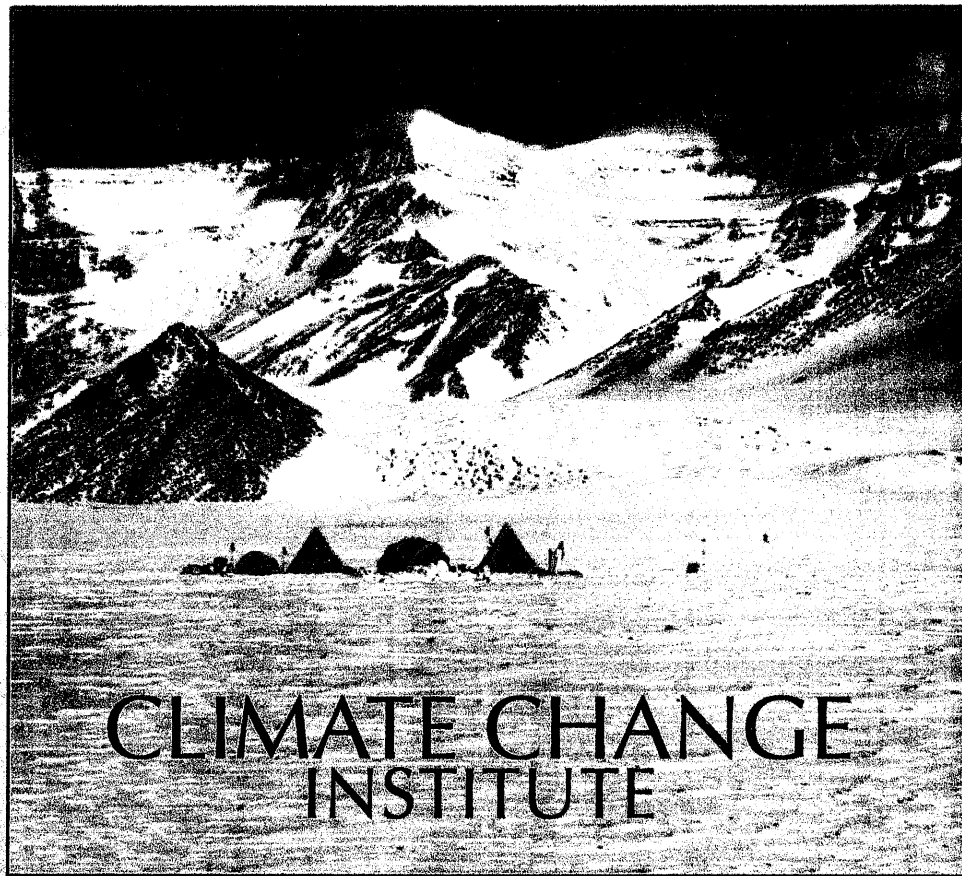


12<sup>th</sup>  
J. Louis Agassiz Symposium



6-7 May, 2004  
D. Twitchell Allen Community Center



The Agassiz Symposium is the annual research meeting of the Climate Change Institute. This year's meeting will take place May 6-7, 2004 at the Doris Twitchell Allen Community Center on the campus of the University of Maine. Faculty, research staff and students will describe their current work in a series of presentations covering the range of topics studied in the Institute, including archeology and anthropology, paleoecology, glacial geology, marine geology, climatology and glaciology. In addition to oral presentations, there will be several research posters on display throughout the meeting.

The keynote speaker for this year's meeting is Dr Johan Kleman, who will present a talk on "Fractal frozen-bed patches – the stabilizing bathmat suckers of mid-latitude ice sheets".

Johan Kleman is currently Professor of Remote Sensing in the Department of Physical Geography and Quaternary Geology at Stockholm University. His research interests are in paleoglaciology, mega-scale glacial geomorphology, and spectral remote sensing of vegetation. An integral part of his research program is fieldwork in remote locations, including the Swedish mountains, Arctic Canada, Quebec and Labrador, and the Dry Valleys of Antarctica. He and his students have had a long association with the Climate Change Institute, including several joint projects with Jim Fastook, George Denton, and Terry Hughes that are currently underway.



## KEYNOTE TALK

### Fractal frozen-bed patches – the stabilizing bathmat suckers of mid-latitude ice sheets

Johan Kleman (Department of Physical Geography and Quaternary Geology, Stockholm University) & Neil Glasser (Center for Glaciology, University of Wales)

In the search for the causes and controls on quasi-cyclic climate signals on the 5- to 100-kyr scale in ice cores and marine records, the question of stable versus unstable mid-latitude ice sheets is critical. Stable ice sheets respond to climate change; unstable ice sheets can drive climate because rapid topographical changes alter atmospheric circulation patterns, and iceberg outbursts may cause meltwater pulses that alter the thermohaline conveyor in the ocean. It has been suggested that cyclic surging caused by frozen to thawed bed conversion of major parts of the Laurentide Ice Sheet caused repeated iceberg outbursts with ensuing sea-level rise and massive sediment deposition in the North Atlantic, and that similar collapse of the West Antarctic Ice Sheet could lead to a 6m sea-level rise on a short enough timescale to be of great concern to humans.

A crucial issue is therefore the spatial extent, layout, and changes over time in the binary subglacial phase regime (frozen-thawed) in the mid-latitude ice sheets. In the absence of a direct subglacial paleotemperature or water phase-state record for former ice sheets, we have explored the dynamics of this coupled frozen patch-ice stream system by inferences from the geomorphological record of the exposed and accessible beds of the LIS, FIS and BIS ice sheets as reflected in remote sensing data, and comparison of this record to radar (RAMP mission) data revealing flow conditions in comparable parts of the present Antarctic Ice Sheet.

We conclude that paleo-ice sheet beds and present ice sheets surfaces give evidence for frozen-bed patches over a six-order of magnitude scale range, and that such patches are of fundamental importance for the stability of ice sheets by laterally constraining and isolating peripheral ice drainage basins and their ice streams. The lateral shear zones of ice streams and tributaries represent guiding structures in ice sheets, favoring headward extension of tributaries and development of shortcuts from embryonic tributaries, a spatial mode of wet-bed extension that is unfavorable to development of the wide all-melted zones thought necessary for major instability in ice sheets. When applied to the Laurentide Ice Sheet and its bed topography, our interpretation of the dynamics of the coupled frozen patch/ice stream system suggests that although the peripheral ice stream zone was highly dynamic, it was isolated from the potentially vulnerable Hudson Bay core area by a "ring of stability" largely encircling Hudson Bay. This ring formed a barrier where an elevated bed, mammilated terrain conducive to "sticky spot" development, and also widespread coherent frozen-bed zones coincided to disfavor deep penetration of ice streams or tributaries into the Hudson Bay area, with the possible exception of the western entrance to Hudson Strait, where tributaries may repeatedly have extended into the core area. The topography of the western entrance to Hudson Strait strongly favored branching into several ice streams or tributaries and therefore lateral isolation of fast-flow zones by frozen inter-stream ridges, a situation which would render rapid switches between fully thawed and fully frozen conditions over wide areas unlikely.

