Ancient air in an Antarctic ice core

Eric Wolff

I work in Antarctica, studying the ice which covers this landmass. In most of Antarctica, when snow falls, it doesn't melt: it just builds up year by year. In the middle of the Antarctic ice sheet, the ice reaches over 3 km thick. By drilling out an ice core (a cylinders of ice typically 10 cm in diameter), we can sample each year of snowfall in sequence. In practice, we collect the ice a few metres at a time using a drill on a long cable. The cores are several meters long when they are removed, but we slice them into sections for analysis.

Ice cores and air bubbles

You can see bubbles in the ice. These are full of air which is hundreds of years old. How do these bubbles form? As the snowfalls get buried, the weight of the layers of snow squeezes snow crystals together until eventually they form a solid network with bubbles of air trapped inside. The impurities in the ice and the air bubbles tell us how the composition of the atmosphere and the climate have changed over time.

An ice core as it is removed from the Antarctic ice

What to look for

The image on pages 10-11 is of a thin piece of ice cut from an ice core drilled out of the Antarctic ice sheet. The bright spots are bubbles of ancient air trapped in the ice as it was compressed. Each of the bubbles is a few tenths of a millimetre across, and each of them contains a sample of air that can be cracked open and analysed in order to find out the composition of the atmosphere in the past. In this particular picture, the ice is only around 1000 years old (and the air just a few hundred years old), but ice cores as old as 800 000 years have been retrieved and analysed from Antarctica.

The photograph overleaf shows a section from an ice core. By analysing it, scientists can find out useful information about the concentrations of gases and pollutants which were in the atmosphere at the time the air was trapped.

A scientist in the Antarctic drills out an ice core

A thin slice of Antarctic ice holds air bubbles, trapped for centuries.
Analysing this air tells us how our atmosphere is changing.

Catalyst

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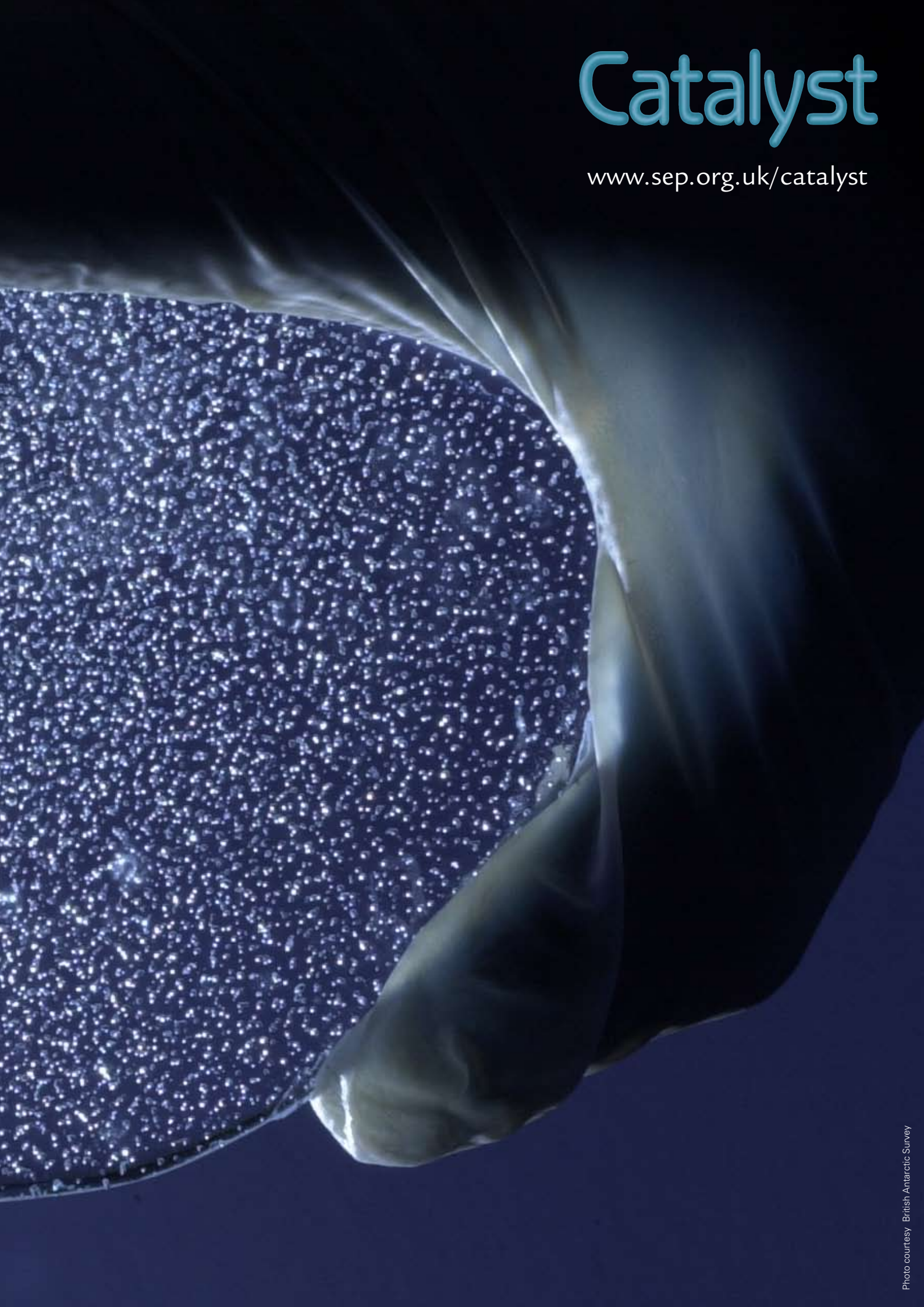

