Antarctic Climate Evolution (ACE)
Paleoclimate and Ice Sheet Modeling Workshop

Northampton, Massachusetts
May 30th-June 2nd, 2002

Draft Workshop Summary

Compiled by

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Introduction

ACE (Antarctic Climate Evolution) is a newly proposed, international research initiative that has grown out of the ANTOSTRAT (ANTarctic Offshore STRATigraphy) project. ANTOSTRAT was sanctioned by SCAR (Scientific Committee on Antarctic Research) in 1996, to reconstruct the Cenozoic paleoclimatic and glacial history of the Antarctic region from the study of the sedimentary record surrounding the continent. The ANTOSTRAT program officially comes to an end in July, 2002. The goal of ACE is to continue the study of Antarctic climate and glacial history, by linking climate and ice sheet modeling studies with geophysical surveys and geological studies on and around the Antarctic continent. ACE research will investigate climate and ice sheet behavior in both the recent and distant geologic past, including times when global temperatures were several degrees warmer than today.

The idea for a new initiative to study Antarctic Climate Evolution was put forward at the ANTOSTRAT meeting The Geologic Record Of The Antarctic Ice Sheet From Drilling, Coring And Seismic Studies in Erice, Sicily, September 8–14 2001 (see http://www.ingv.it/antostrat/antostrat.html). There, members of the ANTOSTRAT and newly proposed ACE steering committees (Appendix I) identified the need for members of the international climate and ice sheet modeling community, with an interest in Antarctic climate and glacial history, to be identified and united with geologists working on the reconstruction of ancient Antarctic climates and ice sheets. In order to promote interaction between these groups, early in the development of an ACE research inititative, a Paleoclimate and Ice Sheet Modeling Workshop was held in Northampton Massachusetts, May 30-June 2, 2002. Financial support for the workshop came from the National Science Foundation, Office of Polar Programs (NSF-OPP) and ANTOSTRAT/SCAR.

The emphasis of the workshop was on the evaluation of the “state of the art” in modeling the climates and ice sheets of the Antarctic paleoenvironment and the development of strategies for purposefully incorporating geologic data into paleoclimate, ocean, and ice sheet modeling studies. A wide range of timescales was discussed. However, emphasis was placed on Paleogene glacial inception and long-term ($>10^4$ year) climate change and ice sheet behavior. The goal of the workshop was to better define the needs of numerical modelers from a geologic data perspective. In turn, Antarctic geologists were asked to consider the types and quality of data they can provide as model boundary conditions, for validation, and for model development.

Workshop Themes

The workshop schedule (see Appendix II) followed three general themes: 1) The geologic record of Cenozoic climates and ice sheets, 2) climate and ice sheet models: assessment and applications, and 3) linkages between models and the geologic record. A series of overview plenary talks were followed by shorter talks focused on specific research projects combining modeling studies with geologic and geophysical Breakout sessions, during the second day of the meeting, were followed by group discussion. A list of needs from both a modeling and data gathering perspective was developed, as was a consensus statement regarding the key questions to be addressed by ACE over its proposed lifetime. More specifically, the modelers were tasked with identifying critical data needs (presumably obtainable from the geologic record) for improving and validating numerical models of ancient Antarctic climates, oceans, and ice sheets. In turn, the geologists were asked to develop a list of needs in terms of model output that may help guide both the acquisition and interpretation of geologic and geophysical survey data. At the end of the workshop, the modelers and geologist were united to discuss strategies for linking geologic data and model output. The issues and recommendations raised at the workshop are outlined below in this workshop summary. A more comprehensive workshop report, including extended abstracts from all workshop participants, is under development. The final workshop report is likely to provide the foundation for ACE related research for the next five to seven years.

An Evaluation of the Current State of the Art in Modeling the Climate, Ocean, and Ice Sheets of the Ancient Antarctic Environment.

