WAIS Divide Ice Core Project

Climate, Ice Sheet History, Cryobiology

A GUIDE FOR THE MEDIA AND PUBLIC

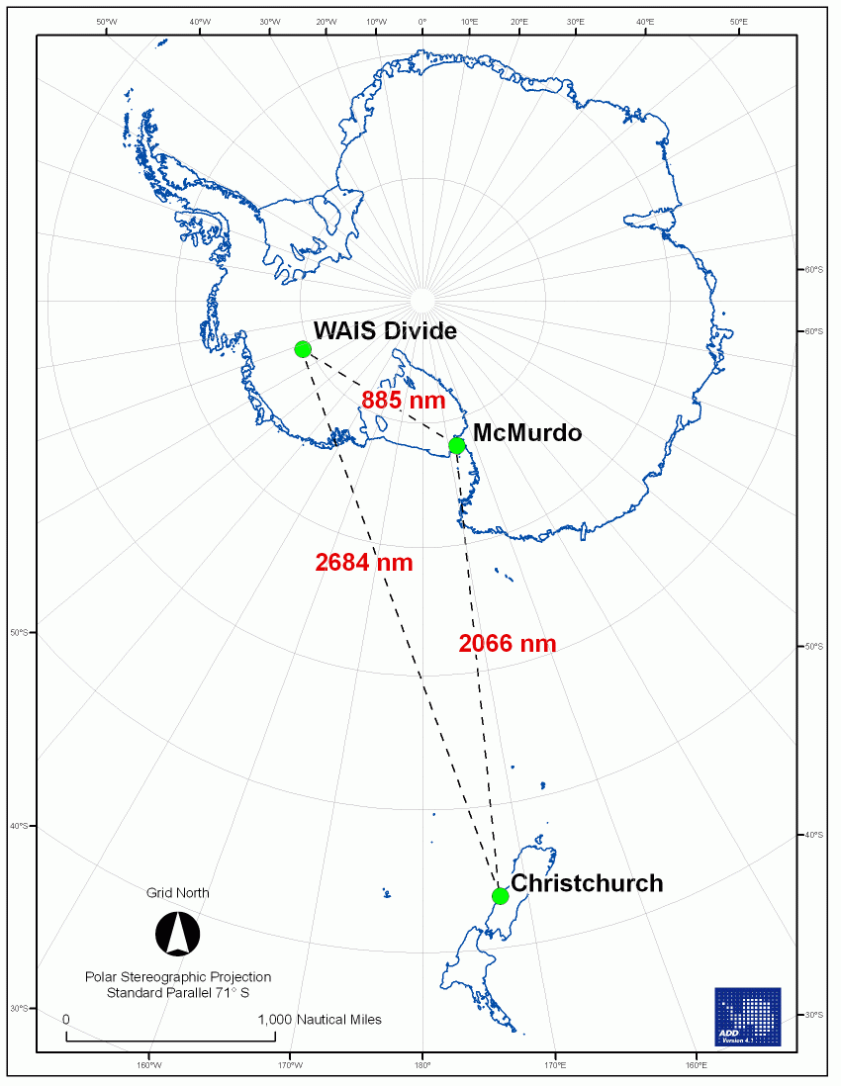
Field Season 2008-2009

WAIS (West Antarctic Ice Sheet) Divide is a United States deep ice coring project in West Antarctica funded by the National Science Foundation (NSF). WAIS Divide's goal is to examine the last ~100,000 years of Earth's climate history by drilling and recovering a deep ice core from the ice divide in central West Antarctica.

Ice core science has dramatically advanced our understanding of how the Earth's climate has changed in the past. Ice cores collected from Greenland have revolutionized our notion of climate variability during the past 100,000 years. The WAIS Divide ice core will provide the first Southern Hemisphere climate and greenhouse gas records of comparable time resolution and duration to the Greenland ice cores enabling detailed comparison of environmental conditions between the northern and southern hemispheres, and the study of greenhouse gas concentrations in the paleo-atmosphere, with a greater level of detail than previously possible. The WAIS Divide ice core will also be used to test models of WAIS history and stability, and to investigate the biological signals contained in deep Antarctic ice cores.

