ACE - Antarctic Climate Evolution

http://www.ace.scar.org/
to continue the study of Antarctic climate and glacial history, by linking climate and ice sheet modelling studies with geophysical surveys and geological investigations on and around the Antarctic continent
<table>
<thead>
<tr>
<th>CENOZOIC</th>
<th>Quat.</th>
<th>Pleistocene</th>
<th>1.8 Ma</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>NEOGENE</td>
<td>Pliocene</td>
<td>5 Ma</td>
</tr>
<tr>
<td></td>
<td>TERTIARY</td>
<td>Miocene</td>
<td>24 Ma</td>
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<tr>
<td></td>
<td>PALAEogene</td>
<td>Oligocene</td>
<td>34 Ma</td>
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<tr>
<td></td>
<td></td>
<td>Eocene</td>
<td>58 Ma</td>
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<tr>
<td></td>
<td></td>
<td>Palaeocene</td>
<td>65 Ma</td>
</tr>
</tbody>
</table>
Rationale for ACE
Variation in the Earth's temperature during the last 65 million years, based on reconstructions from deep-marine oxygen isotope records.

Note the general cooling trend from 50 million years ago. Also note the abrupt “climatic threshold events”.

For example Oi-1 at 33 million years ago when abrupt global cooling led to the first ice sheets developing on Antarctica. Future atmospheric temperature scenarios are based on IPCC greenhouse trace gas projections are shown at top of diagram.

Given the worse case scenario, planetary temperatures could increase in 100-300 years to a level where, according to our knowledge of previous Antarctic glaciations, ice cover on Antarctica could not be sustained.
Recent geological and glaciological field activities in Antarctica, illustrating the variety and spatial extent of existing and forthcoming datasets useful to the ACE programme.
Functions of the programme

The main function of the programme lies in the acquisition and compilation of “ground truth” geoscience data from geophysical surveys and drilling, and the use of these data in developing a suite of palaeoclimate models (both continent-wide and sectorial) for the Antarctic region for significant periods of climate change through Cainozoic times.

ACE will manage work within several sub-committees:

- Last Glacial Maximum & Holocene (Tony Payne)
- Pleistocene (Tim Naish)
- Middle Miocene-Pliocene (Alan Haywood)
- Oligocene Miocene (Rob DeConto)
- Eocene-Oligocene (Jane Francis)
- Radio Echo Sounding (Detlef Demaske)
Sub-committee reports
Last Glacial Maximum
AGU Session

• Session on "Antarctic Ice Sheet Evolution from the Last Glacial Maximum to the Holocene" at the 2005 Fall meeting of the AGU.
• The session concentrated on the recent controversy on the origin of Meltwater Pulse 1A at 14,200 years before present.
LGM in Lambert-Amery region
Lambert Glacier-Amery Ice Shelf System

[Graph showing m altitude vs. km from present ice shelf edge with various data points and labels.]

- 9.5 ± 0.7 km
- 71.4 ± 5.0 m altitude
- 84.4 ± 5.6
- 156 ± 11
- 12 cal ka BP (Domack et al. 1998)
- 15 cal ka BP (Hemer and Harris, 2003)
Middle Miocene-Pliocene

7 – 3Ma
Progress

Special Sessions

Publications

Fieldwork

Current Activities & Future Plans
ACE: Middle Miocene to Pliocene Sub-Committee

Sub-committee members:

Alan Haywood (BAS; Chair)
John Smellie (BAS; Co-Chair)
Carrie Lear (Cardiff University)
Sandra Passchier (Montclair State University)
Paul Valdes (Bristol University)
Allan Ashworth (North Dakota State University)
Fabio Florindo (Istituto Nazionale di Geofisica e Vulcanologia)
Dave Cantrill (Swedish Museum of Natural History)
Roderick van de Wal (Utrecht University)
2005-2006 Field campaign to James Ross Island

Anna Nelson (BAS)
Objectives of the work

• Determine the depositional setting of Neogene glacial sediment on James Ross Island
• Understand the nature of the deforming bed at the ice-bed interface of Neogene glaciers
• Determine the mode of sedimentation, thermal regime, and extent of the ice masses (APIS and local ice cap) associated with Neogene glacial sediment
• Apply these results to climate/vegetation/glaciological models
Mapped Neogene glacial sediment outcrops

