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Life Under Antarctica's Ice

A team drills thousands of feet into the West Antarctic Ice Sheet to reach a lake buried for millennia.

By Douglas Fox | Friday, May 31, 2013
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Scientists prepare to unwrap a sanitized scientific instrument that will measure water currents and temperature in the lake.

Sunlight glared off of the Antarctic Ice Sheet. Slawek Tulaczyk, a 46-year-old glaciologist, squinted in the slanted summer rays as he watched a drama unfold 600 feet away.

A Hercules military cargo plane sat stranded, unable to take off. Its skis had frozen to the snow. The plane had just dropped off Tulaczyk along with 12 workers and 10,000 pounds of gear. They were here to probe one of the last unexplored places on Earth. Beneath the snow's deceptively flat surface, under 2,600 feet of ice, lay a mysterious lake that human eyes had never seen. Tulaczyk, from the University of California in Santa Cruz, had waited six years for a chance to investigate this hidden body of water, called Subglacial Lake Whillans.

Now, as he watched the Herc make its second attempt to take off, he worried. Tulaczyk's flight was the first to shuttle expedition scientists, engineers, technicians and gear to the field, and a stranded plane could prevent the rest of the crew and the last of the equipment from arriving in time.

The Herc's four propellers roared, kicking up a blizzard of snow. The plane did not move.

Members of the Lake Whillans research team board a ski-equipped cargo plane at McMurdo Station.

JT Thomas

Four men shoveled around the Herc's skis, trying to free them. This cold-blooded butterfly could stay alighted on the ice sheet for only so

long. If its engines were shut down for more than a few minutes, they might not restart in the cold.

Lake Whillans had likely not seen the light of day for hundreds of thousands of years, but Tulacyzk and the others who landed that day intended to see what was under the ice. They intended to drill into the lake and sample its water and mud. They intended to lower a camera into its belly. And they intended to find out what, if anything, might live there.

As Tulaczyk watched the Herc on Jan. 17, 2013, the lake remained a mere silhouette pieced together from noisy geophysical measurements involving radar, lasers shot down from satellites and the seismic echoes of shock waves released by explosives detonated in shallow holes in the ice.

A convoy of shipping containers on sleds carries gear 600 miles from McMurdo to the drilling site.

JT Thomas

But for scientists around the world, tapping into this humble lake had come to symbolize a major milestone in exploration. Almost 10 percent of the planet's land area sits locked under glacial ice, where humans have never ventured. Exploring subglacial lakes could help answer many important questions: whether, for example, global warming might accelerate as Antarctica's ice recedes. Sampling Lake Whillans could also provide hints about what kind of life might survive in icy worlds elsewhere in the solar system.

Getting into the lake represented a monumental task. A convoy of tractors had already towed 1.2 million pounds of drilling gear 600 miles from the coast of Antarctica, where McMurdo Station served as a base. Testing of the drill in McMurdo, and subsequent weather delays, had forced the expedition onto a critically tight schedule. Even as drilling was about to begin, the Antarctic summer and workable conditions were nearing an end — giving the team no more than 14 days. "Often fieldwork in this part of Antarctica is like trench warfare," where you dig in and work for months, said Tulaczyk a few days before. "What we are trying to do is a blitzkrieg."

Tulaczyk considered this as he watched the Herc rev its engines a third time. Its body shuddered. Its skis broke loose. The 125,000-pound plane lumbered forward, plowing the airstrip in both directions — a maneuver that lightened the plane's load by incinerating several thousand pounds of fuel.

