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:

Kendrick Taylor	Gabrielle Dreyfus	Anais Orsi
Trevor Popp	Sylvia Englund	Ursula Rick
Joe Souney	David Ferris	Inger Seierstad
Rebecca Anderson	John Mischler	David (Zach) Smith

Season Objectives:

1. Assist NICL with installation of core handling line (CHL) equipment.
2. Maintain highest quality of core throughout the CHL.
3. Winterize CHL equipment.

Assist NICL with Installation of Core Handling Line (CHL) Equipment:

Science Coordination Office (SCO) Field Manager Trevor Popp, along with the National Ice Core Laboratory's (NICL) Geoff Hargreaves and Brian Bencivengo, arrived at WAIS Divide on Friday, December 7 and began the installation of the CHL equipment. Four science technicians – Rebecca Anderson, David Ferris, Ursula Rick and Inger Seierstad – arrived on Monday, December 10 and assisted with the installation of the CHL equipment, the DEP, and the set-up of the warming Jamesway. Chief Scientist Ken Taylor and two more science technicians – Anais Orsi and Zach Smith – arrived on Monday, December 17. The remaining three science technicians – Gabrielle Dreyfus, Sylvia Englund and John Mischler – arrived to camp on Monday, December 24. SCO Operations Manager Joe Souney arrived to camp on January 17.

Modifications and fine-tuning of the CHL equipment continued until drilling with the DISC Drill commenced on January 4.

Several major storms, each of which shut down operations for two days, delayed getting the generators on-line and the arch construction completed.

Maintain highest quality of core throughout the CHL:

Full production coring began on Monday, January 7 with two shifts operating. A third shift was started on January 10 initiating 24 hour/day operations. Coring continued through January 20 with a total of approximately 466 meters being drilled giving a final bore hole depth of 580.58 meters. The core quality produced by the DISC Drill was excellent, although one core was rubble. Average drilled core length was 2.7 meters.

The objective of the CHL is to maintain the highest quality of ice core while logging it and preparing it for shipment back to the NICL in Denver, CO. Ice core temperature was always maintained below -15^{o}C. This season's CHL also involved cutting samples for physical properties (see I-168-M End of Season Field Report) and measuring the electrical properties of the ice. Twenty-one 10-cm samples taken at 20-meter intervals from 120 meters to 520 meters were cut for physical properties. Electrical properties were measured on all 466 meters of ice drilled this season. All ice drilled this season, except for the last three meters, has been shipped back to the NICL and will be worked on at this summer's core processing line.

Winterize CHL Equipment:

After drilling ended on January 20, the SCO and NICL crew winterized the CHL equipment to remain at camp, packed DNF cargo that will stay in McMurdo for the winter, and packed CHL equipment that were being sent back to the NICL for modification. All SCO personnel were out of WAIS Divide by Friday, January 25.

Acknowledgements:
Many, many thanks to all those involved in the WAIS Divide activities this year especially, Matthew Kippenhan's planning management, Kevin Killilea and Elizabeth Morton's camp management, Brian Johnson's science support, Keith DePew and Sharon Lewis' cargo support, Julie Grundberg's (and Sharon Lewis') fixed wing support, and Eric Brown'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.

Credit: *Photo courtesy of Brian Bencivengo (USGS/NICL, 2008)*

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:

Nicole Festian Reed (Metro State College, Denver, CO)

Season Objectives:

The main objectives of field work for this season were to set up the physical properties area in the processing arch, test and calibrate all equipment that will continue to be used during the follow-on drilling seasons, perform density measurements on the recovered core and perform sample preparation for thin and bubble sections.