The geomorphological, geological and cosmogenic isotope signatures of former frozen-bed patches are presented in some detail, as are possible biological and anthropological implications of the presence of uneroded old ground surfaces of great antiquity in formerly glaciated areas.

## 12th J. Louis Agassiz Symposium – Program

Thursday, May 6

8:00 **Coffee and Pastries**

8:25 Introduction and Welcome

8:30 Daniel Sandweiss, James Richardson III, Fred Andrus, Stephen Houk, Dolores Piperno, Elizabeth Reitz & Benjamin Tanner *Correlations between climate and culture change at Siches, an Early to Middle Holocene fishing site in far northern Peru*

8:45 Brian Robinson *Activity areas or migrations in Alaska: progress report on the Alaska project*

9:00 Kristin Sobolik *Big Bend revisited*

9:15 Gordon Bromley & Brenda Hall *Reconstructing Late Quaternary surface profiles of Reedy Glacier, Antarctica*

9:30 Thomas Whittaker *Hypotheses for the origin of the upper carbonate unit, Lake Fryxell, based on 18O and 13C analyses*

9:45 Brenda Hall *Surface level changes of Lake Vanda (Antarctica) over the past 25,000 years*

10:00 **Break**

10:30 Bruce Williamson, Karl Kreutz, Paul Mayewski, Nancy Bertler, Doug Introne, Sharon Sneed, Mike Handley, Erich Osterberg & Mike Waskiewicz *Interpreting local- and regional-scale atmospheric chemistry in the Dry Valleys, Antarctica, using snowpit and firn core records from three glacier accumulation zones*

10:45 Dan Dixon, Paul Mayewski, Susan Kaspari, Sharon Sneed & Mike Handley *Connections between West Antarctic ice core sulfate and climate over the last 200+ years*

11:00 Erich Osterberg, Paul Mayewski, Karl Kreutz, Dave Fisher, Sharon Sneed & Mike Handley *Identification of aerosol source components and North Pacific paleoclimate proxies from Mt Logan summit ice cores*

11:15 Eric Meyerson, Paul Mayewski, Sharon Sneed, Andrei Kurbatov, Karl Kreutz, Greg Zielinski, Yuping Yan & Kirk Maasch *Examination of major Holocene climate change events in ice cores from West Antarctica (Siple Dome), East Antarctica (Taylor Dome) and Greenland (GISP2)*

11:30 Coen Hofstede, Roderik van der Wal, Karsten Kaspers, Michiel van den Broeke, Lars Karlöf, Jan-Gunnar Winther, Elisabeth Isaksson, Gaute Lapppegård, Rob Mulvaney, Hans Oerter & Frank Wilhelms *Firn accumulation records for the past 1000 years on the basis of dielectric profiling of six cores from Dronning Maud Land, Antarctica*

11:45 Paul Mayewski, Kirk Maasch, Yuping Yan, Shichang Kang, Eric Meyerson, Sharon Sneed, Susan Kaspari, Dan Dixon, Vin Morgan & Tas van Ommen *Solar forcing of the polar atmosphere*

12:00 **Lunch**

1:00 Sean Birkel, George Denton, Brenda Hall & Jim Fastook *Using a glaciological model to assess the potential deglacial sources for Meltwater Pulse 1-A*

1:15 Bill Sneed *Satellite observations of Svalbard glaciers to determine mass balance changes*

1:30 Karl Kreutz, Doug Introne, Cam Wake & Kaplan Yalcin *A 550-year ice core hydrogen isotope record from the Eclipse Icefield, St Elias Mountains*

1:45 Fei Chai *The influence of equatorial diatom processes on Si deposition and atmospheric CO<sub>2</sub> cycles at glacial/interglacial time scales*

2:00 Marcus Vandergoes, Ann Dieffenbacher-Krall & George Denton *Chironomid calibration of mountain snowlines in the southern hemisphere*

2:15 Trisha Rude *Paleoethnobotany at Stix and Leaves Pueblo*

2:30 **Break**

2:45 **Keynote Speaker** Johan Kleman & Neil Glasser *Fractal frozen-bed patches – the stabilizing bathmat suckers of mid-latitude ice sheets*

Friday, May 7

**8:00 Coffee and Pastries**

8:30 Dan Belknap & Joe Kelley *New challenges for investigation of local-relative sea-level changes*

8:45 Alice Kelley *Early Holocene adjustment in the Penobscot Valley: implications for geology and archeology*

9:00 Joe Kelley & Dan Belknap *Changes in sea and land level in Ireland: proposed study*

9:15 David Sanger *A five thousand year old swordfishery in the Gulf of Maine*

9:30 Christopher Wright *Historical archeology at Chops Point*

9:45 Peter Leach *Relict oyster bioherms and submerged archeological site potential in Damariscotta River, Maine, USA*

**10:00 Break**

10:30 Hal Borns & Brenda Hall *Is Bölling warming recorded by the southeastern margin of the Laurentide Ice Sheet?*

10:45 Al Wanamaker *The North Atlantic Oscillation and the Gulf of Maine's oceanography: hypotheses and a plan of research*

11:00 Leigh Stearns & Gordon Hamilton *Radarsat SAR backscatter variations and ice sheet conditions along US ITASE traverse routes in West Antarctica*

11:15 Jim Fastook *Ice sheet modeling on Mars*

11:30 Gordon Hamilton *Rates of ice sheet thickness change in West Antarctica*

11:45 Terry Hughes *Perpetual motion: the fatal flaw in glaciology*

**12:00 Lunch**

1:00 Steve Norton *Abiotic controls on the trophic status of oligotrophic surface waters*

1:15 Bert Pelletier *Ice, rocks and humans: paleoindian utilization of ice edge environments in the Maine North Woods*

1:30 Kurt Rademaker *Paleoindian seasonal mobility in the Terminal Pleistocene: investigating the coastal-highland connection in southern Peru*

1:45 Robert Lore *Ceramic period adaptations in the Gulf of Maine: marine, terrestrial, and agricultural inputs*

2:00 Jim Roscoe *Intelligence and the origins of war*

## GLACIOLOGY

### **Perpetual Motion: The Fatal Flaw in Glaciology**

T. Hughes

Gravitational forcing in glaciers is linked to the product of ice thickness and ice surface slope in the glaciological literature. For glaciers such as continental ice sheets that enter the sea and become afloat, gravitational forcing for the floating part is linked to the height of ice floating above water. This is a consequence of basal buoyancy. Glacial flow in ice sheets begins as slow sheet flow spreading from interior ice domes, with most of that flow converging to become fast stream flow that ends as fast shelf flow when the ice streams become afloat. Therefore, stream flow is transitional between sheet flow and shelf flow, and gravitational forcing in ice streams should be represented by a combination of ice surface slope and height of ice above sea level for a given ice thickness. Failure to do this, and relying only on surface slope to provide gravitational forcing, produces flow that becomes faster as "gravitational forcing" becomes weaker and even vanishes when the surface slope approaches zero. This is the defining characteristic of a perpetual motion machine. It is a fatal flaw in glaciology that makes ice sheets only passive components of Earth's climate machine, when in fact they are dynamic components when both sources of gravitational forcing are included in computer models that simulate the flow of ice sheets. When full gravitational forcing is included in these models, they will be able to simulate rapid changes in the size and shape of ice sheets that are large enough to trigger abrupt climate change.

