

## The Plan to Unlock Lake Vostok

After a 6-year pause to consider the risks of environmental contamination, a Russian research team will resume drilling through the Antarctic ice next month

Beneath an ice sheet 4 kilometers thick lies one of the most isolated bodies of water on Earth, the immense Lake Vostok of East Antarctica. It has been locked up, researchers think, for more than 10 million years. But it may not remain so much longer. A team of Russian researchers is poised to resume drilling through its ice cap next month, restarting a project that has been on hold since 1999 while experts debated how to proceed. Despite an extensive review, some still fear that the team's approach could alter the lake and make it impossible to obtain untainted water samples.

But the Russians, led by Valerii Lukin, an oceanographer who directs the Russian Antarctic Expedition and ice coring at Vostok, have promised they will take it slowly, studying the ice as they inch toward the lake's surface. In late 2007, they plan to poke through and take the first sip of the waters.

Vostok is the largest of more than 100 subglacial lakes in the Antarctic. None has been directly sampled, and scientists in a variety of fields are eager to tap one. What they know at present comes mainly from ice cores and flyover observations, including radar and gravity measurements. Geologists and glaciologists want a peek at isotopes taken from the lake to understand how such lakes form and behave. Climate researchers would like to see if the sediments hold records of Antarctica's past. And biologists want to verify studies that suggest Lake Vostok supports life despite its utter darkness, near-freezing waters, and scant nutrients (*Science*, 2 March 2001, p. 1689).

But Antarctic researchers from several nations are concerned about contamination. The borehole at the Russian site now brims with 60 tons of drilling fluid, a soup of kerosene and Freon that teems with foreign bacteria. The critics worry that a leak could muck up the ecosystem permanently. The Russian team, however, is confident that its extraction technique will prevent this. And because Antarctica has no laws—

just international treaties—there is little to hold them back.

### What lies beneath?

Surveys have identified about 145 subglacial lakes dotted around Antarctica, but the figure “is by no means exhaustive,” says Martin Siegert, a glaciologist at the University of Bristol, U.K. “It wouldn't surprise me

reveal much about this period, but sediments on the lake floor could give “a record of Antarctica's change from greenhouse to ice-house,” Studinger says.

Although researchers have taken no direct samples, cores from ice just above Lake Vostok have given them a glimpse of its chemistry and the potential for life inside. Studies of trapped isotopes and of the ice's crystal structure suggest that the ice melts at the base of the sheet, mixes with the lake, and slowly refreezes, locking some water in this “accreted” ice. “We used to think some heat source below Lake Vostok was necessary to keep it liquid,” Studinger says. But isotopes in the accreted ice suggest that the underlying

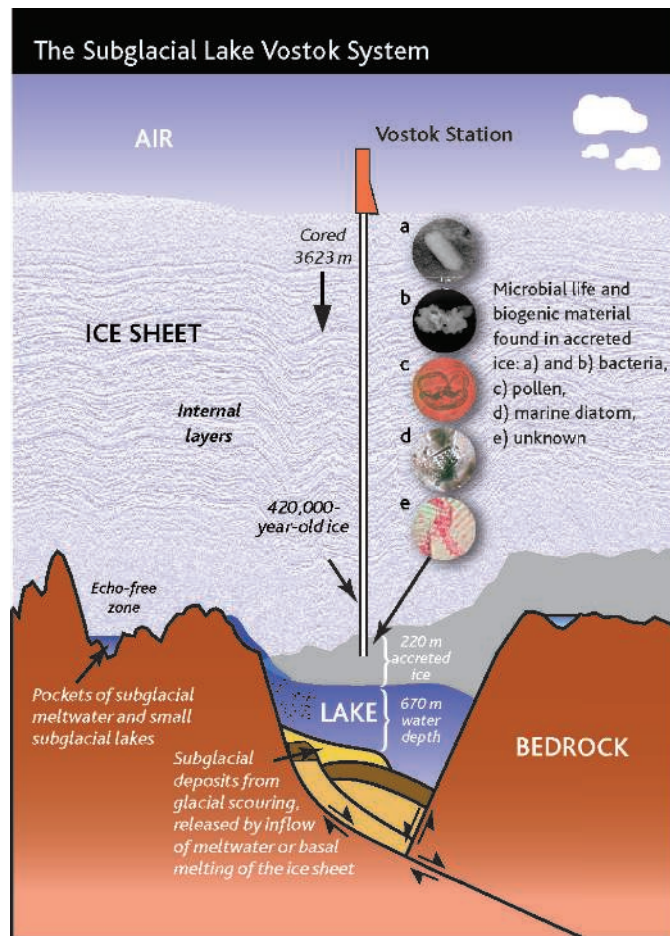
rock “seems to be a rather old and stable piece of crust.” The uniform heat rising from Earth's depths, coupled with the immense pressure of the overlying ice, appears to keep the lake liquid.