Atmospheric Global Climate Models (AGCMs) and Regional Climate Models (RCMs). Numerical GCM modeling of the present climate over the Southern Oceans and Antarctica has improved considerably in the last decade, with better model physics and higher resolution (~2.8 to ~1 degrees latitude). The best GCM distributions of annual precipitation over the Antarctic ice sheet agree with observed maps nearly to within uncertainties in the maps themselves, but there are still some deficiencies in seasonal cycles around the coast. Regional climate models such as RegCM2 and MM5 are being applied more commonly over present Antarctica, with grid sizes of a few tens of km. These models have the potential for resolving regional-scale variations around the coast. However, such regional model simulations over the whole Antarctic domain are nearly as computationally expensive as GCMs.

Ocean General Circulation Models (OGCMs). For pre-Quaternary studies when sea-surface temperatures are not well known from observations, atmospheric and land GCMs must be used in conjunction with an ocean model. Most previous paleo-GCM studies involving Antarctica have used a simple ~50-m slab mixed-layer ocean, but this cannot explicitly capture changes in ocean heat transport caused by changes in ocean circulation in response to changing plate configurations. Coupled atmospheric-ocean GCMs have only recently become able to realistically simulate the modern deep-ocean without the use of ad-hoc flux corrections. Only a few paleoclimatic A-OGCM simulations have been attempted, and most of these have been for the Last Glacial Maximum. Furthermore, coupled A-OGCM runs are computationally very expensive, requiring many hundreds to a few thousand (effective) ocean years of ‘spinup’ to equilibrate the model's deep ocean temperature and salinity distributions. This precludes the application of coupled A-OGCMs to long (geologic timescale) simulations.

In both slab ocean models and OGCMs, perennial and seasonal sea ice is predicted as a prognostic model component. This floating ice, formed from freezing of ocean water as opposed to ice shelves discharged from continental ice sheets (see below), is predicted along with upper ocean conditions as a short-term component of the climate. Realistic distributions are generally achieved for the modern world, but testing of paleoclimatic sea-ice results is hampered by the lack of data on past distributions, especially beyond the Last Glacial Maximum.

Long-Term Coupling. The use of such detailed climate models for Cenozoic Antarctic problems is feasible for a few "snapshots" of climate, isolated in time. A lot can be gained from such experiments, especially if the times and boundary conditions are chosen judiciously. However, for time-continuous problems involving slow transitional changes, such as those evolving over orbital timescales or longer, many such climate solutions are needed. However, simply performing a multidecadal GCM simulation every few hundred years is not computationally feasible. There are basically two ways to address this problem (outlined below). These methods have been applied to several studies of the Northern Hemispheric Quaternary ice ages, but in only one case have they been applied to Early Cenozoic Antarctica.

1. Instead of an A-OGCM, a more computationally efficient global climate model is used that can affordably be solved for the multidecadal climate thousands of times over a long-term simulation. In the simplest, atmospheric and oceanic models, heat transport is diffusive with only one level (an energy balance model). More recently, extremely stripped down, coarse-resolution A-OGCMs have been used in this way. A number of these EMICs (Earth Models of Intermediate Complexity) have been developed in the last few years, particularly in Europe. Whether the quality of their climate simulations is adequate for paleoclimatic problems, particularly for precipitation, remains to be determined.

2. A relatively small number of GCM simulations is performed in advance, for canonical combinations of boundary conditions spanning the ranges anticipated in the long-term simulation. These monthly climates are all stored on the computer, and during the long-term simulation the climate at any time is defined as a weighted average of two or more of the stored climates, depending on the current values of the long-term components (ice-sheet size, orbit, etc.). This technique is still in its infancy, and it remains to be seen whether the degradations involved in the weighting outweigh the advantages of using a full GCM.

In both techniques, the meteorologic variables from the climate model, such as monthly air temperatures and precipitation, are interpolated and lapse-rate corrected to the surface of a much finer grid ice sheet model. The adjusted meteorlogic variables are then used to calculate the net annual surface mass balance on the ice sheet. This, in turn, is one of the forcing fields used to predict the long-term evolution of the ice sheet.

