

Exploring Beneath Antarctic Ice

April 13 2010, by Henry Bortman



Taylor Glacier (foreground) dips into the west lobe of Antarctica's Lake Bonney. In the distance, East Lake Bonney. Credit: ©2007 Bernard Gunn

The NASA-funded ENDURANCE project has completed its second field season robotically exploring the waters of an ice-covered lake in Antarctica. Insight gained by the expedition will help scientists prepare for a future mission to Jupiter's moon Europa.

Evidence found by [NASA's Galileo spacecraft](#) of an ocean on Europa put the giant Jovian moon on the A-list of worlds worth investigating for signs of [extraterrestrial life](#).

Exploring that ocean won't be easy: It's covered by ice perhaps as much as 100 kilometers (62 miles) thick. But late last year, a group of NASA-funded scientists and engineers took an important step toward figuring out how it might be done. The [ENDURANCE](#) project (ENDURANCE stands for Environmentally Non-Disturbing Under-Ice Robotic [Antarctic](#)

Explorer) wrapped up its second field season at [Lake Bonney](#), an ice-covered lake in Antarctica's Dry Valleys.

Lake Bonney is composed of two lobes, connected by a narrow channel. At the west end of the west lobe, Taylor Glacier dips down to and below the lake's ice cover. The lip of the glacier, a small underwater ice shelf, sticks out into the lake some 17 meters (56 feet) below its surface.

As they had done during the project's first field season in 2008, ENDURANCE team members began the 2009 season by melting a hole 2 meters (6.6 feet) wide in Lake Bonney's ice cover and constructing a temporary headquarters around it, complete with a crane capable of lowering the 1300-kilogram (1.4-ton) robot into the lake.

Over the course of a month, sometimes performing multiple runs in a day, ENDURANCE studied the west lobe of Lake Bonney, including the underwater face of Taylor Glacier. Using sonar, it produced a high-resolution bathymetric (depth) map of the west lobe. Simultaneously, it stopped every 100 meters (328 feet) to lower a package of [scientific instruments](#), known as a "sonde," down through the [water column](#) to collect data on temperature, salinity, pH, and several biological indicators. Near the glacier face, it sampled even more frequently.

ENDURANCE had collected a partial set of similar data during the project's first season in 2008. In 2009, ENDURANCE successfully explored the entire west lobe. It also navigated through the channel connecting East and West Lake Bonney, and for the first time explored portions of the east lobe.

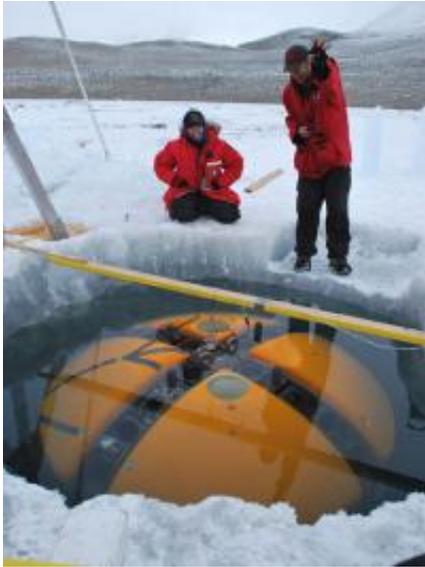
The result is perhaps the most extensive 3-D biogeochemical map of any lake on Earth. "There's not a data set like this for any other lake in the world that I know of," said John Priscu, a professor at Montana State University and a member of the ENDURANCE science team. "The only

way we could have done this study is robotically,” he added.

Over the course of the next year, Priscu and Peter Doran, professor of earth and environmental sciences at the University of Illinois at Chicago (UIC) and principal investigator for the ENDURANCE project, will work with the Electronic Visualization Lab at UIC to produce 3-D representations of the Lake Bonney data that can be studied by viewers sitting in front of 10-by-20-foot screen, able to navigate through the data as though they were swimming through the lake.

