Tales From Ice Time

Two holes through Greenland offer a glimpse of climates past and future

By RICHARD MONASTERSKY

The scene evokes images of surgeons performing a liver transplant in full football gear. Moving quickly but gingerly, a crew of heavily outfitted drillers coaxes a long icicle from its container and hurries the glinting prize to a dumbwaiter. Room temperature here hovers at a dangerously warm level, only 10°C below freezing, and the crew must lower the ice as fast as possible into the safety of a cold snow cellar. They take care not to slip, though. The chunk of frozen water they hold is valued at more than $30,000.

This particular cylinder of ice represents one small step in a five-year effort to probe some of the hottest issues in climate-change research. The U.S. program, called the Greenland Ice Sheet Project 2 (GISP 2), aims to drill a 3,000-meter-deep hole straight through the thickest part of Greenland's glacial cap while collecting ice samples from every layer. At a nearby site, European scientists are drilling and sampling a similar core. Together, the two frozen records will give researchers their best look yet at how Earth's climate has behaved through some 2,000 centuries—a key to understanding what may lie ahead in an era of global warming.

Merely a hand's breadth across, the ice holes serve as tiny windows for gazing far back into the planet's history. Long before our ancestors invented the wheel, let alone the pollution-belching automobile, Earth passed through dramatic warm spells and ice ages. The natural forces that drove these climate shifts—including solar radiation, greenhouse gases and even tiny algae in the ocean—left subtle clues within the Greenland glacial cap. By looking for such evidence in the millennia-old ice, scientists hope to learn what controlled the variations of the ancient environment. Only by understanding the past can experts assess how rapidly Earth will warm as greenhouse pollutants build up in the atmosphere.

Paul Mayewski, GISP 2's chief scientist, sums up the value of the project in a single word: perspective.

"Sitting in the middle of a forest, it's very hard to find out where you are," says Mayewski, a glacial geochemist with the University of New Hampshire in Durham. "If you really want to understand whether we're changing the climate or not, you need to understand [its] natural variability. If you don't have this perspective, you won't be able to understand the relationship between climate and civilization."

From the vantage point of the GISP 2 camp, it's not hard to imagine Earth as it was 18,000 years ago, during the coldest stage of the last ice age. GISP 2 scientists spend their summers in a flat, frozen world some 650 kilometers north of the Arctic Circle, near the highest part of the immense ice sheet blanketing more than 80 percent of Greenland. Beyond the scattered buildings and tents, a white plain stretches in every direction toward unbroken horizons. On an overcast day, sky and snow wear the same dull hue, creating a featureless void that seems to go on forever.

This is how Denmark or Detroit must

Snow and sky blend seamlessly on a cloudy day, with only the buildings of the GISP 2 camp to suggest a horizon. The centerpiece of the U.S. operation is a 52-foot-diameter dome (left), which houses the drill. The 50 crew members have a choice of sleeping quarters: heated barracks or their own, unheated tents.
An icy cliff looms over rocks at the edge of Greenland’s glacier-covered interior — five-sixths of the huge island. Greenland measures almost one-quarter the size of the United States; its ice-free land area is slightly larger than New Mexico.

the timing of particularly large forest fires in North America or Asia.

Like a movie run backward, the drill holes uncover the climate story in reverse. The top layers record the most recent episodes, while those beneath hold increasingly older information.

The two Greenland projects aim to reach both deeper and farther back in time than any other ice record unearthed so far. By the end of next summer, if they finish up as planned, both drilling groups will pull up an ice record dating back more than 200,000 years, containing clues to a time when, according to some anthropologists, our ancestors first ventured out of Africa and began to spread around the world. The Greenland cores will surpass by 40,000 years the world’s longest ice record, drilled in the 1980s by a Soviet and French team at the USSR’s Vostok base in Antarctica (SN: 9/17/88, p.184).

Perhaps even more important, the new

earest this summer, cutting their way to 1.500 meters — just about halfway to the bottom of the ice sheet. The ice at this level dates back to about 8,500 years ago, near the beginning of the current warm period. The European drillers, progressing far more rapidly, have reached the 2,321-meter mark, where the ice is approximately 35,000 years old — firmly in the middle of the last ice age.

GISP 2 has moved more slowly because the crew is still working the kinks out of a new, U.S.-built drill, while the Europeans are using a well-seasoned Danish machine. In mid-July, the U.S. drill froze in the hole, shutting down operations until a supply plane brought glycol to free up the rig. The crew stopped drilling for a second time in early August while awaiting a new shipment of motors, which had been burning out much faster than anyone imagined possible.

Despite such problems, the new drill has some advantages. With a diameter of 5.2 inches, it collects almost twice as much ice for scientific analysis as its 4-inch-wide Danish counterpart. It also has an extremely deep range, allowing U.S. researchers to plan on drilling their next ice hole in Antarctica.