Additional copies of this document are available from the project website at **http://www.waisdivide.unh.edu**

Produced by the WAIS Divide Science Coordination Office with support from the National Science Foundation, Office of Polar Programs.



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WAIS DIVIDE SCIENCE COORDINATION OFFICE

The WAIS Divide Science Coordination Office (SCO) is managed by the Desert Research Institute, Nevada System of Higher Education and by the Institute for the Study of Earth, Oceans, and Space at the University of New Hampshire. The Chief Scientist and head of the SCO is Dr. Kendrick Taylor. The SCO is managed by Mark Twickler.

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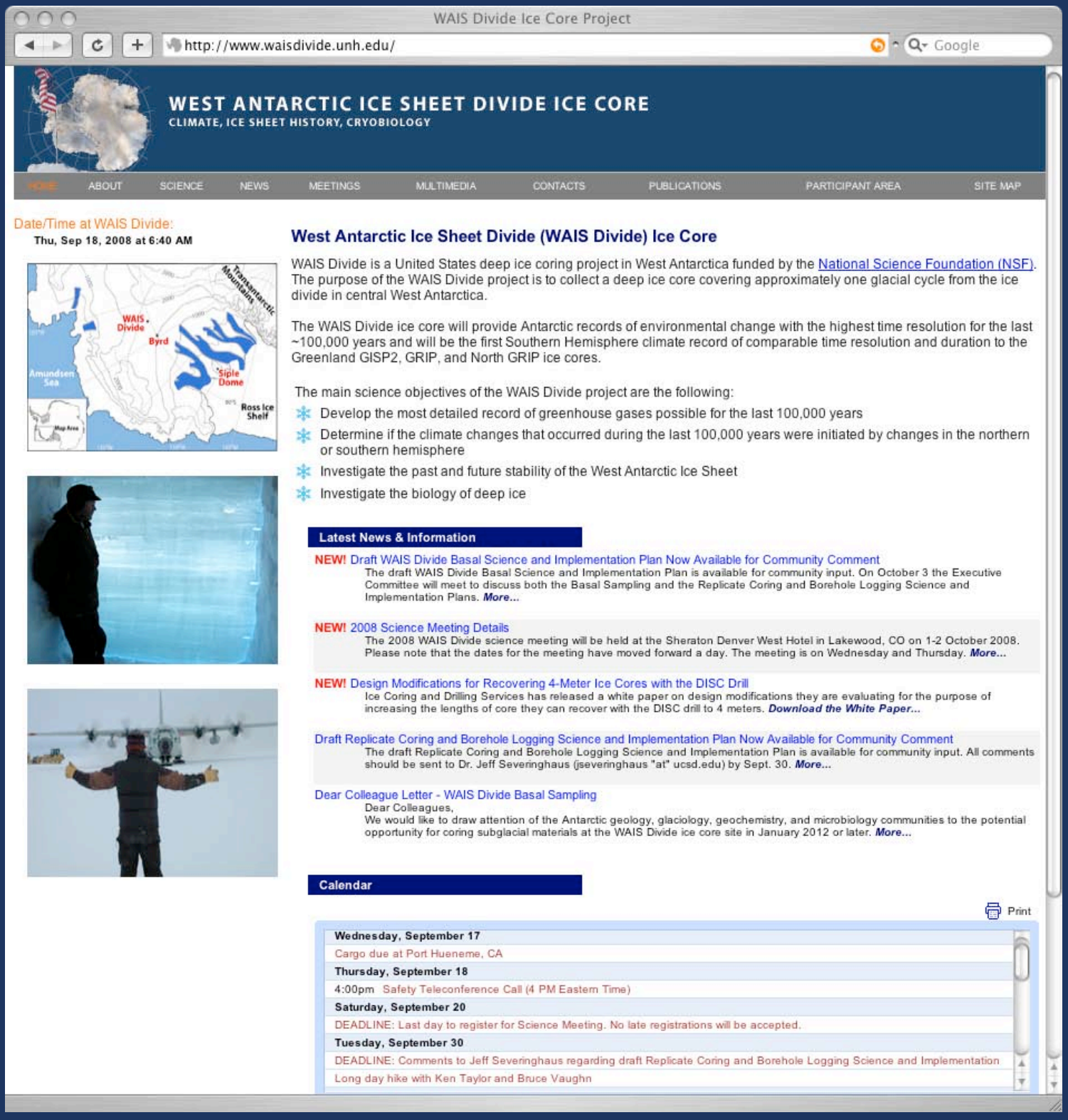
www.waisdivide.unh.edu