The primary scientific disagreements center on whether the lake can sustain life. Microbiologist John Priscu of Montana State University in Bozeman says his group has recently cultured about two dozen samples of bacteria from accreted ice; they can tolerate temperatures below 10°C but grow slowly. He estimates there are about 100 bacteria per milliliter in the accreted ice and predicts that the surface waters hold about 10,000 per milliliter, about a hundredth the density in the open ocean—still a lot given the conditions.

Radically different results come from studies led by Sergey Bulat, a molecular biologist at the Petersburg Nuclear Physics Institute in Russia. Using different methods to clean drilling fluid off ice cores and different standards to identify lake inhabitants, his group found little DNA in the accreted ice that they consider to be from bacteria in the lake. And the DNA they did find, surpris-

ingly, matched most closely that of heat-loving bacteria in hot springs. Bulat speculates that the lake bottom could have warm vents, similar to deep-sea vents.

Still others are skeptical about most of the data on life from Lake Vostok's accreted ice. Molecular biologist Eske Willerslev, who studies ancient DNA at Copenhagen University in Denmark, says, “It's a very promising area, but it needs much more controlled experiments.” The first step toward resolving differences, scientists



if there are more than 1000.” Yet for many scientists, Vostok remains the Holy Grail. The Manhattan-shaped lake is probably the largest—250 kilometers long and 50 kilometers wide—and possibly the oldest. It sits in a deep depression between two tectonic plates, says glaciologist Michael Studinger of Columbia University's Lamont-Doherty Earth Observatory in Palisades, New York. Glaciologists believe it may have formed before Antarctica froze solid, 15 million to 30 million years ago. Climate records don't

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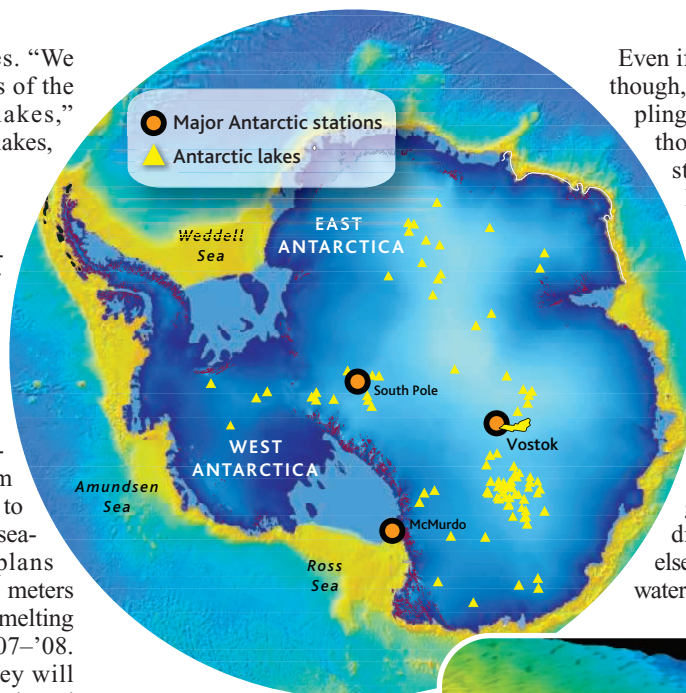
agree, is to get some lake samples. “We know more about the deepest parts of the oceans than we do about these lakes,” Priscu says. “Until we get into these lakes, we’ll just sit here and speculate.”

### A big surprise

Working on climate studies, the Russian team has already extracted one of the world’s longest ice cores above Lake Vostok, drilling 97% of the way through the ice sheet. They stopped to consult other experts around the world in 1999, about 130 meters short of the lake’s surface. The Russian government has given the team permission to use a mechanical drill to go 50 meters further in the 2005–’06 season, starting in November. The team plans to drill mechanically another 50 meters in 2006–’07, then switch to a hot, ice-melting probe for the final 30 meters in 2007–’08. After poking through the base, they will allow water to flood up into the borehole and freeze, then take out an ice core. “It’s a quite cheap, doable, plausible experiment,” Siegert says.