### **Using a glaciological model to assess the potential deglacial source for Meltwater Pulse-1A**

Sean Birkel, George Denton, Brenda Hall, and James Fastook

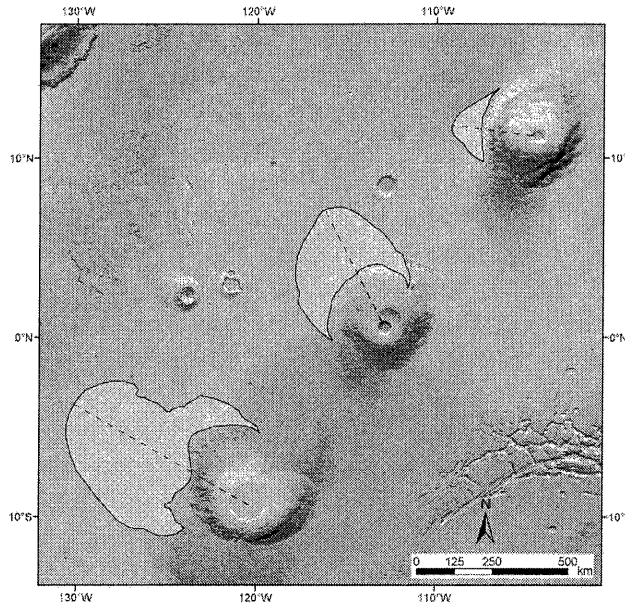
At least two brief intervals of accelerated melting superimposed over periods of slower, more continuous sea-level rise characterize deglaciation following the last glacial maximum. Sea-level reconstructions based on analyses of corals from Barbados and Tahiti, and from sediments on the Sunda Shelf indicate that a rapid discharge of freshwater occurred during the Bölling (~14,000 cal yr B.P.), as well as at the beginning of the Holocene (~11,300 cal yr B.P.). The first so-called meltwater pulse (MWP-1A) caused eustatic sea-level to rise as much as 16-20 m in as few as 300 years. A second meltwater pulse (MWP-1B) reportedly was less significant. The collapse of the Laurentide Ice Sheet is traditionally cited as the source for MWP-1A. However, recent studies argue that the freshwater may have come from the Antarctic. To test these hypotheses, the University of Maine Ice Sheet Model (UMISM) was used to reconstruct the LGM ice sheets. The ice sheets were then melted using ice core temperature proxies as model input. Results show that the timing and magnitude of MWP-1A are consistent with a Laurentide Ice Sheet meltwater source. An Antarctic meltwater source seems unlikely – deglaciation occurred later (mid-to late-Holocene), and contributed at most 14 m over the entire deglacial period.



## **Ice sheet modeling on Mars**

Jim Fastook

Input requirements for a dynamic ice sheet model are described with emphasis on availability from Martian data. The model is applied to Arsia Mons deposits to show its



potential in determining how the climate may have changed in the past on Mars.

## **Satellite observation of Svalbard glaciers to determine mass balance changes**

Bill Sneed

Global climate change is expected to have its most immediate effect in the high latitudes and glaciers and small ice caps of the Arctic may serve well as early indicators of such change. With its more than 2,100 glaciers and its location at the confluence of polar and maritime regimes, Svalbard is an ideal laboratory to study the interplay between climate change and glacier mass balance change. Traditional methods of glacier measurement are impractical or impossible because of Svalbard's remoteness, harsh climate, tortuous geography, and relatively short field season. Satellite remote sensing thus provides an ideal tool for measuring annual and decadal changes to Svalbard's glaciers.

## **Radarsat SAR backscatter variations and ice sheet surface conditions along US ITASE traverse routes in West Antarctica**

Leigh Stearns, Gordon Hamilton

The Radarsat-1 Antarctica Mapping Project (RAMP) mosaic shows significant variations in radar brightness, or backscatter, across the ice sheet. Radar backscatter over Antarctica varies according to the physical properties of the near surface, such as surface roughness, grain size, density, stratigraphy and moisture content. These physical properties are intrinsically linked to larger scale properties including ice divide location, topography, accumulation rate, ice flow and surface melt patterns. Comparing brightness variations in radar imagery with field observations of surface properties enables a fuller understanding of backscatter patterns and makes the Radarsat mosaic a powerful tool for exploring ice sheet processes and behavior. Detailed surface elevation and shallow radar profiles from GPS and GPR surveys along >5,000 km of US ITASE traverse routes in West Antarctica are used to study causes of radar backscatter variations. A series of isolated ice cores, connected to one another by isochronous horizons tracked with ground penetrating radar, yield accumulation rates along the traverse routes. Here, we correlate satellite radar brightness variations with surface topography, accumulation rate and density along the ground traverses, then proceed to infer the surface characteristics of other regions of the ice sheet.

## **Rates of ice sheet thickness change in West Antarctica**

Gordon Hamilton

The West Antarctic Ice Sheet may or may not be contributing the currently observed  $\sim 2$  mm/yr rise in sea level. The reasons for this imprecise assessment stem from the practical difficulties in measuring changes over large spatial scales in a remote environment. Remote sensing techniques (e.g. ICESat laser ranging of elevation changes) are perhaps the best approach, although the results require careful interpretation. An alternative approach is to calculate rates of ice thickness change using measurements of ice vertical velocity and long term accumulation rate. We applied this technique during the US ITASE traverses in West Antarctica. Measurements were conducted in a variety of glaciologic settings, including across ice divides, along contours of constant elevation, along flow lines, and in regions of enhanced ice motion. The results show a range of mass balance responses although a broad pattern emerges in which the ice sheet interior appears to be close to steady state while sites near outlet glaciers show thinning.

## MARINE GEOLOGY

### **Early Holocene Isostatic Adjustment in the Penobscot Valley: Implications for Geology and Archaeology**

Alice Kelley

Early Holocene isostatic adjustment affected the Penobscot Valley in several ways. Sea level regression caused by isostatic rebound initiated the formation of the postglacial Penobscot River. Subsequent, localized isostatic adjustment resulted in the shift of the outlet of Moosehead Lake from the Penobscot drainage to that of the Kennebec. This phenomenon profoundly affected the discharge and capacity of each river system. These changes not only altered the character of the upper portion of both the Penobscot and the Kennebec rivers, but influenced sediment transport and deposition within each system. The alteration in the amount of sediment transported by each river may be responsible for the abandonment of the Penobscot paleodelta, now drowned and buried by fine-grained sediment, and the formation of the latest, western lobe of the Kennebec paleodelta. Gradient changes within the central Penobscot Valley were responsible for the formation of extensive lakes that persisted through the Early Holocene. Recognition of this landscape suggests reexamination of the models applied to the distribution of Paleoindian sites in Central Maine and other, topographically similar, areas. The apparent lack of sites of this period in this region may have a geoarchaeological explanation involving landscape, travel routes, and resources.