Ice Sheet Models. Three-dimensional numerical models of the flow of ice sheets have been applied extensively and successfully to present, past, and future Antarctica, to the Northern Hemispheric Pleistocene ice sheets, and to the major Mesozoic and Neoproterozoic ice ages. They are intrinsically simpler than AGCMs, and it is computationally feasible to run them over continental domains continuously for millions of years. The horizontal resolution of these models is necessarily on the order of a few tens of kilometers, in order to resolve the steep ice sheet flanks. Their dynamics are based on non-linear ice rheology and the shallow ice scaling approximation, with all motion from horizontal (du/dz) shear driven by hydrostatic gravitational forces stemming from the ice surface slope. Longitudinal stresses, which can be important at scales comparable to the local ice thickness and are important in ice streams, are neglected. Ice temperature is important for its stiffening effect on the rheology at colder temperatures and whether the base is at the melt point. In the models, temperature is influenced by advection of the ice, surface temperatures, basal and internal friction, and geothermal heat flux. Other model components include lithospheric temperatures in the upper ~2 km, and Earth models of varying complexity for the lithospheric elastic response and longer-term asthenospheric flow due to ice loading.

Most of the uncertainty in these types of models stems from basal sliding affected by conditions at the base of the ice, such as the distribution of liquid water, the existence of unconsolidated sediment layers deforming by horizontal shear, and the degree of lithologic entrainment into the basal ice. Some ice models include components for the basal hydrology and/or deforming sediment. There is currently vigorous debate concerning the degree of non-linearity in subglacial sediment rheology, and the importance of sediment for large-scale ice-sheet evolution (based mainly on observed behavior of modern West Antarctic ice streams over unconsolidated sediment, and remnant till distributions from Northern Hemispheric ice ages). Despite this uncertainty, models including sediment and its transport as till to the coast are pertinent to the ACE agenda, since they enable the predictions of coastal discharge rates to be compared with observed offshore records.

Some ACE research will require the application of ice sheet models with a fine enough model grid to resolve major valleys through the Transantarctic Mountains, allowing ice from the East Antarctic ice sheet to discharge to the Ross Sea coast. This may be best accomplished by running either high-resolution regional (not continental) ice-sheet simulations over specific drainage basins, or nested grids of variable resolution.

Other ice and sediment related model components that are important to the goals of ACE include:

Ice Shelves. Longitudinal stresses are important in ice shelf dynamics, making numerical models intrinsically more computationally expensive than for ice sheets. Antarctic ice shelf modeling to date has been limited mostly to the present day or a few individual times in the recent past. The finest-grid simulations compare well with the modern observed states of the Ross and Filchner-Ronne ice shelves, using finite-element discretization with fixed ice-sheet boundary geometries. With modest increases in computer power, it should be feasible to use finite-difference grids with movable ice-sheet boundaries to enable long-term simulations. One application important for ACE will be the initial formation of a West Antarctic ice sheet, which in its earliest stage must have grown from a floating ice shelf extending from East Antarctica. Smaller ice shelves may also affect the local distribution of deforming sediments delivered to the grounding line (see below).

Stable Isotopes. Deep-sea core records of isotopic $^{18}O/^{16}O$ ratios in benthic foraminifera are influenced both by changes in global ice volume and local water temperatures. Other deep-sea proxies (Mg/Ca, borehole water $\delta^{18}O$) can be used to separate the two effects, but to date only foraminiferal $\delta^{18}O$ has been measured over the mid Cenozoic with high enough temporal resolution to record orbital variations and other rapid changes. Thus it would be helpful for paleoclimate models to explicitly predict variations in stable isotopic compositions of ocean water, as well as temperature.

