The exploration of Lake Ellsworth: an Antarctic subglacial lake

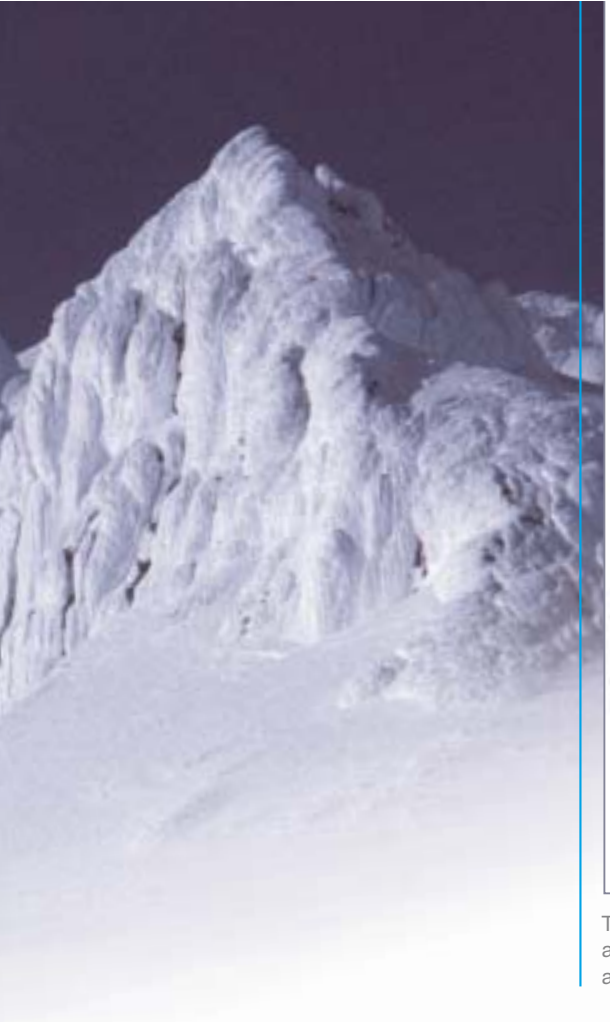
In 1994 scientists met at the University of Cambridge to discuss the exploration of lakes beneath the ice sheets on Antarctica. Ten years later a consortium of UK scientists met at Bristol University to plan the very first expedition. Professor *Martin Siegert* of the Bristol Glaciology Centre, School of Geographical Sciences, was there.

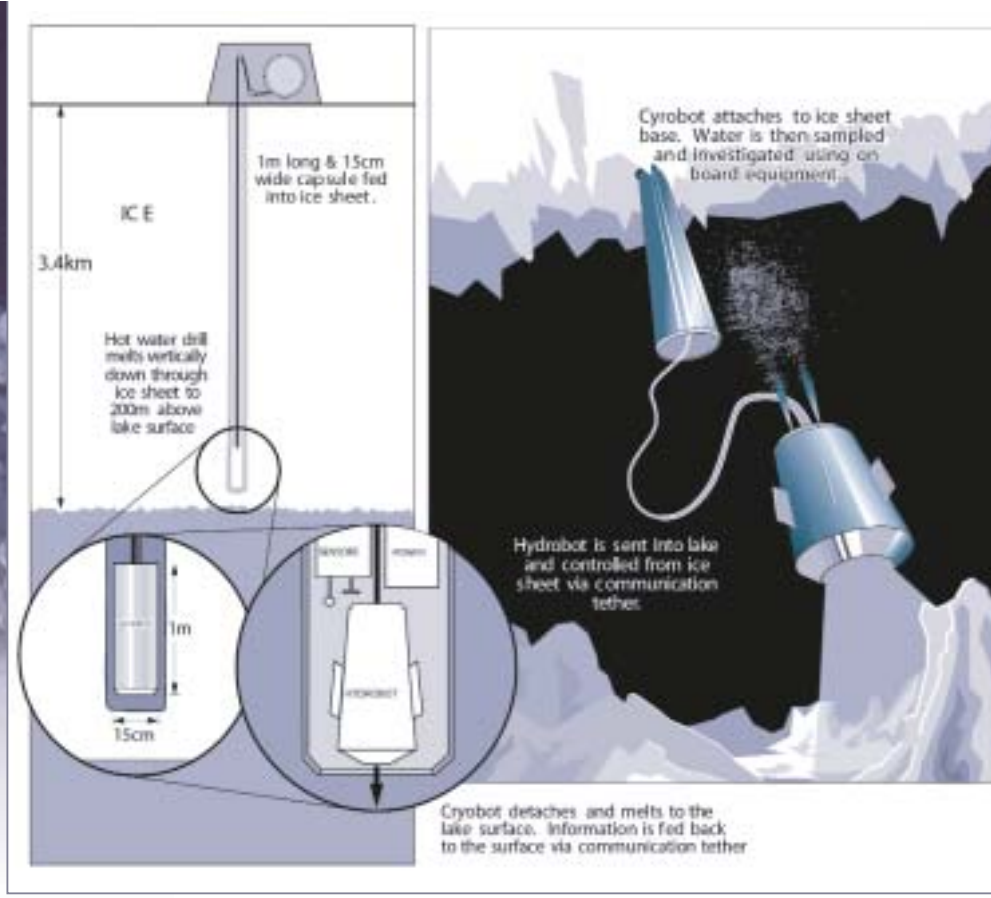
It is now an established hypothesis that subglacial lakes hold unique microbial life and contain important records of past climate change in the sediments on their floors. Consequently, there are important scientific reasons underpinning plans for their exploration. The issue faced today concerns which lake will be the first to be explored. The largest subglacial lake, Lake Vostok, has received widespread media and scientific interest as a likely candidate. However, more recently it has become apparent that a smaller lake might be explored before Lake Vostok.