Aside from the different drilling rigs,

Richard Monastersky visited GISP 2 and GRIP in July with National Science Foundation officials and several other journalists.
Stuck into a wall of the snow trench, a lawnmower over-looks a machine that measures the electrical conductivity of the ice core. The conductivity depends on acids (which can indicate volcanic eruptions) and bases (possibly from distant forest fires) trapped in the ice.

Farther along in the trenches lie cavernous snow rooms, dug at a deeper level where temperatures stay even colder. Here, the bulk of the ice core sits in storage, waiting for transport to laboratories in the United States and Europe.

A few kilometers from the camp, beyond the view of any human settlement, the Greenland ice sheet assumes an air of timelessness. For hundreds of thousands of years, this region has remained essentially the same, cloaked in its mantle of ice.

Greenland's margins have had a far livelier past. During warm, interglacial periods — such as the present — the ice-free coast provides a home for numerous animals, including caribou, musk-ox, hares, foxes and people. During ice ages, the expanding glacial cap envelopes the entire island, driving all life away.

Although the last ice age ended about 10,000 years ago, even minor climate shifts have dramatically affected the course of Greenland's history. In medi-cal evaluation times, unusually warm temperatures in the North Atlantic prompted Norse Vikings to establish the first European settlements on Greenland, following the island's discovery in 982 by Eric the Red. The infamous Viking explored the coastline of Greenland after authorities on Iceland banished him for his murderous habits. Because of the warmer climate back then, he would have found the island's shores more verdant than they are today, and this may have inspired the colorful name he gave it. But many historians take a dimmer view of Eric's motivation. The name Greenland, they say, was a ploy to lure other settlers — one of history's earliest examples of false advertising.

The Norse communities on Greenland thrived for several centuries, during a time now known as the medieval warm period. But the colonists suffered when the Atlantic region turned colder, ushering in a span called the little ice age. During this frigid era, which lasted roughly from the mid-1300s until the 1800s, the Greenland colonies mysteriously disappeared, perhaps because of the harsh environment.

In their ice core, GISP 2 scientists have traced the climatic shifts that exerted such a powerful influence on the history of human civilization on Greenland. The ratios of oxygen and hydrogen isotopes in the ice crystals reveal that the GISP 2 site had elevated temperatures during the medieval warm period. Summertime temperatures actually rose above freezing, an otherwise rare event at the top of the ice sheet.
the ice cap. The isotopes also show evidence of the little ice age, although the cooling at the summit seems less intense than the one recorded in other parts of Greenland and in Iceland.

Playing the climate movie back a little farther, the GISP 2 ice will offer a portrait of the climatic optimum, a time about 7,000 years ago when civilization experienced its warmest period ever. Although scientists have yet to analyze the ice deposited during the climatic optimum, they believe Earth’s average surface temperature may have been about 1.5°C warmer at that time. Mayewski suggests that this period of high temperatures will provide a model for studying the possible effects of a human-induced warming.

The Greenland ice cores will allow the first in-depth look at the climatic optimum and other events that occurred during the Holocene epoch, the period since the last ice age. “Up till now, ice cores have not told us that much about the Holocene,” says Mayewski, because ice from this period is extremely brittle in most glacial sheets. At GISP 2 and GRIP, scientists have taken extreme care while drilling and sampling the brittle Holocene ice.

Venturing even deeper, the drills will cut through layers that formed during the last ice age, a time when human culture first flowered in the form of animal paintings on the walls of southern European caves. Even after a century of study, scientists don’t understand what caused this and previous glacial periods, which have gripped the planet on and off for the last 2 million years. Evidence suggests that slight variations in Earth’s orbit triggered the shifts and that greenhouse gases provided some of the force that cooled and warmed the planet; during the ice ages, carbon dioxide levels dropped by more than 30 percent. But many experts believe some other climate factor or factors must have played an even larger role. By revealing details of the glacial world, the Greenland cores will provide valuable clues for solving the ice age mystery, Mayewski says.

**GISP 2 driller surveys a fresh length of ice core. Working in subfreezing temperatures, drilters must wear waterproof suits and gas masks to protect against the butyl acetate fluid used in drilling.**

Designed to probe events of the past, ice core projects are by nature historical. But each researcher working in this area has one eye looking toward the future.

Most important, evidence culled from the ice can help scientists understand how quickly the world might warm in coming years. Climate experts generally believe greenhouse-gas pollution will raise Earth’s surface temperature, but government leaders say agreement on that issue alone does not justify spending billions of dollars to remodel society. In order to assess the need for action, officials want to know the magnitude of the problem. Will the warming occur so slowly that people and natural ecosystems can adapt, or might conditions shift quite suddenly, wreaking unimaginable damage?