To do this in a coupled long-term model, it is necessary to include water isotopic fractionation and transport in the atmosphere, ocean and ice sheets. Only a few atmospheric and oceanic GCMs have this capability. These models have been applied to the present and LGM; yielding reasonably realistic results for modern ^{18}O in precipitation, although the biggest errors tends to be in high latitudes where precipitation has undergone the most fractionation. Only one or two ice-sheet models currently include isotopic ratios as 3-D tracer fields, applied recently to Greenland in the Quaternary. However, given an A-OGCM with isotopic capability, it is relatively straightforward to add isotopic storage and transport to an ice-sheet model, and explicit predictions of deep water $\delta^{18}O$ should also be possible for selected times in the Cenozoic.

Sediment Distribution. To compare with the wealth of offshore (ANTOSTRAT) core and seismic data, it is necessary to model the continental-scale distribution and evolution of original sediment and till through the Cenozoic. The subglacial sediment models mentioned above, although controversial, are necessary to predict changing distributions under the ice. In addition, the landscape evolution of moraines in ice-free areas need to be included, mainly by fluvial erosion and transport to the coast. For long-term simulations, the generation of new till by the action of ice on exposed bedrock is also necessary to maintain a continental budget of sediment through the Cenozoic. These processes can be modeled as perturbations to the long-term non-ice landscape equilibrium that existed in the early Cenozoic, before the growth of significant ice sheets. Simple parameterizations of these processes have been used in ACE modeling work to date, but improvements may be possible by applying conceptual models derived from observations of landscape evolution under the influence of ice sheets.

The land-based model components described above can predict the delivery of sediment to the grounding line at specific coastal points, including its mineralogy (newly generated till vs. original pre-Oligocene sediment), and provenance. From here, however, the till may be transported by ice shelves and/or local ocean currents to the observed locations of major deposits on the continental shelf (breaks). During transport, the sediment may be sorted by grain size, and after deposition, marine erosion of the deposits can occur. It will be important to account for these effects when comparing the land-based model predictions with the observed sediment core records.

The Potential for Geologic/Geophysical Investigations to Improve Numerical Modeling Studies of Cenozoic Climates and Ice Sheets

Boundary conditions. One of the fundamental limitations of paleoclimate and ice sheet modeling studies comes from the incomplete knowledge and/or poor resolution of boundary conditions. For paleoclimate, ocean, and ice sheet modeling over Cenozoic timescales, these boundary conditions include reconstructions of global and regional paleogeography, paleotopography, paleobathymetry, paleovegetation, ancient atmospheric chemistry, and orbital parameters (Milankovitch forcing).

Validation data. Paleoclimatic/environmental information derived from the geologic record can be directly and indirectly compared with climate, ocean, and ice sheet models for particular time periods. Some data types (outlined below), are used as both model boundary conditions and as a means of validation, and therefore serve a dual purpose. The comparison of model output with the geologic record is an iterative process, whereby the models, usually developed and tested using modern boundary conditions and observations, are applied to ancient boundary conditions under a variety of forcing scenarios. In such a study; 1) the output (model behavior) is compared with information derived from the geologic record; 2) the model formulation, boundary conditions, or forcing are changed according to discrepancies between the model results and the data; 3) the new output (model behavior) is compared with the data; 4) the boundary conditions and/or forcing are changed yet again, and so on. An integrated model-data study can greatly improve confidence in the behavior of a given model and a particular solution. It can also aid the interpretation of observational data, leading to a better understanding of the natural processes involved in the system being investigated. A list of potential contributions from the geologic/data gathering community, in-terms of improving model boundary conditions used in Cenozoic climate, ocean, ice sheet modeling studies, and validation data sets that will contribute to successful model-data comparisons are given below.

