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:

Scientists	Drillers (ICDS)
Joe Souney (UNH)	Bella Bergeron
	Michael Jayred

06/07 Field Season Objectives:
1) Collect a 130 meter ice core located as close to the main borehole location as possible.
2) Collect the 100 meter ice core from the main borehole pilot hole.

Season Overview:
After two flight cancellations due to bad weather (at WAIS Divide), we made it to WAIS Divide on 29 November. On 01 December we began drilling the 130 meter core (Fig. 1). We immediately had to switch out the inner and outer core barrels due to a lack of chip transport up and out of the bore hole. As soon as we started drilling with the "new" (older) core barrels the chip problem went away. We finished drilling the 130 m core on 07 December. Core quality was excellent on almost all of the runs. On 08 and 09 December we moved inside the arch facility and began setting up on the main borehole location to drill the pilot hole. At 13:34 on 09 December 2006 the first core from the main borehole was collected. We finished drilling the pilot hole on 13 December. Core quality was excellent on all runs. Joe departed WAIS Divide on 13 December via a cold-deck flight with all of the ice cores. Bella and Jayred stayed at WAIS Divide to finish (ream and case) the pilot hole and to complete other tasks.

Fig. 1: Drilling the 130 meter core. The arch facility is the silver building to the right of the drill tower. WAIS Divide camp is to the left of the drill tower. This borehole is within several meters of the 2005/2006 130 meter borehole location. The ice cores were measured and logged within the yellow tent.

A site review of the arch facility by a 1-person team from the National Ice Core Laboratory (NICL) was scheduled to take place late in the season so that NICL could view the core storage and processing areas within the arch. However, due to workload constraints at the NICL facility in Denver, CO the WAIS Divide site review was cancelled.

Acknowledgements:
Extreme gratitude to all those involved in the WAIS Divide activities this year especially, Matthew Kippenhan's planning management, Ben Partan's camp management, Brian Johnson's science support, Keith DePew's cargo support, Julie Grundberg's fixed wing support, Billy Texter's construction management, and multitudes of others too numerous to list. Special thanks to the WAIS Divide camp staff and the arch facility construction staff for all of their help and support. 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.

Major Ion Chemistry of the WAIS Divide Ice Core (I-355)
NSF-OPP supported
PI: Jihong Cole-Dai (South Dakota State University; SDSU)

Field Team:

Scientists
Jihong Cole-Dai (SDSU)
Kevin Poenisch (SDSU)

Season Overview:

The main objective of this season's field work was to complete a snowpit study. The two-person team arrived on December 21. A 3-meter pit near the Sowers 300 m hole was dug first and snow blocks were taken from the top to the bottom of the pit and stored in ice core boxes. Simple visible stratigraphy was noted. Several sets of small snow samples were taken with various density samplers (homemade and from BFC). The density of the small samples was measured in the Science Hut of the main camp. The new type of density samplers provided by BFC seemed to work better than either the old style BFC density samplers or homemade samplers.

Between December 26 and January 3, two more snowpits (3-m and 2-m) were dug near the main camp. Snow block samples were taken and vertical density profiles were measured. A total of 24 snow blocks in 8 ice core boxes have been collected in this season and will be retrograded to NICL and eventually to the Ice Core and Environmental Chemistry Lab (ICECL) at SDSU, where sub-samples will be analyzed for major ion concentrations to establish patterns of seasonal variations, to aid in core dating by annual layer counting. All three snowpits were filled back in after sampling was completed.

Preliminary density data (Figure 1) indicate that the average snow accumulation rate at WAIS Divide is about 55 cm of snow per year. This is consistent with previous estimate of 24 cm of ice per year at this site.

Acknowledgements:
The camp staff led by Ben Partan was great! They made sure everything worked as well as it should. After a 36-hour blizzard, the heavy equipment operators and other staff members cleared out the huge snow drifts across camp in a matter of a few hours. The camp was clean, comfortable and fun.

