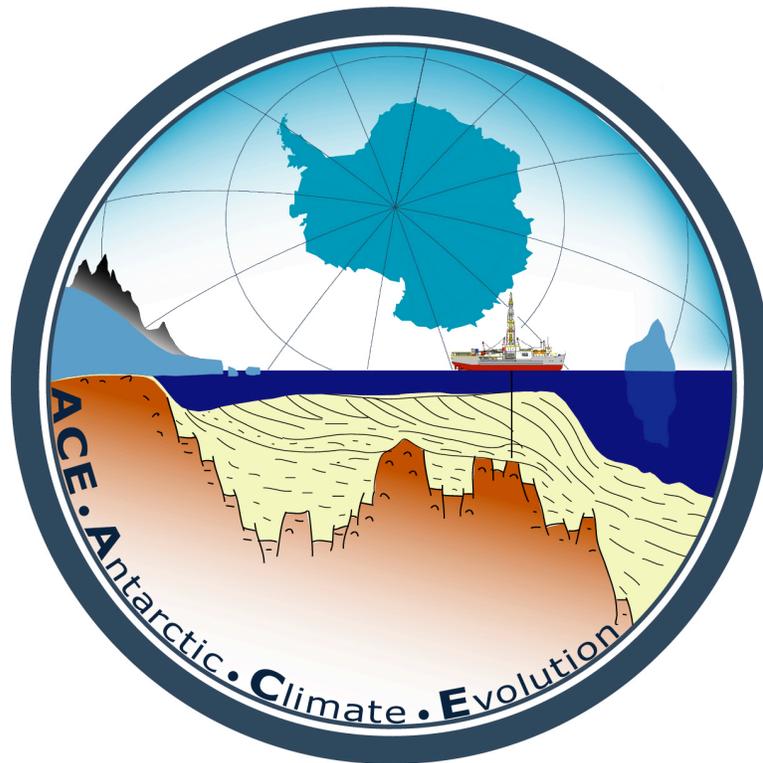


# REPORT ON

## ANTARCTIC CLIMATE EVOLUTION (ACE)



*An international research initiative to study the climate and glacial history of Antarctica through palaeoclimate and ice-sheet modelling integrated with the geological record.*

ACE Scientific Programme Planning Group, March 13 2006.

<http://www.ace.scar.org/>

This report was prepared using a template provided to ACE by the Executive Director of SCAR.

Title of group: **Antarctic Climate Evolution (ACE), Scientific Research Programme**

Estimated SCAR funding required for the next 2 years (in USD): **\$50,000**

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## SUMMARY OF FIVE MAIN ACHIEVEMENTS

ACE promotes the exchange of data and ideas between research groups focussing on the evolution of Antarctica's climate system and ice sheet. Although it has only been running officially since the beginning of 2005, its two-year planning phase and its origins from the former SCAR programme ANTOSTRAT, which ended in 2001, has allowed ACE to develop several advances in our understanding of Antarctic history. ACE's role is to facilitate cooperation between earth scientists through meetings and symposia, to assemble the results of these collaborations in the scientific literature, and to promote the development and funding of international research collaborations. Full details of the ACE programme can be found on its website, launched in January 2005 ([www.ace.scar.org](http://www.ace.scar.org)).

ACE's five main achievements to date include:

**1.** Publication of two papers in *Nature*, which demonstrate that the onset of the Antarctic Ice Sheet at 34 million years was an inevitable consequence of CO<sub>2</sub> lowering, triggered but not solely caused by the opening of the Drake Passage.

DeConto, R.M., Pollard, D. 2003a. Rapid Cenozoic glaciation of Antarctica triggered by declining atmospheric CO<sub>2</sub>. *Nature*, 421, 245-249.

Barrett, P.J. 2003. Cooling a continent. *Nature*, 421, 221-223

**2.** Publication of an ACE paper in *Geology*, showing that the formation of the trough mouth sedimentary fan in Prydz Bay was due to a feedback between the ice sheet and the base that it erodes. The trough carved out by the glacier resulted in faster flow within it and, consequently, a point source for fan development at the shelf break.

Taylor, J., Siebert, M.J., Payne, A.J., Hambrey, M.J., O'Brien, P.E., Leitchenkov, G., Cooper, A.K. Late Miocene/early Pliocene changes in sedimentation paths, Prydz Bay, Antarctica: changes in ice-sheet dynamics? *Geology*, 32, 3, 197-200. (2004).