Summary of Data Needed as Boundary Conditions for Climate/Ocean/Ice Sheet Modeling Studies of Antarctica over Cenozoic Timescales

- Global and regional paleogeographic maps provide the framework for paleoclimate, ocean, and ice sheet model simulations. The application of the most sophisticated A-OGCMs to ancient Cenozoic climates demands careful reconstructions of plate locations, paleotopography (for AGCMs and ice sheet models), and paleobathymetry (for OGCMs). Continental position and the history of ocean gateways in the Southern Ocean may be an important factor in the evolution of Cenozoic climate, especially over Antarctica, due to changes in ocean circulation and heat transport. Fine-tuning tectonic models of the opening history of the Tasman and Drake Passages will provide better constraints on the effects of ocean circulation on cryosphere development.

    - Reconstructions of Antarctic paleotopgraphy, a critical boundary condition for paleoclimate and ice sheet modeling studies, may be possible for the past 40-50 million years, especially in the Transantarctic Mountain Region. Geologic age constraints on the Gamburtev Mountains should be a priority, because preliminary ice sheet modeling studies suggest this region is a likely location for ice sheet initiation.

    - Reconstructed paleo-depths of the continental shelf will be important for constraining simulated ice margin/grounding lines and sequence stratigraphic units.

- pCO_2 records are an important boundary condition for Cenozoic paleoclimate models. Better constraints on the Cenozoic history of atmospheric CO2, particularly through the Paleogene, will be needed to better constrain the importance of pCO_2 relative to other potentially significant climate forcing factors (e.g., orbital forcing and ocean gateways) through the Cenozoic.

- Ancient orbital parameters (values of eccentricity, obliquity, and precession) derived from tuned proxy records, will allow the testing of climate sensitivity to orbital forcing across critical time intervals (e.g., the Eocene/Oligocene and Oligocene/Miocene Boundaries).

- Improved multi-proxy estimates of Southern Ocean Sea Surface Temperature (SSTs) will serve both as an important verification of ocean model simulations and as boundary conditions for AGCM-ice sheet experiments using fixed SSTs instead of predictive ocean models.

- A better general understanding of processes incorporated into ice sheet models can be derived from geological studies. These processes include erosion laws, ice flow and grounding, sediment transport and deposition, and solid earth processes (rheology and lithospheric flexure). Geothermal heat flux is another potential important factor that could be better resolved.

- Like SSTs, reconstructions of paleovegetation can be used as both a boundary condition for the land surface of GCMs, and as validation data, especially for GCMs with predictive vegetation components.

Data Needed for Validation/Calibration of Paleoclimate/Ocean/Ice Sheet Modeling Studies of Antarctica

- A better global ocean history, derived from multi-proxy studies of ancient ocean chemistry, will aid our understanding of linkages between Antarctica and the lower latitudes. Discrepancies between Cenozoic isotopic reconstructions of deep-sea temperatures and ice volume, and more direct records of Antarctic climate and ice volume need to be reconciled. This is one of the most important, potential contributions of the ACE program.

- The evolution of ice sheet geometry can be reconstructed for the last glacial cycle, and possibly back to 10-15 Ma. These reconstructions should include the timing of ice sheet advance and frequency of advance/retreat cycles, the presence/absence of ice streams, and the likely provenance of glacial ice.

- Sediment flux to restricted basins and the continental margins (at specific locations) will allow direct comparison with output from the next generation of ice sheet models, accounting for the generation, transport, and deposition of subglacial sediment.

- Improved bedrock maps will improve calibrations of basal ice sheet behavior, as will better knowledge of the large-scale sediment distribution and basal conditions (frozen/melting) under the present East Antarctic Ice Sheet.

- Climatically forced transitions in mineral assemblages, can be compared directly with climate/ice sheet model simulations under specific boundary conditions, as can the loss of regolith via repeated glacial cycles.

- Glacial regime (temperate, cold-based, or tidewater) deduced from the geologic record can also be compared directly with climate/ice sheet simulations under specific boundary conditions and forcing scenarios.

- Sea ice extent and first occurrences at particular locations will improve our understanding of potentially important linkages between sea ice and Antarctic climate change over a wide range of time scales.

