by the National Science Foundation under Grant Numbers ANT-0838843 (University of Maine) and ANT-0838849 (Princeton University).

Upcoming Meetings

June 28 - July 7 2011
Session C02: Ice Cores and Climate - International Union of Geodesy and Geophysics (IUGG) General Assembly, Melbourne, Australia
www.iugg2011.com/program-iacs.asp

10-16 July 2011
11th International Symposium on Antarctic Earth Sciences, Edinburgh, Scotland
www.isaes2011.org.uk/

20-27 July 2011
XVIII International Union for Quaternary Research (INQUA) Conference, Bern, Switzerland
www.inqua2011.ch/

28-29 September 2011
2011 WAIS Divide Science Meeting, Scripps Seaside Forum, La Jolla, CA
www.waisdivide.unh.edu/meetings/

14-15 October 2011
2011 Northwest Glaciologists Meeting, Portland State University, Portland, OR
www.glaciers.pdx.edu/

5-9 December 2011
AGU 2011 Fall Science Meeting, San Francisco, CA
www.agu.org/meetings/

22-27 April 2012
EGU General Assembly 2012, Vienna, Austria
www.egu.eu/meetings/meeting-overview.html

1-5 October 2012
IPICS 2012 Open Science Conference, Giens, France
www.ipics2012.org/

Ice Core Working Group

Karl Kreutz, Chair
University of Maine

Murat Aydin
University of California-Irvine
Gases

Ian Baker
Dartmouth College
Physical Properties

Ryan Bay
University of California-Berkeley
Borehole Logging

Brent Christner
Louisiana State University
Biology

Tom Neumann
NASA
Surface Glaciology

Erin Pettit
University of Alaska-Fairbanks
Ice Flow Dynamics

Mark Skidmore
Montana State University
Biogeochemistry

Eric Steig
University of Washington
Isotopes

Kendrick Taylor
Desert Research Institute
At Large

In 1986, the National Academy of Sciences recommended developing an Ice Core Working Group of representatives from institutions prominent in ice coring activities. Administered by the NICL-SMO, ICWG is organized around scientific disciplines, rather than institutions. Members are elected to a three year term, with the committee chair typically serving three years.

NICL Update

By Betty Adrian, Acting Technical Director, National Ice Core Laboratory

Richard Nunn, NICL Assistant Curator, talks about the NICL and ice cores to the Geology Club of Metropolitan State College during a February 4, 2011 tour of the facility. Photo: Josh Hicks

IT'S MIDSUMMER IN DENVER, and the city has been baking under a heat wave for a couple of months. But in one small corner of the sprawling Denver Federal Center campus in the nearby suburb of Lakewood, about a dozen people are bundled up in thickly insulated Carhartt jumpsuits, wool caps, scarves and gloves.

For the past year the National Ice Core Laboratory (NICL) management and staff has been working on the completion of the NICL freezer infrastructure upgrades. The new LED lighting project was recently completed. Now when the staff walks into the lab and turns on the lights, work can begin immediately. There is no wait time for the lights to heat up and come on. We have instantaneous bright light in the room! The LED lights cost substantially less to operate than the previous metal halide lights; in addition, the LED lights produce significantly less heat than the metal halide lights. The mechanical contractor has already had to make some adjustments on the refrigeration system as a result of less heat going into the freezer and exam room. The cost to purchase and install these lights was significantly less than originally anticipated. Also, a substantial XCEL energy rebate will be received as a result of the installation of these new LED lights.

Eirik Ogilvie-Wigley, Brian Bencivengo and Mick Sternberg offload WAIS Divide ISC boxes from the 2010-11 field season ice retro into the NICL freezer. March 15, 2011. Photo: NICL

The evaporative condenser upgrade project is anticipated to commence within the next month. NSF provided the funds to the USGS last year. Unfortunately, the USGS was in the process of upgrading its financial system just as the paperwork was submitted to the Contracting Office. After an inability to get complete proposals from qualified contractors, the USGS is in the process of finalizing the contract with the vendor who will be performing the work. Once this has occurred, the contractor will need to purchase the new evaporative condenser. The contractor has 150 days to complete the project. The contractor anticipates the lead time to get the equipment purchased and build may take as long as 60 days. This project should have minimal to no impact on the WAIS Divide core processing line which begins on June 1.