Website

The WAIS Divide website (www. waisdivide.unh.edu) contains an enormous amount of information about the project, including funded science projects, project updates, a photo gallery, publications, field reports, and much more. Please visit the website often for the latest project news, images, and updates.

PROJECT SNAPSHOT

WAIS DIVIDE FACTS:

WAIS Divide = West Antarctic Ice Sheet Divide Ice Core Project

Chief Scientist:
Dr. Kendrick Taylor (kendrick@dri.edu)
Desert Research Institute, Nevada System of Higher Education

Site characteristics:
- Latitude: 79.468° S
- Longitude: 112.086° W
- Surface elevation: 1,759 meters
- Distance from current flow divide: ~24 kilometers
- Current average annual surface temperature: -31° C
- Ice thickness: 3,465 meters
- Distance from McMurdo Station: 1,639 kilometers

What are we doing at WAIS Divide?
The purpose of the WAIS Divide project is to collect a deep ice core covering approximately one glacial cycle from the ice divide in central West Antarctica. The WAIS Divide ice core will provide Antarctic records of environmental change with the highest time resolution for the last ~100,000 years and will be the first Southern Hemisphere climate record of comparable time resolution and duration to the Greenland NEEM, GISP2, GRIP, and North GRIP ice cores.

What makes the WAIS Divide ice core special?
- The most significant and unique characteristic of the WAIS Divide project will be the development of climate records with an absolute, annual-layer-counted chronology for the most recent ~40,000 years.
- Due to the high snowfall rate at WAIS Divide, the ice core record will have a very small offset between the ages of the ice and the air (i.e., gases) trapped in the ice. Because of this small age difference between the gases and the enclosing ice, a decadal-precision climate chronology relative to the Greenland ice cores is expected.
- The combination of high-time resolution and the small age offset will allow us to study interactions between climate variations and atmospheric composition with a level of detail previously not possible in deep long Antarctic ice core records.
- Unlike the Greenland ice cores, an excellent atmospheric CO2 record is expected to be obtained from the WAIS Divide ice core since Antarctic ice has an order of magnitude less dust than Greenland ice.
- Many other gases (both greenhouse and non-greenhouse) and their isotopes will be measured at unprecedented precision and resolution.

What is an ice divide?
An ice divide is analogous to a watershed divide. An ice sheet divide separates opposing flow directions of ice on an ice sheet.

Why do we want to drill near an ice divide?
Snow and ice that accumulates on an ice divide moves vertically downward with time. As you move laterally off of an ice divide the ice increasingly moves horizontally. Irregularities in the bedrock below the ice sheet can cause horizontally moving layers of ice to bend and fold thus disturbing the internal layering of the ice. Ice coring is typically made on top of ice divides to minimize these potential interferences in the stratigraphic record caused by horizontal ice movement. The WAIS Divide drill site is actually ~24 kilometers downslope of the current ice divide because ice divides can migrate over time. Drilling slightly off of the current ice divide helps ensure that no divide migration has compromised the stratigraphy of the ice core record.

Why WAIS Divide?
The WAIS Divide site was chosen because it is an almost exact analogue to GISP2 in Greenland in terms of accumulation rate, temperature, gas age-ice age difference, and distance from the ice divide.

How many people are involved?
More than 100 scientists, students, and technicians from the United States are involved in the project.