- Terrestrial paleoecologic reconstructions based on foliar, wood, and phytolith analysis, can provide a great amount of climatic information, including the seasonal distribution of temperature and precipitation. Climate models with predictive vegetation components can be directly compared with the fossil record.

Numerical Models Applied to Geologic Problems: Data Gathering and Data Interpretation

- Numerical ice sheet models can provide both continental and regional visualizations of ice sheets, ice margins, and likely regions of subglacial erosion through time. High-resolution models (<10 km) will be required to resolve individual ice streams and the transport of ice through individual mountain troughs and basins.

- Model boundaries should be extended northward, into the Southern Ocean. This will require explicit representation of ice shelves, tidewater glaciers, and grounding lines.

- Predictions of isotopic tracers (D/H and d18O) in ice sheet, climate, and ocean models, will allow more direct comparisons with proxy records (see discussion above).

- Coupling of ice sheet models with climate and ocean models allows for the testing of sensitivities to a variety of forcing factors that are recognizable in the geologic record (i.e., CO_2, orbital parameters, ocean circulation, uplift, etc.) Sensitivity experiments can be run, testing the effects of ice forcing directly from geologic phenomena such as uplift and volcanism.

- Coupling of sediment schemes to ice sheet models will allow predictions of sediment flux vs. time at specific locations through the Cenozoic. Lithology of the coastal discharge (original vs. ice-generated) and sediment provenance can also be predicted. Marine transport of till from grounding line to shelf deposit sites can include grain sorting and subsequent erosion. All of these model data can be readily compared with observational data obtained via coring and seismic surveys.

What Can Numerical Models Provide the Geologic (Data Gathering) Community?

- Numerical models of the climate-ocean-cryosphere system can provide an integrated, physically-based understanding of phenomena recognized in the geologic record at critical intervals throughout the Cenozoic and over a wide range of timescales.

- Model results can improve the spatial consistency of field data via the extrapolation between data locations based on model results. Recommendations on where to go (in space and time) and what to look for can also come from model simulations.

- Models have the potential to provide spatially and temporally continuous Earth Systems scenarios of climatic change, allowing the examination of interactions between representative components of the climate system.

- The latest generation of climate-ice sheet models can be modified to produce synthetic proxy data for direct comparison with the geologic record. These include vegetation distributions, isotopes (D/H, $\delta^{18}O$), climate and ice sensitive sediments and fossils, eustatic sea-level curves, sediment mass flux and sequence stratigraphy.

Immediate Questions Appropriate for ACE Research Over the Next Five-Seven Years: Primary Thematic Issues, Priorities, and Goals, as Determined by Consensus Among Workshop Participants Given the Recent Model Developments Described Above

General Thematic Issues

- The nature, timing, and forcing mechanisms responsible for the onset of Antarcitc glaciation in the Paleogene.

- The nature of major glacial fluctuations throughout the Cenozoic, over sub-orbital to tectonic timescales. This will demand a better understanding of the sensitivity of both the West and East Antarctic ice sheets to forcing including: (changes in CO_2 and the global carbon cycle, orbital parameters, ocean circulation/gateways, uplift, and sea level).

- The impact of the Antarctic environment (ice sheets and Southern Ocean conditions) on the global climate system (linkages to other latitudes).

While ACE's approach should remain process rather than "time-slice" oriented, several critical events in Cenozoic climate/cryosphere history were recognized as immediate foci of ACE research. A more detailed list of the priorities/questions mirrored here, can be found in ANTOSTRAT's SCAR Report #16.

- Were there significant Mesozoic and Early Cenozoic ice sheets? If so, what was their size, geometry, nature of variability, and what impacts did they have on the global climate system?

- When did Eocene cooling first allow the onset of limited Antarctic ice caps?

- What mechanisms were responsible for the Eocene/Oligocene boundary transition and the initial continental-scale glaciation of East Antarctica? How does the more direct record of earliest Oligocene glaciation compare with model results and the proxy (isotopic) record of the event?

