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West Antarctic Ice Sheet (WAIS) Divide Ice Core Project

The West Antarctic Ice Sheet (WAIS) Divide ice core drilling project is a major paleoclimate study funded by the National Science Foundation and comprised of 30 individual projects from 16 universities around the United States. Dr. Kendrick Taylor, chief scientist of the Desert Research Institute, is the Principal Investigator.

Research Goals

- 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; and
- Investigate the biology of deep ice.

Significance

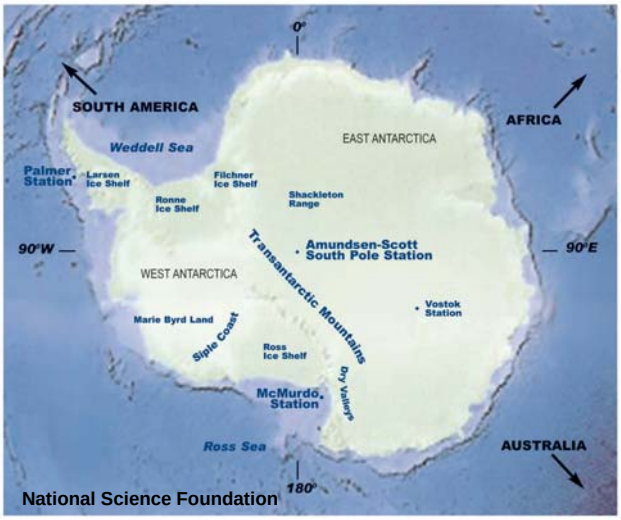
The WAIS Divide ice core has the highest time resolution of any core ever extracted on Earth. The study will provide the most detailed record of greenhouse gases -- including carbon dioxide -- ever measured for the past 100,000 years of Earth's climate history. Scientists will be able to determine annual data for the past 40,000 years by analyzing the electrical properties and chemistry of the ice cores, which vary seasonally. They also date the cores by identifying volcanic ash layers from known eruptions (see image, below).

The core will be the first Antarctic core comparable in time resolution to the Greenland Ice Sheet Project (GISP) and Greenland Ice Core Project (GRIP). Thus, data from the study will enable scientists to compare past temperature fluctuations between the poles and help them determine whether past climate changes known to have occurred in the Northern Hemisphere also happened in the Southern Hemisphere. The study will provide more information about the transport of heat between the Arctic and Antarctic by the atmosphere and oceans, as well as more certainty about the relationship between carbon dioxide and temperature in the atmosphere.

What is an ice core?

An ice core is a cylindrical sample of deep ice taken from Antarctica, Greenland or other locations in high mountain glaciers. Glaciologists retrieve cores in order to analyze gases from ancient air bubbles trapped within the ice, as well as hydrogen and oxygen isotopes (forms of these elements that have the same chemical properties but different atomic masses) in the ice itself, in order to understand Earth's past climate.

The Antarctic ice sheet is a massive glacier moving slowly over bedrock toward the Southern Ocean. It is comprised of the East Antarctic Ice Sheet and West Antarctic Ice Sheet (WAIS). The ice sheet has formed over hundreds of thousands of years from annual snowfall that has accumulated layer by layer. Each layer is eventually compressed into solid ice due to the weight of more recent snow above it – a process that traps bubbles of atmospheric gases within the ice. At the WAIS Divide site, this change occurs at a depth of about 300 feet below the surface of the ice sheet, which is about two miles thick.



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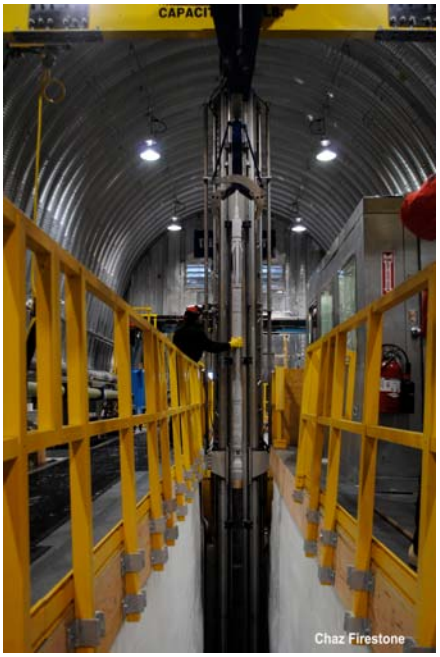
Why WAIS Divide?
One of the main reasons the WAIS Divide site was chosen is the weather. Its average annual snowfall rate is about 20 inches per year, which translates into an ice accumulation rate of 8.66 inches per year for the past few hundred years – high for interior Antarctica. This leads to more distinguishable, highly resolved season-by-season layers in the deep ice compared to other Antarctic cores. Annual layers of deep ice are apparent for at least the past 40,000 years. Deeper into the ice, gases can be measured within a 200 to 500 year margin for an additional 60,000 years.