### **New Challenges for Investigation of Local-relative Sea-level Changes**

Daniel F. Belknap and Joseph T. Kelley

Maine has experienced complex changes in local relative sea level since the waning of the Late Wisconsinan Laurentide ice sheet. This marine-based ice sheet retreated from the coast of Maine ca. 15 ka in contact with deep coastal water. Much isostatic rebound had already occurred concurrent with thinning and retreat of the margin. However, fossils and geomorphic features recorded the evidences of sea level and environmental conditions only after the grounding line passed inland. Highstand shorelines and glaciomarine fossils record the presumably short period of equilibrium ca 13.5 ka that varies in elevation from +60 to >130 m (because of post-glacial tilting). Despite the apparent brevity of this highstand, significant erosional shorelines with sea stacks, caves and erosional bluffs mark this period. Rapid rebound caused a fall in local relative sea level to 60 m below present sea level 10.8 ka when a new (short-term) equilibrium was reached between eustatic rise and rate of isostatic rebound. Subsequent relative sea-level rise was rapid as well, to -20 m ca. 9 ka. One challenge to be faced is the lack of correspondence of widely accepted global numerical models and the direct data from the Gulf of Maine. Likely reasons include simplifying assumptions of mantle and lithospheric properties and lack of control for local lithospheric heterogeneity. On the other hand, studies at Lake Mead, present glacial margins, and in paleo-ice margins such as the Gulf of Maine, Newfoundland, and Northern Ireland suggest that isostatic response occurs rapidly and on short as well as long wavelengths. Between 9 ka and 7 ka a plateau in the sea-level curve as well as evidence of tilting of lakes in Maine may be explained by the retreat of a marginal bulge. The evidence for marginal bulges of both small and large scales is strongly suggested by field evidence in many parts of the world, yet is not

accommodated in most numerical models. The late Holocene portion of the relative sea-level record for the northern Gulf of Maine is very well constrained by salt-marsh peat data. On the finest scale, recent studies have attempted to find evidence for climatic oscillation (e.g., the North Atlantic Oscillation) and acceleration due to human induced global warming. Some workers push the salt marsh record to or beyond the limitations of the data used high precision analyses of single core indicators. Sometimes these high precision records cannot be reproduced in cores less than a meter apart. We advocate a technique of high-resolution stratigraphic transects to follow transgressive and regressive overlap boundaries indicative of overall marsh response to relative sea-level changes. The challenge is to use foraminifera, plant fossils, sedimentology and geochemistry to determine the limits of precision of salt-marsh peat analyses and their use as sea-level proxies. Other challenges overall include the comparison of isotopic records between marine and terrestrial sources (the reservoir effect), identification of specific materials for dating by AMS, and the determination of "indicative meaning" of datable materials with respect to paleoenvironment.

### **Changes in sea and land level in Ireland: proposed study**

Joseph T. Kelley and Daniel F. Belknap

Relative sea-level change was profound in Ireland. Coastal areas were impacted by eustatic sea-level rise, possibly at varying rates, but also affected by isostatic adjustment produced by local and regional ice sheet growth and decay. In Northern Ireland a late-glacial raised shoreline is recognized at approximately 14 ka at 25-30 m above current sea level. Offlap sand and gravel unconformably overlie glacial-marine mud and are truncated at the shoreline by erosion. Modeled lowstand depths are around 10-13 m below present sea level, but recent seismic reflection work suggests lowstand shoreline deposits at -30 m. In the middle Holocene sea level varied above and below present level, with prominent shorelines evident several meters above present sea level.

Relative sea level changes have influenced human settlement of Ireland and sea level rise is a factor in contemporary coastal erosion. Existing observational data are scarce, however, and modeling efforts cannot account for these data nor reliably make predictions into the future. To better understand sea-level change in this complex area we are planning to collect cores from features interpreted from seismic reflection data as lowstand shoreline deposits in the summer of 2004. Based on seismic reflection data, we believe submerged beaches and peat deposits exist as deep as -30 m. In addition, we will conduct ground-penetrating radar studies of raised shorelines to identify deposits that may be cored to investigate stratigraphy and recover organic material suitable for dating. Finally, to begin to assess the spatial variability of sea-level change around Ireland, we will examine Lough Neagh, the largest lake in the United Kingdom, for raised and submerged shorelines as indicators of regional tilting.

## **The influence of equatorial diatom processes on Si deposition and atmospheric CO<sub>2</sub> cycles at glacial/interglacial time scales**

Fei Chai

The causes of the glacial/interglacial cycle remain unknown, although the primary driver is changes in CO<sub>2</sub>, likely controlled by the biological pump and nutrient cycles. We suggest that a Si cycle decoupled from nitrogen (N) may cause the equatorial Pacific to be a positive feedback to CO<sub>2</sub> change and help cause atmospheric CO<sub>2</sub> to lead changes in ice-volume in the Pleistocene. The modern equatorial Pacific is a source of atmospheric CO<sub>2</sub>, due to silicate limitation of diatom productivity, resulting in unused nitrate. An ecosystem model incorporating diatoms and their interaction with non-Si requiring phytoplankton recreates this condition. This model, and data of opal mass accumulation rate (Si flux proxy) and Vostok core CO<sub>2</sub>, are used to evaluate the influence of silicate supply and diatoms on glacial/interglacial atmospheric CO<sub>2</sub>. Our results suggest the equatorial Pacific maybe driven into either net source or sink modes by silicate supply due to changing Si trapping in the Southern Ocean.

## ANTHROPOLOGY/ARCHEOLOGY

### **Paleoindian Seasonal Mobility in the Terminal Pleistocene: Investigating the Coastal-Highland Connection in Southern Peru** Kurt Rademaker

How and by what route(s) did people first migrate into South America? How did climate change help to structure ways in which the earliest settlers adapted to the late Pleistocene environments of southern Peru? Current models include a coastal migration, a highland migration, or simultaneous coast and highland migration routes. Archaeologists are unlikely to resolve questions concerning the nature of the coastal-highland cultural relationship and the definition of early migration routes into South America until they recover additional, comparable archaeological and paleoenvironmental data from contemporary early sites on the coast and in the interior highlands. Obsidian artifacts from the early coastal site of Quebrada Jaguay in southern Peru came from the Alca source in the highland Cotahuasi valley, suggesting a link between these two distant areas. These data constitute the only known direct connection between early coastal and highland occupations. During summer 2004, a University of Maine team will investigate three Preceramic highland archaeological sites near the Alca obsidian source to acquire data for comparison with Quebrada Jaguay and explore the possibility that seasonal movement between the coast and highlands was a defining feature of the early settlement of South America.