- The Oligocene/Miocene boundary period appears to exhibit highly dynamic ice sheets, possibly paced by orbital forcing. What boundary conditions are necessary to account for such behavior and how do more direct records of Antarctic ice sheet variability compare with proxy climate/ice volume records from lower latitudes?

- What was the cause of the Miocene isotopic excursions (Mi events) and the eventual expansion and cooling of the Antarctic ice sheet?

- The glaciation of West Antarctica near the Miocene–Pliocene boundary has not been modeled, nor have the effects of the closure of intercontinental seaways linking the south Atlantic and Pacific oceans.

- What was the nature of the Early-Mid Pliocene warming, and how was it manifested on Antarctica? The possibility of significant continental deglaciation during this interval has long been debated. ACE's approach of combining model studies with data analysis is well suited to addressing this controversial problem.

- What was the nature of the LGM in and around Antarcitca? Can our best models do a reasonable job simulating those conditions? A wealth of data including sea ice extent, ice volume, grounding lines, and SST data, will be helpful in validating the modeling schemes used for other time periods.

- One of the most significant issues raised at the workshop, is the apparent disconnect between Paleogene-Miocene paleoenvironmental reconstructions in the McMurdo Sound region (Cape Roberts Project) indicating gradual and steady climatic deterioration on Antarctica through the late Paleogene and early Neogene, vs. benthic $\delta^{18}O$ studies indicating a period of dramatic global warming through the late Oligocene and early Miocene. One of ACE's potential contributions to the general paleoclimate community will be the reconciliation of apparent contradictions between lower latitude isotopic proxy records of global temperature, ice volume, and eustatic sea level, and the more direct records of the Antarctic paleoenvironment.

WWW Site Developement

The workshop participants concluded that significant advances in our understanding the Cenozoic evolution of Antarctica will be made through the directed combination of numerical modeling studies, and geologic and geophysical data analysis. The greatest single step toward facilitating interaction between the modeling and geologic communities is communication. The World Wide Web offers the greatest potential for the transfer of knowledge and data. Therefore, an immediate goal of ACE will be the development of an ACE website to serve as an information gateway for ACE researchers and the greater community. At the very least, the ACE website should:

- Provide contact information for scientist working on specific projects related to ACE.
- Provide links to data sources (both model data and geologic data suitable for model boundary conditions and validation).
- Provide information on ACE related activities, meetings, and workshops.
- Provide biobliographic information on relevant publications.
- Serve as bulletin board for discussions related to ACE administrative business and science objectives.

A new ACE website is presently under construction (see www.geo.umass.edu/ace), following the recommendation of the workshop participants.

APPENDIX I

Workshop Conveners
Robert DeConto – University of Massachusetts, USA
Dave Pollard – The Pennsylvania State University, USA

ACE Steering Committee
Robert DeConto – University of Massachusetts, USA
Robert Dunbar – Stanford University, USA
Carlota Escutia – Texas A&M University, USA
Fabio Florindo – Instituto Nazionale di Geofisica e Vucanologia, Italy
Thomas, Janecek – Florida State University, USA
Robert Larter – British Antarctic Survey, UK
Tim Naish – Institute of Geological and Nuclear Sciences, New Zealand
Ross Powell – Northern Illinois University, USA
Martin Siegert – University of Bristol, UK.

ACE Advisory Panel
Peter Barrett – Victoria University, New Zealand
Alan Cooper – Stanford University, USA

APPENDIX II

Workshop Program

Thursday, May 30th

Arrival, hotel check-in, opening reception in Wiggins Tavern 6:00-8:00 pm

Friday, May 31st

8:00 am Breakfast in the Hampshire Room

8:00-9:00 Registration in the Hotel Lobby

Scientific Presentations in the Hampshire Room

9:00-9:10 Rob DeConto: Introduction

9:10-9:20 Scott Borg: Opening Remarks

<u>Data: The Geologic Record of Cenozoic Climate and Ice Sheets</u>

9:20-9:50 *Peter Barrett: Keynote Lecture: Antarctic Glacial History: Conflict and Resolution

