Ice cores reveal climate change clues

To predict the future it is necessary to understand the past. In the field of climate change study of past environmental variation is limited, especially for events in the distant past. But ice cores extracted from deep in the polar regions offer a unique insight. The European EPICA project ventured to Antarctica to retrieve two continuous ice cores that extend the historical climate record back 800 000 years. Their analysis of the ice within these cores has made an extremely significant contribution to improving understanding of climate change, its mechanisms and consequences.

The European consortium that grew into EPICA was largely established during a large European project (GRIP) initiated in Greenland in 1990. The success of the Greenland research allowed the EPICA community to propose an Antarctic project. Ice cores retrievable from Greenland could take the record back 125 000 – 145 000 years, but Antarctica has much older ice to offer with the potential to go back over one million years.

The scope and size of the project was huge and involved considerably more challenges than the Greenland operations. Due to the size and duration of the undertaking, EPICA was financed via national contributions and a series of EU projects, the first being during FP5. European community funding has been continuous in supporting this important work over more than a decade.

Ice space

Two drilling sites were selected for ice core extraction: one in the Indian Ocean sector of Antarctica called Dome C and the other in Dronning Maud Land in the Atlantic Ocean sector. Operating in Antarctica resembles in many ways space exploration. The environment is alien and hostile. It is only possible to drill during the three-month Antarctic summer. At other times it is just too cold.

All equipment had to be brought by ship to the coast and then hauled to the drill sites by surface traverse. Near the coast deep crevasses are a constant danger. But the inland Antarctic interior is like a very cold dessert. "It is beautiful and very peaceful," says Dr. Hubertus Fischer, EPICA leader from the Alfred-Wegener Institute. "It really feels like being in the middle of nowhere. But one advantage is that if you are not sick when you get there you won't get sick – it is a sterile environment."

An Ice Core Drill works like an apple corer recovering at maximum a three-metre-long core. Both EPICA ice cores were drilled to a depth of 3 000 metres. At the deeper levels the process slows down and the retrieved cores get shorter. To complete the EPICA cores each took between 3 000 and 5 000 drill runs over several drilling seasons.

Hot results

Analysis of the EPICA cores has significantly extended our climate knowledge and the results have become the 'gold standard' for data on past changes in Antarctic climate. "From the cores ancient environments can be reconstructed including temperature, precipitation rate, atmospheric composition (CO_2, CH_4, NO_2 and other greenhouse gases [GHGs]) and we can use the N_2/O_2 isotope ratio as a reference for dating samples," says Fischer. "We can look at aerosols (sea salt and mineral dust) deposited in the ice, which are important for other bio-geochemical cycles and the radiative budget of our planet."

The EPICA team has now established a record of the Antarctic climate extending back 800 000 years showing how it has evolved over this period. One significant finding is that the 'warm', interglacial periods prior to 450 000 years ago were significantly cooler than those experienced in more recent cycles. And the amount of CO_2 in the atmosphere and the Antarctic climate have been tightly coupled over the entire period examined.

Highest GHGs levels now

The ice cores reveal that atmospheric levels of CO_2 and CH_4 – the two most important GHGs – are now at their highest levels for the last 800 000 years. Today, the level of CO_2 is about 30 % greater than the previous record, and there is two to five times more methane.

The ice cores also allow a unique and direct comparison between northern and southern hemispheres. High resolution analysis reveals a tight coupling of climate events in Greenland and Antarctica. This supports ideas on the influence of ocean heat transfer that may impact on current climate modelling.

Another significant result shows that mineral dust aerosol is an order of magnitude higher in glacial times compared to warmer times. This additional dust (which also contains iron) was capable of fertilising the marine biosphere – in particular to fix more CO_2 in the Southern Ocean. Models suggest that this iron fertilisation of the southern seas could only reduce CO_2 concentrations by ~30-40 ppm at most.

More work to do

The work of the 12-member-EPICA consortium is continuing. Currently, EPICA members are involved with a major project in Greenland with other international partners. But they are also interested in searching for older ice in Antarctica that could extend the record back to 1.5 million years.

This would be interesting because, around 900 000 years ago, there was a clear change in the climate system. Since that time the glacial/interglacial cycle has been roughly 100 000 years. Before then, the cycle was 40 000 years. Hopefully, ice core data can help explaining this.

The Descartes Prize will be used to continue and coordinate efforts in the EU research community that built EPICA. “It will be used to support continuing meetings including annual meetings of students and technical workshops – providing the ‘academic glue’ that keeps international collaborations functioning,” concludes Fischer. “And it will help in the planning for our next Antarctic project.”

INFO

EPICA – European Project for Ice Coring in Antarctica

Category

Earth Sciences

Partners

Dr Hubertus Fischer
Alfred-Wegener-Institute for Polar- and Marine Research
Am Handelshafen 12, Bremerhaven 27570, Germany
Tel: +49 471 48311174
Fax: +49 471 48311271
E-mail: Hubertus.fischer@awi.de

with:

Prof. Jean-Louis Tison
Université Libre de Bruxelles, Belgium
Prof. Thomas Stocker
University of Bern, Switzerland
Prof. Dorthe Dahl-Jensen
University of Copenhagen, Denmark
Dr Valérie Masson-Delmotte
CNRS/Commissariat à l’Énergie Atomique, France
Dr Gérard Jugie
Institut Polaire Paul Emile Victor, France
Dr Massimo Frezzotti
Ente per le Nuove Tecnologie, l’Energia e l’Ambiente, Italy
Prof. Valter Maggi
Università degli Studi di Milano Bicocca, Italy
Dr Michiel van den Broeke
Universteit Utrecht, The Netherlands
Dr Elisabeth Isaksson
Norsk Polarinstitutt, Norway
Dr Margareta Hansson
Stockholm University, Sweden
Dr Eric Wolff
National Environmental Research Council/British Antarctic Survey, United Kingdom