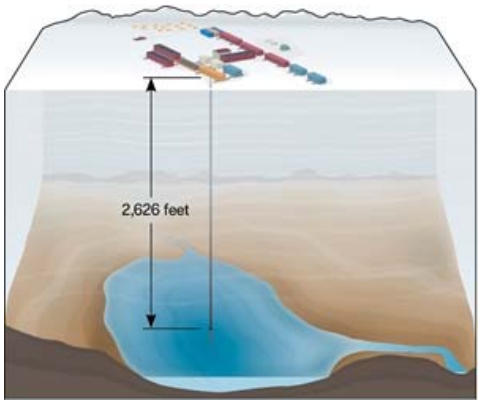
As the Herc traversed the skiway a fourth time, eight solid-fuel rockets mounted on its sides ignited, heaving the plane into the air.

Tulaczyk sighed with relief. The team's goal lay tantalizingly close, only half a mile directly below. But, as the plane's departure had showed, in these conditions even seemingly straightforward tasks, like melting a hole in the ice, often prove difficult.

Path to Exploration

The story leading to Lake Whillans extends back more than 50 years. For most of the 20th century, the Antarctic Ice Sheet was viewed as timeless, unchanging. A few scientists even suggested that nuclear waste be stored permanently inside it.

But in the latter half of the 20th century, a new technique, called ice-penetrating radar, allowed scientists to see through broad swaths of the ice and revealed entire buried mountain ranges, as tall as 9,000 feet. In the late 1960s and throughout the 1970s, Hercules aircraft with downward-looking radars flew thousands of miles of survey lines across the continent to map the subglacial landscape. This view changed the way scientists thought of Antarctica.



In January 2013, a drill cut half a mile through the Antarctic Ice Sheet to Subglacial Lake Whillans.

Kellie Jaeger/DISCOVER/NIU

Glaciologists also noticed that, in some places, the ordinarily jagged landscape beneath the ice was perfectly flat and the radar reflection unusually bright — indicating water instead of rock.

People didn't expect to find lakes under the ice, but today, over 200 are known to exist in Antarctica. The lakes are fed by geothermal heat that seeps up from the Earth's interior, melting away the bottom of the ice sheet at a rate of several dime-thicknesses per year and liberating water from the ice.

In the mid-1990s, a lake containing 1,300 cubic miles of water (as much as Lake Michigan) was detected 12,000 feet below the surface of the ice in East Antarctica, beneath where the Russians had spent years drilling into the ice sheet to study its history. When the Russians' drill came within 600 feet of the underlying lake, now called Lake Vostok, the ice that they were bringing up suddenly changed, from transparent to dirty, dotted with specks of mud. This dirty ice represented muddy water from Lake Vostok that had frozen back onto the bottom of the ice sheet.

John Priscu, a lake biologist from Montana State University in Bozeman, got his hands on a pound and a half of this dirty ice. Priscu had already found bacteria and algae thriving in small lakes along the coast of Antarctica. Only the upper 10 to 30 feet of water in these lakes was frozen as ice, so sunlight filtered through, allowing life to power itself through photosynthesis. But a lake as deeply buried as Vostok would be entirely dark, so any life there would have to use some other energy source.

A submerged camera reveals what Lake Whillans looks like.

Alberto Behar, JPL/ASU

At 6:20 a.m. Jan. 28, half a dozen people in sterile white suits gathered at the drill platform, awaiting the first sample of Lake Whillans water.

A taut cable inched out of the borehole. Brent Christner, a microbiologist from Louisiana State University, chipped globs of frost off the cable with a hammer. An opaque bottle rose into view. Priscu carried it into a laboratory. People crowded in as the first water from Subglacial Lake Whillans was decanted into a clear tube.

The liquid was honey-colored. An electrode was dipped in — a number flashed onto an LCD. The water conducted electricity strongly, evidence that it was laden with mineral salts that could serve as food for microbes. A whoop of excitement went up.

The Search for Life

The subglacial environment is often described as extreme. But Lake Whillans has turned out to be surprisingly hospitable.

The lake registered at just 31 degrees Fahrenheit, slightly warmer than the coastal seas near McMurdo Station, which teem with sea stars, 100-pound toothfish and other living things. Pressure from the ice sheet overhead keeps the subglacial water liquid by lowering its freezing point several degrees.