Season Overview:

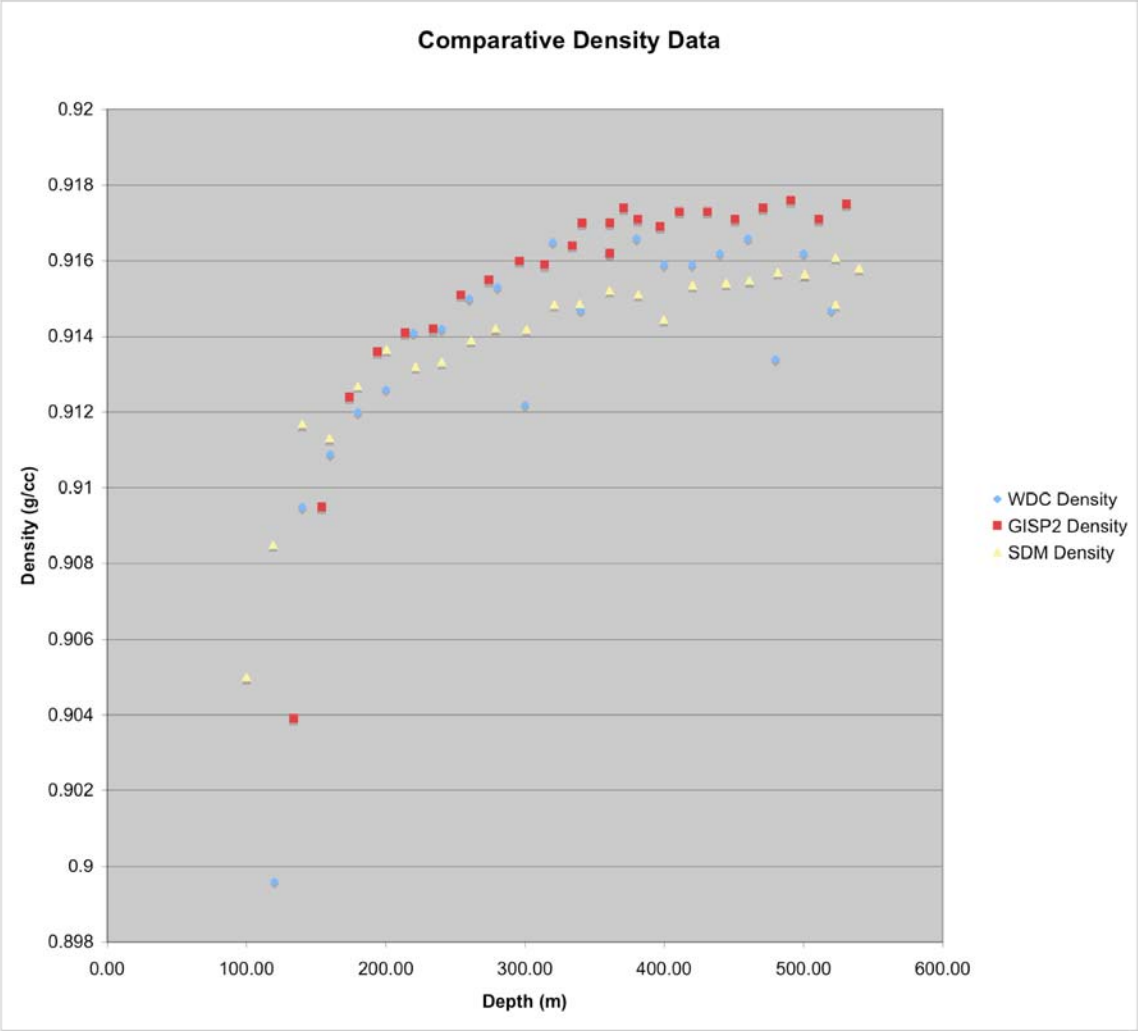
Nicole Reed deployed to Antarctica this season to perform field density measurements and section preparation on the core in support of I-168-M (Richard Alley, Penn State, P.I.). 552 lbs. of science cargo had been sent into the field in preparation for these activities.

