Drilling for Insight in Antarctica

Polar Expeditions Shed Light on Global Warming

The Antarctic Geological Drilling (ANDRILL) Program drilled to a new record depth of 1,000 meters below the seafloor from the site on the Ross Ice Shelf near Scott Base in Antarctica.

September, 2007. In the relative warmth of an Antarctic spring, when the coastal temperature rises to the freezing point, a 60-ton drilling platform is towed sledgelike to its operating site across floating sea ice. No more than 25 feet of ice separate the rig and the chill, hypersaline waters of McMurdo Sound. Fifteen hundred feet below the ice is the sea floor, and below that, layers of rock built of millennia of sedimentary deposits. The rig is the heartbeat of a scientific enterprise. And, with the help of Apple technology, its drill cores will yield insights into the changing climate of our planet.

This is the Southern McMurdo Sound Project (SMS), the second Antarctic data-gathering project for ANDRILL (ANtarctic geologic DRILLing), a scientific initiative funded by Germany, Italy, New Zealand and the United States. ANDRILL is focused on uncovering the geologic history of the Antarctic continent. Its findings have meaning for every one of us.

Antarctica, bigger than Europe, bigger than Australia, bigger than the U.S., stores a huge percentage of the earth's fresh water in its coast-to-coast freezer. The oceans meet here, and the dense, cold water that flows from under Antarctica's ice sheets creates currents that affect water movement and weather patterns around the earth. Melting ice in Antarctica raises sea levels worldwide. What happens here affects us all.

Sea levels are currently rising at a rate of a tenth of an inch per year. These and other environmental phenomena, including changes in atmospheric gases and global temperature levels, are taken by most scientists as unmistakable indications that the earth is warming. The International Polar Year (2007–2009), of which ANDRILL is a part, is a collaborative effort by scientists to examine the geologic history of the polar regions and their current behavior to provide perspective on these changes.

"We're trying to recover the geologic record of ice shelf and ice sheet behavior in Antarctica," says ANDRILL staff scientist Dr. Richard Levy. "We really have very little evidence of how the ice sheet behaved in the past. We want to know how the ice shelf and the ice system have responded to climate changes over the last 15-20 million years. To do that we have to drill through the ice and get to the sediment layers that are preserved in the basins that surround the continent."

The Core of the Matter: Displaying the Record of the Sediments

The Southern McMurdo Sound Project will be ANDRILL's second Antarctic drilling project. It will apply the same technology and methods as the first ANDRILL expedition — the McMurdo Ice Shelf Project (MIS), begun late in 2006 and completed early in 2007. MIS drilled to 4200 feet below the seafloor, starting with wider diameter pipe (the riser), then using successively smaller drill pipes inside the larger pipes, deploying a total of 20,000 feet of pipe. The team drilled 20 feet at a time, pulling up a 3.5-inch-diameter core in the first stage — a half-hour procedure — and drilled again. At greater depths, where they used smaller-diameter pipe, they pulled longer, narrower cores — roughly 30 feet long and 1.5 to 2.0 inches in diameter. Curators at the drill site washed the cores and cut them to three-foot lengths. The cores were then transported to McMurdo Station, where they were sliced in half longitudinally and protected with PVC liners. One half was boxed and archived; the other went to the sedimentology room. Each was marked to show the top end and the depth at which it was cut.

Dr. Larry Krissek (The Ohio State University) in front of Corelyzer. Photo taken by Betty Trummel, Humann Elementary School, Crystal Lake, Illinois.

Cores were scanned with a high-resolution camera. The digital image data was fed into a Corewall core-analysis system that included an Intel-based Mac Pro workstation and two 30-inch Apple Cinema Displays in an 8-megapixel tiled configuration. Corelyzer, a visualization tool that is part of the Corewall software suite, enabled ANDRILL scientists to enlarge images of the cores from their original diameters (1.5 to 3.5 inches) up to 30-inch diameters and make annotations.

"I think Corelyzer is considered a major breakthrough for scientists who need to look at visualizations of drill cores," says Dr. Jason Leigh, Director of the Electronic Visualization Laboratory (EVL), where Corewall was developed. "Formerly, they would split the cores, take pictures of them, and pretty much never touch or see the core again — and they couldn't look at the imagery at full resolution either. We enable them to see those cores again as they were first obtained and do much more with them."

