Investigation of Climate, Ice Dynamics and Biology using a Deep Ice Core from the West Antarctic Ice Sheet Ice Divide (I-477)
NSF-OPP supported
PI: Ken Taylor (Desert Research Institute)

Field Team:

Tim Bartholomaus	Bess Koffman	Kendrick Taylor
Susan Lilja Buchardt	Logan Mitchell	Bruce Vaughn
Marie DelGrego	Anais Orsi	Gifford Wong
Natalie Kehrwald	Spruce Schoenemann	John Fegyveresi

Field Season Summary:
We had an extremely successful field season. It got off to a rough start when budget cuts and problems with the camp's forklift delayed the science and drilling teams by two weeks. The science and drilling crews arrived at the very comfortable camp during the first week of December. It took another two weeks to set up the core handling and drilling equipment, train the crew, develop procedures, and conduct safety drills. We started around-the-clock operations with three shifts on December 22. Thirty-one days later, with only 4 rest days, we met our goal for the season, and then ran out of time and space to store the core.

Most of the season we were drilling brittle ice, in which the gas pressure in the ice is sufficient to spontaneously fracture the core when it is brought to the surface. We used several new methods to maximize the core quality. The resulting core quality is the best I have ever seen for brittle ice. By 1310 m the pressure was sufficient to push the air bubbles into clathrates and the ice was no longer brittle. Below this we pulled up clear unfractured 2.5 m pieces of ice.

Instead of the traditional approach of drilling and handling two meter long segments of brittle ice, we used a new drilling method. First, we drilled a one meter long piece of ice, and then pulled the drill up to snap the core off the bottom of the hole. Then, instead of bringing the drill back to the surface, we lowered the drill back down and drilled and snapped off a second one meter long piece of ice. Then we lowered the drill down a third time and drilled and snapped off a 0.5 m long piece of ice. Only after drilling 2.5 m, which is about the limit of the drill, did we bring the drill back to the surface. On alternate trips down the hole we would reverse the order so the 0.5 m long pieces would fill a single 1 m long core tray. This new drilling method allowed us to handle the core in 1 m long segments which reduced the size of the core handling and storage areas, provided higher quality core then would be obtained by cutting the brittle ice, and it allowed us to collect more core each trip down the hole.

Once the core was on the surface it was pushed out of the drill onto a carefully aligned and rigid support system. The careful alignment of this system using survey equipment was critical. The core passed through a new and more effective vacuum system for removing fluid from the core. The core was extruded into plastic netting, which held the core tightly together even after it had spontaneously fractured. To minimize the thermal shock to the core the core handling was done in an area that was refrigerated to a temperature of -30 C.

The combination of these new methods, breaking the core into the desired length while it was down hole and still under pressure, careful alignment of the core handling system,

the netting, the low temperature in the core handling area, and a lot of really careful and focused people, all contributed to the high core quality.