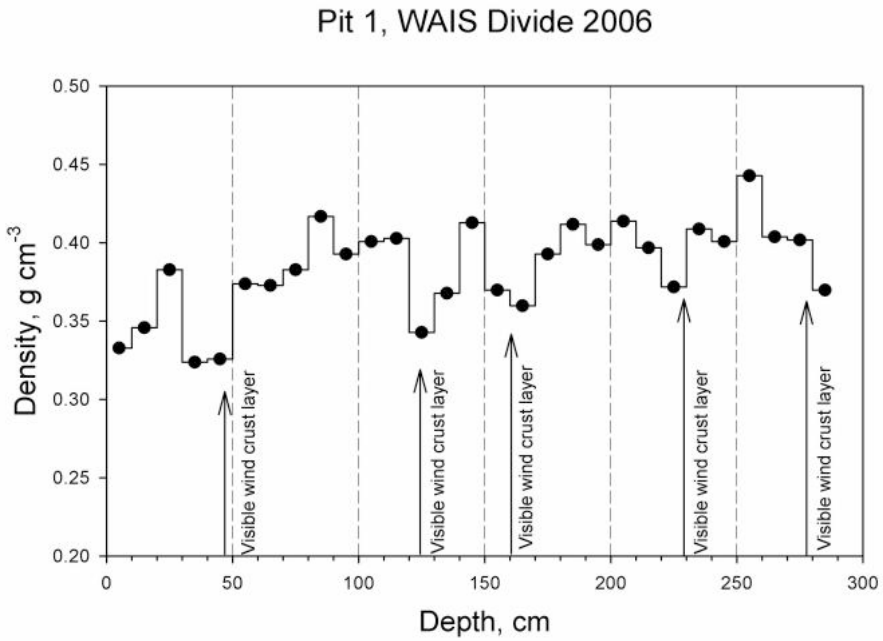


Fig. 1: Snowpit 1 density profile.

Spatial Variability in Firn Properties from Borehole Optical Stratigraphy at the Inland WAIS Core Site (I-171)

NSF-OPP supported
PI: Edwin Waddington (University of Washington; UW)

Field Team:

Scientists
Ben Smith (UW)
Jessica Drees (UW)

06/07 Field Season Objectives:
1) Survey an array of boreholes with an optical logging instrument
2) Survey the borehole array with ground penetrating radar
3) Collect two shallow cores for density and grain size measurements

Season Overview:
We (Smith and Drees) arrived in McMurdo November 13. Our flight to WAIS Divide was originally scheduled for November 19, but weather and Herc availability forced a delay until November 21. The weather at WAIS Divide was initially poor, with continual 10 - 20 knot winds and blowing snow. We began by logging four holes drilled and capped in the 2005-6 field season, which allowed us to practice our field techniques without the risk of blowing snow collecting in our computers.

We drilled our first hole to 20 m, on November 25. We were favorably impressed with the ease of use and simplicity of the Sidewinder system. However, because of the large number of holes we were planning, and because Smith was recovering from a broken arm and had difficulty handling the drill stem at depths greater than 16-18 m, we decided to limit later holes to 16 m.

Until the end of November, we continued to drill additional holes while logging holes from previous seasons. At this point, the weather improved markedly, and for the first time we were able to operate our logging equipment without setting up a tent to protect our computers from blowing snow. From this point on we were able to log each hole after 15 minutes or less set-up time, and worked to catch up logging previously drilled holes.

The break in weather also allowed us to begin ground-penetrating radar surveys over our boreholes. Continued cold temperatures required that we build enclosures over the radar antennas to keep them warm with hot water bottles. Early indications are that the accumulation rate varies by around 2% in the area upstream of the main WAIS Divide borehole, on spatial scales of 2-3 km.

On December 8, Steve Profaizer, a reporter with the Antarctic Sun, came with us to log two holes and to drill another. His account of the field experience, plus photos, is available at http://www.waisdivide.unh.edu/Reference/Download.pm/261/Document. We collected core for collaborators on 12/11, during which a videographer from USAP filmed our drilling operations.

On December 12, we drilled our last hole. We left camp 12/14 on a cold-deck flight. We had drilled and logged 14 holes, a total of more than 230 m. We collected samples from two firn pits and collected two short cores to share with collaborators in the US.

Acknowledgements:
We would like to thank Bella Bergeron and Mike Jayred for drilling advice, and Joe Souney for core-handling instructions. Ben Partan and the WAIS Divide camp crew ran a great operation, and took care of us in high style. Julie Palais provided critical support throughout. Bob Hawley originally designed the hole logging equipment, and Ken Taylor, Mary Albert and Tom Neumann all gave essential scientific advice.

