



United States
Antarctic Program



"News about the USAP, the Ice, and the People"

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The Antarctic Sun



Photo Credit: Jay Johnson/WAIS Divide

The Deep Ice Sheet Coring (DISC) drill tilts toward the borehole for coring operations during the 2010-11 field season. Later this year, the drill will be modified with a new replicate coring system to extract ice cores from the side of the present borehole that are of interest to scientists, such as abrupt climate change events.

Repeat experiment

New replicate ice core system will target abrupt climate change events

BY PETER REJCEK, *ANTARCTIC SUN* EDITOR
Posted June 29, 2012



Scientists have been extracting ice cores from Antarctica for the better part of 50 years. But no one has tried to do what a team of researchers and engineers propose at the end of this year from a field camp in one of the snowiest regions of the West Antarctic Ice Sheet (WAIS).

“No one in the world has developed a system to replicate ice cores at any chosen depth and at any chosen azimuth within an existing borehole,” said Alex Shturmakov, director of engineering and research for [Ice Drilling Design and Operations \(IDDO\)](#) at the [University of Wisconsin-Madison](#). “We are very excited. It’s always interesting to work on something that nobody ever worked on before. It is an engineering challenge.”

The multiyear [WAIS Divide project](#) recovered an ice core 3,405 meters into the ice sheet — the deepest ice core ever drilled by an American-based team. The major drilling operations were completed during the 2010-11 field season, with the hole deepened by about 75 meters during the most recent Antarctic summer, leaving a 50-meter environmental barrier above where the ice meets bedrock to prevent accidental contamination of the subglacial water system.

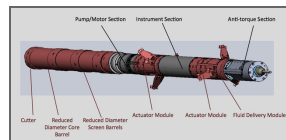


Photo Credit: IDDO

Schematic of the replicate coring system.

[See previous article — [The last core: WAIS Divide deepens borehole for research into climate change.](#)]

The ice core represents a window back in time on the Earth’s climate. Scientists can analyze bubbles of various gases trapped in the ice — particularly the important greenhouse gas carbon dioxide — to get a sample of the ancient atmosphere. Dust and chemicals found in the ice can also provide details about past climate.

But what makes the WAIS Divide ice core particularly special is the same thing that makes it an extremely difficult place to reach and work — tons of snow. That gives researchers fat annual layers of accumulation, which translates into a high-resolution paleoclimate record for the last 62,000 years.

"Abrupt climate change is a major focus of this ice-coring effort, and so we're going to be looking in great detail at one or two of the abrupt climate-change events," said [Jeffrey Severinghaus](#), a professor of geosciences at [Scripps Institution of Oceanography](#) who is heading up the replicate coring science program for the WAIS Divide project.

It took about five years for drillers to punch through nearly the entire ice sheet, recovering a single sliver of Antarctic ice. That very finite supply is coveted by many researchers, who eventually must destroy their samples to conduct various analyses. That's where [replicate coring](#) comes in.

Engineers at IDDO, which designed and built the [Deep Ice Sheet Coring \(DISC\) Drill](#) used for the WAIS Divide project, have developed a system to re-enter the borehole and extract additional ice related to areas of scientific interest, such as the abrupt climate change events mentioned by Severinghaus.

"Basically, it transforms the DISC drill into replicate coring system through the inclusion of several new components," explained Shturmakov, the project manager for both the DISC drill and replicate coring system, which has been in development since 2009.

Components of the system were tested at the end of the 2011-12 field season after researchers conducted further measurements of the borehole itself. Shturmakov said the attempts to penetrate the ice by deviating from the borehole illustrated what needed to be addressed this summer in Madison.

"We do not plan to test [it] next season. We know what to fix and we know how to fix it," he said, adding that full-scale tests are under way now in Madison.

Scientists hope to extract about 250 meters of new ice cores from several sections, going down more than 3,000 meters deep for one section dating back 38,000 years to a period of abrupt warming during the last glacial period.

"It's an abrupt climate change that happened at a time when Earth's orbit was not changing. In other words, you don't have the complicating influence of the Earth's orbit," said Severinghaus, referring to the time



Photo Credit: Krissy Dahnert/IDDO

*The replicate coring system
being tested in Madison,
Wis.*

period dubbed Interstadial 8 during the last glacial period.

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Photo Credit: Kristina Dahnert/WAIS Divide

IDDO driller Elizabeth Morton assists with borehole logging operations. The replicate drill must be able to deviate from the main borehole on the "uphill" side so that additional borehole logging can be done; otherwise, the borehole instrument may slip into the newly created hole on the "downhill" side of the borehole.