Ice records drilled previously indicate the climate can sometimes fluctuate with surprising speed. In particular, studies of the GISP 1 core, drilled from 1979 to 1981 in southeastern Greenland, suggest that the North Atlantic region warmed by a striking 7°C in a half-century (SN: 6/17/89, p.374). That drastic rate of warming about 10,500 years ago far outpaces what the world is currently experiencing.

“That really surprised us, that things could happen so quickly,” says James White of the University of Colorado at Boulder, who helped compile the new data. “It’s a reminder that climate is not predictable.”

With only one hole, it is difficult to know whether compression and movement of the ice have skewed the climate evidence, say researchers. But with two nearby holes, investigators can cross-check to verify what they find. Given the importance of the record and the expense of drilling, “it’s essential to know that the record is valid,” that it is not physically deformed,” says Mayewski. NSF will pay more than $20 million for GISP 2, while the Europeans are spending something less than $15 million on GRIP, says Dansgaard.

Two holes also provide a larger volume of ice, allowing more extensive measurements. And they offer a safety net in case drilling problems “trash” a particular section of ice core, as happened at GISP 2 earlier this season. When the U.S. drill inexplicably turned the ice core into mush, the crew lost a dozen meters of core, corresponding to about 50 years of ice record. The GISP 2 researchers plan to fill in their loss with European data.

But even while they tout the benefits of the current arrangement, some researchers privately say that such scientific advantages do not justify the cost of drilling separate holes in the same region. “If I controlled the money,” comments one GISP 2 scientist, “I would not put [two nearby holes] as a high priority.”

— R. Monastersky
Boulder, a participant in GISP 1 and 2. To put the ancient warming in perspective, White imagines how it might have affected someone living in England at the time: "In less than a human lifetime, you would have gone from a very cold glacial climate to one which was not terribly different from that of today. That is very dramatic."

The GISP 1 core holds evidence of several other large temperature shifts during earlier periods of the last ice age, but such rapid jumps and dips don’t show up in Antarctic cores. Some investigators read that discrepancy as a sign that the Greenland ice has recorded regional climate flips in the Northern Hemisphere, generated by changes in a sensitive system of North Atlantic ocean currents, says Wallace Broecker of Columbia University’s Lamont-Doherty Geological Observatory in Palisades, N.Y.

Some of the GISP 1 findings, however, conflict with the Antarctic evidence against rapid worldwide changes. One puzzling clue from the Greenland ice core points to a climate shift about 10,500 years ago involving the entire planet. According to measurements of gas trapped in the GISP 1 ice, levels of carbon dioxide around the globe jumped by 50 parts per million in the space of 50 to 100 years. Such a huge surge would equal or perhaps surpass the amount of carbon dioxide spewed into the atmosphere during the last century by the burning of fossil fuels.

The carbon dioxide measurements astounded scientists, who remain unable to explain a natural change that large. However, many have questioned the findings’ validity because the GISP 1 drilling site often warmed above freezing, an effect that could have altered the gas levels in the bubbles. Situated at a much higher elevation, the GISP 2 and GRIP camps don’t face the same warm weather problem as GISP 1 did, so the ice from these holes should resolve whether the quick carbon dioxide rise actually occurred.

"If the [carbon dioxide] jump is there [in the new records], it’s going to be extraordinarily hard to explain and very, very interesting. So we’re all waiting to see," says Broecker.

He and other scientists view the evidence for quick changes in the past as a potential warning of what might lie ahead. They believe climate—especially in sensitive regions of the globe—may be unstable only up to a point. If humans put enough pressure on the environment, they could knock the world’s climate out of balance and send it reeling to a new and potentially very different form.

"It isn’t a totally predictable system. It’s somewhat like Russian roulette," Broecker warns. "We’ll find out [eventually] what it will do, and maybe it will be very humble and do almost nothing. But on the other hand, maybe in 100 years it will undergo some big transition."

The issue of quick climate change motivates much of the research at GISP 2 and GRIP; as these holes are uniquely situated to uncover such events in the past, Antarctic cores do not record the rapid swings, and other Greenland cores have reached only into the last ice age. The current projects will pass through the last ice age, then into the warm interglacial period, about 120,000 years ago, and eventually into the second-to-last ice age.

That triumph must wait till next year, though, for the endless days of Arctic summer have passed and Greenland’s summit grows more inhospitable with each nightfall. Temperatures now dip to −40°C as the sun spends almost half of its time beneath the horizon. The European camp, closed for a month already, has taken on the appearance of a ghost town. At the U.S. site, crew members busily prepare to ship out in mid-September. They plant long bamboo poles around camp to help locate buildings and supplies come springtime, when snowdrifts will obscure almost everything around. Boarding the transport plane for the flight out, the scientists and drillers take seats in the cavernous cargo bay, next to stacks of long, insulated boxes. Inside lie lengths of the precious ice core—pieces of Greenland, pieces of time.