Breaking Antarctica's ice

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Antarctica's University Valley, where later this month NASA's IceBite team will field-test Honeybee Robotics' rotary-percussion drill, boring a meter deep into the subsurface ice. Credit: M. Marinova

Over the course of the past decade, NASA spacecraft have identified several sites on Mars where conditions capable of supporting life existed in the past. One of the most promising of these sites, and a good candidate for a follow-up mission designed explicitly to look for signs of life, is the shallow subsurface at the Phoenix landing site in the arctic northern plains of Mars. Indeed, the region where Phoenix landed some scientists believe, may still be habitable today.

As an early step toward developing the technology for a return mission to the martian polar north, members of NASA's IceBite team will head out this month to explore University Valley, in Antarctica's Dry Valleys. Astrobiology Magazine will be following their activity while they're in the field, regularly posting blog entries from IceBite team member Margarita Marinova. Visitors to the Astrobiology Magazine site will be able to ask questions of the IceBite team by clicking the Ask a Scientist button that will appear in our IceBite stories and blog entries.

University Valley is of interest because it never gets warm enough there for subsurface ice to melt, so the overlying layer of soil remains dry year-round. This dry-soil-over-ice arrangement, common on Mars but extremely rare on Earth, resembles the near-surface stratigraphy at the Phoenix landing site.

“Everywhere in the northern hemisphere where there’s permafrost, it is wet and it gets muddy in the summer,” says Chris McKay, a planetary scientist at NASA’s Ames Research Center (ARC) in Moffett Field, California, and the principal investigator of the IceBite team. “In Antarctica, and only in Antarctica, we find a completely different phenomenon called dry permafrost, in which we find ice-cemented ground on top of which we find dry, bone dry soil, and the whole system never gets warm enough for that ice to turn to liquid.”

Last year the IceBite team conducted reconnaissance in University Valley and placed a series of weather stations there to monitor conditions during the Antarctic winter. This year, they will return to test IceBreaker, a drill designed and built by Pasadena, California-based Honeybee Robotics. Ice Breaker can burrow up to a meter (3 feet) into the ice and frozen soil and deliver samples to the surface for scientific analysis.

Honeybee Project Engineer Gale Paulsen adjusts settings for the Mars Simulation Chamber in preparation for a test of the company’s rotary-sonic drill. Credit: Henry Bortman

IceBreaker is a rotary-percussive drill: it both rotates and hammers on its target. By combining percussion with rotary motion, “you get a highly efficient drill system,” says Kris Zacny, director of Honeybee’s Drilling and Excavation Program. Rotary-percussive drills are hardly a rarity; you can buy them off the shelf at Home Depot. But IceBite has been optimized for the frigid, near-vacuum conditions on Mars. For example, while most drills are lubricated to prevent their internal parts from sticking to each other, because Mars is so cold, IceBite’s internal parts are instead coated with a Teflon-like anti-stick surface.

The IceBite team will perform three series of tests. The first will be in McMurdo Station, a research center in Antarctica with ready access to tools, spare parts, electricity, and the Internet. Hopefully the Internet connection will enable a group of fifth-grade students in Pleasanton, California to operate the drill via remote control.

"Then we're going to pick it up and put it in the back of a truck, and drive it to a remote site near McMurdo, an unaltered site, and drill in the rock of McMurdo, which is probably a better Moon analog than Mars analog," says McKay. The final test will be in the still-more-remote University Valley, accessible only by helicopter. IceBite has been tested successfully in Honeybee's Mars Simulation Chamber, where the temperature and atmospheric conditions can be tuned to approximate those on Mars. But the upcoming tests in the Antarctic will be the first time the drill will be subjected to the uncertainties of field operation.

One thing Zacny and his colleagues will monitor closely during these tests will be the temperature of the drill bit. A temperature sensor in the bit and control software will hopefully guarantee that during drilling operations the bit doesn't get too hot. If it does, the subsurface ice can melt, and if it refreezes before the bit can be pulled out of the hole, the bit will get stuck. If this happens on Mars, says Zacny, "you're done. You'll never be able to pull the drill out of the hole."

They'll also be looking at how effective the drill is at delivering useful samples to the surface for scientific analysis. In the lab, "we prepare our own [rock and ice] simulants," says Zacny, "so we kind of understand what can go wrong. In the field, however, "you have no idea what's below the surface until you drill and you see the cuttings of samples being conveyed to the surface."

Zacny hopes to learn more about how dry permafrost samples behave during drilling, "how it behaves when you finally pull it out to the surface, what's the best way to transfer it to the instruments. And what happens to the sample when it comes up to the surface, how much mixing there is between samples that come up from different depths."

In addition to testing IceBreaker, the IceBite team plans to map the depth of the subsurface ice, both in University Valley and in other nearby valleys. “A question has arisen as to what sets [the ice] depth,” says Margarita Marinova, a research scientist at ARC. “So a lot of my time will be spent on actually going through the valleys, digging pits or poking holes and trying to figure out what depth to the ground ice is.”

Another team member, Andrew Jackson, an associate professor in the Department of Civil and Environmental Engineering at Texas Tech University in Lubbock, Texas, will study perchlorate. Historically, Jackson’s research focus has been on terrestrial perchlorate, in particular its impact on the Earth’s ozone layer. On Earth perchlorate occurs primarily in very dry places, such as the Atacama Desert in Chile. It is known to exist in the Antarctic Dry Valleys, but no-one has yet studied its presence there.

In addition to shedding light on Earth’s climate, perchlorate, which was found in the soil at the Phoenix landing site, is important to understanding the possibility of life on Mars. Perchlorate acts as a strong anti-freeze, lowering the freezing point of water. “Most salts do this, but perchlorate is particularly good at it,” says Jackson. “If we can see that in Antarctica, if we can show this perchlorate is actually doing that,” Jackson says, “that’s really important for Mars,” where temperatures rarely get above the freezing point.

In addition, many terrestrial microbes can “breathe” perchlorate in place of oxygen. If perchlorate-respiring microbes are found living in tiny pockets of liquid water within Antarctica’s subsurface ice, perhaps the subsurface ice in the frozen northern plains of Mars could also be considered a viable habitat for present-day life.

Stay tuned during the next month for regular updates from the IceBite team, and remember, if you have questions you’d like to ask anyone on the team, click the Ask a Scientist button and tell us what you'd like to know. We'll forward your question and get a response as quickly as we can.

Source: Astrobio.net

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