**3.** Publication of **THREE** special issues on the glacial and climate history of Antarctica:

Florindo, F., Cooper, A.K. and O'Brien, P.E. (Editors), 2003. Antarctic Cenozoic palaeoenvironments: geologic record and models. *Palaeogeography, Palaeoclimatology, Palaeoecology*, vol. 198, Issues 1-2, 1-278.

Florindo, F., Harwood, D.M., Wilson, G.S. (Editors), 2005. Long-term changes in Southern high-latitude ice sheets and climate: the Cenozoic history. *Global and Planetary Change*, vol. 45, 1-264. This issue featured a mix of modelling and data papers with a focus on the Eocene–Oligocene boundary and the initiation of ice sheet growth, together with papers on seismic stratigraphy and reports from drilling around the margin.

Barrett, P., Florindo, F. and Cooper, A. (Editors) (2006). "Antarctic Climate Evolution - view from the margin". *Palaeogeography, Palaeoclimatology, Palaeoecology*, v. 231, p 1-252. The papers within

this issue cover a wide range of techniques and timeframes concerning the evolution of the Antarctic continental margin, ranging from detailed sedimentary analyses of the Cape Roberts Project core to numerical modelling investigations of ice sheet growth and decay.

4. Since 2004, ACE has organised seven dedicated sessions at international workshops (details below).
  - August 2004; A full session of the International Geological Congress, organised by Fabio Florindo and Peter Barrett, entitled ‘Cenozoic Antarctic Glacial History’.
  - December 2004; A full session at the Fall AGU, organised by Alan Haywood and Paul Valdes, entitled “Antarctic Climate, Neogene Proxies, and Climate Modeling”. The session addressed Antarctic and global proxy records of Neogene climate and environmental change. The aim was to synthesise results from marine and terrestrial proxy data for the Miocene and Pliocene and to combine them with outputs derived from numerical climate and ice-sheet models.
  - August 2005; An international symposium, co-sponsored by ACE (with International Association of Sedimentologists (IAS), the main sponsor, plus the International Commission of Snow and Ice, the International Glaciological Society, the International Quaternary Association, the Quaternary Research Association and the British Geological Survey) entitled "Glacial Sedimentary Processes and Products". The meeting was held at the University of Wales Aberystwyth. It promoted dialogue between researchers in the fields of contemporary glacial processes, glacial sedimentology and ice sheet modellers in order to advance these fields in an integrated way. Contributions were given from researchers working on all aspects of glacial sedimentary processes and products in glaciomarine, glaciolacustrine and terrestrial settings, from Archaean times to the present day.
  - August 2005; A full session of the Earth Systems Science symposium, held in Calgary, Canada, and organised by Alan Haywood, entitled “The Last Great Global Warming: Proxy Reconstructions and Modelling the Pliocene Climate”. The Pliocene was the most recent period in Earth history in which temperatures were as warm as they are likely to be within the next century. The session addressed fundamental questions concerning our knowledge of the Pliocene world, including what the biota, climate and environments of the Pliocene were really like, why was the climate warmer than today, what was the nature of Pliocene climate variability and what relevance does the period have to the future climate change debate?
  - September 2005; An international workshop, co-sponsored by ACE, entitled “Cenozoic onshore and offshore stratigraphic record from the East Antarctic margin: recent results and future directions”. The meeting was organised by Laura De Santis and Carlota Escutia Dotti. Its aim was to discuss the state of knowledge of Cenozoic East Antarctic ice sheet evolution and to define future research activities in the east Antarctic margin, including activities related to proposed IODP Wilkes Land drilling.
  - December 2005; Fall AGU special session organised by Tony Payne, Colm O’Cofaigh and Glenn Milne (all member of the LGM-Holocene Committee) on "Antarctic Ice Sheet Evolution from the Last Glacial Maximum to the Holocene: Recent Advances From Modeling and Field Investigations". The aim of the session was to bring together modellers and field-based researchers working on the evolution of the Antarctic Ice Sheet (AIS) from the time of the Last Glacial Maximum (LGM) and extending into the Holocene. The main theme of the session was to discuss new results that advance our understanding of the development of the AIS during this period and the consequent implications for regional and global climate change, as well as future AIS retreat. The session was very well attended and attracted contributions from the following communities: terrestrial glacial geology and geomorphology; marine geology and geophysics; studies of high-resolution ice core and sediment core records; glaciological modelling; climate modelling; and modelling of glacial isostatic adjustment.