EVL: Visualization for Geoscientists

The Electronic Visualization Laboratory at the University of Illinois at Chicago has been the source of many widely used visualization tools, including the well-known CAVE environment. Corewall, a software/hardware solution developed under an NSF grant, enables geoscientists to store and view images of scanned cores at high resolutions. Co-principal EVL investigators Andy Johnson and Luc Renambot, working with graduate students James Lee and Julian Yu-Chung Chen, combined Mac workstations and Apple Cinema displays with Corewall's Corelyzer core analysis software to provide tiled, high-resolution viewing platforms.

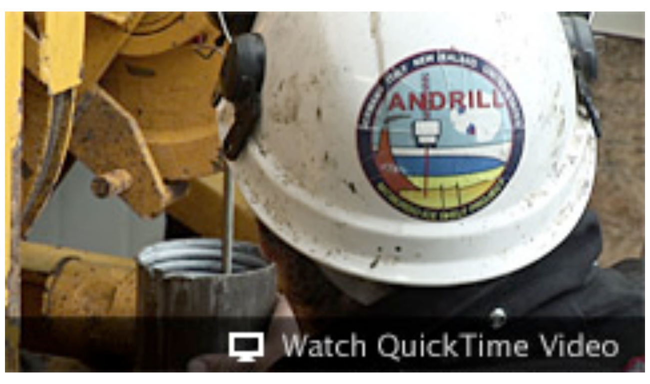
"The introduction of the 30-inch Apple Cinema Displays made creating tiled displays with fewer screens much easier," says Jason Leigh, Director of EVL. "It's great to have so much aggregate resolution on one big display. The standard Corewall configuration is now two 30-inch Apple Cinema Displays with 8 megapixels of resolution."

Other software in the Corewall suite, developed at other institutions under the same NSF grant, provide a database for the storage of annotation data, a browser for locating cores of interest at websites worldwide, and a system for the geographic correlation of cores drilled in proximity to each other.

The CoreWall project development team includes researchers from the Lacustrine Core Repository at the University of Minnesota, the Borehole Research Group at Lamont-Doherty Earth Observatory of Columbia University, and INSTAAR at the University of Colorado.

