# 11th J. Louis Agassiz Symposium

## Climate Change Institute

8-9 May 2003

Bangor Lounge - Memorial Union

1865 THE UNIVERSITY OF MAINE

# Agassiz Symposium, May 8 & 9, 2003
## *Climate Change Institute, University of Maine*

### SCHEDULE OVERVIEW

All talks, posters, coffee breaks, and lunches will be held in the Bangor Lounge in the Memorial Union.

**Thursday, May 8th**

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|---|---|
| 8:30am | Introductions |
| 8:45am to 10am | Talks |
| 10am to 10:30am | Coffee Break |
| 10:30am to 12pm | Talks |
| 12pm to 1pm | Lunch |
| 1pm to 2:30pm | Talks |
| 2:30 to 3pm | Coffee Break |
| 3pm to 4:30pm | Keynote Speaker, Dr. Michael E. Moseley<br>Professor of Anthropology, University of Florida<br>& Member of the National Academy of Sciences<br>***El Niño-induced Floods in the Andean Desert*** |

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**Friday, May 9th**

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|---|---|
| 8:30am | Introductions |
| 8:45am to 10am | Talks |
| 10am to 10:30am | Coffee Break<br>Poster presenters will be present to answer questions |
| 10:30am to 12pm | Talks |
| 12pm to 1:30pm | BBQ Lunch |
| 1:30pm to 3:15pm | Talks |

## ABSTRACTS & SCHEDULE DETAILS

### Thursday, May 8th

8:45-9:00

**Archaeology in Downeast Maine**

*David Sanger and William R. Belcher (U.S. Army Central Identification Laboratory, Hawaii)*

During the 1980s, archaeological field work in the Roque Island archipelago, Washington County, resulted in information spanning roughly 4,000 years. Prior to about 4000 B.P. rising sea levels had still not created the archipelago. Excavations at the long crescentic beach on Roque Island unearthed evidence for a Terminal or Late Archaic tradition dominated by a core and blade technique, the first identified for the Maine-Maritime Provinces region. At nearby Great Spruce Island, we found close to 2,000 years of occupation incorporated into a shell midden that provides data on subsistence, seasons of occupation, housing, and technology. Comparisons with other coastal areas suggests that the Roque Island sites affiliate closely with the Quoddy region of eastern Maine and New Brunswick. Possible explanations include developing local ethnicity and regional vegetation patterns.

9:00-9:15

**Refining Time and Space in the 1950s at Bull Brook**

*Brian Robinson*

A major part of the current research on the Paleoindian Bull Brook site depends on the accuracy of the site plan showing a circular arrangement of artifact concentrations. It is possible that the site represents the largest known intentional settlement plan known from Paleoindian times. Evaluating and refining the excavation plan provides a critical foundation for subsequent anthropological and technical analysis, to test this proposition. The site was excavated largely by avocational archaeologists in the 1950s, who took field notes and photographs. Current work involves extensive interviews with Bill Eldridge (the major record keeper for the excavations), reconstructing the order of hundreds of color slides that were mostly unlabeled, and correlating these with written records to provide a day by day account of the excavations. The photographs provide one of the primary means of refining the excavation plan, and for investigating topographic and stratigraphic relationships with the Pleistocene land form.

9:15-9:30

**Obsidian Procurement by Peruvian Paleoindians: Nature v. Culture at Quebrada Jaguay – a progress report**

*Harold W. Borns, Daniel H. Sandweiss*

Excavations by D. Sandweiss at the Quebrada Jaguay site in southern Peru have confirmed that Paleoindian-age peoples of South America (ca. 11,000-10,000 BP) included maritime adaptations among their subsistence systems, indicating greater diversity in lifeways than previously recognized. Among the remains recovered were fragments of the volcanic glass obsidian which are the byproducts of making tools. Obsidian comes from a limited number of deposits in the Andes, and it is possible to determine the source of a particular piece of this material by analyzing its chemical composition. All of the obsidian at the Quebrada Jaguay site came from a single source, about 165 km away at a place called Alca. Another source, commonly used in later prehistory, lies somewhat farther away along an easier route, near the town of Chivay. Why did the inhabitants of Quebrada Jaguay turn exclusively to the Alca source for their obsidian? One answer may be that even at this early period, human groups engaged in territorial behavior, with access to particular areas and resources determined by group affiliation. However, before pursuing such intriguing social interpretations, it is necessary to eliminate natural causation. In this case, it is possible that the Chivay source, located at a higher altitude than Alca, may have been covered by glacial ice when the Quebrada Jaguay site was occupied, especially as this is exactly the time of the Younger Dryas glacial advances in the northern and extreme southern hemispheres. Our preliminary research using cosmogenic surface exposure age dating suggests that a small ice cap expanded during Younger Dryas time over the Chivay obsidian source.

9:30-9:45

**Fishshift: Geoarchaeological Insight into Multidecadal Climate Change in the Pacific Basin**

*Daniel H. Sandweiss and Kirk Maasch*

Recent work by Chavez et al. (*Science* **299**, 217 [2003]) correlates anchovy- and sardine-dominated fisheries with subtle climate change in the Pacific Basin during the 20th century. The anchovy regime is characterized by cooler conditions and lower frequency El Niño/Southern Oscillation (ENSO) events, while the sardine regime is associated with warmer conditions and higher frequency ENSO. Excavations at Lo Demás, an Inca-period (ca. A.D. 1480-1540) fishing site at 13 25' S on the Peruvian coast, recovered evidence for a shift from an anchovy- to a sardine-dominated fishery at about A.D. 1500. This shift correlates with records for increasing ENSO frequency at the same time and suggests that fish fauna from Holocene archaeological sites in coastal Peru may provide insight into multidecadal climate change in the Pacific Basin.