Detection of Crystal Orientation Fabrics in the Divide Region Using Polarimetric Radar Methods (I-163M)

NSF-OPP supported

PI: Charlie Raymond and Kenichi Matsuoka (University of Washington)

Field Team:

Kenichi Matsuoka
Donovan Power
Hans Christian Steen-Larsen
Vanessa Palmer
Maurice Conway

Season Overview:

The top ~200 m of the ice sheet was investigated using a polarimetric radar method. Strain grids that were installed last season were reoccupied using GPS. This project aims to detect alignment of crystals in ice (ice fabrics) using ice-penetrating radar. As ice deforms, ice fabrics are produced, which, in turn, influence further deformation. Consequently, measurements of fabric variations can help reveal the deformation history of the ice and indicate how the ice will deform in the future. The polarimetric radar measurement is the most feasible way to determine horizontal variations of ice fabrics.

This season, 1.3-GHz (L band) radar was used to examine the top ~200 m with a high (0.6 m) vertical resolution. This depth range was not observed in the last season using 60-MHz and 179-MHz radar systems, because measurements down to about 2500 m depth requires transmission of powerful radio wave which prevents investigation of the near surface close to the radar system. Radar measurements of the shallow ice are essential to clarify whether anisotropic features at greater depths are caused by ice strain (within the ice) or by near-surface depositional processes. The radar system was housed in a Faraday cage on a Komotek sled and towed by a skidoo (Fig. 1). A new antenna configuration was installed on the housing used last season (Franken sled). At nineteen sites shown in Figure 2, the azimuth of the sled was changed by 15^{o} intervals. Radar data were collected for each azimuth so that we can see how the radio-echo intensity varies with the polarization. Radar profiling was also made to connect all of these sites.

Each strain grid consists of five markers several kilometers away from each other. Reoccupation of markers installed one year ago gives local-mean ice-flow velocity and stain in the vicinity. The strain grids were installed and reoccupied at all polarimetric radar measurement sites and two other sites. This strain configuration enables us to simulate fabric development under the current glaciological conditions. The simulated fabric will be used as a reference to interpret anisotropic features found in radar data.

All radar and GPS measurements were made successfully and the data is currently being analyzed.

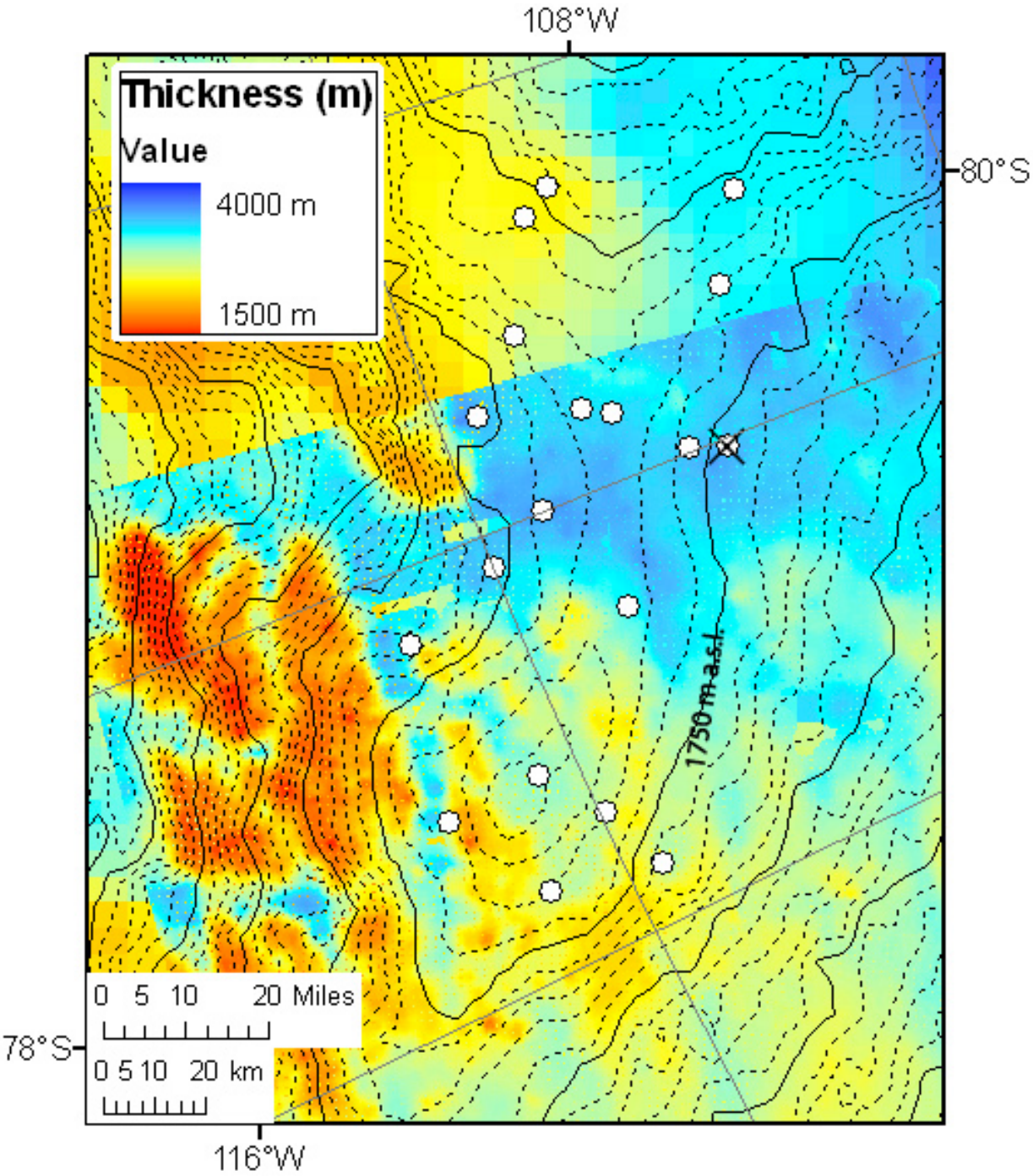
The field team of five personnel arrived in McMurdo early December. The Franken sled radar system was adapted and tested on the ice shelf near McMurdo. It took about three weeks. The field team was deployed to the WAIS Divide camp on December 27th. After the preparation and day trips to sites within about 30 - 50 km from the divide camp, the team made a 600-mile-long traverse for about a month. The traverse was completed January 22nd and all team members were returned to McMurdo on January 26th. More information about the project including the view of fresh eyes of first-comer students (web journal with photos) can be found at http://www.ess.washington.edu/matsuoka/wais/wais.html