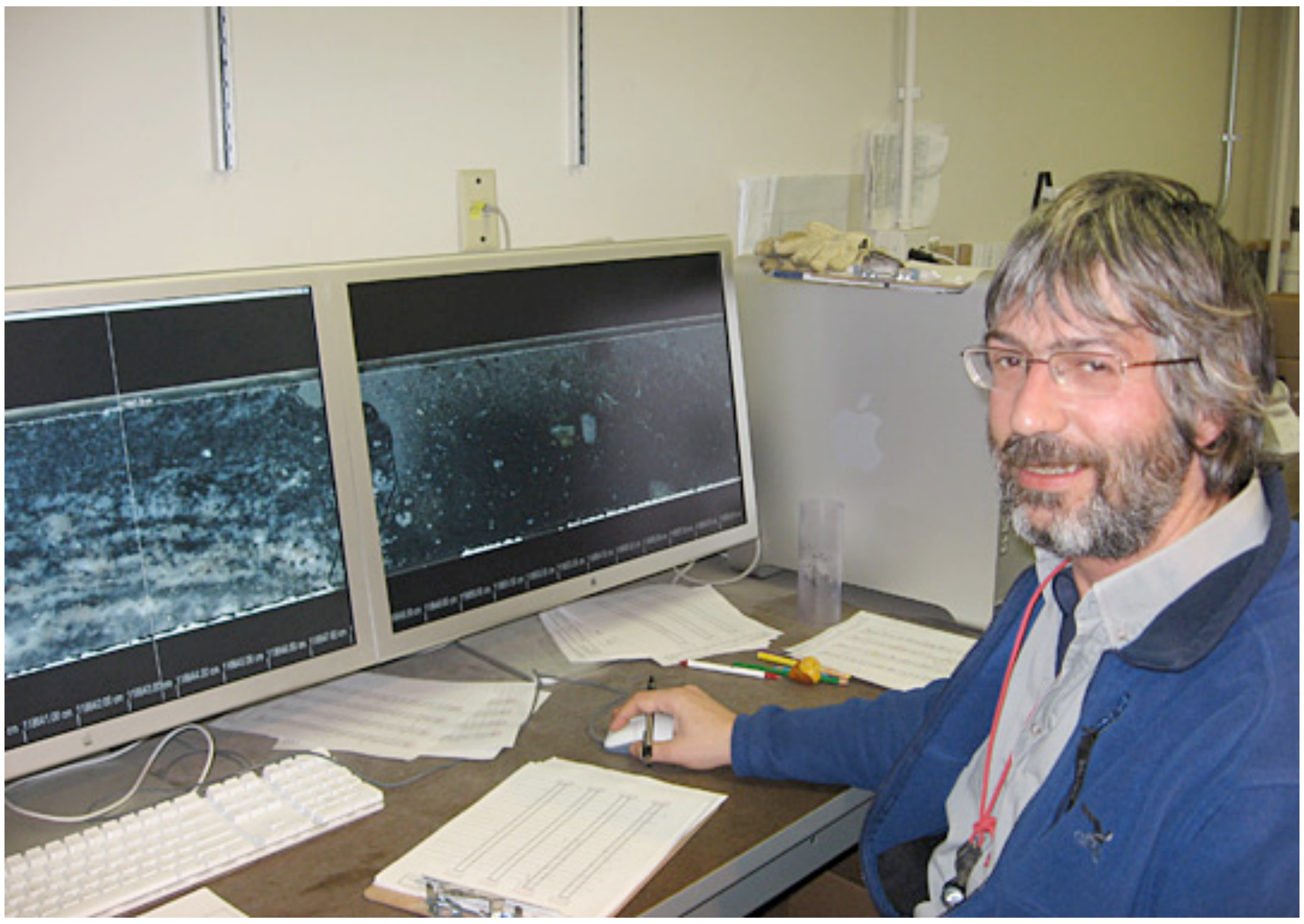
Drilling for Insight in Antarctica

Up close and personal on the ANDRILL project. Produced by Megan Berg — ANDRILL Media Specialist.



Drilling for Insight in Antarctica

What the Sedimentologists See



Dr. Franco Talarico (University of Siena – Italy) in front of Corelyzer. Photo taken by Betty Trummel, Humann Elementary School, Crystal Lake, Illinois

"Besides viewing the raw core and the high-res enlarged images," says Levy, "our scientists are able to use Corelyzer to integrate into the on-screen display physical properties such as sonic velocity, magnetic susceptibility, and density curves. You can actually fly up and down the core, and look at those data on the Mac in real time.

"We might see an interval that looks fairly homogeneous, but notice that its physical properties change. Why? We can use the 30-inch screens to identify the interval, go back and look at the raw core, and come back to the screen. So we can interact between the technology and the raw core to help refine and adjust our descriptions.

"One of our scientists has the job of describing the rock fragments he sees in the core. Where do these sediments come from? Can they help us learn where the glaciers that are dumping at this site have been picking up material? So Corelyzer helps us reconstruct paleoglacial activity."

In the evenings, the ANDRILL sedimentologists on the MIS expedition took other scientists on a tour of the day's cores. The scientists sat at the Cinema Display screens to identify sections of the raw cores they wanted to sample for laboratory analysis. Core sections containing volcanic ash were dated radiometrically. Other sections were dated by biostratigraphy – the distribution of fossils. "At this point we're able to date the top 600 meters to be about 5 million years and younger," says Levy.

Apple in Antarctica: Dependability Matters

As someone has said, there isn't a lot of tech support in Antarctica. The stability of the Mac platform was of major importance to the scientists who used it constantly during the ANDRILL MIS expedition.

"We took down a Mac Pro with two 30-inch Apple Cinema displays," says Josh Reed, IT and Data Manager for the MIS project. "We also brought a PC, but it wasn't as stable with Corelyzer as the Mac. There were crashes and it was pretty frustrating."

"What we've noticed," says Jason Leigh of EVL, "is that the geoscience community treats technology like these tiled displays as an instrument, not a computer They want something they can turn on and use, and that's it. That's where I think Apple is significant here, because it's a trusted vendor, producing very stable technology that geoscientists like using anyway."

That is true of Richard Levy, an ANDRILL paleontologist and biostratigrapher who confesses to being a Mac person. "I also believe that Megan Berg, who designed our excellent web site, was born in front of a Mac," says Levy. "She made me switch from PowerPoint to Keynote the other day."

At A Glance

One obvious need of the ANDRILL polar expeditions is a computing platform with hardware and an operating system that are stable. In the absence of a large IT support team and computer scientists, the systems needed to be easy to use and reliable. The expedition also needed large, high-resolution displays on which photos of drill cores could be enlarged and scrutinized.