Main science objectives:
- Develop the most detailed record of greenhouse gases possible for the last 100,000 years
- Determine if the climate changes that occurred during the last 100,000 years were initiated by changes in the northern or southern hemisphere
- Investigate the past and future stability of the West Antarctic Ice Sheet
- Investigate the biology of deep ice

Executive Committee:
Dr. Kendrick C. Taylor (Desert Research Institute) - Chair
Dr. Richard B. Alley (Pennsylvania State University)
Dr. Edward J. Brook (Oregon State University)
Dr. Joseph R. McConnell (Desert Research Institute)
Dr. John C. Priscu (Montana State Univesity)
Dr. Jeffrey P. Severinghaus (Scripps Institution of Oceanography)
Dr. James C. White (INSTAAR, University of Colorado)

Funding:
The Office of Polar Programs at the National Science Foundation (NSF) funds the project with most of the science funding coming from the Glaciology Program managed by Dr. Julie Palais. Some additional science funding is provided by the Antarctic Organisms and Ecosystems Program. Logistical support is from NSF's Division of Antarctic Infrastructure and Logistics.

PROJECT DETAILS

WAISCORES

The WAISCORES project is part of the U.S. National Science Foundation's West Antarctic Ice Sheet (WAIS) initiative, which is aimed at understanding the influence of the WAIS on climate and sea level change. The WAISCORES project called for two deep ice cores to be collected from West Antarctica: one from a coastal location and one from an inland location near the Ross/Amundsen ice divide region. Siple Dome was selected as the coastal location and drilling began in November 1996 and finished in January 1999. WAIS Divide was selected as the inland location and drilling began in the 2006/2007 season. It is anticipated that bedrock will be reached by the 2009/2010 season.

WAIS Divide Site Selection

High-resolution, grid-based airborne geophysical surveys of the Ross/Amundsen ice divide region were conducted during 1994-1996 and identified several sites with favorable surface topography, ice thickness, accumulation rate, and bedrock topography characteristics. On-ice site reconnaissance started in 1995/1996 with exploratory traverses into the area and the drilling of three shallow firn cores to confirm the preservation of climatic signals in the snow and ice. Ice flow modeling and temperature calculations were applied to the candidate sites to predict time scales and annual layer resolution. This was then followed by two seasons of ground-based geophysical surveys to further investigate the candidate sites.

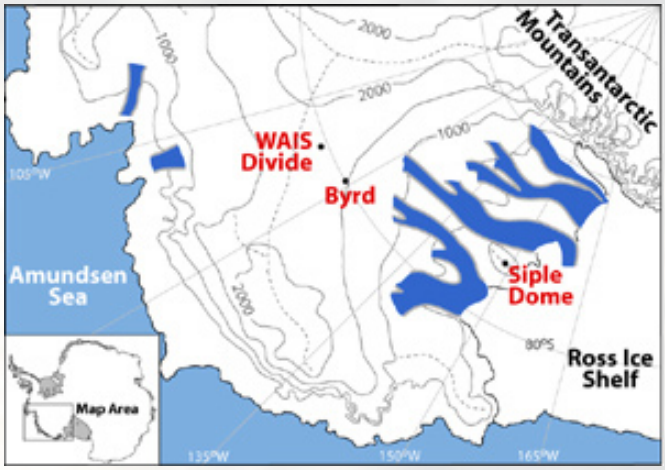
The WAIS Divide site was selected based on the following site requirements:

1. Relatively smooth bed topography and minimal horizontal ice flow.
2. Individually identifiable annual layers of at least 1cm thickness in ice 40,000 years old.
3. Ice-accumulation rate sufficient to reduce the age difference between the gases in the ice and the ice itself to less than 500 years.
4. Well-behaved stratigraphy to an age of at least 80,000 years.

WAIS Divide Activities Already Completed

2005/2006 Field Season:

- Establishment of seasonal field camp at WAIS Divide
- Began construction and assembly of drilling and core handling/processing arch facility
- Drilled several shallow ice cores



2006/2007 Field Season:

- Began interior arch construction activities
- Drilled 130 meter ice core outside of arch facility
- Drilled and cased 100 meter pilot hole inside arch facility
- Installed two DISC Drill gantry cranes inside arch

2007/2008 Field Season:

- Installed DISC Drill and core handling equipment
- Drilled to 580 meters depth with DISC Drill