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Searching for Ancient Air on the Taylor Glacier

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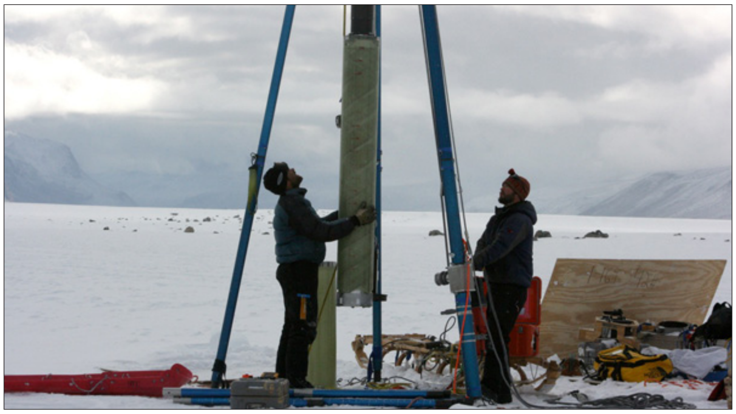

Tanner Kuhl and Dr. Robb Kulin operate the new Blue Ice Drill. Photo: Thomas Bauska

While that may sound like a lot of ice, it is only a "drop in the bucket" for scientists looking to make ambitious measurements such as the radiocarbon content of methane, which requires a 1,000 kg sample. To make measurements like this, which are either impossible or very difficult in traditional deep ice cores, scientists have begun looking for areas of ablation on the ice sheet where glacier flow has exposed old ice on the surface; often referred to as blue ice zones. In these regions the flow of the ice combined with ice removal by sun and wind have done the work of the drill and brought the old ice to the surface.

One group who pioneered work on ancient air from ablation zones in Greenland recently completed a successful two-month season working on a new site on the Taylor Glacier in Antarctica. The science team, led by co-PIs Jeff Severinghaus (Scripps Institution of Oceanography) and Ed Brook (Oregon State University) included Vasilii Petrenko (University of Rochester), Hinrich Schaefer (National Institute of Water and Atmospheric Research in New Zealand), Daniel Baggenstos (SIO), Thomas Bauska and James Lee (OSU). Tanner Kuhl and Robb Kulin (Ice Drilling Design and Operations) led the drilling operation and Paul Rose provided invaluable science support.

To understand the stratigraphy of the site the team made over 300 methane measurements in the field. By comparing the methane variations found in the Taylor Glacier ice with the atmospheric history of methane known from deep ice cores, the team was able to identify layers of ice spanning the last glacial termination (~20,000 to 8,000 yrs BP). This work resulted in the identification of the YD-PB layer in a steeply dipping four-meter layer of ice directly underfoot. This outcropping layer can be followed up and down the glacier for hundreds of meters, essentially yielding an unlimited amount of ice.

The main focus of this past season's work, however, was to recover air samples from much older ice (~50,000 years old) to understand how carbon-14 is produced in ice by cosmic rays. These samples were drilled with the recently developed Blue Ice Drill (BID) designed by IDDO of the University of Wisconsin. This drill, capable of recovering a 24 cm diameter core with a length of >1.0 m, drilled a total of 580 meters of core from about 30 different holes. Volumetrically, ~26 cubic meters of ice were drilled. For comparison, the entire 3300 m WAIS Divide core volume is ~39 cubic meters. The 1,000 kg ice samples selected for carbon-14 measurements were melted and the air was extracted on site.

The team was also able to recover ample amounts of ice that will allow for very high-precision measurements of the stable isotopes of carbon dioxide and methane during the last glacial termination. Daniel Baggenstos lead a heroic effort to chainsaw a 40 meter trench in order to recover samples for dust, trace element analysis and water isotopes across the initiation of the last deglaciation. Reconnaissance samples were taken to investigate the possible presence of Eemian age ice (~125,000 years ago) and the stratigraphy of ice older than the last glacial maximum (~20,000 years ago).

Drs. Hinrich Schaefer and Vasilii Petrenko load a one meter long section of core into the air extraction melter. Each core weighs about 40 kilograms. Photo Credit: Thomas Bauska

Next season, the team will sample the YD-PB for carbon-14 of methane. These measurements will be used to test theories about the origin of rapid variations in methane during the last deglaciation. The team hopes to establish the Taylor Glacier as an ancient air and ice sample archive that can be utilized for future research.

This work is funded by the National Science Foundation under Grant Numbers ANT-0839031 (Scripps Inst. of Oceanography) and ANT-0838936 (to Oregon State University).

A Story Captured in Ice

By Daniel J. Vaccaro
Reproduced with permission from *Regis University Magazine*, Volume 19: Issue 2, Spring 2011

Ice. It's frozen water, right? We use it to chill beverages. To reduce swelling. It makes ponds perfect for skating. And roads dangerous for driving. But would you believe it can tell the story of our lives? Or the history of our planet? This is not some kind of new-age ice reading either.

IT'S HARD SCIENCE. ICE SCIENCE.

Essentially, it goes something like this. The story of our world is written in snow. Or more specifically in the layers of deposited snow that fall each year in the high and cold places of the planet, which eventually compact into ice and form glaciers. Those layers are like chapters in an encyclopedia, a natural chronicle of years, which document the climatic and atmospheric conditions of the earth at the time in which the snow originally fell. Studying or reading these layers allows scientists to know what was happening on our planet thousands of years ago and is the key to understanding global climate change.