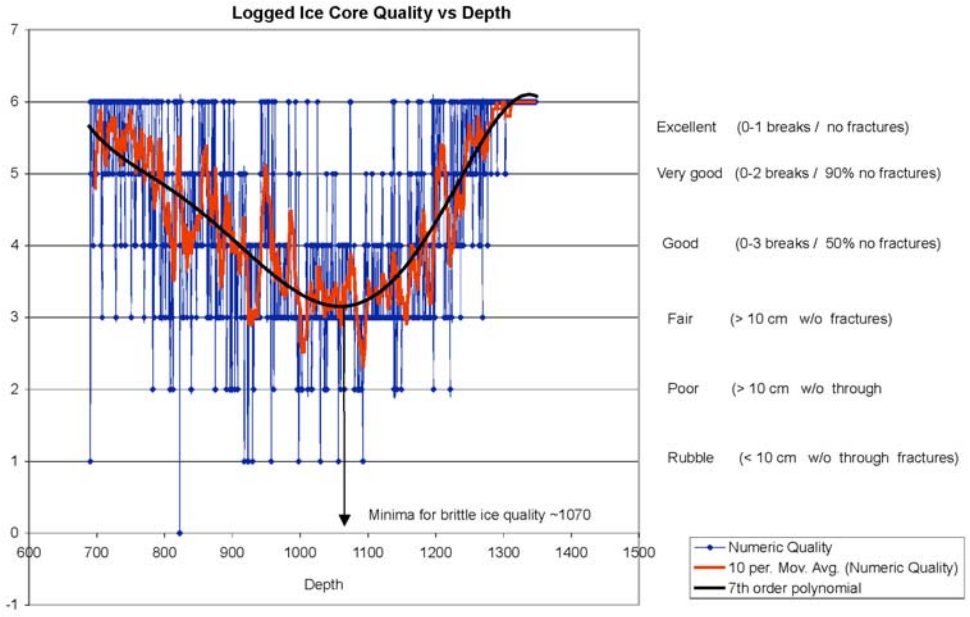
None of this work came easily. On the drilling side of the arch, Jay Johnson and his crew spent tedious hours monitoring the drilling process on the control computers and making adjustments to the drill. Some of the adjustments were as small as 0.002 inches. You should think of the drill as a scientific instrument, not just a piece of drilling equipment. The drill crew had some down hole electrical problems, likely caused by just a few milliliters of ethanol that got in the hole as a result of deicing the drill. It was tricky but IDDO quickly figured out what was wrong and fixed it.

On the core handling side of the arch, NICL (Geoff Hargreaves and Brian Bencivengo) were diligent about establishing the core handling procedures. The core handling crew (mostly graduate students that were hired by the SCO) spent long hours in a noisy, windy, and cold environment doing the tedious job of documenting the core length and fractures. Anais Orsi and Bruce Vaughn organized lots of the details and filled in the occasional gaps.

Besides just collecting ice we also made science measurements. Natalie Kehrwald (hired by DRI but from OSU), John Fegyveresi (PSU) and Marie DelGrego (DRI) made electrical measurements on the ice cores. The measurements were made in the field instead of at NICL because the core quality is better in the field than at NICL. The measurements show strong well-resolved annual layers that will be used to determine the age of the ice. John also made vertical and horizontal thin sections of the ice below the brittle zone. Anais Orsi (Scripps) made borehole temperature measurements in a 300 m hole that will be used to help interpret the gas records. Bess Koffman (U-Maine) collected snow pit samples that will be used as part of the trace chemistry work.

The RPSC camp staff supported all of this work, lead by camp manger Ben Partan. There was a construction crew to set up camp at the beginning of the season, a crew to maintain the electrical, ventilation, cooling, and other systems at the arch, and another crew to do all the things typical of a small town (mechanics, communications, air craft transportation, waste disposal, cargo, medical, and of course food, really great food considering where we were). There was a big storm around Thanksgiving, then a month of gorgeous calm and clear skies. At the end of the season, when we were trying to move a lot of cargo and people, the weather closed in and we had the typical multi day waits for planes. No one likes to wait days for a plane, but as always, the 109th Air National Guard got our equipment and us in and out safely.

Along the way the entire camp crew pulled together into a tight community. Some of the highlights were the Christmas dinner and party, the New Years' Winter Olympics, a talent show, a traveling dance party held on a large and slow moving sled, and the occasional quite time with old and new friends. It takes a lot of personal effort and really positive attitudes to keep the energy high in a field camp, and this crew did that in style with seemingly endless ways to keep everyone engaged and in high sprits.



Acknowledgements:
Many, many thanks to all those involved in the WAIS Divide activities this year especially, Matthew Kippenhan's planning management, Ben Partan's and Theresa Tran's camp management, Brian Johnson's and Cara Ferrier's science support, Sharon Lewis' cargo support, Julie Grundberg's and Sharon Lewis' fixed wing support, and Billy Texter's construction management. Special thanks to the WAIS Divide camp staff and the arch facility construction staff for all of their help and support this season. This project would not be possible without the dedication and continual support of Julie Palais, Brian Stone and George Blaisdell, our sincere thanks to them.