Nicole arrived in camp on December 23rd. The first week was spent unpacking cargo and setting up the physical properties work space in the processing arch. Equipment calibrations were completed the following week after 120 AC power had been made available in the physical properties area. Testing on scrap ice indicated that there were stability problems with the stage on the sledge microtome that had been issued from Crary. ICDS personnel fabricated a new stage onsite. This stage remains in the custody of the project and will be used during upcoming field seasons at WAIS Divide.

Density measurements were performed on 21 10-cm samples taken at 20-meter intervals from 120 meters to 520 meters. Samples from the core at 540, 560, and 580 meters were deferred due to brittle behavior. Subsampling and lay-up for thin and bubble sections were accomplished on six samples. A hardware problem with the photography computer developed early in the processing and, as a result, only one photograph was recorded. Sectioning and photography will be completed during the cpl at NICL. All physical properties samples were packed in a segregated ISC container and will be retroed with the main ice shipment to NICL. The photography computer is being returned for repair or replacement.

Comparison of the densification behavior among WAIS Divide, Siple Dome, and GISP2 shows that densification at WAIS Divide is similar both in rate of change and absolute density values to GISP2. The three curves converge at about 180 meters. Below this depth, Siple Dome density values are generally lower than those for both WAIS and GISP2. The rate of change of densification flattens out at about 350 meters for both WAIS and GISP2 indicating probable bubble-pressure equalization at that depth.

Considerable low scatter in the density data from WAIS is probably indicative of the need to standardize the elapsed time between core acquisition and density measurement. It is likely that several of the low datapoints reflect wait periods that are unacceptably long at ambient temperatures in the processing arch.


Comparative Density Data
Density (g/cc)
0.92
0.918
0.916
0.914
0.912
0.91
0.908
0.906
0.904
0.902
0.9
0.898
0.00
100.00
200.00
300.00
400.00
500.00
600.00
Depth (m)
WDC Density
GISP2 Density
SDM Density

National Ice Core Laboratory (NICL) Activities at WAIS Divide 2007-2008 (I-478)

NSF-OPP Supported

NICL Field team:

Geoffrey Hargreaves

Brian Bencivengo

Season Objectives:

1. Unpack, assemble, calibrate and test core-handling equipment in processing arch.
2. Provide hands-on training to core handlers for all CPL operations and procedures before drilling commences.
3. Upon startup of drilling operations confirm all procedures and modify as required. Provide additional hands-on, step-by-step training for all handlers.
4. Troubleshoot and modify and/or repair CPL system components as required.
5. Review core logging data each day for accuracy and completeness.
6. Provide oversight for CPL operations during regular shift.
7. Provide daily update to WSD-SCO representative on progress, issues arising, and ice retro requirements.
8. Ensure that all CPL systems are prepared for winter-over storage in the processing arch.
9. Pack all retro cargo
10. Upon leaving camp, ensure that all cargo is entered correctly into the retro cargo stream, meeting with the RPSC cargo coordinator at MCM. Re-pack as necessary and acquire all northbound TCNs before re-deploying.

Season Overview:

Equipment was unpacked, setup, installed and tested.

All individuals were trained on all aspects of the core handling operation, starting with core reception / logging station, 1m measurement logging and cutting station, database operation, cart loading, core packing, loading core boxes onto wood skids, gantry / hoist operation and loading skids onto air force pallets.

The core handling operation for WAIS divide uses several pieces of equipment that have never been utilized before in a field core logging operation: computers (in warm boxes) accessing a database, digital measuring sticks, and a Fluid Evacuation Device (the FED, for removing most of the drill fluid off of the core). We are also moved ice core 16m at a time on roller racks, instead of moving individual cores.

Most of the components worked flawlessly.

The Fluid Evacuation Device removed more of the drill fluid from the ice core in Antarctica than it did during testing in Greenland.

The wine netting did an excellent job of containing the core.

