Out of the ice

Tiny air bubbles trapped in polar ice provide up to 900,000 years of global climate data

Polar and glacial ice is a lot more than frozen water. It contains tiny bubbles of ancient air that was initially covered by snow and became trapped as the snow was buried and compressed into ice. Scientists can tell what the climate of the time was like by extracting this air and analyzing it for dust, ash, atmospheric gases—even radioactivity. They can date the air based on how deeply the bubbles were buried, since the deepest layers of ice are the oldest.

By driving a long hollow tube into the polar ice caps of Antarctica and Greenland, which are over 3000 m deep, researchers have extracted long cylinders or cores of ice that provide a climate record dating back hundreds of thousands of years. Ice cores offer a unique glimpse of prehistoric conditions. Changes in the global temperature and the composition of the air can be examined simultaneously and there are usually no interruptions in the data. The current ice core record covers the last six and a half ice ages.

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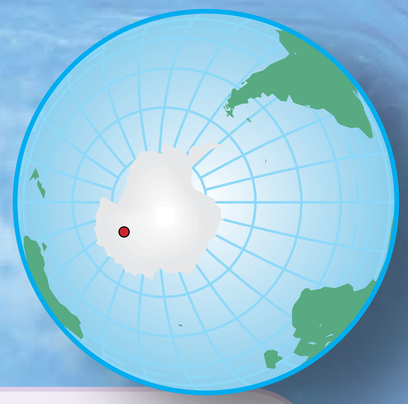
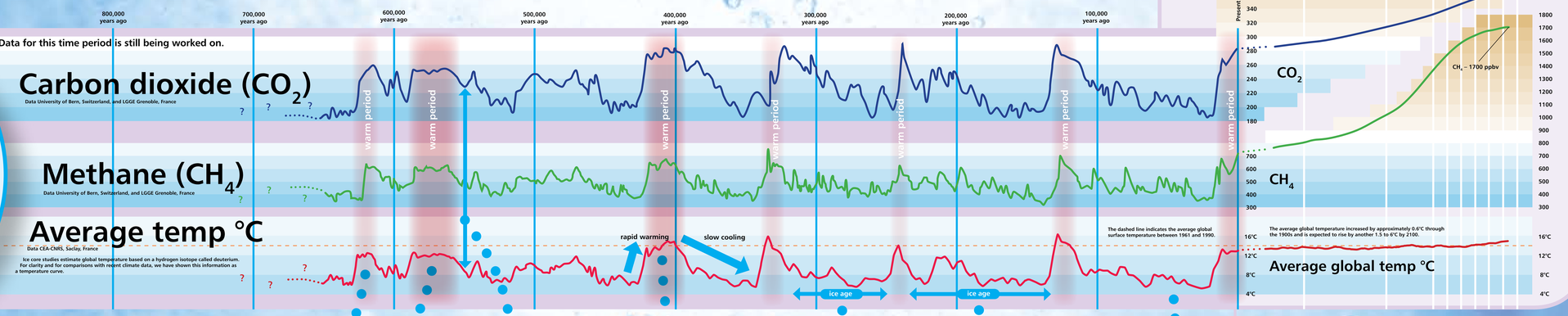
Research station at Dome Concordia erected as part of the European Project for Ice Coring in Antarctica (EPICA). The ice thickness at this location is estimated at 3,309 ± 20 m. The drilling was successfully terminated at a depth of 3,270.2 m on December 21, 2004. The age of the deepest ice is about 900,000 years.



The station is 3,233 m above sea level, 75° 06′ S, 123° 21′ E, and has an annual mean temperature of about –54.5°C!

Off the scale!

Ice core studies indicate that concentrations of atmospheric carbon dioxide and methane are currently higher than they have been in 650,000 years. Both gases have been accumulating in the atmosphere since the Industrial Revolution, when fossil fuels became a major source of energy. High levels of these gases are expected to cause a significant change in the global climate because of the contributions they make to the greenhouse effect.



Critical gases

By absorbing heat from the Sun, carbon dioxide and methane contribute to the greenhouse effect that keeps the Earth warm. Ice core studies show that atmospheric concentrations of these gases have been changing in tandem with the global temperature over the last six glacial cycles.

Visit the Time Tunnel in the Life Sciences Gallery for a more indepth look at how this ice core data relates to human population, species extinction, energy use, and so much more.

The oldest warm periods on record were cooler than more recent ones.

Which changes first?

Increases in carbon dioxide may have amplified warming trends that were already underway, with one exception. About 550,000 years ago an increase in carbon dioxide may have induced a warm period.

Each ice age has ended with rapid warming, followed by a slow return to cooler conditions.

A cool greenhouse

Ice core studies show that the Earth has been a cool place for most of the last 650,000 years. Ice ages have been the norm, except for brief warm periods like the one we are currently enjoying.

During the most recent ice age, the average global temperature was only 6–8°C cooler than the 1961–1990 average.

A small portion of this time line is also covered the panel to the right, which examines the climate of the last two thousand years.

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Drill head and ice core from a depth of 3,200 m from Dome Concordia Station. The age of the ice is about 800,000 years. This ice core contains a continuous climate history of the past 900,000 years.

Drill head and ice core from a depth of 2,874 m from Dome Concordia Station, drilled on November 30, 2002. The age of the ice is about 491,000 years.

Drill head and cutters were designed and constructed by Henry Rufli (University of Bern, Switzerland).

(Copyright: L. Augustin, LGGE Grenoble, France)

Thin cut of a polar ice sample illuminated through two polarizing filters. Grain boundaries appear in rainbow colours; the gas bubbles enclosed in the ice are dark. The diameter of the bubbles ranges from 1 to 3 mm.
The analysis of the gas composition in these bubbles permits the reconstruction of greenhouse gas concentrations (CO_2, CH_4, and N_2O) of the past 900,000 years.

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