5. ACE has established links with ongoing research activities concerning geological and geophysical data acquisition, and modelling as follows:

- ANDRILL (a deep sediment core drilling project in Antarctica): ACE co-sponsored the last steering group meeting of ANDRILL, in Leeds, July 2005. The results of ANDRILL are of direct relevance to ACE as they address the evolution of the Antarctic ice sheet in response to climate change in the Ross Sea region. Consequently, many of the ACE team are also members of the ANDRILL community, and thus the two groups have strong synergies and connections. The ANDRILL community met jointly with the ACE steering committee at the San Francisco AGU meeting in December 2005.
- Radio Echo-Sounding: ACE has assembled a committee to promote the acquisition of radio-echo sounding data in Antarctica, from which subglacial topography, which make up a critical yet currently incomplete boundary condition of numerical models, can be established. This group will meet at the European Geophysical Union, Vienna April 2006.
- Modelling: Following its workshop on modelling, held in 2002, ACE has overseen the development of new models of the ice-ocean-climate-lithosphere system in Antarctica, which are currently being used to investigate earth system processes. For example, DeConto and Pollard has recently built a model that predicts sediment transport beneath the ice sheet. When included in time-dependent runs of ice sheet development the model reveals how sediments are eroded and deposited. Such output can be compared against the geological record to help understand ice sheet histories.

## **PROGRAMME DISSEMINATION**

In terms of dissemination, posters and brochures for ACE have been designed, as has a logo, and these have been distributed at numerous international conferences over the past four years. The ACE website is available at [www.ace.scar.org](http://www.ace.scar.org), and has received over 2000 hits since May 2005. These items provide a means by which future scientific results may be provided to a broad audience.

## **PROGRESS AGAINST PRIOR WORK PLANS**

### **What is the overall rationale and goal for each activity?**

As stated in the ACE proposal (2004), “the main function of the programme lies in the acquisition and compilation of “ground truth” geoscience data, and the use of these data in developing a suite of palaeoclimate models (both continent-wide, Southern Ocean-based, and sectorial) for the Antarctic region for significant periods of climate change through Cenozoic times”. To meet this aim, the project has established an implementation plan, approved by the SCAR executive committee in 2005.

### **What were the planned milestones and deliverables?**

The first year of ACE involved executing the first stage of the implementation plan. Specifically, this meant establishing a series of sub-committees to deal with each of the time and process-led themes of ACE. In addition, ACE committed to analysing geophysical data of the Antarctic ice sheet englacial structure, in order to ascertain information related to ice flow and accumulation changes.

### **What milestones were met, and what deliverables provided?**

The ACE implementation plan has been undertaken as agreed. All the subcommittees proposed have been established and work has begun within them. The scientific commitment to analysis ice sheet geophysical data has been met fully.

### **What were the main achievements during the 2-year cycle?**

The main achievements of ACE over the last TWO years have been:

- to activate its implementation plan,
- to undertake SEVEN special sessions at international conferences,
- to publish TWO special volumes dedicated to papers presented at ACE meetings

### **What are the links to other national and/or international activities?**

ACE has relevance to several major international programmes. In particular several members of the ACE programme are also involved in the Antarctic Drilling Programme, ANDRILL. ANDRILL aims to acquire sedimentary records of past climate change from a variety of locations around the Antarctic Continent. ACE is able to support ANDRILL by offering small funds to assist with meetings, and helping the integration of numerical modelling and geological data.

ACE has good connections with the science programme of the European Project for Ice Coring in Antarctica (EPICA). ACE can assist EPICA by facilitating comparison, integration and modelling of EPICA (and other ice coring) results with palaeoclimatic data from other sources (e.g. marine and lake sediment cores and terrestrial geological records). In particular, ACE can serve as a means by which the ANDRILL, EPICA and ice sheet modelling communities may integrate.

ACE is in the process of establishing links with PAGES (the ‘past global changes’ programme of the IGBP <http://www.pages.unibe.ch>). Julie Brigham-Grette was present at the ACE steering committee meeting (December 2005) to discuss ACE participation within PAGES. One possible way forward is for ACE to take responsibility for the full production of a PAGES sponsored publication on past changes in Antarctica.