Projected Field Schedule

2008/2009 Field Season - 2010/2011 Field Season

- Continue deep drilling with DISC Drill

2011/2012 Field Season

- Reach bedrock with DISC Drill
- Borehole Logging

2012/2013 Field Season

- Borehole Logging, Basal Sampling, Replicate Coring

WAIS Divide compared to other Antarctic ice cores

Other Antarctic ice coring programs focus on different time scales than the WAIS Divide project. The very high-time-resolution Australian work at Law Dome and the British Berkner Island work focus on the current warm period and the transition to the industrial era. The low-time-resolution EPICA ice cores from Dome C and Dronning Maud Land, the Japanese Dome Fuji ice core, the Italian Talos Dome ice core, and the Russian Vostok ice core focus on records of glacial-interglacial time scales (i.e., several hundreds of thousands of years). The WAIS Divide ice core will provide Antarctic records of environmental change with the highest time resolution for the last ~100,000 years.

SCIENCE PROJECTS

PROJECT	Lead PI(s)	Affiliation	Email
Physical Properties of the WAIS Divide Deep Core (Collaborative Research)	Alley, Richard Cuffey, Kurt	Pennsylvania State University University of California - Berkeley	ralley@geosc.psu.edu kcuffey@berkeley.edu
Atmospheric, Snow and Firn Chemistry Studies for Interpretation of WAIS Divide Cores	Bales, Roger	University of California - Merced	rbales@ucmerced.edu
Gases in Firn Air and Shallow Ice at the Proposed WAIS Divide Drilling Site (Collaborative Research)	Battle, Mark Brook, Ed Saltzman, Eric Severinghaus, Jeff Sowers, Todd White, James	Bowdoin College Oregon State University University of California - Irvine Scripps Institution of Oceanography Pennsylvania State University University of Colorado - Boulder	mbattle@bowdoin.edu brooke@geo.oregonstate.edu esaltzma@uci.edu jseveringhaus@ucsd.edu sowers@geosc.psu.edu james.white@colorado.edu
Atmospheric Carbon Dioxide and Climate Change: The WAIS Divide Ice Core Record	Brook, Ed	Oregon State University	brooke@geo.oregonstate.edu
Constructing an Ultra-High Resolution Atmospheric Methane Record for the Last 140,000 Years from WAIS Divide Ice Cores (Collaborative Research)	Brook, Ed Sowers, Todd	Oregon State University Pennsylvania State University	brooke@geo.oregonstate.edu sowers@geosc.psu.edu
Cosmogenic Radionuclides in the WAIS Divide Ice Core (Collaborative Research)	Caffee, Marc Welten, Kees	Purdue University University of California - Berkeley	mcaffee@purdue.edu kcwelten@berkeley.edu
Major Ion Chemistry of WAIS Divide Ice Core	Cole-Dai, Jihong	South Dakota State University	jihong.cole-dai@sdstate.edu
Western Divide West Antarctic Ice Cores (WAISCORES) Site Selection	Conway, Howard Waddington, Ed	University of Washington University of Washington	conway@ess.washington.edu edw@ess.washington.edu
Stable Isotopes of Ice in the WAIS Divide Deep Ice Core (Collaborative Research)	Cuffey, Kurt Steig, Eric White, James	University of California - Berkeley University of Washington University of Colorado - Boulder	kcuffey@berkeley.edu steig@ess.washington.edu james.white@colorado.edu
Microparticle/Tephra Analysis of the WAIS Divide Ice Core (Collaborative Research)	Dunbar, Nelia Kreutz, Karl	New Mexico Inst. of Mining and Tech. University of Maine	nelia@nmt.edu karl.kreutz@maine.edu
High Temporal Resolution Black Carbon Record of Southern Hemisphere Biomass Burning	Edwards, Ross	Desert Research Institute	ross.edwards@dri.edu
Trace and Ultra-Trace Chemistry Measurements of the WAIS Divide Ice Core	McConnell, Joe	Desert Research Institute	Joe.McConnell@dri.edu

(Continued on next page)