9:50-10:20 *James Zachos: Keynote Lecture: Cenozoic Glaciations as Inferred from Deep-Sea Oxygen Isotope Records

10:20-10:40 Peter Barker: Geological Constraints on Antarctic Ice Sheet Models

10:40-11:00 Rob Dunbar: ACE, SOIMAGES, ANDRILL, SHALDRILL, IODP - How can they get us what we need to test our ideas about Antarctic Glacial Evolution

11:00-11:25 Coffee Break

11:30-11:50 Fabio Florindo: Future Antarctic Margin Drilling- The ANDRILL Initiative and McMurdo Sound Portfolio

11:50-12:10 Alan Cooper: Cenozoic Paleoenvironments of the Prydz Bay Region from Drilling by ODP Legs 119 and 188

12:10-12:30 Tim Naish: Constraining the Deep-Ocean Archive of Cenozoic Climate With Shallow-Marine Sediment Data From the Antarctic Continental Margin

12:30-1:30 Lunch

1:30-1:50 Reed Scherer: Diatoms in Antarctic Glacigenic Sediments as Sedimentary Tracers of Past and Present Ice Sheet Processes

1:50-2:10 John Smellie: Ice Sheet Reconstructions and Ice Dynamics in Northern Antarctic Peninsula Over the Past 10 myr: How Investigations of Onshore Volcanic Sequences Can Contribute

Modeling Antarctic Climates and Ice Sheets

2:10-2:40 *Martin Siegert, Keynote: Utilizing the Geological Record to Reconstruct Former Ice Sheet Configurations in Antarctica

2:40-3:10 Robert Oglesby: Issues in Modeling Antarctic Climate Evolution

3:10-3:30 Tony Payne, present-day Antarctic ice sheet modeling: Numerical modelling of the flow patterns of the present-day Antarctic Ice Sheet

3:30-4:00 Coffee Break

4:00-4:20 Andrew MacKintosh: Late Quaternary evolution of the East Antarctic Ice Sheet in the Australian Sector, 60-90° E: Empirical Evidence and Modelling Studies

4:20-7:00 Posters/Discussion/Bar Service (Beer and Wine)

Saturday, June 1st

8:00-9:00 Breakfast in Hampshire Room

9:00-9:20 Shawn Marshall: Antarctic Ice Sheet Modeling

9:20-9:40 Rob DeConto: A coupled climate-ice sheet model applied to the early Cenozoic history of the Antarctic Ice Sheet: Testing the effect of CO_2, ocean circulation, and orbital parameters

9:40- 10:20 Dave Pollard: Antarctic sediment evolution simulated by a coupled climate-ice sheet-sediment model.

10:00-10:20 Martin Roy: Evolution of the Laurentide Ice Sheet Dynamics Through Changes in Subglacial Geology: An Analogue for the Antarctic Ice

10:20-10:40 Ross Powell: Integrating Glacial and Glacimarine Sedimentary

Processes with Glaciological Models for Quantitative Modeling of Glacial Sequence Stratigraphy

End of talks

10:40-11:15 Coffee Break

Breakout sessions and group discussion

11:15-11:30 Discussion of breakout agendas and participant work assignments

11:30-12:30 Two separate breakout groups: data and modeling

12:30-1:30 Lunch

1:30-2:30 Two separate breakout groups continued

2:30-3:00 Reconvene in Hampshire Room, reports from two groups

3:00-3:15 Coffee Break

3:15-5:00 Group discussion on the integration of models and geologic data

5:00-5:30 Synthesis, list of recommendations/strategies, final wrap-up

5:30-7:30: Continued discussion if required, bar service (beer and wine).

Sunday June 2nd
Check-out and departure

APPENDIX III

Participant List

Name	**Contact Information**
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