It's essential, cutting-edge research. And it's happening right here in Denver at the National Ice Core Lab (NICL), which stores, curates and studies ice cores drilled in the Polar regions of the world. The NICL is owned by the National Science Foundation, and operated and maintained by the U.S. Geological Survey.

In one of the "warmer" rooms of the freezer, the one kept at -24 degrees Celsius to be specific, Lacey Fischer, RC '11, a student intern from Regis University, diligently goes about her duties. Bundled in layers of winter clothing, she employs a variety of saws and hand tools, delicately preparing ice samples for scientists to study. Her number one priority is to ensure the integrity of the ice, so it can be most useful in this important research.

Fischer, an environmental science major from Denver, Colo., decided that she wanted to intern at the NICL her sophomore year at Regis when she visited the facility with her geology class. She finally had an opportunity to secure an internship in her final semester. "I am fortunate to be working with scientists who are pioneering in the field of ice science," Fischer says. "It is a great learning experience."

This formative learning experience was facilitated by Betty Adrian, an alumna of the Regis College Class of 1981. Adrian, the technical director for the NICL, understands that the value of this educational partnership goes both ways. "Internships help lay a solid foundation for students as they graduate and move into the next phase of their lives," says Adrian. "In addition, a lot is learned by those who bring an intern into the workplace. Seeing the passion that many of these students have is rejuvenating and can excite staff and management to perform better. It is truly a win-win relationship that helps build tomorrow's leaders."

Internships also help students discern career paths. Sometimes, a student immediately falls in love with the work and knows that it will be a lifelong vocation. Others learn what they don't want to do. Fischer falls into the former category. Her internship confirmed that her passion could find a suitable outlet in the working world. She will continue her work with the NICL until September, processing a fresh set of ice cores from the West Antarctic Ice Sheet. Afterwards, she plans to apply for graduate school in biology.

For now, Lacey spends a lot of her time hanging out in a freezer, which won't sound half as bad once the sweltering summer descends. It's her passion after all. And it's for a good cause. There is much to be learned from ice. The columns extracted from glaciers, the shards pulled from these mammoth time capsules, have much to teach human kind about its own story. About its past and its future. Thanks to her internship with the NICL, Lacey Fischer will likely find that ice played an equally essential role in the story of her own life.

"I am fortunate to be working with scientists who are pioneering in the field of ice science," Fischer says. "It is a great learning experience."

NICL Update

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The General Services Administration (GSA) has been performing many upgrades on the Denver Federal Center over the past nine months. As a result the NICL staff faced issues related to broken domestic water lines, unforeseen power outages, and foreseen weekend-long power outages to name a few. The NICL staff looked at these situations as opportunities to test the various systems. We took advantage of these multiple opportunities and are happy to report that all went extremely well. We test our systems periodically, but by having the systems "tested" in the manner in which they have been tested the past several months, it is great to know that they work as planned.

The NICL staff is currently preparing for the WAIS Divide CPL. The NICL staff currently consists of two interns – Lacey Fischer (Regis University) and Mick Sternberg (Metropolitan State College, Denver), two students – Eirik Ogilvie-Wigley (University of Colorado, Boulder) and John Melrose (Metropolitan State College, Denver), Richard Nunn (Assistant Curator), Brian Bencivengo (Assistant Curator), Geoff Hargreaves (Curator), and Betty Adrian (Acting Technical Director). Equipment is being secured in its CPL location, tables are brought into alignment, and we are taking care of the last minute items on our checklist. Lacey Fischer was recently featured in the Regis University Magazine for her work as an intern with the NICL (see *A Story Captured in Ice* on page 6).

WAIS Divide Ice Core Update

2010-2011 Field Season Review

AFTER A ~16-DAY WEATHER DELAY, RPSC opened WAIS Divide via a Basler on November 8 with a seven person put-in team. Thanks to Don Voigt's efforts in McMurdo we were able to get a skeleton crew of two drillers, Kristina Dahnert and Jim Koehler, into WAIS Divide earlier than planned, which turned out to be critical in helping us make up some of the lost days. These two drillers worked with the RPSC carpenter crew to assess damage sustained by the Arch over winter and begin repairs on the Arch structure and the drill slot.

Drilling operations resumed on December 16, only about a week behind schedule, at 2,566 meters depth. Throughout the season the DISC Drill routinely produced 20+ meters per day of perfect 3+ meter long cores. There were several instances during the season when there were potential season-ending problems with the DISC Drill, including a kinked cable. In each instance, however, the IDDO engineers and drillers were able to overcome the problems and keep us drilling with a minimal amount of drill "down time". Due to the delayed camp opening and challenges encountered with the drill, the drilling was extended through January 29th, five days later than originally planned. On January 28th the season's depth goal was reached at 3,331 meters (10,928 feet) – making the WAIS Divide Ice Core the deepest ice core ever drilled by the U.S. and the second deepest ice core ever drilled by any group.