### **Activity Areas or Migrations in Alaska: Progress Report on the Alaska Project** Brian Robinson

The Alaska Project has been pursued at the University of Maine for the past six years with project director Frederick H. West. Research focused on the analysis of a large number of archaeological sites in the Tangle Lakes Region of Central Alaska, and in particular on a concentration of Denali Complex sites. The latter is a late Pleistocene, early Holocene complex characterized by microblade, burin, and biface technology that some archaeologists, including the principle investigator of the Tangle Lakes research, think represents the first migrants over the land bridge to North America. Different models have archaeological complexes in Alaska representing separate migrations across the land bridge, or simply different activities of the same people. This presentation provides an update on these models as viewed from the Tangle Lakes.

## **Intelligence and the origins of war**

Paul ("Jim") Roscoe

In most animal species, intraspecific fighting takes a ritualized form that minimizes the risks of injury and death to the combatants. Game theory indicates that these 'ritualized' fights allow contestants to evaluate who would win a fight to the death without actually having to fight to the death. How and why, then, have humans escaped these evolutionary constraints to become a species that perpetrates high rates of intraspecific killing? Drawing from data on primate violence, Wrangham and his colleagues have suggested a safety-in-numbers argument. Humans and chimpanzees have the capacity to organize social coalitions: thus individuals can reduce their risks of injury and death in confrontations by contriving to attack isolated rivals in coalition with others. Under these circumstances, intraspecific killing becomes a viable option and explains both chimpanzee lethal violence and human ambush. Wrangham further hypothesizes that the coalitional nature of chimpanzee and human lethal violence has fostered the evolution in these species of a 'demonic male' psychological complex that disposes adult males to attack and kill rivals under conditions of numerical imbalance. In this presentation, I propose a parsimonious alternative to the demonic-male hypothesis: the inclination to deploy lethal collective violence is not a genetic disposition but an epiphenomenon of emergent intelligence. In this 'developed intelligence' hypothesis, chimpanzees and humans have no need of a genetically-based disposition to capitalize on the advantages of deploying lethal violence; they are sufficiently intelligent to figure out the costs and benefits for themselves. The disposition to use lethal violence, in other words, is the result of selection in the mind rather than in nature.

## **Correlations between Climate and Culture Change at Siches, an Early to Middle Holocene Fishing Site in Far Northern Peru**

Daniel H. Sandweiss, James B. Richardson III, Fred Andrus, Stephen Houk, Dolores Piperno, Elizabeth J. Reitz, and Benjamin Tanner

In 2001, we carried out excavations in Area II at Siches, an early fishing site located near Talara, Peru. Since that time, extensive radiocarbon dating and analyses of lithics, vertebrate fauna, molluscan and fish otolith geochemistry, and phytoliths have deepened our knowledge of this site. All of these remains show a change from Early to Middle Holocene. The initial occupation dates to the Early Holocene and shows a mixed subsistence system dominated by marine fauna but including terrestrial fauna and plant foods, possibly domesticated. After a 2000 <sup>14</sup>C yr hiatus in the record, apparently the result of one or more erosional events, the Middle Holocene occupation shows a subsistence system based almost exclusively on marine organisms. We have previously identified different Early and Middle Holocene climatic regimes related to changing ENSO frequency, and the cultural patterns evident at Siches correlate temporally with these changes.

## **A five thousand year old swordfishery in the Gulf of Maine**

David Sanger

For more than 50 years archaeologists have been aware of a Late Archaic period (circa 3800-5,000 B.P.) swordfishery in the Gulf of Maine. From Maine sites we have high numbers of large, adult, fish bones, rostra (bills) and vertebrae, together with harpoons and other equipment. The large number of sites suggests that swordfish would have been within easy striking distance of the central Maine coast. Today, basking swordfish do not occur inshore. In an attempt to learn more about swordfishing in the Archaic period we recently interviewed Nova Scotian fishermen who hunted swordfish with technology generally similar to that in use during the Late Archaic period. These modern observations have provided us with some insights into Late Archaic practices.

## **Big Bend Revisited**

Kristin D. Sobolik

I am going to review the status and progress of archaeological research in Big Bend National Park, Texas. My research in Big Bend included excavation at three archaeological sites in diverse ecotones of the Park, supervision of two M.S. Students conducting lithic analyses and lithic sourcing of Apache Canyon chert source, supervision of a number of undergraduate students on botanical and faunal research of the sites, and research on taphonomy of the region. My research on stratified archaeological sites is being combined with the NPS large-scale survey of the Park to elucidate prehistoric occupation through time and across space in the huge region.

## **Historic Archaeology at Chops Point**

Christopher Wright

Department of History

I will be presenting preliminary information on my thesis research which includes an analysis of faunal subsistence remains and clay tobacco pipe stems recovered during archaeological excavations at Chops Point along the Kennebec River near Dresden, Maine. The site contains Ft. Job Lewis and a settlement that date to just after Queen Anne part of the 18th century. The area that the site is situated on saw almost continuous usage throughout the 18th and 19th centuries. Analysis of clay tobacco pipe stems will aid in determining the age of the Chops Point Site. Analysis of the faunal material will open a window into a part of the daily life of the areas inhabitants following resettlement.

In addition to revealing information on dietary and animal husbandry practices, analysis will focus on ascertaining trade relations with Natives and other English settlements in the area, food hierarchies based on rank or social status. The analysis of the faunal material will further that knowledge by adding information regarding trade and adaptation and perhaps refocus attention on the resettlement of Maine after Queen Anne.



## **Relict Oyster Bioherms and Submerged Archaeological Site Potential in Damariscotta River, Maine, U.S.**

Peter A. Leach

My thesis research involves the development of a method of refining the search for submerged prehistoric sites using relict oyster reefs, which are potential subsistence resources for prehistoric populations. Oyster reefs exhibit a diagnostic 'chaotic' reflector on seismic reflection profiles, allowing ease of identification. Relict oyster reefs have been located in Dodge Lower Cove, Damariscotta River, Maine, U.S., offering a unique location to develop such a method of refinement. The oyster discussed herein, *Crassostrea virginica*, ranges from the Gulf of St. Lawrence in Canada to the Gulf of Mexico and is bound by a suite of environmental factors within this range.

Archaeological site potential models applied to local paleogeographic reconstruction, relative to an extinct oyster bioherm, can provide a higher-resolution search area than systematic survey of submerged environments based solely on large-scale geographic indicators such as drowned river channels. This proposal is of importance to Maine archaeology given the paucity of coastal archaeological sites before 5000 BP, and to the entire east coast of the United States given the broad distribution of *C. virginica*.