Photo courtesy British Antarctic Survey

Analysing air bubbles in ice

If you think of the ice as a container, then the air in the bubbles can be treated just like a sample of modern air collected in a canister. It just has to be extracted from the bubbles. This is done by placing the ice in a vacuum chamber and first removing all the modern air from the chamber. Then the ice can be cut into tiny pieces to release the air from the bubbles, and the chemical content of the air: nitrogen, oxygen, carbon dioxide and so on, can be measured by instrumental methods such as mass spectrometry and infrared spectroscopy. In fact, bubbles like the ones shown here are present only in the upper few hundred metres of an ice sheet. Below that the pressure actually causes them to dissolve into the ice as crystals called air hydrates (which have cages of water molecules surrounding each molecule of the gas). Fortunately, once the core has been drilled, the air can still be retrieved from air hydrates by the same methods.

The clean room at the British Antarctic Survey's headquarters in Cambridge where ice is analysed. The room needs to be completely clean to prevent modern impurities from contaminating the ice.

Results

The CO_2 content of the atmosphere has been measured routinely only since the 1950s. Almost everything else we know about its history comes from ice cores. From them we know that the concentration remained between 180 and 300 parts per million by volume (ppmv, ie the fraction of the volume of the air which is CO_2) for the entire 650 000 years until 1800 AD. Since the early 19th century, the concentration has increased, from 280 ppmv to its value this year (2008) of 383 ppmv, and is rising by 2 ppmv per year. The concentration of the next most important greenhouse gas, methane, has doubled in the same period.

Drilling ice cores in Antarctica

Obtaining ice samples like the one in the picture requires a huge effort, often involving scientists and engineers from several nations. The ice in the picture came from an Antarctic ice cap called Berkner Island, and was drilled by a joint UK and French team. The ice was 950 m thick at this site. Sand was found at the bottom of the hole, suggesting that the ice sheet was built on dunes of wind-blown sand. The oldest ice core so far retrieved from Antarctica was obtained by a 10-nation European team called EPICA (European Project for Ice Coring in Antarctica), and reaches back 800 000 years.

Dr Eric Wolff is one of the British Antarctic Survey's senior chemists. Read more about his Life in Science on page 4.

Look here!

For information about the British Antarctic Survey and the work which they do see, **www.bas.ac.uk**

Removing an ice core at the Berkner Island site.

All photos on pages 4-5 and 9-12 courtesy of British Antarctic Survey unless otherwise stated