Extreme science in the Arctic

February 25 2015, by Erin Spain

A research team from Northwestern University was dropped by helicopter in the desolate wilderness of Greenland with four weeks of provisions and the goal of collecting ancient specimens preserved in Arctic lakebeds.

This was not the plot of a reality TV show. It was how a group of rugged scientists, led by Northwestern geologist Yarrow Axford, began an Arctic field research expedition to investigate climate change near the rapidly melting Greenland ice sheet during the summer of 2014.

The samples they collected are of great interest to the scientific community concerned about global climate change and Greenland's shrinking ice sheet—the second largest in the world and the only contemporary ice sheet outside of the Antarctic. Covering three-quarters of Greenland, the ice sheet is now losing hundreds of billions of tons of ice a year.

Adjusting to 24 hours of daylight, the Northwestern researchers spent nearly a month in northwest Greenland living and working in remote, wild territory at the edge of the ice sheet. Day in and day out they collected mud and sediments layered with centuries of crucial clues about environmental changes from below bodies of water with enchanting names such as Secret Lake and Wax Lips Lake.

"Lakes are libraries of information about the past," said Axford, an assistant professor of Earth and planetary science in the Weinberg College of Arts and Sciences who has traveled to the Arctic for research

16 times. "They are amazing at preserving things."

Axford's team is particularly interested in samples from the past 11,700 years, known as the Holocene Epoch.

"Greenland's Holocene climate history is surprisingly poorly known," she said. "One goal of this work is to help answer the urgent question: 'How and how quickly do Greenland's glaciers respond to a warming climate?' and these samples will help us answer that question."

Now under analysis in Axford's lab at Northwestern, the samples the team collected range in age from modern day to an estimated 130,000 years old and show climate changes that occurred over multiple glacial and interglacial cycles. The mud and sediments contain layers of organic material such as insects, pollen and mineral grains that have accumulated year after year.

"These lake sediment cores provide geological records that reveal a picture of Greenland's changing environment over thousands of years," Axford said. "If we understand its past, we can better predict how the ice sheet will respond to climate change in the future."

The trip is part of a larger collaborative climate change research project, supported by the National Science Foundation's Office of Polar Programs, with scientists from Northwestern, Dartmouth College and the University of Maine. Axford also has support from the Institute for Sustainability and Energy (ISEN) at Northwestern for her research in Greenland. The team will publish what they find in the samples over the next few years and combine what they've discovered with their research partners.

The end project of the collaboration between the three institutions will be the reconstruction of the Holocene climate in northwest Greenland via inferences from reconstructed local ice caps, ice cores and Axford's team's data from lake sediments.

"To tie what we learn about past climate change to the future, we will collaborate with a computer modeler at the University of Maine who will assess what we discovered and give a better prediction of how the ice sheet may behave in the next 100 years," Axford said.

The Big Melt?

Satellite images show that the Greenland ice sheet—the second-largest mass of ice in the world—has been melting and shrinking fast in recent decades, moving its mass to the oceans at ever-increasing rates of hundreds of billions of tons of ice a year.

If the melting continues, it is expected that sea levels will rise and threaten coastlines worldwide, causing destruction and displacing millions. But these predictions are not perfect. Computer-based simulation models are used to estimate how fast sea levels will rise, but climate scientists express concern that rates of future sea level change are still very hard to estimate with confidence.

"We need reliable, scientific-tested data to improve the computer models and test hypotheses about climate change," said Everett Lasher, a Ph.D. student in Axford's lab who was part of the team in Greenland. "To do this, we are going straight to geology, pulling core samples from below the water to build geologic records. Core samples are one of the best sources of climate change data."

Lasher and fellow Ph.D. student Jamie McFarlin are making climate change in the Arctic the focus of their careers at Northwestern. They jumped at the opportunity to work alongside Axford on this summer's field study.

"We are thousands of miles from home, studying the interaction between the biosphere, the hydrosphere, the cryosphere and the atmosphere," McFarlin said. "It is fascinating and exactly the kind of opportunity that I had hoped for when I came to Northwestern."

Preparing for an Arctic Adventure

Arctic field research requires months of logistical planning and attention to safety. Through an agreement with the National Science Foundation, the U.S. Air Force provides the researchers with military flights from the eastern U.S. to the Thule Air Force Base in Greenland. Thule is the U.S. Department of Defense's northernmost installation, located 750 miles north of the Arctic Circle. From there a chartered helicopter drops them at study sites and campsites even farther afield, on rocky lakeshores in areas where few have been.

"We have one map and that is probably the only map of the area and part of it just says, 'unexplored,' and I think that about sums up why we went there," Lasher said. "No one knows a whole lot about the area, clearly, so it is an important place to explore and study and that is what we are doing."

There is little vegetation on this vast landscape, but there are, potentially, polar bears. To keep the team safe, Axford hired Alex P. Taylor, a bear guard with expedition and bear-related experience. Taylor, who headed to Antarctica to help another science team shortly after the trip to Greenland, doubled as a photographer and videographer, capturing the work taking place nearly every day.

Axford and her students took field safety training courses to prepare for the environment.

"Safety is the top priority," she said. "Luckily we didn't encounter any polar bears this time."