> Lake Ellsworth is located beneath 3.5 km of ice in West Antarctica

The choice for exploration of the UK-led consortium is called Lake Ellsworth: a 10 km-long subglacial lake in West Antarctica. Lake Ellsworth was discovered by a technique known as radio-echo sounding, which works in a manner similar to seismic sounding, only using radio waves instead of sound waves. Subglacial lakes are easy to identify using this technique, as the style of reflection from a lake's surface, being flat, bright and smooth, is distinct from an ice-rock contact, being undulating, faint and rough (see right). Lake Ellsworth is located beneath 3.5 km of ice in West Antarctica, and is one of only four lakes outside East Antarctica, where more than 100 lakes have been found (including Lake Vostok).

Exploration of subglacial lakes involves the major technical challenge of somehow getting through the ice above and then into the water. There are two methods available. One is to drill through the ice, the other is to melt the ice. Drilling (or coring) the ice is unlikely to be appropriate for lake access because, to ensure that the core does not freeze against the cold ice, antifreeze must be pored into the core. Such antifreeze (usually a kerosene-based liquid), if it ever gets into the lake, would be a major contaminant, and would undermine the scientific credibility of the programme: who would trust the results of microbial detection if the equipment used had not passed contamination controls? This leaves melting the ice as the only feasible method. There are two ways of melting down into a subglacial lake. One is to use a 'thermo probe', which melts ➜





The exploration of Lake Ellsworth, involving hot-water drilling through the ice and the deployment of a 'hydrobot' probe into the lake, which will measure and sample water and lake-floor sediment

The detection of Lake Ellsworth using radio-echo sounding

➜ the ice as it travels down the ice column, which then freezes above it. Energy could be supplied to the probe via a tether which unwinds from the probe. The disadvantages, that 3.5 km of wire has to be stored in the probe and that the probe cannot return to the ice surface – thus disallowing sample return – mean that this technique is not well suited to subglacial lake research. This leaves hot-water drilling; a technique similar to ice coring, but using hot water to melt a hole within the ice. The problem with hot-water drilling is that no-one has ever drilled through more than about 2 km of ice. Thus, its proposition requires the largest hot-water drill to be designed. The major advantage that lake Ellsworth has over other lakes, from a hot-water drilling perspective, is that the ice in West Antarctica is likely to be much warmer than in East Antarctica, thus making hot-water drilling much easier. Moreover, the major advantage of hot-water drilling over other access techniques is that it is the only one that allows samples to be returned from the lake to the ice surface.

The UK plan for exploration of Lake Ellsworth is in three stages. The first is to undertake the detailed geophysical reconnaissance of the lake. This will involve radio-echo sounding to map the lake surface, and seismic sounding to measure the water depth. A proposal, led by the University of Bristol, has been submitted to the Natural Environment Research Council. The plan is to undertake the survey in the Antarctic summer of 2006-07. Stage two is to develop the technology required for lake access, measurement and sampling. Stage three is to undertake the fieldwork to explore the lake (see above). These last two stages are the focus of the Bristol-led plan for subglacial lakes research.

The exploration plan involves dropping a probe, tethered to the surface, through a borehole excavated by hot-water drilling, to the lake. The probe will contain a series of instruments, including sophisticated equipment to detect microbial life. The probe will be lowered through the water column, measuring and sampling the water body as it does so, to the lake floor. At this point it will obtain a sample of the lake-floor sediment and return to the ice surface. Samples will then be scrutinised in a variety of UK laboratories.

The Bristol-led plan for subglacial lakes research is the first of its kind. If successful, it will pave the way for other similar environments to be explored, both in Antarctica and on icy planets and moons elsewhere in the solar system. Consequently, the detection of life in Lake Ellsworth may be seen in future as a step to the discovery of extraterrestrial life. ■

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