Apple Solution

ANDRILL scientists use Corewall systems consisting of Mac Pro workstations and tiled 30-inch Apple Cinema displays to view enlarged high resolution scan images of its cores. The reliability of the Macintosh platform has sustained the output of the sedimentology team through challenging daily schedules during the expeditions.

Apple Technology Supporting the First ANDRILL Expedition

ANDRILL

- 1 Mac Pro workstation
- 1 Power Mac G5 workstation
- 5 30-inch Apple Cinema Displays
- 1 20-inch Apple Cinema Display
- 4 MacBook Pros
- 1 MacBook
- 4 PowerBook G4s
- 4 iPods

CHRONOS

- 1 MacBook Pro

EVL

- 1 Mac Pro workstation
- 2 30-inch Apple Cinema Displays
- 1 MacBook Pro

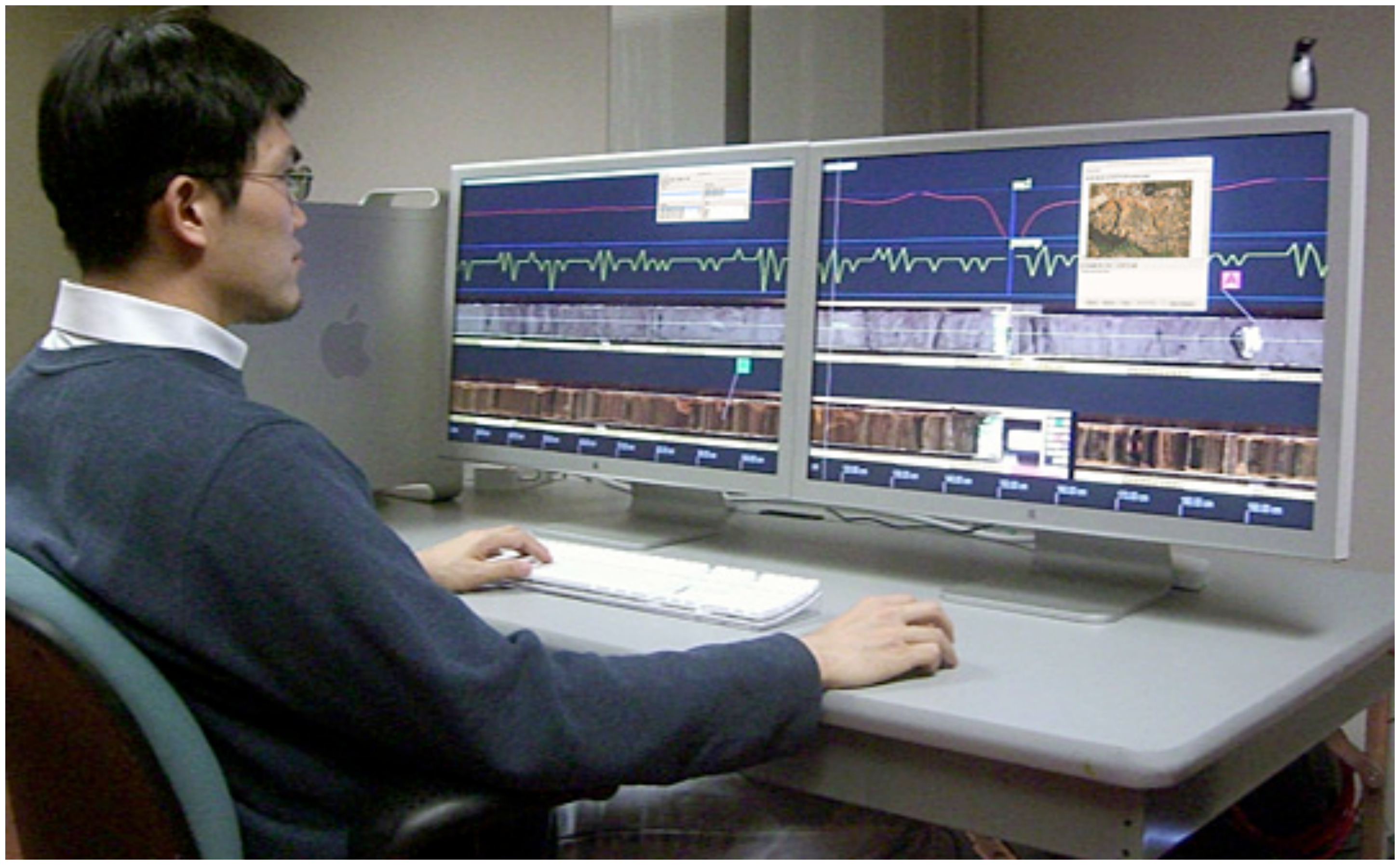
On-Site Science Team

An estimated 40–50% of the roughly 60 scientists, students, and technicians on site used Apple laptop systems