Physical Properties of the WAIS Divide Deep Core (I-168-M)
NSF-OPP Supported
PIs: Richard Alley (Pennsylvania State University) and Kurt Cuffey (University of California-Berkeley)

Field Team:
John Fegyveresi (Penn State University, University Park, PA)

Season Objectives:
To characterize the physical properties of the core, gain additional useful information from observing snow pits and surface evolution, and conduct exploratory research on drilling chips to see whether information can be gained from them to help the drilling effort.

Season Overview:
Note: Due to the brittle nature of the ice drilled this season, it was known in advance that the number of physical properties samples that would be obtained from the deep core would be limited. Because of this fact, the first half of the field deployment was primarily dedicated to performing ice-chip studies, snow pit studies, and assisting with core-handling duties. Towards the end of the season, once drilling reached more-ductile ice, several samples were obtained and mounted.

John Fegyveresi deployed to Antarctica December 1st, handled cargo in McMurdo, and then to WAIS Divide on December 9th. During the field season, John regularly photographed ice chips produced by the drilling (10-12 images per sample, both dry and suspended in drill fluid), recorded chip characteristics, and recorded drilling parameters such as drill-shoe configuration. John logged core-break tensions for each run. During this time, John also dug two snowpits from which he took various density and isotope samples. In addition, John documented various surface and crusting observations and also assisted the science technicians with various core handling duties.

For the last 2 weeks at the WAIS Divide camp, John was able to obtain 18 physical properties samples. These samples included both horizontal and vertical sections from depths of 1340 meters through 1500 meters, at 20 meter intervals. These samples were cut, prepared, mounted, and labeled on-site. Because there was no ice leaving the camp this season, all 18 physical properties samples were placed in an ISC box and stored in the Arch basement with the ice cores. Next season, these samples will be shipped out to the NICL at the beginning of the season so that both thin sections and bubble sections can be prepared and photographed. The bubble section images that will be created from these samples (as well as those from last year's samples), will eventually be used to help model paleoclimates of West Antarctica.

Atmospheric, Snow and Firn Chemistry Studies for Interpretation of WAIS−Divide Cores (I-151-M)

NSF-OPP supported

PI: Roger Bales (University of California, Merced)

Co-Is: Wolfgang Rogge (University of California, Merced) and Markus Frey (British Antarctic Survey and UC Merced)

Field Team:

Wolfgang Rogge and Sylvain Masclin (University of California, Merced)

Season Objectives:

To make concurrent measurements of atmospheric ozone (O_3), nitric oxide (NO), formaldehyde (HCHO), hydrogen peroxide (H_2O_2) and methylhydroperoxide (CH_3OOH) of sufficient duration and accuracy to constrain modeling of the atmospheric boundary layer chemistry of HO_x radicals ($OH+HO_2$), including diel cycles, snowpack sources and response to changes in surface UV radiation.

Season Overview:

Both members of the field team deployed to Antarctica on November 10th, handled cargo in McMurdo, and arrived at WAIS Divide on December 3rd. Much of the 1st 2 weeks was spent on setup of the Polar Haven tent and the instruments at a clean-air site 3.5 km from the main camp. Staff from the main camp worked with the team during this period to establish the satellite camp. Wolfgang Rogge departed WAIS Divide on December 18th, and Sylvain Masclin continued making measurements and collecting samples through January 11th.

The field team sampled the snow surface daily, collected profiles of firn samples from 3 shallow snowpits and twice sampled fresh snow following precipitation events. Each location of the surface snow and snowpit sampling was recorded with a GPS to avoid risk of contamination or artifact during subsequent resampling. All these samples were shipped to UC Merced for analysis of concentrations of nitrate (NO_3^-), HCHO, H_2O_2 and CH_3OOH.

Continuous atmospheric measurements of HCHO, H_2O_2, CH_3OOH, NO and O_3 were made daily. Measurements of O_3 were most straightforward, and data quality appears to be excellent. The team had planned to measure vertical profiles of O_3, but cargo limits necessitated leaving the profiling equipment in McMurdo. Data quality of NO is also thought to be excellent, with the caveat that calibration gas only arrived at the end of the deployment owing to a mixup. Delay in receipt of reagents for the peroxide detector, problems with the tent heater, and generator problems introduced severe instrument stability problems and limited reliable measurements of HCHO, H_2O_2, CH_3OOH. However, measurements from past ITASE deployments in the area will be used for these species. Firn air was sampled at the site on January 9th and 10th. A weather station (lent by the Crary Lab) was set up at the satellite camp to monitor the wind speed and direction, as generator exhaust can contaminate samples, and record temperature variations, which can influence the atmospheric concentrations.

