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Antarctica, Australia and Global Climate Change: Greenhouse to Ice House

May 2000 The frozen continent of Antarctica was once a relatively warm place that featured rain forests with southern beeches and ferns, researchers participating in the Ocean Drilling Program (ODP) discovered after spending two months at sea studying marine sediment cores.

The rain forest existed 40 million years ago, when Australia and Antarctica were joined together. What happened as they separated had dramatic consequences for the world's, and Australia's climate.

These events were the subject of a just-completed deep-sea sediment coring expedition off Tasmania by the Ocean Drilling Program's giant drillship, *JOIDES Resolution*.

On 6 May, the vessel berthed near Circular Quay in Sydney after almost two months at sea, having departed from Hobart on 16 March.

On the cruise an international group of 30 geoscientists, led by Australian Dr Neville Exon of the Australian Geological Survey Organisation and American Dr Jim Kennett of the University of California at Santa Barbara, studied 4500 metres of sediment core recovered from five drill sites. When placed end-to-end this core would extend ten times across Sydney Harbour beneath the Harbour Bridge. The deepest hole drilled during the cruise reached 960 metres beneath the sea bed, and the shallowest site was located in water more than 2000 m deep, deeper than Mt Kosciusko is high.

The sediment cores consist of mineral grains, spores and pollen derived from the land, and the hard parts of innumerable minute creatures that lived in the seas off Tasmania during the last 70 million years. They record conditions in the ocean and on land from the end of the Cretaceous (the age of dinosaurs) through to the present day, and help us put Australia's historical climatic fluctuations into a long-term context.

The drill sites are located on sunken continental blocks extending 600 km south of Tasmania. This region had been at polar latitudes during the late Cretaceous, when Australia was snuggled up against Antarctica. In fact, these continental blocks could be considered part of Antarctica until about 35 million years ago, when Australia separated from its southern neighbor. The cores from our drill sites show that throughout this time period this part of Antarctica was relatively warm, with little ice, and supported temperate rain forests with southern beeches and ferns - part of the "Greenhouse" world. The sea in this region was also relatively warm and shallow.

Temperatures reached a peak at about 55 million years ago, when the entire planet was much warmer, and ocean circulation was quite different than today. About 45 million years ago, Australia started to move northward away from Antarctica at a rate of about 5 cm per year, the rate at which our fingernails grow. This separation was to have great climatic consequences.

By about 30 million years ago, when the Tasmanian land bridge had separated from Antarctica, cold currents were able to circulate around Antarctica, thereby isolating it from warm currents flowing southward from the tropics, and allowing ice sheets to form there. The sediment cores show that as the formerly warm, shallow seas around Tasmania were cooling and deepening, much of the land bridge had subsided beneath the ocean, and less sediment came from the land. There were large temperature fluctuations over relatively short time periods, the details of which can be read in the cores. The cores contain sedimentary oozes, consisting largely of calcareous and siliceous skeletons of microscopic plankton, which accumulated on the seafloor after dying. By 15 million years ago, most of Antarctica was a frozen continent buried deep under ice caps, and the Earth had entered the "Ice House" world.

The ODP cores contain dust particles which became more abundant after 5 million years ago, as Australia became drier and these particles were increasingly blown offshore. By that time, Australia's movement northward into mid latitudes, combined with progressive global cooling, led to massive aridity of the continental interior. The global cooling eventually led to the periodic ice ages of the last 2 million years. We currently live in a warm spell between glacial periods.

Future research on the cores will refine the shipboard results and enable the scientists aboard the vessel to build up a detailed record of what happened through time in this climatically important region of the world, and build a coherent story of 'how' and 'why' these changes occured. Comparisons with sequences drilled elsewhere along the Antarctic margin will further improve our understanding of these momentous changes in Earth's history, and will provide additional boundary conditions for understanding modern climates.

The Ocean Drilling Program, an international partnership of scientific institutions and governments, explores the Earth's history and evolution. The Ocean Drilling Program is funded principally by the U.S. National Science Foundation, with substantial contributions from its international partners. These include the Federal Republic of Germany, Japan, the United Kingdom, the Australia/Canada/Chinese Taipei/Korea Consortium for Ocean Drilling, the European Science Foundation Consortium for Ocean Drilling (Belgium, Denmark, Finland, Iceland, Italy, The Netherlands, Norway, Portugal, Spain, Sweden, and Switzerland), France, and the People's Republic of China. The program is managed by Joint Oceanographic Institutions, a consortium of 14 U.S. institutions, with Texas A&M University responsible for science operations and Lamont Doherty Earth Observatory responsible for logging services. Sydney University hosts the Australian Secretariat of the Ocean drilling Program.

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