Richard Levy studying core at the drill site laboratory. Photo taken by Peter West, National Science Foundation

Drilling for Insight in Antarctica

The Scientific Consensus: We're Altering an Ages-Old Climate Pattern



Julian Yu-Chung Chen in front of two 30" Apple Cinema Displays and a MacPro running Corelyzer, displaying high resolution core image along with sensor data plots.

"What we're seeing from the body of results of climate research worldwide," says Levy, "is that if you go back in time some five million years you will see a period when the earth was 2-3 degrees warmer than it is today. That was a natural occurrence, with no impact from humans. Looking at the natural cyclicity, we should be heading into a glacial period, starting to cool again. Instead, the earth is warming." Many scientists see a clear correlation between today's rising temperatures and human activity.

"We know that atmospheric carbon dioxide levels during past natural warm cycles were about 300 parts per million (PPM)," says Levy. "But we're currently pushing the CO2 level up to 380 or 400 PPM, which is unprecedented over the last 400,000 to 500,000 years, even all the way back some 15 million years ago. Some models predict that CO2 may rise to 900 PPM over the next one to two hundred years. And if that does cause warming, we would expect to see Earth begin to behave as it did naturally thirty five million years ago when ice sheets first formed on Antarctica. The difference is that human activity appears to be contributing to climate warming."

Findings from the 2006-2007 ANDRILL expedition indicate one thing clearly: projected warming of the earth's climate will likely impact the current stable state of the Ross Ice Shelf. If as part of the current warming trend, the Ross Ice Shelf collapses - a distinct possibility - that could mean the loss of the West Antarctic Ice Sheet. And that, says Levy, could mean a sea level rise of up to 20 feet. The loss of the sea ice and the ice shelf, and the related impact on the formation of the cold, dense water beneath them will have a profound effect on the way oceans circulate and affect climate.

How soon and how quickly could all this happen? Nobody knows. But ANDRILL, and the many other studies that are part of the International Polar Year, may ultimately tell us much more about it.

PSICAT: An Award-Winning Graphical Note-Taker

It's one thing to look at core images and describe them. It's another to keep track of what you see for scientific reference when the drill is pulling cores nonstop day and night. On a peak day, the curators may send nearly 200 feet of core to the sedimentologists.

During previous scientific drilling projects sedimentologists recorded core descriptions by using pen and paper, marking up a diagram for every 20-foot or 30-foot section of core. Another team member re-drew the diagrams using graphics software so they could be stored and accessed electronically, but the drawings remained static and discrete. Trying to get a broader perspective by looking at a sequence of drawings was challenging.

Into this breach came PSICAT (Paleontological-Stratigraphic Interval Construction and Analysis Tool), a Java-based program for creating stratigraphic diagrams of drill cores. It provides a graphical environment and a palette of tools. Scientists now voice their descriptions, and a team member uses a MacBook Pro to transcribe them in PSICAT. The running record is displayed on a 30-inch Apple Cinema Display for all to see.

"The compelling reason for using PSICAT is that PSICAT captures the data as it's drawn," says Josh Reed, who developed the PSICAT program for CHRONOS, an NSF-funded geoinformatics initiative at Iowa State University. Scientists can now run fast searches for something that may be only a centimeter long.

PSICAT also gives the team a way to summarize findings daily instead of waiting until the end of the expedition. There isn't time to look at drawings and draw conclusions during a working day. PSICAT, however, can automatically generate summaries on a Mac Pro or a MacBook Pro at the end of each day. The team can view them on a Cinema Display, identify emerging trends, and focus on specific indicators in the next day's cores.

PSICAT recently received an award for being the best open-source Eclipse Rich Client platform application of the year. Reed, who developed PSICAT on a Mac Book Pro, accepted the award for CHRONOS. As IT and data manager for the ANDRILL MIS project, Reed used the same MacBook Pro to log cores in Antarctica.