Antarctic ice cores

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Terrestrial and marine paleoclimate records are very sparse in the southern hemisphere, particularly at high latitudes. However, this is where ice cores come into their own. Antarctic ice cores provide a firm and well-resolved anchor for our understanding of how climate has evolved over 800 kyr, and provide climate information for assessing how the Antarctic Ice Sheet may have varied over the same period. They are also the best archive for determining the history of greenhouse gas concentrations and offer unique data on other important forcings, such as volcanic aerosol and solar.

Characteristics of Antarctic ice cores

Almost the whole of the Antarctic ice sheet fulfills the basic requirements for good ice core records, namely that snow is laid down in regular layers without significant loss or percolation by melting. In near coastal areas, relatively high snow accumulation rates allow the collection of records for which annual layer counting is possible. This is the area of choice for well-resolved and precisely dated records of recent centuries. In central regions of the Antarctic plateau, the ice is very thick (~3 km) but the snow accumulation rate may be as low as 2 cm water equivalent. It is in this region that records extending back over hundreds of thousands of years can be found, although the dating is necessarily less precise.

The water isotopes in the ice act as a good proxy of Antarctic temperature and also provide information on conditions over the ocean (the source of the water vapor). Due to the low impurity content of the ice, Antarctic cores are well suited to analysis of trace gases, and the chemical content provides information about environmental conditions in the Southern Ocean and other southern continents.

Recent centuries

As atmospheric measurements of greenhouse gases have only been carried out routinely for, at most, a few decades, ice cores have for some time been relied upon to show how greenhouse gas concentrations increased during the past two centuries, and how they varied in the preceding period. A new study (MacFarling Meure et al., 2006) has extended the period of high-resolution to 2 kyr, expanded the high-resolution work from CO2 and CH4 to include N2O, and filled in gaps in the previous records. Together with the existing data and other data from sites with lower-resolution that confirm most of the details, this work provides a definitive account of greenhouse gas variability and trend; it is indeed

References


For full references please consult: www.pages-igbp.org/products/newsletter/ref2007_2.html

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Figure 1: Map of cores and locations mentioned in text. Inset: photo of WAIS Divide site, with camp in center and drilling site top left corner (E. Brook).
Past Climate Dynamics: A Southern Perspective

Glacial-interglacial cycles

Probably the biggest excitement in the ice core community in the last few years has come from analyzing the oldest parts of three newly completed deep ice cores: the EPICA cores at Dome C and Dronning Maud Land, and the Dome Fuji core (Fig. 1). Much of the new science coming from these cores has relied on advances in datums that are accurate enough to allow reliable conclusions to be made regarding the phasing of insolation forcing and climate changes.

The water isotope analysis of the Dome C core has now been completed at high resolution and reveals the temperature history of Antarctica back to just beyond 800 kyr (Fig. 2) (Jouzel et al., 2007), confirming that glacial cycles occurred at 100 kyr intervals throughout but with different styles and amplitudes. It has now been shown that every Dansgaard-Oeschger (DO) event in the northern hemisphere appears to have a subdued counterpart in the south (EPICA Community Members, 2006); further improvements in the definition of the phasing between northern and southern records are still needed but this result is highly suggestive of ocean heat transport as the main player in these changes. The pattern of climate variability seen in each glacial cycle strongly suggests that DO events occurred in earlier glacial periods (Jouzel et al., 2007). Chemical records (Wolff et al., 2006) covering the EPICA Dome C period open up the possibility of assessing the causes of climate change through a range of environmental parameters, since the chemical signals provide information about, for example, South American climate, aerosol concentrations, inputs for iron fertilization, sea-ice extent and marine productivity.

Ongoing projects and future plans

The brief summary above omits numerous interesting data sets, analytical developments and interpretive improvements. Further progress will also come from a number of projects that are currently under way. The US West Antarctic Ice Sheet (WAIS) Divide ice core (Fig. 1) is intended to provide a high-resolution (comparable to Greenland) record of the last glacial cycle in West Antarctica; this should be a particularly good core for assessing the phasing between north and south and between climate and CO2. The camp construction and pilot hole were completed in 2006/07 and the core should be drilled in the next 3 seasons. Meanwhile, other sites have progressed and contribute to a spatial network of cores covering a similar period. At Berkner Island (Fig. 1), sand was collected from the cold base of the ice sheet in 2005/06 and 948 m of ice is now being processed. This core is revealing both the climate and the ice sheet configuration in the Weddell Sea sector of Antarctica.

Meanwhile, drilling is continuing at Talos Dome in Victoria Land, from the depth of 1300 m reached in 2006/07 (Fig. 1).

For the future, IPICS (International Partnerships in Ice Core Science; www.pages-igbp.org/science/initiatives/ipics/whitewapapers.html) has defined a series of 4 priority science projects and associated technical challenges. Of the 3 projects including Antarctica, one has the ambitious aim of reaching still older ice and assessing the climate and trace gas content during 40 kyr climate cycles that preceded the mid-Pleistocene revolution. Other projects aim to construct a network of cores covering the last 40 kyr, to assess the spatial pattern of change during rapid climate events, and a network of cores representing 2 kyr to contribute Antarctic data to climate reconstructions.

References


For full references please consult: www.pages-igbp.org/products/newsletter/infostories2007_2.html