SCIENCE PROJECTS

PROJECT	Lead PI(s)	Affiliation	Email
Optical Imaging Support for the National Ice Core Laboratory	McGwire, Kenneth	Desert Research Institute	Ken.McGwire@dri.edu
Anisotropy, Abrupt Climate Change, and the Deep Ice in West Antarctica (Collaborative Research)	Pettit, Erin Waddington, Ed	Portland State University University of Washington	epettit@pdx.edu edw@ess.washington.edu
Climatology, Meteorology, and Microbial Metabolism in Ice with Dust Loggers and Fluorimetry	Price, Buford	University of California - Berkeley	bprice@berkeley.edu
Climatology, Volcanism, and Microbial Life in Ice with Downhole Loggers	Price, Buford	University of California - Berkeley	bprice@berkeley.edu
Paleo Records of Biotic and Abiotic Particles in Polar Ice Cores	Priscu, John	Montana State University	jpriscu@montana.edu
Detection of Crystal Orientation Fabrics near the Ross/Amundsen Sea Ice-Flow Divide and at the Siple Dome Ice Coring Site using Polarimetric Radar Methods	Raymond, Charles	University of Washington	charlie@ess.washington.edu
Glaciological Characteristics of the Ross/Amundsen Sea Ice-Flow Divide Deduced by a New Analysis of Ice-penetrating Radar Data	Raymond, Charles	University of Washington	charlie@ess.washington.edu
Nitrogen and Oxygen Gas Isotopes in the WAIS Divide Ice Core as Constraints on Chronology, Temperature, and Accumulation Rate	Severinghaus, Jeff	Scripps Institution of Oceanography	jseveringhaus@ucsd.edu
Multiple-Isotope Analysis of Nitrate and Sulfate in the West Antarctic Ice Sheet Divide Ice Core (Collaborative Research)	Steig, Eric Thiemens, Mark	University of Washington University of California - San Diego	steig@ess.washington.edu mthiemens@ucsd.edu
Investigation of Climate, Ice Dynamics and Biology using a Deep Ice Core from the West Antarctic Ice Sheet Divide	Taylor, Ken	Desert Research Institute	kendrick.taylor@dri.edu
Investigation of the Stratigraphy and Timescale of the WAIS Divide Ice Core Using Electrical Methods	Taylor, Ken	Desert Research Institute	kendrick.taylor@dri.edu
Histories of Accumulation, Thickness and WAIS Divide Location from Radar Layers using a New Inverse Approach	Waddington, Ed	University of Washington	edw@ess.washington.edu

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SCIENCE PROJECTS

PROJECT	Lead PI(s)	Affiliation	Email
Self-consistent Ice Dynamics, Accumulation, Delta-age, and Interpolation of Sparse Age Data using an Inverse Approach	Waddington, Ed	University of Washington	edw@ess.washington.edu
Spatial Variability in Firn Properties from Borehole Optical Stratigraphy at the Inland WAIS Core Site	Waddington, Ed	University of Washington	edw@ess.washington.edu

The most up to date information on funded science projects can be found at:
www.waisdivide.unh.edu/Projects/DisplayAll

ORGANIZATIONS INVOLVED

	**NSF** National Science Foundation www.nsf.gov	Funding for WAIS Divide is provided by the NSF Office of Polar Programs (OPP). *Science Contact*: Dr. Julie Palais, Antarctic Glaciology Program, NSF-OPP, jpalais@nsf.gov *Logistics Contact*: Dr. Alexandra Isern, Antarctic Research Support, NSF-OPP, aisern@nsf.gov *Media Contact*: Mr. Peter West, Public Affairs Specialist, NSF, pwest@nsf.gov
	**DRI** Desert Research Institute www.dri.edu	The Chief Scientist and head of the Science Coordination Office (SCO) is Dr. Kendrick Taylor at the Desert Research Institute, Nevada System of Higher Education.
	**UNH** University of New Hampshire www.eos.sr.unh.edu	The Science Coordination Office (SCO) is managed by Mr. Mark Twickler at the Institute for the Study of Earth, Ocean, and Space at the Univesity of New Hampshire.
	**ICDS** Ice Coring and Drilling Services www.ssec.wisc.edu/icds	ICDS is the NSF-designated drilling contractor for the project. ICDS is responsible for the design, fabrication, testing, and operation of the Deep Ice Sheet Coring (DISC) Drill. See page 11 for more information.
	**NICL** National Ice Core Laboratory nicl.usgs.gov	NICL is responsible for the fabrication of the core handling and core processing equipment, the design of the core handling process plan, and also for the long-term storage of the core when it is brought back to the U.S. See page 12 for more information.
	**RPSC** Raytheon Polar Services Company www.rpsc.raytheon.com	RPSC is the Antarctic logistics provider for the NSF and provides all of the Antarctic infrastructure support and logistics for the project. RPSC designed, constructed, and operates the deep field camp at the WAIS Divide field site in West Antarctica. See page 13 for more information.
	**USAP** United States Antarctic Program www.usap.gov	The United States Antarctic Program (USAP) supports scientific research in Antarctica and is funded by the NSF.

