# Hidden Antarctica: What lies beneath

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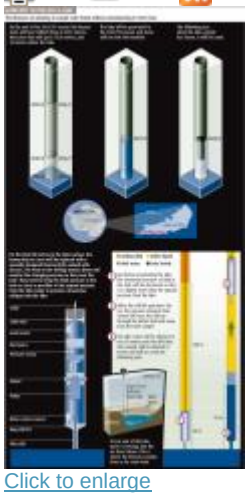

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## Tools



**Audio:** *Hear Gabrielle Walker discuss this feature as part of SciPod, **New Scientist's** weekly podcast.*

The underwater world of Lake Vostok is dark, deep and above all mysterious. From the moment researchers realised that a body of water big enough to fill the whole of Lake Michigan was buried

beneath the Antarctic ice sheet, they have wanted to know what was hidden inside. Locked in by a layer of ice some 4 kilometres deep, the lake has not seen the light of day for at least 15 million years.

Where there's water, there could also be life - but what kind of life? Could there be bacteria or algae, or perhaps even hydrothermal vents brimming with strange sunless creatures? There might be nothing alive down there at all - but if so, that would make Lake Vostok the only body of liquid water ever found that is utterly lifeless. We could soon know, because the deep, dark lake is about to be breached.

The surface at Vostok is officially the coldest place on Earth, with winter temperatures that can shatter steel. Four kilometres below, the base of the ice sheet has melted under the pressure of the ice above it to form hundreds of metres of liquid water. Hints of this water beneath the ice in this remote part of the Antarctic interior were confirmed in the 1990s, when satellite and seismic measurements revealed the astonishing size of the lake. The real excitement, though, began when Russian drillers collecting a record of past climate from the ice found themselves inadvertently holding pieces of Lake Vostok in their hands.

They hadn't broken into the lake but, thanks to the lake's unique setting, they ended up with a sample of the lake water all the same. In its northernmost part, the lake melts up into its ice ceiling, while in the southern part water was refreezing into the ice sheet. By good fortune, the Russian science base at Vostok, and hence the ice coring site, had been placed right above this frozen sample of Vostok's water. (*New Scientist*, 4 December 1999, p 34).

Biologists immediately clamoured for samples of this so-called accretion ice, and in 1999 several independent research groups announced that the ice seemed to contain faint traces of life. It wasn't long, however, before a dispute broke out, when the bacteria that American researchers maintained were bona fide inhabitants of Lake Vostok were denounced by a joint French and Russian team as nothing more than contamination (*New Scientist*, 7 August 2004, p 6).

In April this year, the various sides of the Vostok debate met at a workshop held at the French Glaciology Institute in Grenoble to try to resolve their differences. The meeting produced, if anything, more questions than answers.

One reason for believing the lake might be sterile came from a calculation made in 2003 by Chris McKay from NASA Ames Research Centre in Moffett Field, California. He realised that the constant process of melting and refreezing that created the ice extracted by the Russian drillers would effectively act as an air pump. In the north, as the ice above the lake melted, the air that was trapped in the ice when it originally formed from layers of snow would be released into the lake water. In the south, as the lake water refroze, the dissolved air would be left behind in the liquid water. If that process continued for long enough, the water would be pumped full of dissolved gas like a bottle of champagne. The problem for life is that the water would be "hyperoxic", with more than the normal level of oxygen - some 50 times more, according to McKay's figures, a quantity that would be lethal (*Geophysical Research Letters*, vol 30, p 1702).

However, biologist Peter Doran of the University of Illinois at Chicago, who was a co-author on McKay's paper, is now having his doubts. "I won't be surprised if we were wrong," he says. "Microbes love gradients, and Vostok could be hyperoxic at the top but anoxic [low in oxygen] at the bottom."

Another reason for the disagreement is that there is so little biological material in the accretion ice that it is hard to be sure it has really come from the lake. A team of biologists led by Jean-Robert Petit from the Laboratory of Environmental Glaciology and Geophysics in Grenoble, France, and Sergey Bulat from the Petersburg Nuclear Physics Institute in Russia have drawn up a list of all possible contaminating organisms. When considering what organisms found in the accretion ice might have come from the lake, they rule out any that can also be found in the drilling fluid, the station at Vostok, or their labs in France and Russia. According to this ultra-stringent criterion, the accretion ice bears no evidence whatsoever for life in the waters of Lake Vostok.

"Some people are aghast at the prospect of breaking through the ice"

The team has, however, recently found traces of life that may have come from beneath the lake. Bulat and his colleagues noticed that some of the accretion ice contained small amounts of sediment, which, they conjecture, came from the floor of the lake and had been flung up into the lake water by some seismic convulsion. Clinging to these fine particles of mud, they have found traces of DNA from a type of bacteria normally found in waters of 50 to 60 °C: a thermophile. This implies that the floor of the lake might be more geologically active than anyone had realised. Thermal vents there might release chemical nutrients to fuel the sort of life found around "black smoker" chimneys deep in the world's oceans.

However, tectonics experts are cool about this possibility. Robin Bell from the Lamont-Doherty Earth Observatory in Palisades, New York, says that the area around Vostok was certainly once very active - which is why there is a deep basin for the lake to fill in the first place - but seismological studies suggest that the activity has now quietened down. "There are faults all around Vostok, and there could be some minor reactivation," she says. "It wouldn't surprise me if there was warm water flowing up the faults." However, she thinks there are unlikely to be seriously hot vents at the bottom of the lake.