The wine net applicator was not robust enough and would allow the netting to tear away from the holder while core was being pushed into the netting; we changed to clamping the netting onto the FED. Unfortunately the force required to push the core into the net began to break the core. Wine netting application will be redesigned.

The BALLUFF digital measuring sticks worked flawlessly, including the line laser pointers.

The buffer table (used to move core from the receiving table to the 1m logging/cutting table, also used to store full runs of core should the drillers get ahead of the logging operation) had no problems.

The 14” circular saw proved to be a superior choice for cutting ice. Although the 14” circular saw does have difficulties with brittle ice, they are considerably less so than with band saws.

The computers and laser printers in their warm boxes worked continuously once they were put online.

The core logging database (DB) failed during operation. The DB added an extra page for 1m tray logging, this threw off several tracking counters causing the system not to allow any more data entry. While this was a major disappointment, it was not a major problem. We simply reverted to logging into paper notebooks.

The core lifters (hand crank platform hoists) worked well.

Roller racks: moving core on roller racks worked well. We observed that it does take two people to move a rack safely.

The drying booths dried the carts of core in 12 hours or less.

The hoist /gantry worked smoothly. We had some difficulties with the hoist traversing on the gantry due to frost buildup on the I-beam from the refrigeration unit defrost cycles.

The pallet jack was indispensable, but had some problems due to the snow on the floor, also mostly from refrigeration unit defrost cycles.

The Pallet loader for lifting the wood skids onto the air force pallets worked well. It has a couple degrees of tip when lifting the skids of ice, which did not constitute a serious problem but required operator attentiveness.

The Air Force Pallet roller setup worked extremely well.

The refrigeration units kept the working area below –15°C, but were noisy and the defrost cycle left lots of snow on the floor, which made the floor slippery.

During the setup and subsequent operation, there were some minor changes to equipment configuration that had to be made, which were easily accomplished in the field. A couple of examples: The 4m tray return rack had to be repositioned closer to the receiving table, and blocked up ~8 inches to allow clearance with the receiving tray tower section. A support leg was added to the 2m cutting tray at the cutting station.

Three items were returned to CONUS for reconfiguration:

1. The FED needs to have sturdier mounts.
2. The 4m receiving table needs mounts that are adjustable for height and level.
3. The wine net applicator must be rethought, redesigned and fabricated.

All computers and equipment that requires updates and repairs were returned to NICL.

The FED and tower sections for the receiving table were returned for equipment mounting rework.

All other sensitive equipment was shipped to McMurdo for warm storage.

Equipment left on site was covered and bagged to keep out frost and snow.

Ice Coring and Drilling Services (ICDS) Activities at WAIS Divide 2007-2008 (T-350)

NSF-OPP Supported

ICDS Field Team

Laurent Augustin	Kristina Dahnert	Brent Folmer
Scott Haman	Michael Jayred	Jay Johnson
Jim Koehler	Tanner Kuhl	Bill Mason
Nicolai Mortensen	John Robinson	Paul Sendelbach

Season Objectives:

1. Complete installation and check-out of drill equipment.
2. Core to a final depth of 800+ meters.
3. Winterize equipment.

Complete Installation of DISC Drill Equipment:

Lead Driller Jay Johnson, Kristina Dahnert, Brent Folmer, Scott Haman, and Michael Jayred arrived at the WAIS Divide Camp December 3 and began the installation of the drill equipment. Four more members of the crew – Laurent Augustin, Bill Mason, Nicolai Mortensen and Paul Sendelbach – arrived on December 17 and assisted with the completion of the equipment installation. Check-out of the drill began on December 28 with the powering-up of the winch. The remainder of the crew – Jim Koehler, Tanner Kohl, and John Robinson – arrived on December 29. Check-out of the drill continued until January 3 when the pilot borehole was reamed with the DISC Drill. Brent Folmer the ICDS electrician on the project left WAIS Divide on January 1.