You can find more information about these organizations and their involvement in the WAIS Divide project at:
www.waisdivide.unh.edu/sciencesupport/index.html

DRILLING DEEP

THE DEEP ICE SHEET CORING (DISC) DRILL

The DISC Drill is a electromechanical drill designed to cut and retrieve cores of ice 122mm in diameter to depths of 4,000 meters. The conceptual design of the DISC Drill was developed in 2002-2003 based on science requirements written by Kendrick Taylor, the U.S. Ice Core Working Group, and the U.S ice coring community and on engineering performance objectives. The DISC Drill utilizes many technologies proven on Russian and European ice coring drills, as well as several new innovations. The drill was designed and manufactured by a team consisting of engineers and technicians from the University of Wisconsin-Madison and various subcontractors. Assistance was also provided by the U.S. ice coring community, the European ice coring community, and the polar logistical support organizations in the U.S. The DISC Drill will be housed within the drilling arch (see photo below) at WAIS Divide.

The rotating drill head contains 4 razor sharp cutters that shave out an annulus of ice, which the 14 m long drill slides down into. As the drill slides down into the annulus it slides over the core, which is 12.2 cm in diameter and 2.7 m long. When a cable pulls up the drill, four cams grab the core and fracture it. After the drill is pulled back to the surface, it is lowered from a vertical to a horizontal orientation. An arrow is marked on the core to indicate which side of the core was facing north when the core was in the ice sheet.

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The DISC Drill consists of several major subsystems.

Drill Sonde:
The sonde is the down-hole portion of the drill system that cuts the ice. The sonde consists of a cutter head, a core barrel in which the core is collected, screens to remove chips from the drill fluid, a motor and transmission to drive the cutter head, a pump to circulate ice cuttings in the drill fluid through the sonde, an instrumentation/control section, and an anti-torque section to stabilize the drill in the borehole. The top of the sonde connects with the drill cable.

Drill Cable:
The cable is used to suspend the drill sonde in the borehole. The cable also provides electrical power and fiber optic communication to the drill. The cable diameter is 15 mm.

Tower:
The tower consists of a mast (constructed of modular truss sections) at the top of the borehole with a number of pulleys to allow for the raising and lowering of the sonde. Once the sonde is out of the borehole, the tower tilts horizontally to allow for the removal of the ice core.

Winch:
The winch provides the means of hoisting the drill from the borehole. The components of the winch system include the winch drum which can hold 4,400 meters of cable, a level-wind system which allows for the payout of cable from the winch drum with a single sheave, and a drive system.

Drill Fluid:
The borehole fluid provides hydrostatic compensation, necessary to prevent closure of the borehole due to glaciostatic pressure of the surrounding ice.


Drilling arch

NATIONAL ICE CORE LABORATORY

The National Ice Core Laboratory (NICL) was established in 1993 and is located at the Denver Federal Center in Lakewood, Colorado. NICL is a joint program funded by the National Science Foundation (NSF) and the U.S. Geological Survey (USGS). NICL is housed administratively within the USGS, Office of the Regional Executive for Geology, Central Region, which is responsible for all operational aspects of the facility. The facility's most important responsibility is for the safe and secure storage and curation of ice cores that are collected primarily by NSF sponsored projects.