## **Ceramic Period Adaptations in the Gulf of Maine: Marine, Terrestrial, and Agricultural Inputs**

Robert J. Lore

Archaeological investigations at site 5.06 located on the Saco River in Biddeford, Maine indicates that it is the area described by Samuel de Champlain in his narratives of 1604. Champlain attests to encountering a large settlement where horticulture was an active component of subsistence. The northern limits of agriculture in the Gulf of Maine are not firmly established, nor are its affects on traditional subsistence strategies. Faunal remains from this site serve as a baseline to evaluate the impact that horticulture had on populations adapted to the littoral. Researchers suggest that the rich ecotones of the Gulf of Maine, coupled with a marginal climate for crops precluded the adoption of horticulture by many groups. Comparative analysis with temporally related sites includes a locale to the north that lacks a horticultural potential, as well as a site to the south where horticulture was a primary component of subsistence. The preponderance of marine derived taxa attests to the success of this adaptation.

## **Ice, Rocks and Humans: Paleoindian Utilization of Ice Edge Environments in the Maine North Woods**

Bertrand Gilman Pelletier Jr.

This presentation will outline a project that will synthesize current archaeological, geologic and biological data in order to determine if paleoindian groups in the New England / Maritimes region utilized an Ice Edge Environment (IEE). By exploiting multiple environments in relatively close geographic proximity; more specifically, transitional areas known as ecotones, humans increase their access to resources while decreasing the amount of energy spent traveling to them. This research will focus on two

specific areas of northern Maine, both of which are believed to contain remnant Pleistocene ice features. The first area of interest is the remnant ice patch that existed to the north of Oxbow, Maine. Recent archaeological data from melting Canadian Yukon glaciers documents an interaction between Humans and Caribou "on the ice". The Oxbow remnant ice patch was active between 11,000 B.P. and 10,000 B.P. and would have been an excellent summer resource for both caribou and the paleoindians that hunted them. The second area is the Munsungan /Chase lakes region, the source of Munsungan chert, a prized lithic resource. It is very likely that Munsungan and Chase lakes may have been a single, larger glacial lake during the time of paleoindian occupation. These remnant Pleistocene ice features must be more clearly defined before a systematic archaeological survey can be instituted. The objective of the archaeological survey will be to test the "IEE Model which supports the summer exploitation of caribou living on or around the Oxbow remnant Ice Patch.

## GLACIAL GEOLOGY

### **Reconstructing late-Quaternary surface profiles of Reedy Glacier, Antarctica**

Gordon Bromley, Brenda Hall

East Antarctic outlet glaciers flowing into the Ross Sea have been shown to respond to volume changes in the West Antarctic Ice Sheet. When grounded ice last advanced through the Ross Sea Embayment, the lower reaches of the Beardmore, Hatherton, Mackay, Reeves, and Reedy Glaciers thickened by as much as 1,000m (Denton *et al.*, 1989) in response to the damming effect. Subsequent recession of the Ross Sea grounding line during the Holocene resulted in the lowering and steepening of the outlet glacier surfaces and the isolation of moraines, drift sheets, and erratics on adjacent mountainsides. Reedy Glacier (86°S) drains the Polar Plateau of the East Antarctic Ice Sheet, and emerges from the Transantarctic Mountains ~100km behind the Siple Coast grounding line of the West Antarctic Ice Sheet. We are mapping depositional landforms adjacent to Reedy Glacier to reconstruct the glacier surface profile at the LGM and during subsequent deglaciation. In addition, exposure-age dates from the former ice margins are providing a chronology of Ross Sea deglaciation from the LGM to the present. This research forms a vital test of the 'swinging-gate' model of Ross Sea deglaciation (Conway *et al.*, 1999) and will help ascertain whether retreat of the West Antarctic grounding line has ended or is ongoing.

### **Surface-Level Changes of Lake Vanda (Antarctica) over the Past 25,000 Years**

Hall, B.L.

Lake Vanda (77°30'S, 161°30'E, 76 m deep), a closed-basin lake in central Wright Valley, has experienced high-magnitude and high-frequency water-level changes over the past 25,000 years in response to regional changes in hydrologic balance and climate. Relict deltas and shorelines as much as 475 m above the present-day lake record prominent highstands. During this past field season, we cored the sediments in Lake Vanda in order to reconstruct a continuous record of water-level changes and to document the presence and timing of lowstands. Although work on these cores has not yet begun, stratigraphy observed in the field indicates that the lake has undergone several periods of evaporation to low volume. These findings are consistent with the variability recorded by the relict deltas and shorelines and are promising for future work on lake-level changes in Wright Valley.

## Hypotheses for the origin of the upper carbonate unit, Lake Fryxell, based on $^{18}\text{O}$ and $^{13}\text{C}$ analyses

Thomas E. Whittaker

Multiple proxy records demonstrate dynamic shifts in depositional environment in Lake Fryxell ( $77^{\circ}36'\text{S}$ ,  $163^{\circ}08'\text{E}$ ), lower Taylor Valley, Antarctica. Here, I concentrate on the interpretation of a unique  $\text{CaCO}_3$  deposit (Unit 2 of the Fryxell Basin stratigraphy). For this study I focus on cores F1 (18 m water depth) and F14 (10.1 m water depth); however, Unit 2 is present in nearly every core retrieved from the lake.

Unit 2 is a  $\text{CaCO}_3$ -rich (35-100%) deposit with typically sharp upper and lower contacts. The  $\approx 30$  cm thick horizon has a composite uranium-thorium isochron age of  $7.7 \pm 2.9$  kyr (2 sigma error). Variability in  $\delta^{18}\text{O}$  in both cores is negligible ( $-27.3$  to  $-29.3\text{‰}$  excluding errors and an outlier) and all measurements are statistically identical. The  $\delta^{13}\text{C}$  records, however, display a marked trend of increasingly heavier isotopic values from the bottom to the middle of Unit 2 ( $\sim 3\text{‰}$  change). The trend then reverses and values become lighter ( $\sim 1.5\text{‰}$  change) toward the top. In a third core with identical stratigraphy, radiocarbon dates from Unit 2 undergo a reversal at approximately the same location in the unit as the  $\delta^{13}\text{C}$  peak. I outline two hypotheses for the depositional environment responsible for Unit 2: (a) that Unit 2 is an evaporite deposit, and (b) that Unit 2 is the result of increased biological productivity in the water column.

## PALEOECOLOGY

### **Chironomid Calibration of Mountain Snowlines in the Southern Hemisphere**

Vandergoes, Marcus J., Dieffenbacher-Krall, Ann C., and Denton, George H.

The Southern Hemisphere is of key importance for determining the symmetry and magnitude of past climate change and whether changes recorded show an in- or out-of-phase relationship with the Northern Hemisphere, information that is essential for resolving root causes of abrupt climate changes. Millennial-scale oscillations in the Southern Hemisphere may correlate with those observed in Greenland ice records. However, pollen data from South American and New Zealand give mixed signals with respect to late-glacial climate changes observed in snowline records. The primary goal of this project is to develop modern chironomid-temperature data sets for the Southern Hemisphere, and to apply them to late-Quaternary-age lake sediment to determine past temperature changes. Chironomids are small, flighted midges, which begin life as larvae dwelling in lacustrine sediment. They are sensitive to summer surface water temperatures as larvae and able to disperse rapidly as adults, rendering them responsive to short-term climate changes. This technique has been widely developed in Europe and North America where it has been used to determine past climate conditions and human impact on aquatic ecosystems. Our work represents a first effort to infer quantitative temperature information from Southern Hemisphere chironomids. Here we outline the progress of the project after 1 year and discuss some preliminary results.