Bad weather delayed getting the generators on line and facility construction completed and, as a result, set-up and check-out of the drill equipment took about a week longer than would have normally been necessary.

Core 800+ Meters:

The first ½ meter of core was drilled accidentally while reaming and clearing the borehole. The first "real" core was drilled on January 4 and the second core on January 5 as core handling equipment was checked-out and adjusted.

Production coring began on Monday, January 7 with the crew operating in two shifts. A third shift was started on January 10. Coring continued through January 20 with a total of approximately 466 meters being drilled giving a final bore hole depth of 580.58 meters.

The amount of time available for production drilling was 9 days less than had been planned and the total depth drilled, therefore, was short of the 800+ meter goal for the season. Average core production was about 37 meters per day with a total of 180 runs made.

Core quality was excellent, although one core was rubble. Average core length was 2.7 meters.

Winterize Equipment:

Once it was decided to stop coring for the season, the crew winterized the equipment to remain at the site and packed components that were being sent back to Madison in two days – far less than the 7 days anticipated in the schedule. All ICDS personnel were out of WAIS Divide by January 22.

Credit: *Photo courtesy of Jay Johnson (ICDS, 2007)*

Raytheon Polar Services Company (RPSC) Activities at WAIS Divide 2007-2008

RPSC WAIS Divide Project Manager: Matthew Kippenhan

The third season for the WAIS Divide Ice Core Project ended on 05 February 2008. After another very busy, successful season the camp staff winterized the entire camp's infrastructure and equipment on snow berms until next October when everything will start all over again. This season focused on supporting 11 science groups and the ice coring project construction and start-up operations. Numerous twin otter flights utilized the smooth 10,000 foot skiway and fuel bladders throughout the summer months while nearly 40 LC-130 Hercules missions brought in passengers, materials, and bulk fuel regularly. However, poor weather conditions across the Antarctic continent impacted camp operations and flight schedules on several occasions, some of which shut down all aircraft operations for up to 10 days consecutively. Typically, adverse weather and cancelled supply flights means limited outside work and delays in material arrivals, so the team was constantly adjusting priorities to stay on track.

Foremost on the construction list was completing Phase 3 interior arch work and installing and commissioning the large Caterpillar generator modules in time to begin coring operations scheduled for 22 December 2007. Simultaneously, ICDS and NICL personnel were busy installing the DISC Drill and core handling line (CHL) equipment. Weather issues and delayed materials occurred in early December, so the power module project was delayed by two weeks making it difficult to complete on time. In response, the construction crew temporarily supplied electrical power to the arch facility for the remaining field season and resources shifted to finishing off loose arch projects. Once adequate power was supplied, the DISC Drill and CHL equipment was tested and eased into daily operations until the final core was produced on 20 January 2008. The arch facility is nearly completed with only a small punch list of items and issues to address prior to next season's startup. However, since the power module was not completely commissioned as scheduled, one of the first priorities for next season will be to finish them so coring operations can begin as early as possible.

As ice coring operations were ending, other science projects on-site were also winding down as the camp staff started to prepare for closing the camp. This is a large endeavor considering all tent structures are taken down, building modules closed up, and general cargo moved to the winter snow berms. Building winter berms begins several weeks before the camp closeout starts since it is a very time consuming activity and there is limited heavy equipment resources. Once winter staging is complete and the camp population is down to the last team necessary, all mechanical equipment is winterized and bermed for the winter also. The camp closeout usually takes a large camp and construction crew of up to 22 persons around 14 long days to complete.

All in all, approximately 709, 235 lbs of cargo, passengers, and fuel was flown in by LC-130 Hercules aircraft to support this season's construction, science, and operations. A peak population of 62 persons was at camp in early January. The camp staff and arch construction crew did another great and safe job in a very remote camp. With the addition of the CReSIS project next season, another busy, challenging field season is already in the works for 08-09.

Credit: *Photo courtesy of Brian Bencivengo (USGS/NICL, 2008)*