The lab will produce individual “color 3-D plots ... of all the different parameters,” Doran said, that will highlight the structure of chemical, temperature and biological gradients within the lake. Further, combining multiple data sets into composite plots will enable the science team to visualize relationships between parameters. For example, how the amount of light available at various points in the lake affects the presence of chlorophyll, an indicator of photosynthetic activity; or, for parts of the lake where data was collected in both 2008 and 2009, “how some parameters have changed from year to year.”

Of particular interest to the team was the area beneath the underwater Taylor Glacier ice shelf, where ENDURANCE found evidence of a stream of frigid water flowing into the lake that had not been present the previous year.



ENDURANCE PI Peter Doran (right) and Vickie Segal greet the arrival of the bot at the secondary melt hole near the base of Taylor Glacier. Credit: Stone Aerospace

But the tip of the glacier dips down to about 20 meters (66 feet) below the lake surface. At about 17 meters (about 56 feet) below the surface, a chemocline, an increase salinity, occurs in Lake Bonney’s water, and this saltier water is more buoyant than the overlying layer of fresher water. In order for ENDURANCE to sink down into the salty water, more weight needed to be added.

“If we wanted to go under the glacier, we’d have to come up with some way to reballast the vehicle to go below this chemocline, because the density went up by almost 20 percent,” said Bill Stone of Stone Aerospace, who heads the company that designed and built the robot. Without the added weight, ENDURANCE “would bob on that chemocline like a cork.”

The extra weight would cause problems for most operations, so it

couldn't be added to the vehicle at operation central, where every day the massive crane pulled ENDURANCE in and out of the hole in the ice. Instead, the team melted a second hole in the ice near the glacier and set up a small portable gantry to lift the bot just far enough out of the water to pile on 120 kilograms (265 pounds) of lead. ENDURANCE was then lowered back down into the water, now heavy enough to sink into the saltier layer. After exploring this denser region, ENDURANCE returned to this second hole and the lead weights were removed, allowing the vehicle to return unencumbered to the main access hole.

Ideas are already in development, Stone said, to reconfigure ENDURANCE to explore beneath Europa's ice. Miniaturization will be critical to that effort. He envisions a parent craft that carries "a redundant collection of sub-bots." The parent craft, he says, "images the gross topography" and "maneuvers toward places of interest," but stays "well away from the dangerous obstacles." When it discovers a feature worth exploring in more detail, it spins off a sub-bot to take close-up images, collect higher-resolution chemical and biological data, and retrieve samples for chemical and biological analysis by scientific instruments on-board the parent craft.

One critical procedural question that will need to be addressed before launching a spacecraft to explore Europa's ocean is to what degree it will operate autonomously. ENDURANCE is capable of performing its tasks without human intervention, but operating that way took a toll on the science return.

In 2008, Doran says, when ENDURANCE operated fully autonomously, "we couldn't see the science data live. The thing would be out collecting data and we wouldn't know what it collected until it came back. And sometimes the sensors were not working properly and they needed some kind of treatment and we couldn't do that until after it got back and we'd wasted a whole day." In 2009, however, during most of its runs,

ENDURANCE was connected via an optical fiber that fed data to a computer screen. “We were there on the site tweaking it the whole time,” Doran says. “We would [have gotten] a data set if we weren’t there, but it would [have been] nowhere near as good a data set.”

Maintaining communication with a sub-ice explorer on Europa will be difficult. In addition to the delays introduced by the time it takes for radio signals to travel between Earth and Europa will be the difficulty of keeping up a communications link between the moon’s surface, through kilometers of ice, to a vehicle continuously changing position in the ocean below.

Despite the challenge, Priscu says, having that feedback loop may make the difference between scientific success and failure. “If we send something to Europa, having a data feed come back so we can make decisions on the fly, in near-real time,” he argues, will be “invaluable.”

Source: Astrobio.net

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