### **Paleoethnobotany at Stix and Leaves Pueblo**

Trisha Rude

Stix and Leaves pueblo is a thousand year old archaeological site in the Mesa Verde region of Colorado. It is one of the few early Pueblo II period sites excavated in the area. For my thesis, I analyzed ancient seeds and charcoal recovered from hearths and firepits of Stix and Leaves. I examined 1) the relative quantity of weedy, non-weedy, and domestic plant remains, 2) the differences in plant remains between rooms and kivas, and 3) the species of firewood used at the site. Through my analysis, I found that weedy plant remains were more common in the assemblage than domestic or non-weedy remains. I also found that sagebrush (*Artemisia tridentate*) achenes were concentrated primarily in kivas. I identified most charcoal as juniper (*Juniperus* sp.), which indicated that the environment around Stix and Leaves pueblo was not deforested.

## CLIMATE

### **Connections Between West Antarctic Ice Core Sulfate And Climate Over The Last 200+ Years**

Daniel DIXON, Paul A. MAYEWSKI, Susan KASPARI, Sharon SNEED, Mike HANDLEY

In this study, data from fourteen, 50m- to 115m-deep, sub-annually dated ice cores are used to investigate recent spatial and temporal concentration variability of the sea salt (ss)SO<sub>4</sub><sup>2-</sup> and excess (xs)SO<sub>4</sub><sup>2-</sup> in West Antarctica. Empirical Orthogonal Function (EOF-multi-dimensional principal component) analysis is employed to assess and interpret the differences and relationships in total SO<sub>4</sub><sup>2-</sup> loading over time and from site to site. The spectral properties of the SO<sub>4</sub><sup>2-</sup> component from each EOF time series and the ss and xsSO<sub>4</sub><sup>2-</sup> data are analyzed for periodicities ranging from 2-50 years to determine whether the climate signals in these ice cores are associated in any way with phenomena such as the solar cycle, sea ice extent, El Niño-Southern Oscillation (ENSO), Antarctic Oscillation (AAO), or the Pacific Decadal Oscillation (PDO).

### **Firn accumulation records for the past 1000 years on the basis of dielectric profiling of six cores from Dronning Maud Land, Antarctica**

C. M. Hofstede (Maine), R. S. W. van de Wal, K. Kaspers, M. R. van den Broeke IMAU, Utrecht), L. Karlöf, J.-G. Winther, E. Isaksson (Norsk Polarinstitut), G. Lappegård (University of Oslo), R. Mulvaney (British Antarctic Survey), H. Oerter and F. Wilhelms ( Alfred-Wegener Institut)

This paper presents an overview of firn accumulation in Dronning Maud Land in Antarctica over the past 1000 years. It is based on a chronology established with dated volcanogenic horizons detected by dielectric profiling of six medium-length firn cores. In 1998, the British Antarctic Survey retrieved a medium-length firn core from western Dronning Maud Land. During the Nordic EPICA traverse of 2000/2001, a 160-meter long firn core was drilled in eastern Dronning Maud Land. Together with previously published data from four other medium-length ice cores from the area, these cores yield 50 possible volcanogenic horizons. All six firn cores cover a mutual time record until the 29th eruption. This overlapping period represents a period of approximately 1000 years with mean values ranging between 43 and 71 mm w.e. The cores revealed no significant trend in accumulation. Running averages over 50 years, averaged over the six cores, indicate temporal variations of 5%. All cores display evidence of a minimum in the mean annual firn accumulation rate around the year 1500 AD and maximums around 1400 and 1800 AD. The mean increase over the early 20th century was the strongest increase, but the absolute accumulation rate was not much higher than around 1400 AD. In Eastern Dronning Maud Land a 13% increase is observed for the second half of the 20th century.

## **The North Atlantic Oscillation and the Gulf of Maine's Oceanography: Hypotheses and a Plan of Research**

Alan D. Wanamaker

The climate of the Atlantic sector and surrounding continents exhibits considerable variability on a wide range of time scales. A substantial portion of climate variability on interannual-to-decadal time scales over the Atlantic Basin is associated with the North Atlantic Oscillation (NAO), which is the dominant pattern of atmospheric circulation variability. The NAO has proven to affect, temperature and precipitation patterns, winds, storm tracks, agricultural harvests, water management, energy supply and demand (most notably in Western Europe, North Africa, Middle East, and North America), ocean circulation, sea surface temperatures and yields from fisheries in the Atlantic sector. Hypotheses for the potential role NAO variability plays on the Gulf of Maine's oceanography will be discussed. A research plan for testing these hypotheses using stable oxygen isotope ratios and trace metal analyses in marine bivalves, over a range of time-scales, will be outlined.

## **Interpreting local- and regional-scale atmospheric chemistry in the Dry Valleys, Antarctica using snowpit and firn core records from three glacier accumulation zones.**

Bruce Williamson, Karl Kreutz, Paul Mayewski, Nancy Bertler (Victoria University), Douglas Introne, Sharon Sneed, Michael Handley, Erich Osterberg, Mike Waskiewicz (Data North)

The McMurdo Dry valleys in Victoria Land, Antarctica, provide an intriguing area for climate study, with a coastal location and atmospheric chemistry potentially reflecting both coastal and interior weather patterns in different seasons of the year. During November of 2003, snow pit samples and shallow firn cores to ~15m depth were recovered from three sites in the region: the Clark, Commonwealth and Blue Glaciers, at elevations of 770, 690 and 1000 meters, respectively. Snowpit samples from these sites, collected at 2cm resolution, are currently being analyzed for stable isotope ratios ( $\delta^{18}\text{O}$  and  $\delta^2\text{H}$ ), major ionic chemistry and trace metals, including Al, B, Ba, Ca, Fe, S, Sr and the rare earth elements. Preliminary results for the Clark and Blue Glaciers show that concentrations of major ionic species are significantly higher in seasonal peaks for the Clark Glacier than they are for the Blue Glacier. Oxygen isotope ( $\delta^{18}\text{O}$ ) minima are also from 2 to 8‰ lower for the Clark glacier than they are for the Blue glacier. Different hypotheses to explain these observations, including altitude effects and other site-specific factors such as aspect and ice cover differences on the slopes surrounding each glacier, will be discussed.