The WAIS Divide site was also chosen because of its location on the ice sheet. Scientists study ice sheet dynamics to tell how ice has moved over time and the exact distance ice at each depth has traveled from. An ice sheet *divide* is the location at which ice flows downhill in opposite directions, similar to the boundary of a watershed. Although ice near a divide moves vertically downward, it experiences less horizontal movement than ice at other areas of an ice sheet. Drilling near a divide minimizes the distance deep ice has traveled. The position of ice sheet divides can change slightly over time, so drilling at the WAIS Divide site takes place slightly off the divide to ensure the ice below is more stable. Also, because the bedrock beneath WAIS Divide is relatively smooth, less folding and bending of ice have taken place compared to other locations on the ice sheet. The layers of ice are relatively flat, undisturbed and in tact.

Antarctic ice contains much less dust than Greenland ice. As opposed to the Arctic, which is an ocean surrounded by continents, Antarctica is an ice-covered continent surrounded by an ocean. Because of this, the WAIS Divide core contains less dust than comparable cores from Greenland. Dust is an important feature in ice cores. As annual layers of snow are compressed into solid ice, dust interferes with the interaction between snow crystals and the surrounding air, altering the concentration of carbon dioxide trapped within the ice. Thus, much of what scientists know about carbon dioxide concentrations in the past has come from Antarctic ice cores.



The Drilling Process
Taylor and other scientists working in the U.S. ice core field, along with engineers at the University of Wisconsin-Madison and other partners, devised a one-of-a-kind Deep Ice Sheet Coring (DISC) drill to use at WAIS Divide (see image, left). It began drilling the main core during the 2007-2008 field season and will operate through at least the 2010-2011 field season. The drill consists of a long hollow steel tube with four razor-sharp cutters at its bottom edge. It is housed in "the arch" – a high-ceiling steel building located at the field camp. As the drill is lowered vertically into the ice sheet, it rotates, cutting out a cylinder-shaped core of ice about 4.8 inches in diameter (about the size of a CD) and 10.5 feet long. It is then retracted back up into the arch. The core is removed and the process begins again.

Storing, Transporting and Analyzing the Core
After a core segment is drilled, it is kept in a refrigeration unit at a temperature less than four degrees below zero Fahrenheit, the temperature at which gas bubbles can escape from the ice. In the field, Taylor and his team identify the annual layers in each core segment by measuring the electrical conductivity of the ice, which differs depending on whether the original snowfall occurred in summer or winter. They also make note of layers of ash or other volcanic particles.

After the initial analysis, the core segments are stored in a basement beneath the surface of the ice sheet, flown to McMurdo Station (the largest of the three permanent research stations run by the U.S. Antarctic Program) in climate-controlled U.S. military jets, carried by ship to California, and then transported by truck to the National Ice Core Laboratory (NICL) in Colorado. There, samples of the core are cut and distributed to universities, where most of the analysis takes place. A section of each segment is saved and stored at NICL at 33 degrees below zero Fahrenheit.

Scientists analyze gases from the air bubbles, such as carbon dioxide, methane and other greenhouse gases. In addition, they measure sea salt and trace elements such as lead trapped in the ice (in Greenland ice cores, lead has been a useful indication of human impact, since it is expelled by the burning of fossil fuels). They also measure hydrogen isotopes from melted ice to determine the atmospheric temperature at the time of snowfall, and oxygen isotopes to reveal humidity. This information is then entered into climate models to show the relationship between temperature and gases over thousands of years. Ice core researchers expect to complete the analysis of the WAIS Divide ice core within three years, though interpretation of the data may go on longer.

Current Status: Field Season 2009-2010
Because of harsh weather conditions, the WAIS Divide study has a short field season. During the most recent season, the field camp opened in November 2009 (during Antarctic summer) and closed on January 25, 2010. The drill was only operated for 35 days due to interruptions by severe weather. It reached a depth of nearly 8,400 feet. Scientists hope to complete the project during the 2010-2011 field season by drilling down to 10,925 feet. The bedrock lies 11,368 feet below the surface of the ice sheet.

Resources

- *WAIS Divide Ice Core Drilling Project Website:* **http://www.waisdivide.unh.edu**
- *WAIS Divide Media and Public Guide:* **http://www.waisdivide.unh.edu/Reference/Download.pm/621/Document**
- *WAIS Divide Videos:* **http://www.waisdivide.unh.edu/outreach/video.html**
- *West Antarctic Ice Sheet Initiative:* **http://neptune.gsfc.nasa.gov/wais**
- *National Ice Core Laboratory*: **http://nicl.usgs.gov**
- *Greenland Ice Sheet Project:* **http://www.nerc-bas.ac.uk/public/icd/grip/griplist.html**
- *Greenland Ice Sheet Project II:* **http://www.gisp2.sr.unh.edu**
- *Greenland Ice Core Project:* **http://www.ncdc.noaa.gov/paleo/icecore/greenland/summit/document**
- *Landsat Image Mosaic of Antarctica:* **http://lima.usgs.gov**
- *National Climatic Data Center, Ice Core Gateway:* **http://www.ncdc.noaa.gov/paleo/icecore/current.html**
- *Scientific Committee on Antarctic Research, iceREADER* **http://www.icereader.org/icereader**
- *C. Firestone. "Icy Hunt for Old Air,"* Nature *463, 408-409 (2010):* **http://www.nature.com/news/2010/100127/full/463408a.html**

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