2005-2006

2006-2007
Diamictite: clast-poor, unsorted sediment

Conglomerate: clast-rich, unsorted sediment
Diamictite: clast-poor, unsorted sediment

Conglomerate: clast-rich, unsorted sediment

Striations

SR clasts

Exotics
Diamictite: clast-poor, unsorted sediment

Conglomerate: clast-rich, unsorted sediment

Diamict = glacial event
Shells = interglacial event

Encrusting bryozoans
Bivalves (pectens)
Preliminary results

• Presence of fossils within sediment suggest Neogene interglacial events
• Loaded, deformed contacts suggest coeval glacial and volcanic activity during Neogene period
• Clast lithology suggests both local and Antarctic Peninsula Ice Sheet provenance
• Bedrock striation orientations suggest local ice cap provenance
2005-2006 Field Campaign to the Ross Sea Volcanoes

John Smellie (BAS) & Sergio Rocchi (University of Pisa)

Extracting 10 million years of Antarctic ice sheet history from volcanic sequences in north Victoria Land
LOCATION & OBJECTIVES:

- Examine 400 km of EAIS margin
- Document 13 million years of Earth history
- Determine the timing of the transition from a warm (dynamic) to a cold (stable) ice sheet
Current/Future Activities

Special Issue of Palaeogeography, Palaeoclimatology, Palaeoecology

Middle Miocene to Pliocene chapter for ACE book

Second field campaign to James Ross Island

Major contribution to ISAES-2007

International Antarctic Neogene meeting – Cambridge UK in 2008
Oligocene Miocene

34 – 20 Ma
DeConto and Pollard, 2003
Southern ocean sea ice expands in the presence of land ice
34-16 Ma Ice Volume

Ice volumes ranged between 50-125% modern EAIS during 34-17 Ma

Ice volumes were smaller, 25-70% modern EAIS, during 17-16 Ma

(Orbital envelopes correlate with major events)

Pekar and DeConto, 2006 (Palaeo3)
There’s still an important Model-Data Conflict

- Model requires $\text{CO}_2$ variations $\sim 2.5$ to $4\times \text{PAL}$ to force “observed” Antarctic ice variations in the Miocene

- $\text{CO}_2$ record shows only $\sim 0.7$ to $1.4 \times \text{PAL}$

Pagani et al., 2005
Are Vegetation-climate feedbacks important?

..but the fossil plant record needs to be improved

Conference session and new data compilation at Antarctic Earth Sciences meeting 2007
Eocene – Oligocene
58 – 30 Ma

From greenhouse .............. to icehouse

- Compilation of current info on Eocene and Oligocene environments of Antarctica for ACE book
- Target for future ANDRILL drilling programme
- www.andrill.org – fantastic web site
Radio Echo Sounding

• Newly formed (2005)
• Yet to meet formally
• Aim: to integrate various RES surveys in Antarctica
• Output: better coverage of RES data, essential as input to models
• Plans….
ICECAP will...

• Determine ice thickness and bed topography (necessary for numerical models)
• Measure internal ice sheet layering between ice core sites
• Mark the best place for new deep ice cores (and other palaeoclimate ice records)
• Comprehend lithospheric structures
• Quantify the structure and topography (and possibly lithology) of the Gamburtsev Mountains
• Determine the amount and basal water present in East Antarctica, including subglacial lakes
• Inspect how the Aurora Basin sector of the East Antarctica ice sheet is losing mass
GigaGAP: Gamburstev RES
Achievements (since 2004)

• Publication of papers in Nature and Geology
• Three special issues published
• Seven dedicated sessions at international conferences
• Links with ongoing research activities (ANDRILL, ICECAP)
• Implementation plan established and initiated
Plans for next two years

- Activation of sub-committee work
- Integration between modellers and geologists
- IPY activities
- Antarctic Earth Science meeting, USA 2007
- Modelling symposium in 2008