Acknowledgements:

The radar system was loaned to us by Dr. Shuji Fujita at the National Institute of Polar Research, Tokyo, as a part of collaborative research. Special thanks go to WAIS Divide camp staff led by Ben Partan, science construction staff led by Woody Haywood, and NSF support led by Julie Palais. This project is supported by NSF OPP-0440847.

Figure 1: 1.3-GHz radar system on a 16-foot-long Komotek sled. The antennae are attached to the aluminum plate rear the sled and looks down. The grey Faraday cage houses the radar system. The front black part hosts an operator during the polarimetric measurements. Other components include a GPS antenna (white, roof), a lamp letting us know system errors (red, roof), a fuel cradle (blue, front), and a generator box (behind the fuel cradle).

Figure 2: Location of polarimetric radar measurements (open circles). A cross shows the divide camp. Contour lines show the elevation (a.s.l.) of ice-sheet surface by 10 m (dashed lines) and by 50 m (solid lines). Background color indicates the ice thickness compiled from SOAR and BEDMAP databases.



Ice Coring and Drilling Services (ICDS) Activities at WAIS Divide 2006-2007
NSF-OPP Supported

ICDS Field Team:

Beth Bergeron	Brent Folmer
Michael Jayred	Jay Johnson
Jay Kyne	

Season Objectives
ICDS had four major objectives at WAIS Divide during the 2006-2007 field season:

1. Core a 130-meter hole outside the drill arch
2. Drill and case a 100-meter pilot hole inside the drill arch for the deep core project
3. Install the 9-ton DISC Drill gantry crane inside the drill arch
4. Test the effect on core quality using a small amount of drilling fluid in a 300-meter hole

Core 130-Meter Hole
Beth Bergeron and Michael Jayred arrived at WAIS Divide on November 29 and began coring the hole outside the drill arch using a 4-Inch drill. A depth of 133 meters was reached on December 7 and the crew moved the drill into the arch to drill the pilot hole on December 8. Joe Souney of the University of New Hampshire and the WAIS Divide Science Coordinating Office processed the core.

Drill and Case Pilot Hole
Bergeron and Jayred began drilling the pilot hole on December 9 after RPSC cut a slot in the floor of the drill arch for the drill pit. Coring of the hole with the 4-Inch drill was completed on December 13 at a depth of 114 meters. The core from the hole was collected and processed by Joe Souney.