Ice Drilling Design and Operations (IDDO) group Activities at WAIS Divide 2008-2009
(T-350)
NSF-OPP Supported

IDDO Field Team:

Jay Johnson	Kristina Dahnert	Elisabeth Morton
Bill Mason	Tanner Kuhl	Bill Neumeister
Nicolai Mortensen	Patrick Casidy	John Robinson
Paul Sendelbach	Dave Ferris	

Season Overview:
IDDO operations at WAIS Divide this season began on December 3 with the arrival of Lead Driller Jay Johnson, Bill Mason, and John Robinson. Kristina Dahnert and Paul Sendelbach arrived on December 5 and 6, respectively. The WAIS Divide camp construction crew had the arch opened up and ready for the drill crew when they arrived, so they were able to get to work right away unpacking wintered-over gear, installing upgrades, and starting up equipment. On December 9 the second group of drillers (Patrick Casidy, Elisabeth Morton, Dave Ferris, Bill Neumeister, and Nicolai Mortensen) arrived. Tanner Kuhl arrived on December 18.

The first core was drilled on December 16 from a depth of 580.43 m. With only minor modifications to their drilling techniques the drillers were able successfully to make multiple core breaks and recover up to three core segments of predetermined lengths in one run. This allowed the core handlers to store the brittle ice in 1m trays and eliminated the need for it to be cut before packing and shipping next season. At 1318 m the ice was again ductile enough to saw so one-piece drilling was resumed. Drilling ended on January 22, one day ahead of schedule, with the core storage basement filled to capacity. The final bore hole depth was 1514.9 m. The DISC drill produced high quality core throughout the season.

Packing, which included unspooling of the winch cable (to be replaced by a longer, 3800 m, cable next season), and winterizing of the drill system was completed over the next three days. The entire crew left WAIS on January 26 after a safe and very successful season.

Raytheon Polar Services Company (RPSC) Activities at WAIS Divide 2008-2009

RPSC WAIS Divide Project Manager: Matthew Kippenhan

The fourth field season for WAIS Divide closed on 07 February 2009 as scheduled. The Basler aircraft pulled out the remaining camp staff that day after a very busy and successful season.

It all started on 01 November 2008 when the Basler delivered the first wave of camp staff to begin digging out from the past winter. The Basler has proved to be an excellent opening season aircraft for installing small crews to start prepping equipment and structures prior to arrival of the large construction crews. After several weeks, the entire camp infrastructure was up and running to support numerous science teams and their research efforts. Passengers were continuously arriving and departing camp as aircraft arrived keeping everyone busy with lots of cargo moving in and out. Thirty-five LC-130 Hercules missions supplied camp operations and researchers this season. Exactly 710,786 pounds of cargo, fuel, and passengers were transported to camp from McMurdo Station, a 3.5-hour flight each way. There were of course several typical weather delays throughout the season that would last up to one week without aircraft support, but overall the weather was much better than last season.

The camp staff continued to provide excellent support for the drilling project while several other science groups were working in the immediate area. A new addition to the season was supporting an overland traverse for The Center for Remote Sensing of Ice Sheets (CReSIS). The traverse consisted of two Tucker Sno-Cats with multiple sleds carrying equipment and supplies for the small team of researchers. The traverse returned to camp in January and winterized their equipment schedules to be used next season. Their two Tucker Sno-Cats were very useful with assisting with camp closing and maintaining the 10,000 foot skiway.

Despite only a few storms and heavy equipment issues, camp operations ran smoothly for the entire season. The drill arch continues to bury and shift slightly, but is being monitored to anticipate structural issues inevitable to structures built on snow foundations. Nevertheless, the camp and arch are in good shape to start the fifth field season sometime in late October 2009.