Lake Whillans also contains oxygen, which is injected into the subglacial space by air bubbles released as the ice sheet melts. It would be enough oxygen, in some cases, to support worms, starfish and other marine invertebrates on the seafloor.

The spot where Lake Whillans sits today was once a shallow seafloor. Reed Scherer, a marine micropaleontologist from Northern Illinois University, saw evidence of this when he smeared mud from the lake onto a glass slide.

Scherer placed the slide under a microscope and twisted a knob. A glassy object snapped into focus — a round disk, serrated on the edge, perforated with dimples — the shell of an aquatic microscopic organism called a diatom. “Probably Miocene,” he said. “Likely 10 to 15 million years old.” The slide contained around a hundred crushed diatom shells.

What is now Lake Whillans was probably covered and uncovered by the ice sheet dozens of times as the climate swung back and forth over the past 20 million years. The ice most recently rolled over the lake sometime between 120,000 and a million years ago, depending on which of several warming episodes the ice sheet did or didn’t withstand. Any life that exists in the lake today may represent hangers-on from its ice-free time.

But any survivors needed to overcome a major challenge. The ice cut off sunlight and photosynthesis — the main source of energy for most ecosystems on Earth’s surface. So subglacial life, if present, would have to power itself through the chemical breakdown of minerals instead.

The honey color of that first sample of Whillans water provided a hint: a sign of tiny mineral grains (pulverized by glaciers), some smaller than a red blood cell. That glacial grinding turned the minerals into good microbe food, much as the milling of wheat into flour makes it more digestible to humans.

On Jan. 28, Trista Vick-Majors, one of Priscu’s Ph.D. students, took a long-awaited step: She added DNA-sensitive dye to a sample of lake water — the first attempt to detect life in Lake Whillans. As she viewed it through a microscope, she saw specks of green shining against a background of black — cells glowing in response to the dye — as many as 1.6 million cells in each cubic inch of water. Those cells were the first ever found unambiguously in a subglacial lake.

A researcher labels sediment samples from Lake Whillans.

JT Thomas

A Balancing Act

A portrait of life beneath Antarctica's ice will take time to emerge. Louisiana State University microbiologist Christner is using DNA sequencing to census hundreds of microbe species from the lake. It will provide a glimpse of what taxonomic groups they belong to.

Christner's and Priscu's teams are also growing microbes from more than 500 cultures collected from the lake. "We may be coming up with cultures that people study for the next 50 years," says Christner.

Understanding microbial life and the mineral breakdown that it incites under the ice sheet could help answer some momentous questions about whether global warming will speed up as Antarctica's ice recedes. Some scientists believe that microbes under the ice may have produced billions of tons of methane — a potent greenhouse gas that could escape as the ice retreats, causing warming to accelerate.

On Feb. 1, Tulaczyk and his students made one last use of the borehole. They lowered a string of vibration sensors into it. The bottom sensor hung 60 feet above the lake. Those sensors, which the ice would encroach on and eventually envelop, would document the private life of Lake Whillans over time, recording rumbles of turbulence and tumbling rocks as currents washed through the lake. This information would help Tulaczyk understand whether subglacial water lubricates the flow of ice, and whether it might play a role in the runaway acceleration of glaciers that has occurred in some parts of Antarctica. The hole was covered in plywood, and snow piled on top.

A mile west stood 21 squat silhouettes, backlit in the afternoon sun. The team had bulldozed these snow platforms into existence. Twenty sleds and 700,000 pounds of gear would soon be parked atop them for winter, safe above the snowdrifts that would unfurl for half a mile in their wakes.

As winter darkness falls and the mercury drops to 50 degrees below zero, those parked sleds remain a gesture of hope: If budgets allow, Tulaczyk and Priscu will return next year, drill more holes and continue exploring Antarctica's hidden world.

See more stories and multimedia from Lake Whillans in this special report.

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