## **A 550-year ice core hydrogen isotope record from the Eclipse Icefield, St. Elias Mountains**

Karl Kreutz, Doug Introne, Cameron Wake (UNH) and Kaplan Yalcin (UNH)

To test hypotheses related to late Holocene climate variability in the North Pacific region, a 350-meter ice core was recovered from the Eclipse Icefield (St. Elias Mountains, Yukon Territory, Canada) during 2002. The annual accumulation rate at the site (~1.5 meters water equivalent per year) is sufficient to ensure accurate reconstructions of interannual to decadal-scale climate over at least several hundred years. High-resolution sampling (2-10 cm) and analysis of the ice core for stable hydrogen isotope ratios has been completed to a depth of 303 meters, and clear annual fluctuations are present in the isotope dataset throughout the core. Based on analysis of sulfate and tephra datasets, several known volcanic horizons have been identified and used to verify the annually counted depth/age scale including the 1452 AD Kuwae tephra at a depth of 296 meters. Based on multiple counting techniques, we estimate the depth/age scale error to be  $\pm 1$  year over the past 550 years. Ongoing work to calibrate the isotope record in terms of local and regional meteorology as well as preliminary interpretations of late Holocene ocean/atmosphere variability in the North Pacific will be discussed.

## **Solar Forcing of the Polar Atmosphere**

P.A. Mayewski, K. Maasch, Y. Yan, S. Kang, E. Meyerson, S. Sneed, S. Kaspari, D. Dixon, V.I. Morgan (Australian Antarctic Division) and T. van Ommen (Australian Antarctic Division)

Solar variability is an important driver of climate change as evidenced by previous studies that demonstrate associations between observed historical records of solar activity and climate change and also between millennial scale variability in paleoclimate records (Greenland ice cores and North Atlantic marine sediments) and variability in cosmogenic proxies for solar variability. To further elucidate the solar-climate association we present highly-resolved, annually dated, calibrated climate proxies from several Antarctic ice cores that reveal decadal scale associations with a South Pole ice core  $^{10}\text{Be}$  proxy for solar variability over the last 600 years and annual scale associations with the sunspot cycle. We show that increased (decreased) solar irradiance is associated with increased (decreased) zonal wind strength near the edge of the Antarctic polar vortex. The association is particularly strong in both the Indian and Pacific Oceans and as such may contribute to understanding climate forcing that controls drought in Australia and other Southern Hemisphere climate events. Our identification of solar forcing of the polar atmosphere and its impact on lower latitudes offers a mechanism for the initiation of abrupt climate change events that operate on decadal and faster scales.



## **Examination of Major Holocene Climate Change Events in Ice Cores from West Antarctica (Siple Dome), East Antarctica (Taylor Dome), and Greenland (GISP2)**

E.A. Meyerson, P.A. Mayewski, S.B. Sneed, A.V. Kurbatov, K.J. Kreutz, G.A. Zielinski, Y. Yan, and K.A. Maasch

A newly developed paleo-atmospheric circulation time-series from Siple Dome, West Antarctica is compared to the existing GISP2, Greenland, and Taylor Dome, East Antarctic paleo-atmospheric circulation series. The three records are compared over the Late-Quaternary, followed by detailed examination of major climate change events covering the Holocene. A rise in Siple Dome sea-salt (ss)  $\text{Na}^+$  over the Holocene from ~9000 years ago to present is related to an increase in the penetration of marine air masses from the South Pacific concurrent with lowering of the ice surface over the Ross Sea Embayment. Notably, mean Siple Dome ssNa concentrations over the last ~1000 years are higher than values seen over the full ~98,000 year record. The Siple Dome record stands in marked contrast to the "classic" high-to-low, Glacial-to-Holocene ssNa values, noted in the GISP2 and Taylor Dome records. Siple Dome ssNa and non-sea-salt (nss)  $\text{K}^+$  series capture the same major Holocene climate change events identified in GISP2, centered on ~8200, ~5700, ~2900, and ~400 years (i.e., the Little Ice Age). Dating errors prior to ~2000 years BP are potentially too large to determine the exact phasing of climate event timing from site to site. Examination of ice core series <2000 years BP suggests that Siple Dome and Taylor Dome record onset of Little Ice Age atmospheric circulation intensification over the Southern Ocean circa AD 1250, compared to onset over the North Atlantic recorded at GISP2 closer to AD 1400. Siple Dome dust levels rise after AD 1600, most likely when southern continental sources become available due to Little Ice Age induced environment changes or polar atmospheric circulation expands to include source regions in South America, Australia, and/or Africa.

## **Abiotic Controls on the Trophic Status of Oligotrophic Surface Waters**

Stephen A. Norton

The presentation will explore the linked hypotheses that: (1) Oligotrophic streams responding to episodic or longer-term acidification (from atmospheric deposition of acidic compounds or natural long-term acidification) export more dissolved Al and a substantial amount of particulate  $\text{Al}(\text{OH})_3$  with adsorbed  $\text{PO}_4$ , but maintain low dissolved  $\text{PO}_4$ . (2) Biologically available P may be reduced to below pre-acidification values in the stream and in down-stream lakes. (3) Sediments in lakes whose watersheds have acidified, for any reason, have higher concentrations of P associated with larger sediment fluxes of particulate  $\text{Al}(\text{OH})_3$ . (4) Biologically available P in the water column may have been reduced during acidification, causing oligotrophication.

## **Identification of Aerosol Source Components and North Pacific Paleoclimate Proxies from Mt. Logan Summit Ice Cores**

Erich Osterberg, Paul Mayewski, Karl Kreutz, Dave Fisher (Geological Survey of Canada), Sharon Sneed, Mike Handley

Mount Logan, Yukon, Canada (60°37' N, 140°31' W), is ideally located close to the semi-permanent Aleutian Low pressure center, which dominates North Pacific winter weather patterns and is strongly related to the strength of ocean-atmosphere climate oscillations such as the Pacific Decadal Oscillation (PDO) and El Niño-Southern Oscillation teleconnections. Glaciological time series from the uppermost 7 m of the 2002 Mount Logan summit ice core (5343 m asl) reveal a probable annual signal dominated by a dust component ( $\text{Ca}^{2+}$ ,  $\text{Mg}^{2+}$ ,  $\text{SO}_4^{2-}$ , Al, Fe, Ti, Sr, V, Pb, U, REE suite) and a marine component ( $\text{Na}^+$ ,  $\text{Cl}^-$ ,  $\text{K}^+$ ,  $\text{SO}_4^{2-}$ ). These signals have been distinguished using various statistical analysis techniques including empirical orthogonal functions (EOFs), factor analysis (FA), positive matrix factorization (PMF) and Pearson correlations (PC). The large suite of elements being analyzed from the new Mt. Logan summit core (Na, Cl, Ca, Mg, K,  $\text{SO}_4$ ,  $\text{NO}_3$ , Al, Fe, Pb, Ti, Sr, Ba, V, Mn, Zn, Cd, Cu, Co, Cr, U, Ce, Bi, Se, Sb, As, REEs) will allow air-mass tracing and identification of aerosol source regions, and increase the robustness of paleoclimate proxies developed from the time series. New glaciochemical proxy records of atmospheric circulation, sea-level pressure and temperature from the 1980 Mt. Logan summit ice core will be presented and discussed.