Their campsite consisted of sleeping tents and a cooking tent, rafts and scientific equipment surrounded with an electric fence powered by a car battery—added protection to keep the team safe from curious polar bears.

McFarlin, an experienced backpacker, said the polar bear threat didn't make her nervous but going without a good way to bathe for almost one month did.

"I usually like to jump into a river to wash off on backpacking trips in California," she said. "But this is very different, because it is so much colder. You can't jump into the water, but you make do."

Even though the trip took place during July and August, the team had to deal with frigid conditions. Summer temperatures in northwest Greenland are on average 45 F and can be below freezing at night. High winds are common, and the team encountered snowstorms. Warm clothes, boots and sleeping bags were necessary and so was high-calorie prepackaged food. All of the supplies and equipment needed were gathered and packed by the Northwestern researchers in Evanston and shipped to Greenland ahead of the trip.

A Typical Day

The sun is almost always up in Greenland during summer months. Adjusting to nearly 24 hours of daylight can be difficult. The team tried to stay on a schedule and marked the start of a typical day at the campsite with a modest breakfast (usually coffee and instant oatmeal). They then hiked to a nearby body of water to launch Axford's custom-built raft, called a "coring rig," for a day of collecting samples.

The raft is designed to break down into small pieces that fit into a helicopter and can be carried by the team across rocky terrain. A plywood platform lashed to the top of the raft provides a place for the team to stand while they work, anchored over the sites they want to sample. A coring device, fitted with a plastic tube and holding a piston, is lowered into the water from a seven-foot aluminum tripod built into the middle of the raft.

Every part of the process is powered by human muscle, and the physically demanding work also requires intense concentration. It can take hours, even days, spent on the raft in the wind and cold weather, to collect one perfect core from the bottom of a lake.

"It is hard work but delicate work, too," McFarlin said. "You're pulling sediments out of lakes, and everything you collect is what you get to use in the lab, so you have to be very careful. You don't want to contaminate anything and compromise your ability to read the samples later."

After a day of coring, the team headed back to the campsite to warm up, take notes, document the samples, prepare a meal and plan out the next day's events. Off in the distance were floating icebergs, rocky mountain peaks, a few birds, but little other scenery or wildlife.

"It is what I imagine working on the moon might be like," Axford said. "There are a lot of rocks —- and they disintegrated my hiking boots."

Lasher, too, noted the otherworldliness of the scenery. "The landscape is bizarre and bare, but it is also beautiful," he said.

The only way to communicate with the outside world was by satellite phone, and most phone calls involved scheduling helicopter flights to transport the group to a new lake and campsite.

This extreme isolation requires careful planning and a lot of self-sufficiency, but it is helpful for the researchers in many ways.

"Being in the field is a time of focus when you really do put all distractions aside and think about what is right in front of you—the science, the safety, the logistics," Axford said. "There's no email inbox competing for your attention."

A windstorm hit the area just three days before the end of the trip. The team was forced to collapse their tents and tie them down to protect their equipment and samples as nearly 70 miles per-hour gusts of wind threatened to blow everything away.

"We missed a day on the water, but morale was high because we knew we had already collected some great samples," Lasher said. "We just hunkered down together and waited for the weather to pass."

Luckily, nothing was damaged, and everyone made it out of the field safely.

"It was a very successful summer season in the field," Axford said. "The sites we were able to get to yielded amazing samples."

Cracking Open the Cores

A few months later, as fall quarter got underway at Northwestern, a group of students from the earth and planetary sciences department gathered in Axford's lab to catch a glimpse of one of the freshly split lake cores.

"There is a little bit of a mystery involved," Lasher said. "What exactly is inside of these tubes? We think we have great samples, but we don't really know until we split them open."

The plastic tubes that house the lake cores vary in size, with some of the largest measuring three meters long. When opened, the cores reveal layers of mud, some darker in color than others, representing different points in time.

Extracting material for radiocarbon dating is one of the first steps in the lab, Axford said. Lasher has started measuring stable isotopes of oxygen in the organic materials found in the mud to track environmental change.

McFarlin is focusing on tiny insects, known as chironomids or nonbiting midges, found in the cores to infer temperature history and ecologic shifts. She also is working with another Northwestern Earth and planetary sciences professor, geobiologist Maggie Osburn, on expanding the use of specific biomarkers in high Arctic lakes as proxies for climate change.

"To have these cores back in the lab, at our fingertips, it is an awesome feeling," Lasher said. "It will keep us busy for the next five years, but there is a lot of interesting science that will come out of this."

A Powerhouse Department

A handful of other scientists from the department of Earth and planetary sciences at Northwestern also traveled to the Arctic over the summer to work on NSF-funded research led by Andrew Jacobson, associate professor in the department of Earth and planetary sciences.

As climate change becomes more of a global concern, scientists with the skills to do research in the Arctic are becoming more in demand, and Northwestern is positioned to make major contributions.

"Most parts of the Arctic are very difficult to get to," Axford said. "Not many people and especially not very many scientists have been there.

Everything we learn is a new discovery, and that is the biggest privilege a scientist can have."

Provided by Northwestern University

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