Reaming of the hole began on December 13. Jay Johnson and Brent Folmer arrived at site on December 13. Reaming of the hole was completed on December 27 with the top 88.5 meters of the hole reamed to 12 inches in diameter, the hole from 88.5 meters to a depth of 91.5 meters reamed to 7 inches in diameter, and the hole between 91.5 meters and approximately 111 meters deep reamed to 7 inches in diameter. The top 88.5 meters of the hole was cased using a 9 ½-inch inside diameter, 10 ¾-inch outside diameter HDPE pipe. Casing of the hole was completed December 26.

Johnson, Jayred, and Folmer left WAIS Divide on December 27.

Install Gantry Crane
ICDS shipped both of its gantry cranes to WAIS Divide with the goal of getting at least the 9-ton crane installed during the 2006-2007 season to facilitate the assembly of the drill system during the 2007-2008 field season. Both the 9-ton crane and the 2-ton crane used for handling the drill sonde were assembled and tested using a temporary generator.

Test Effect of Using Small Amount of Drilling Fluid
ICDS used the opportunity afforded by having the 4-Inch drill at WAIS Divide to test the effect on core quality of using a small amount of drilling fluid as a cutting “lubricant”. After the completion of the drilling and casing of the pilot hole, ICDS Engineer Jay Kyne and Beth Bergeron used the 300-meter hole drilled during the 2005-2006 field season for the test. The hole had closed enough during the year that it had to be reamed from approximately 250 meters to the bottom. Several cores were collected drilling without the fluid, but core quality did not equal that achieved during the 2005-2006 season. Unfortunately, the use of the drilling fluid did not seem to improve the quality either. Results will be evaluated.

Raytheon Polar Services Company (RPSC) Activities at WAIS Divide 2006-2007
RPSC WAIS Divide Project Manager: Matthew Kippenhan

The second field season for the WAIS Divide ice core project ended on 07 February 2007. The successful season focused on supporting 8 science groups and the second phase of construction on the arch interior. Science activities included regular twin otter and Basler Turbo 6 aircraft support from the camp. With many science teams traveling in and out of the camp, the average population tended to be around 21 persons including a camp staff of nine. However, the camp remained busy throughout the months with managing daily camp and flight operations scattered with many poor weather days.

Arch interior work started soon after the camp was up and running. Activities included hand excavating with electric chainsaws the main drill tower slot, winch pit, and the core storage basement. As the excavation at each location was concluded, the construction crew, lead by Billy Texter, installed floor footings and floor panels. Lighting and ventilation ductwork was also installed; however, a delay in receiving the fans and electrical distribution panels as scheduled will push their installment to next season. Four air conditioning units for the core processing area were installed but were not tested due to lagging electrical panels. Cursory temperature monitoring prior to closing the arch for the winter showed the core storage basement lingering around -14 F and upper core processing area around +4 F on nicer days. The core processing arch was insulated with R-12 fire resistant blankets. The smaller arch is now showing signs of snow drifting reaching its arch peak, which will greatly add to the insulation for maintaining a cold work area. During December, two ICDS team members arrived at camp to install the two large gantry cranes in the drilling arch area. These cranes will provide them with immediate heavy lifting support when the main drill is installed. There will be a moderate punch list of remaining items to construct or install in conjunction with installing the drill and core processing equipment scheduled for next season. RPSC is currently working on next season's schedule. Fortunately, despite the tremendous danger and effort of hand excavating over 15,500 cubic feet of firn, block by block, the construction crew only reported several muscle strains and pains.

Towards the end of the season, the NSF approved four additional LC-130 missions above plan that flew in the first shipments of drilling fluids that were previously staged in McMurdo Station. There is currently enough drilling fluid on site to conduct the first season's goals. A total of 28 LC-130 Hercules missions brought in approximately 435,000 lbs. of cargo, passengers, and fuel. After two seasons, a total of 1,356,181 lbs. of cargo, passengers, and fuel have been flown to the field camp. A major challenge for this season was winterizing the camp. Since the arch is into it's interior construction phase and not available as a large storage shed as last season, all camp cargo and equipment was winterized outside on a 400' snow berm. As one can guess, it is very time consuming building such a large snow berm and the process begins a month before needed.

As the camp was closing, the annual resupply vessel, the American Tern, arrived at McMurdo Station with several milvans of WAIS Divide items. These items consisted of the third bulk purchase of both drilling fluids, a second aircraft cargo sled, aluminum ice core trays, and ISC boxes preloaded with core tubes. These items will remain in McMurdo Station the winter months until the following field season begins.