**Breaking through**

Meanwhile, other biologists maintain that the accretion ice does contain signs of life. Martyn Tranter from the University of Bristol in the UK has found that traces of ground-up rocks in the accretion ice go hand-in-hand with high bacterial body counts. "Bugs like eating rocks," he says, "and the ice sheet grinds rocks up nicely. You'd expect more biomass where you have a higher concentration of minerals, and if you look at the chemistry and biology of the accretion ice separately, that's exactly what you see."

As the debate continues, Brian Lanoil from the University of California, Riverside, echoes the feelings on both sides. "We're getting close to the limit of what we can do with accretion ice. What we need now is samples from the lake itself."

And that's exactly what Russian scientists plan to collect. Earlier this year, they restarted their drilling programme at Vostok for the first time in eight years. Next season, they plan to drill down to within a whisker of the lake surface; the following year, they will break through.

Reaction to this prospect is mixed. Some researchers are aghast. The Russian borehole over Vostok was not designed for studying the lake and, as is standard practice, it has been filled with aviation kerosene - basically, jet fuel - to stop the hole refreezing. If any of this were allowed to contaminate the lake, the consequences would be disastrous.

However, Vladimir Lipenkov from the Arctic and Antarctic Research Institute in St Petersburg is confident the project design will avoid this. They plan to put a buffer layer of "clean fluid" down at the bottom of the hole before breaking through. The buffer fluid is heavier than kerosene and both repels and is lighter than water, so will lie between the lake and the drilling fluid. A specially designed drill will then break through the ice at the bottom of the borehole, and the pressure of the lake water will force water a few metres up into the hole, pushing the buffer fluid and the kerosene up and away from the lake water (see Diagram). The Russians plan to leave this water to freeze, and will return the following year to drill down and bring back samples.

It's a bold plan. Some fear that if the lake is highly pressurised, simply breaking into it could create the effect of a shaken champagne bottle and spurt a fountain of kerosene and lake water all the way up to the surface. However, Lipenkov maintains that by adjusting the quantity and therefore downward pressure of kerosene in the hole, the drillers will be able to control the lake's pressure and prevent leaks.

Some researchers are rejoicing at the prospect of finally getting samples from Vostok. John Priscu, an ecologist at Montana State University at Bozeman and another co-author on McKay's paper, who is

firmly on the "life" side of the Vostok debate, says: "I'm behind them. Let's do it. Let's break the ice. We won't know for sure what there is until we go in there."

Not everyone is so enthusiastic. NASA planetary protection officer John Rummel, who is charged with preventing the contamination of other planets, feels that some level of risk is always necessary in such difficult environments. "The only way you can protect against all hazards in Antarctica or anywhere else is not to study it," he says. "The question is, is this a reasonable risk?" For now, he is reserving judgement. "We don't typically drill into champagne corks with a plug of oil and then see what happens. I wish the Russians well, but I think they should be very careful."

The news earlier this year that Antarctic lakes may well be connected (see *Terra Incognita*) has also sent a frisson through the Vostok community. Contaminate just one lake, and everything downstream will get contaminated as well. On the other hand, if Vostok truly is connected to the rest of the Antarctic ice, it is less likely to be oversaturated with oxygen, and therefore more likely to contain life.

"Every wet subglacial environment we have ever sampled contains microbes," says Lanoil. "Lake Vostok is the only one on Earth that is supposed to be sterile. But if the West Antarctic ice sheet has got life and all the other subglacial systems have got it, what makes Vostok so special?" Maybe, we're about to find out.

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**Life under the ice**

While others wrangle over whether Lake Vostok harbours living creatures, one enterprising biologist has taken a different tack to investigate the question of life under Antarctica's ice. Brian Lanoil of the University of California, Riverside, was excited to hear that researchers from the California Institute of Technology had pulled up mud samples in 2000 from "wetlands" below a gigantic ice stream in West Antarctica.

The team who drilled down to collect the mud had no thoughts about life. They just wanted to know the mud's mechanical properties, to figure out what role it played in allowing the overhead ice to flow.

Lanoil knew that the mud came loaded with water, and where there's water, he reasoned, there's also life. So he begged a few samples. The mud had already been sitting around in a refrigerator for more than a year when he got his hands on it, but he wasn't too worried about contamination - it should take about three years for water to penetrate just 1 centimetre into the mud's pores from the outside.

To be on the safe side, Lanoil cut off the outer 2 centimetres of mud and then examined what remained. Sure enough he found a host of bacteria. There wasn't much diversity - just three different species - but they are nonetheless Antarctica's first uncontested deep bugs.

Lanoil believes that the mud sample's history may have affected the relative numbers of different bacteria, but not the overall composition of the ecosystem. "Whatever is there now in the centre of the core must have been there before," he says.

Researchers think this could be the first of many discoveries of life in the wetlands beneath Antarctica's ice. Glaciologist Slawek Tulaczyk from the University of California, Santa Cruz, believes this raises an important philosophical point about other planets that seem to be devoid of living things. "Even if they look dead from the outside, 2 kilometres down they may still be alive," he says. "Antarctica is a lifeless desert on the surface, but if you go deep enough it's a very different story."