ACE is developing links with the JCADM (Joint Committee on Antarctic Data Management) and, to assist with this link, Rob Bauer has been recruited to the ACE steering committee.

### **What deviations were made from the work plan, and why?**

None

### **What SCAR funds were allocated to the activity?**

ACE received \$21,000 from SCAR in 2005. In addition, ACE received \$5000 in 2005 from an anonymous donor, and \$8000 were carried forward from the previous year: total \$34,000.

### **How were the SCAR funds spent?**

SCAR funds have been used sparingly over the last two years. This low spending has, with the agreement of Colin Summerhayes, been possible by arranging ACE meetings at international symposia where funds for travel and accommodation are available from other sources. SCAR has not, thus far, paid for the bulk of ACE meeting expenses. ACE funds are consequently being built up to a level in which a large international ACE meeting is possible (possibly in 2006). Some ACE funds have been spent, as follows:

	<b>Funding (2005)</b>	<b>Expenditure</b>	<b>Funds</b>
	<b>34,000.00</b>	<b>12,742.45</b>	<b>21,257.55</b>
ACE web (University of Massachusetts, R Dunbar)	2,000.00	2,000.00	
IACT (ACE)Workshop Escutia 05 (US\$ 5,000)	5,000.00	5,000.00	
ACE mtg, Vienna		2,352.15	
ACE data entry (Darren Atkinson, Aberystwyth)		363.64	
ANDRILL (Jane Francis)		776.95	
East Ant. Margin Wshp., Spoleto, Italy, Sept 05		1,020.45	
ACE SSG Mtng., San Francisco, Dec 05		1,229.26	

**A further \$21,000 has been awarded in 2006.**

## **PROPOSED WORK PLAN FOR THE NEXT 2 YEARS:**

### **What new activities are planned?**

The tasks, deliverables and time-lines we envisage are outlined in the table below. This should be viewed as a guide, as it is difficult to be prescriptive in charting future progress in research.

<b>Themes</b>	<b>2005-6</b>	<b>2006-7</b>	<b>2007-8</b>	<b>2008-9</b>	<b>2009-10</b>
<b>Holocene/last glacial maximum/ and Pleistocene</b>	Internal layers, ice flow and accumulation reconstruction.	Complete review of Antarctic ice sheet – ice shelf – Southern Ocean record	Review of data collected by IMAGES and ANDRILL projects.	Assess reviews of Quaternary and Pliocene in light of new data from S Ocean and sub-Ross IS core.	Publish state-of-the art report on data and modelling AIS history and behaviour from a perspective of both long term (10 <sup>3</sup> -10 <sup>6</sup> years and short-term (1 to 10 <sup>2</sup> years) climate change over the last 5 million years.
<b>Pliocene</b>	Continue review of sedimentary cores from Legs 178 and 188 (plus sediment cores from national programs).  Continue fostering IODP proposals for Wilkes Land and Ross Sea.  Earth Systems Processes 2 meeting in Calgary, August	Continue review of sedimentary cores from Legs 178 and 188.	Complete review of on-land and offshore record.  Revise IODP proposals for Wilkes Land and Ross Sea.  Develop proposals using SHALDRIL and ANDRILL technologies.  Convene session at ISAES, Santa Barbara USA	International meeting on the Neogene and Antarctica, Cambridge, summer 2008.	
<b>Middle Miocene</b>	Continue review of sedimentary cores from Leg 188.  Continue fostering IODP proposals for Wilkes Land and Ross Sea	Complete review of offshore record – revise IODP proposals for Wilkes Land and Ross Sea.  Develop proposals using SHALDRIL and Cape Roberts (ANDRILL) technologies.	Revise IODP proposals for Wilkes Land and Ross Sea.  Convene session at ISAES, Santa Barbara USA	International meeting on the Neogene and Antarctica, Cambridge, summer 2008.	Publish state-of-the art report that includes new data from ANDRILL, SHALDRIL, IMAGES and IODP integrated with modelling AIS history and behaviour for the period from 50 to 10
<b>Oligocene-Miocene boundary</b>	Continue review of Cape Roberts cores.		Convene session at ISAES, Santa Barbara USA	Assess reviews in light of new ANDRILL,	