But critics of the plan worry that the pressure may drive lake water into the drilling fluid. Some point to a bad experience with the North Greenland Ice Core Project in 2004. Researchers drilled to the bottom of the island’s ice sheet to collect water samples but had a “big surprise,” says glaciologist Sigfus Johnsen of Copenhagen University, who worked on the project. Five meters higher than expected, water flooded into the hole and got contaminated with drilling fluid. Perhaps they broke through sooner, Johnsen says, because the base was not flat but ridged with high conduits. Priscu’s group found bacteria in the ice core, but he asks: “Are they from the drilling fluid or the bottom of the ice sheet? We don’t know.” Willerslev, who has also studied the same cores, says, “The samples are completely contaminated and completely useless.”

A mishap like this is unlikely at Vostok because the ice ceiling over the water is unlikely to have conduits, Johnsen says. Still, the base might have weak “soggy ice” that will give way, worries microbial ecologist Cynan Ellis-Evans of the British Antarctic Survey in Cambridge. Others contest this: “There are no arguments to say the quality of the ice is poor,” says glaciologist Jean-Robert Petit of the Laboratory of Glaciology and Geophysiology of the Environment in Grenoble, France. And the Russians are “very good drillers and have great engineers,” Priscu says. “They seem genuinely concerned about environmental disasters.” Nonetheless, Petit, Priscu, and others are concerned.



**Unseen.** Buried under 4 kilometers of ice, Vostok (radar image, inset) is believed to be the largest subglacial Antarctic lake.

“No one has said what an appropriate level of cleanliness would be” in water samples, says geologist Robin Bell of Lamont-Doherty Earth Observatory. Many are also skeptical of the Russian team’s plans because their drilling equipment has not been field-tested. (Project chief Lukin says tests are not necessary.) “There’s a lot of discomfort with the Russian plan,” Bell says.

Even a little bacteria from the drilling fluid could swamp life in the lake or swap DNA and viruses with indigenous microbes. If the lake gets exposed to outside bacteria, says microbial ecologist Cynan Ellis-Evans of the British Antarctic Survey, “you’ve opened Pandora’s box.” The Russians’ plan has also drawn the ire of the Antarctic and Southern Ocean Coalition (ASOC), a nongovernmental watchdog organization. “Russia’s using technology that was never designed to be ultraclean. It’s not up to the task,” says Ricardo Roura of ASOC.

But Lukin thinks the critics are exaggerating. He agrees that the lake is under pressure: He estimates about 375 times atmospheric pressure at its surface, comparable to the deep ocean. But he says the weight of the drilling fluid in the borehole should roughly balance it, holding the drilling apparatus in place and keeping the lake’s water put. Besides, Lukin says, the apparatus is designed to prevent leakage: “I am convinced the concerns about possible contamination of the lake’s water with the drilling fluid do not have any physical grounds.”

Even if the Russian plan goes smoothly, though, some question the value of sampling water from the lake’s surface. “I thought that’s what we were already studying [in accreted ice],” Ellis-Evans says. “I cannot see that what they’re planning would put us all that far ahead.”

### Rivals

While the Russian team has been formulating its plan and seeking approval, researchers in other countries have been cooking up plans to explore other subglacial lakes. Some argue that before going for the crown jewel, Vostok, drilling methods should be tested elsewhere first. A leading option is hot-water drilling, a fast and clean but energy-

intensive method that many think impractical for Vostok, which boasts Earth’s coldest recorded temperature,  $-89^{\circ}\text{C}$ . U.K. researchers are focused on Lake Ellsworth, a relatively small subglacial lake in West Antarctica, and Italian researchers are targeting Lake Concordia, a neighbor of Vostok in East Antarctica

about half the size. These plans are in their infancy, however, and researchers are unlikely to get in and take water samples before 2007, when Russia plans to enter Vostok. Should Russia decide to go ahead without waiting for data from other sites, there is little other countries could do.

The main forum for vetting research proposals is the annual Antarctic Treaty Consultative Meeting, where researchers submit environmental assessments and get back advice. The Russian team has already submitted preliminary assessments for the next 2 years. This satisfies the requirements for now, but the treaty requires Russia to submit a more comprehensive assessment 60 days before drilling to the water’s surface. After they see the details, researchers worldwide will weigh in.

Countries are not obliged to follow such advice, but normally they do. If Russia were to go forward in the face of international opposition, “it would absolutely be a big break from tradition,” Ellis-Evans says. Lake Vostok could become a test of how well the treaty actually protects the continent. “It’s a showcase for the Antarctic Treaty,” Priscu says. But ultimately the decision on whether and how to go into Lake Vostok rests with Lukin’s team and the Russian government.

—MASON INMAN

Mason Inman is a writer in San Francisco, California.

