Drilling for Insight in Antarctica
Polar Expeditions Shed Light on Global Warming

September 27th, 1997, in the remote wasteland of an Antarctic spring, when the coastal temperature rises to the freezing point, a 60-ton drilling platform is‘axed sideward to its operating site across floating ice. No more than 25 feet of ice separates the rig and the chill, hyperaccreting waters of McMurdo Sound. Fifteen hundred feet below the ice is the sea floor, and below that, layers of muds of millenia of oceanic deposit, the rig is the headquarters 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 Methodist School Project (SMS), the second scientific data-gathering project for ANDRILL (Antarctic geologic Drill)ing, a scientific initiative funded by Germany, Italy, New Zealand and the United States. ANDRILL is focused on unraveling the geologic history of the Antarctic continent. Its findings have meaning for each of us.

Antarctica, bigger than Europe, bigger than Australia, bigger than the U.S., drains a huge percentage of the earth’s fresh water into its ice cap—rain on the fresher. The ocean meets here, and the dense, cold water that flows from Antarctica’s ice shelves creates currents that affect ocean movement and weather patterns, around the world. Digging into Antarctica raises sea levels worldwide. What happens here affects all of us.

Sea levels are currently rising at a rate of 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 uncontestable indications that the earth is warming. The International Polar Year (2007-2008), 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 climate change.

“We’re trying to remove the geologic record of ice shelf and ice sheet behavior in Antarctica,” says ANDRILL’s staff scientist Dr. Richard Leigh. “We have very little evidence of how the ice sheet behaved in the past. We want to learn how the ice shelf and the ice core 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 passes.”

The Core of the Matter: Displaying the Record of the Sediments
The Southern Methodist University School Project was the second ANDRILL expedition to the McMurdo Sound region of Antarctica. The project, it will apply the same technology, and methods as the first expedition—described in the McMurdo Ice Shelf Project (MISP), begun in 1993 and completed in 1997. MISP, drilling to 4230 feet below the surface, started with wider diameter pipe (3.5 feet), then using successively smaller-diameter pipes inside the larger tubes, drilling a total of 12,000 feet of pipe. The core drilled 20 feet at a time, pulling up a 2.5-inch diameter core in the first stage—a half-hour procedure. When the diameters, where they used smaller-diameter pipe, they pulled longer, continuous cores—roughly 30 feet long and 3.5 to 3.8 inches in diameter. Once the core was cut, it was then sliced in three-foot lengths. The cores were then transported to McMurdo Station, where they were dried in half-inch fractions and preserved with Peril glue. One half was boxed and archived; the other went to the sedimentology rooms. Each was marked to show the top end and the depth at which it was cut.

Core-so were equipped with a high-resolution camera. The digital image data was fed into a Corewall core-analysis system that included an infrared/Mac Pro workstation and two 30-inch Apple Cinema Displays on an 8-megapixel (megapixel) configuration. Corewall’s visualization tool is part of the Corewall software suite, enabled ANDRILL scientists to examine images from the cores at their original diameters (0.5 to 3.8 inches) up to 30-rings diameters and make annotations.

“I think Corewall is an optimal breakthrough for scientists who need to look at visualizations of drill cores,” says Dr. Leigh. With the help of the Electronical Visualization Laboratory (EVL), which Corewall was developed. “Formerly, they could split the cores, take pictures of them, and try much more output on the core again and—fingers couldn’t look at the image at full resolution either. We enable them to see those cores again as they were first obtained and did much more with them.”

EVL: Visualization for Scientists
The Northern Illinois University‘s Visualization Laboratory of Chicago has been the center of many widely used visualization efforts. These efforts have included: true-color 3D visualization of the world’s largest cathode-ray tube, the development of the first full-color 3D visualization of megapixel imaging, the production of a gigapixel image of the world's largest building, the development of a software/hardware visualization solution for large displays, the development of a software/hardware visualization solution for large displays, and the development of a software/hardware visualization solution for large displays. ANDRILL's visualization of the earth's core has been one of the most successful of these efforts, and has been widely used by scientists and researchers worldwide.
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What the Sedimentologists See

"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 each core scan, 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 M5 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 M5 expedition.

"We took down a Mac Pro with two 30-inch Apple Cinema displays," says Josh Reed, IT and Data Manager for the M5 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 tilted 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 reliable 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."
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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 CorelDraw, 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 cyclicality, 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 for hours, 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.