NICL's Involvement with WAIS Divide:

- Coordination with RPSC on processing arch requirements and design
- Design and fabrication of core handling/processing system
- Design and support of core quality and sampling history database
- Support field operations with NICL staff at WAIS Divide
- Modify core handling/processing equipment as required based on field performance
- Provide input to SCO for modifications to handling/processing procedures if needed
- Long-term storage of WAIS Divide core when it is brought back to the U.S.
- The main sampling of the ice core will be done at the NICL facilities in Denver, Colorado

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Mr. Geoff Hargreaves
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Core handling/ processing arch

THE NICL FACILITY IN DENVER, COLORADO:

- NICL's main archive freezer is 55,000 cubic feet in size and is held at a temperature of -36 degrees Celcius
- A second room for examination of ice cores, held at -25 degrees Celcius, is 12,000 cubic feet in size and is contiguous with the archive area
- There is also a Class-100 HEPA-filtered, cold clean room
- NICL also maintains space outside the freezer facility for material fabrication, storage, changing areas, offices, and visiting scientist workspace
- NICL currently stores over 14,000 meters of ice core collected from various locations in Antarctica, Greenland, and North America

RAYTHEON POLAR SERVICES COMPANY

Raytheon Polar Services Company (RPSC) is the Antarctic logistics provider for the National Science Foundation. The main function of RPSC is to provide support to the United States Antarctic Program.

WAIS Divide Involvement:

- Design, construction, and operation of the WAIS Divide field camp in West Antarctica
- Design and construction of drilling and core handling/processing arch facility
- Provide support to science parties operating at/from WAIS Divide
- All logistics of personnel and cargo movement

WAIS DIVIDE CAMP FACTS:

- Established in the 2005/2006 field season
- Operational generally from first week of November through early February
- Camp staff consists of 10-12 people
- Camp population of 50-70 people (staff, scientists, visitors)
- Supported by LC-130, Twin Otter, and Basler Turbo 6 missions from McMurdo Station
- Camp structures consist of a communication tent, medical tent, galley tent, recreational/wash tent, 3 Jamesways, mechanic shop, generator module, science tent, and the drilling and core handling/processing arch
- Heavy equipment at camp consists of a 953 Caterpillar, a Tucker Sno-Cat, a Pisten Bully, and a Caterpillar D4 Bulldozer.
- Communications equipment consists of HF and VHF radios, Iridium satellite phones, and the GOES satellite system for internet, FTP and email connectivity
- All camp structures (except for the arch), equipment, and cargo is winterized outside on berms at the end of each field season
- The drilling arch is 100’ (L) x 30’ (W) x 27’ (H)
- The core handling/processing arch is 84’ (L) x 30’ (W) x 16’5” (H)
- The core storage basement, located beneath the core handling/processing arch, is 60’ (L) x 12’ (W) x 12’ (H)

CONTACT:

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WAIS DIVIDE ACRONYMS

CO2	Carbon Dioxide
DISC	Deep Ice Sheet Coring (Drill)
DRI	Desert Research Institute
EPICA	European Project for Ice Coring in Antarctica
GISP2	Greenland Ice Sheet Project 2
GOES	Geostationary Satellite Server
GRIP	(European) Greenland Ice Core Project
HEPA	High Efficiency Particulate Air
ICDS	Ice Coring and Drilling Services
NICL	National Ice Core Laboratory
NSF	National Science Foundation
OPP	Office of Polar Programs (NSF)
RPSC	Raytheon Polar Services Company
SCO	Science Coordination Office
UNH	University of New Hampshire
USAP	United States Antarctic Program
USGS	United States Geological Survey
WAIS	West Antarctic Ice Sheet
WAISCORES	West Antarctic Ice Sheet (Ice) Cores

PHOTO/FIGURE CREDITS

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Inset: ICDS, 2008
Center: D. Zastrow, 2005/2006

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Map: RPSC
Photo: J. Souney, 2006

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Left Top: ICDS, 2006
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Right (from top to bottom):
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D. Zastrow, 2005/2006
J. Souney, 2006
M. Kippenhan, 2007
ICDS, 2006/2007
J. Souney, 2006

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