Many people were part of the team that made this possible, and some of them really stepped up this field season. Nicolai Mortensen was at WAIS Divide a month longer than planned. At several times the success of the season depended solely on his brain and hands. Jay Johnson, Kristina Dahnert and Gifford Wong relentlessly pushed to get to the depth goal while keeping the crew in good spirits during stressful times. Paulene Roberts kept the camp running smoothly and well integrated with the coring operations. Julie Palais was our advocate in McMurdo and in Washington D.C., enabling the project to get more than its share of attention, including the season-saving five-day extension.

For more information about the season's activities, visit:
http://waisdivide.unh.edu/fieldreports/index.shtml

http://waisdivide.unh.edu/ProjectUpdates/ViewProject.shtml

The WAIS Divide Ice Core project completed major coring operations on January 28, 2011, after five years of work, reaching a target depth of 3,331 meters making the WAIS Divide ice core the deepest U.S. ice core ever drilled and the second deepest ice core ever collected. Photo credit: Jay Johnson; Date taken: January 28, 2011

NICL Core Processing Line (CPL)

This summer's CPL began on June 1. We have just under 1400 meters of ice to process this year (1,955 – 3,331 meters depth) and hope to get through as much of this ice as possible with a CPL stop date of August

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WAIS Divide Ice Core Update

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19. If we don't reach our 3,331-meter depth goal by August 19 we plan to process the remaining ice, along with the additional core we hope to collect this coming field season (see 2011-2012 Field Season below), during summer 2012. The NICL CPL is as important to the project as the drilling of the core itself and the Science Coordination Office Representative for this task is Peter Neff. Each week Peter will provide an update of the CPL's progress, which will be posted at:
http://waisdivide.unh.edu/ProjectUpdates/ViewProject.shtml

2011 Science Meeting

The 2011 WAIS Divide Ice Core science meeting will be held on September 28-29 at the Scripps Seaside Forum in La Jolla, CA. The meeting will have activities for all of both days and the evening of the 28th. Everyone associated with the project is encouraged to attend.

Also Tuesday, September 27 is reserved for the WAIS Divide Executive Committee meeting and other TBD "pre-meetings". If you have a "pre-meeting" that you would like to hold, please contact the WAIS Divide SCO ASAP so that we can work on accommodating your needs As more details about the meeting are worked out they will be posted online at:
http://waisdivide.unh.edu/meetings/index.shtml

2011-2012 Field Season

The 2011-2012 field season at WAIS Divide will involve logging of the main borehole for temperature, optical, sonic, and seismic properties, possible deepening of the main borehole (and subsequent logging of the deepened hole), and testing of the new replicate coring capability of the DISC Drill. Don Voigt will be on site for the entire field season as the SCO Representative. Gary Clow will be onsite during the borehole logging as the Chief Scientist for Borehole Logging, and Jeff Severinghaus will be onsite during the drilling as the Chief Scientist for Replicate Coring.

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
A Study of Atmospheric Dust in the WAIS Divide Ice Core Based on Sr-Nd-Pb-He Isotopes	Kaplan, Michael	1043471
Carbonyl Sulfide Measurements in the Deep West Antarctic Ice Sheet Divide Ice Core	Aydin, Murat	1043780
Climate, Ecosystems and Human Society as Recorded in the First Ice Core Extracted from the Tyrolean Alps	Gabrielli, Paolo	1060115
Closing the Isotope Hydrology at Summit: Measurements of Source Regions, Precipitation and Post-deposition Processes	Noone, David	1023574
Collaborative Research: Completing an Ultra-high Resolution Methane Record from the WAIS Divide Ice Core	Brook, Edward Sowers, Todd	1043518 1043500
Collaborative Research: Continued Study of Physical Properties of the WAIS Divide Deep Core	Alley, Richard Spencer, Matthew	1043528 1043313
Collaborative Research: Greenland Ice Sheet Snow Accumulation Variability: Filling Knowledge and Data Voids	Box, Jason Forster, Richard	0909469 0909499
Collaborative Research: Replicate Coring at WAIS Divide to Obtain Additional Samples at Events of High Scientific Interest	Brook, Edward Cole-Dai, Jihong Severinghaus, Jeffrey	1043522 1043508 1043421
Collaborative Research: Stable Isotopes of Ice in the Transition and Glacial Sections of the WAIS Divide Deep Ice Core	White, James Steig, Eric	1043167 1043092
Constraining Englacial Temperatures through Active Seismic Methods	Peters, Leo	1043675

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