<b>Eocene-Oligocene</b>	Continue review of sedimentary cores from Leg 188.  Continue fostering IODP proposals for Wilkes Land and Ross Sea.	Paleogene-Neogene climate-ice sheet modelling workshop at the ANDRILL data integration meeting in New Zealand in 2007	Convene session at ISAES, Santa Barbara USA	SHALDRIL and IODP data.  Greenhouse-Icehouse trans. Session at AGU-Fall meeting, Dec 2008	Ma ago.
<b>Radio Echo Sounding</b>	Analyse existing data to reveal internal layer structure of both ice sheets	Plan future exploratory research	Begin new surveys of East and West Antarctica, to fill data gaps.  Convene session at ISAES, Santa Barbara USA	Continue surveys, and provide data to numerical ice sheet modeling community.	Continue surveys, and provide data to numerical ice sheet modeling community.

Outline of tasks, deliverables and timelines for work to be carried out under the aegis of the ACE programme from 2005 to 2010.

Further plans for ACE in 2006-7 include:

- (1) a special session of the 2006 EGU entitled "Deep Time Perspectives on Climate Change: Marrying the Signal from Computer Models & Biological Proxies" - Session CL16,
- (2) A field campaign in 2006, led by the British Antarctic Survey on James Ross Island. The aim of the fieldwork is to map, describe, sample and photograph glacial sedimentary sequences and associated fossils on James Ross Island. The rock and fossil samples will be analysed to create realistic environmental reconstructions and new data on environmental change, particularly Antarctic ice sheet history, over the past 7-10 million years. Particular foci of the work are to identify the source region(s) and thermal regime(s) of former ice sheet(s), to document any significant impact caused by the so-called "warm Pliocene" interval (the period between 3 and 5 million years ago), and to identify and date periods of significantly reduced ice cover (so-called "interglacials"). The warm Pliocene period is the closest analogue for Earth conditions that we are likely to experience in the next 100 years. The new information obtained from this project will be used as critical input to climate models identifying how global change will occur throughout the next 300 yrs.
- (3) Fostering the IODP Wilkes Land drilling plan, now in the preliminary IODP drilling schedule for Austral summer 2008-2009.
- (4) Developing the IODP Ancillary Programme for obtaining a Holocene ultra-high resolution record of climate variability from the Adelie Drift (Wilkes Land)
- (5) Supporting and encouraging involvement with the ANDRILL programme.
- (6) Developing an international plan for the collection of airborne and ground based geophysical data relating to the Antarctic ice sheet (i.e. ice thickness and bed elevation data in current 'data free' zones and in regions of glaciological change).

### **What are the new planned milestones and deliverables for each (new or continuing) activity?**

None

### **What SCAR funds are required to support the activities and how will they be used?**

SCAR funds are requested to assist with workshops and symposia. It is essential to note that ACE has resisted spending money solely on ACE steering committees, but cannot rule out such expenditure in the future. The funds unspent in the last year should be viewed as a tremendous effort on the part of ACE. These saved funds must be made available for ACE in the next two years.

**Why is SCAR support needed for these activities (what is the value added)?**

There is a great deal of value-added to ACE activities. Most of these are underpinned by funding from national research councils. The part that ACE plays is to pull together in international partners in a way not possible without SCAR support. The result is that ACE, and therefore SCAR, excels in supporting international research on issues related to Antarctic Climate Evolution.

**To what extent will these activities complement other national and international activities?**

ACE's role is to bring together the scientific efforts of the international community, which are likely to be funded by individual research councils. For example, ACE has assisted with a recent steering committee of ANDRILL, and has initiated an international committee to oversee the development of geophysical data acquisition in Antarctica.

**IPY CONTRIBUTIONS****What IPY projects are SSG members contributing to and which are they leading?**

ACE has been accepted as a fully endorsed project of IPY. It has strong links with BIPOMAC, a project aiming to understand the glacial history of both polar regions.

**What progress has been made against past recommendations?**

No scientific recommendations have been made to date.

**SUPPORTING INFORMATION**

ACE's steering committee and subcommittee members include scientists from Argentina, Australia, Belgium, China, France, Germany, the Netherlands, New Zealand, Sweden, UK and the USA.

**Names and affiliations of co-Chairs**

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