Replicate cores should help shed light on abrupt climate changes

An abrupt climate change is an event that occurs on a timescale measured in decades. An interstadial is a warm interlude during a glacial period that begins with an abrupt warming of about 10 degrees Celsius in Greenland and Europe that last several hundred years. There were more than 20 interstadials during the last glacial period, which lasted about 100,000 years. It ended about 10,000 years ago with the beginning of the current Holocene, a warm pause between glacial periods known as an interglacial.

The changes in Earth's orbit — known as the [Milankovitch Cycle](#) — are believed to cause gradual changes from glacial to interglacial climate over tens of thousands of years. While today's warmer interglacial period and the gradual cooling of the past 5,000 years are a result of this natural cycle, manmade greenhouse gases, particularly carbon dioxide, are causing a counter warming.

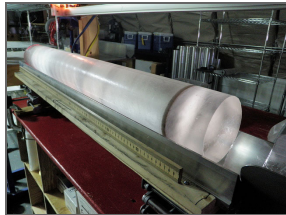


Photo Credit: Heidi Roop/WAIS Divide

A prominent ash layer in an ice core from WAIS Divide.

Severinghaus said a sudden change in water mass circulation in the Atlantic Ocean appeared to trigger Interstadial 8. At least that's the hypothesis.

“We’re testing it rigorously by looking at which changes first — Antarctica or Greenland,” he explained. “The reason this hasn’t been possible before is because all Antarctic ice cores, except WAIS Divide, are rather low-accumulation-rate ice cores.”

Most ice cores have annual layers about 2 to 3 centimeters thick, with even that resolution disappearing toward the bottom of the ice sheet, as the layers compress together. The WAIS Divide ice core has layers as thick as 22 centimeters per year.

“These events are resolved in exquisite detail. We’ll be able to say whether some event happened in Antarctica 10 years before or 10 years after the corresponding event in Greenland,” he said.

The complex relationship between the polar regions was the subject of a paper recently published in the journal *Geophysical Research Letters* on which Severinghaus was a co-author. The researchers found evidence of Europe’s Little Ice Age in the WAIS Divide borehole, suggesting it was a global event.

[See related article — [Global phenomenon: WAIS ice core reveals connection to Little Ice Age in Northern Hemisphere.](#)]

Another interstadial the researchers will target with the replicate drill is known as the Bølling oscillation, which occurred about 15,000 years ago and is found about 2,700 meters deep in the ice core record. The WAIS Divide team also hopes to bring up ice containing ash from a major volcanic event known as Old Faithful that took place about 18,000 years ago when the ice sheets reached their maximum extent for the last time.

Did the volcanic event have a role in ending the last ice age? That's another question the project hopes to address with the additional ice, according to Severinghaus.

That will hinge on Shturmakov and his team doing what no one has done before. One of the biggest challenges is the requirement that the drill must deviate a few degrees toward the upside of the borehole.

"It's much harder to do the deviation," Shturmakov said. "It's hard because you need push the drill on the upper side. ... It's a major challenge for the replicate drilling."

The "uphill" requirement is because the researchers are still interested in measuring properties of the borehole itself. Borehole logging involves lowering an instrument that measures properties such as the geometry of the borehole and the temperature of the surrounding ice. The changes in the shape of the borehole since the ice core was drilled give information on the flow of the ice, and the temperatures reveal the past temperatures at the site.

Severinghaus said ideally that replicate coring would wait until the borehole measurements were complete. But the WAIS Divide field camp, particularly the arch housing the drilling operation, is being crushed by the high snow accumulation.

"It's a time-constraint situation. We don't have infinite time to do this, unfortunately," Severinghaus said. "I have a lot of confidence that they're going to figure it out and we're going to get [replicate] core this time

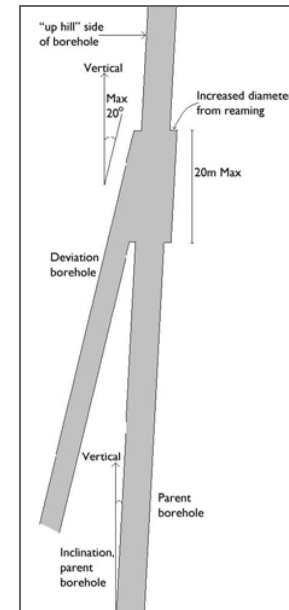


Photo Credit: IDDO

A simple diagram of the replicate coring parameters.

around.”

NSF-funded research in this story: Jeffrey Severinghaus, University of California San Diego-Scripps Institution of Oceanography, [Award No. 1043421](#)  ; Jihong Cole-Dai, South Dakota State University, [Award No. 1043508](#)  ; and Ed Brook, Oregon State University, [Award No. 1043522](#)  .

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