9:45-10:00

**Mardu Children, Hunting, and Life History Strategies**

*Douglas Bird*

A long childhood is the focus of many scenarios of human evolution because relative to other primates human juvenile periods are very long. Among our closest ape relatives the juvenile period, from weaning to first reproduction, lasts from between 6 to 8 years and is supported mostly by the juvenile's own foraging effort. In humans the juvenile period is nearly twice as long. And during that time children's consumption of resources greatly exceeds what they produce for themselves. What selection pressures might have lengthened the period of dependency and delayed reproduction among humans? Two hypotheses are prominent in the literature. One is that humans need an extra long time to learn complex subsistence strategies, and the other is that long juvenility is the pleiotropic effect of selection for long life-spans. This talk examines some predictions generated by these hypotheses using new ethnographic data on children's hunting strategies among the Mardu of Australia's Western Desert.

10-10:30am Coffee Break

10:30-10:45

**Paleoethnobotany at Stix and Leaves Pueblo, Colorado**

*Trisha Rude*

In this talk, I will present preliminary results from my thesis research. For my thesis, I will analyze archaeological plant remains from Stix and Leaves Pueblo, a thousand year old archaeological site west of Mesa Verde National Park in Colorado. I hope to discover: 1) how heavily people at the site depended on agriculture, 2) whether the pueblo hosted religious feasts, and 3) how many types of corn were grown at the site. Stix and Leaves Pueblo, a multi-roomblock site dating from AD 935-1060, is one of very few excavated Pueblo II sites in the region. The Pueblo II period (ca. AD 900-1150) at Mesa Verde predates aggregation of communities into large villages, and is marked by population growth, variable climate conditions, and later periods of food stress and small-scale warfare. I hope to use ecological concepts of risk, food choice, and diversity to explain Pueblo II changes that may have lead to the Mesa Verde region's abandonment by AD 1300.

10:45-11:00

**Burnt Bone and X-Ray Diffraction: Experimental Approaches to Interpreting Calcined Assemblages**

*Robert Lore*

Burnt bone is a common occurrence on archaeological sites and is often the only faunal material available for interpreting subsistence strategies. Although these data have the potential to provide significant information, there are inherent limitations that have to be addressed. Faunal specimens rarely reflect the full breadth of subsistence activities at an archaeological site, and taphonomic factors can restrict their interpretive value. The morphological and chemical transformations which occur in

burnt bone are evaluated through experimental incineration. These transformations are based on changes in gross morphology, color change, and crystal size. Change in crystal size was determined though the use of XRD (X-Ray Diffraction). Hydroxyapatite is the primary inorganic component of bone, and changes in crystalline size refer to this mineral. Results of experimental incineration indicate that they can serve as a baseline for interpreting archaeological specimens.

11:00-11:15

**Ancient DNA Research**

*Kristin D. Sobolik*

Analysis of ancient DNA is a relatively new field of study which has reopened scientific inquiry into a number of research venues previously considered "stalled" due to lack of new or further evidence. For this talk, I showcase some of the most recent research on ancient DNA, as well as present current research that I am involved in. These DNA studies have provided insight into the origins of humans, Neanderthal lineage, Old World and New World diseases, colonization of Australia and the Americas, animal evolution as a response to climate change, and domestication of plants and animals. My research involves analysis of prehistoric dietary changes through time, advent of and changes in domesticated crops, and sex determination of samples.

11:15-11:30

**Non-Invasive Archaeological Investigations Using Ground Penetrating Radar**

*Alice R. Kelley and Allen Gontz*

Ground penetrating radar (GPR) is a nondestructive, rapid, high-resolution geophysical technique that provides continuous vertical sections profiles across an area of interest. Because all information is acquired at the ground surface, there is no disturbance of buried material, making it an ideal tool in a sensitive cultural setting. In spring of 2003, GPR was used to identify the location of unmarked internments in a small, 19th century family cemetery in southern Maine. The presence of three, distinct marked graves allowed characterization of the GPR returns produced by a single burial, enabling us delineate the cemetery. The completed survey of the plot identified 12 anomalies consistent with burials.

11:30-11:45

**12,000-year Record of Lake-level Change at Mathews Pond, Piscataquis County, Maine**

*Andrea Nurse*

A study of late-glacial and Holocene lake-level changes at Mathews Pond will contribute to the data base of lake-level change information for northeastern North America, and will establish a 12,000-year paleohydrology record for the watershed surrounding Big Reed Forest Reserve, the largest old-growth forest stand in northeastern United States. Mathews Pond is a small, closed-basin, groundwater-seepage lake located in an upland, forested region of Piscataquis County, Maine, within the Munsungun Lake and Aroostook River drainage system. The entire lake basin is lined with a thin layer of glaciolacustrine silt and clay, indicating that glacial meltwater briefly filled the basin 14,000-13,000 radiocarbon years before present. The lake existed as a shallow pool in the deep area of the basin between 11.0 and ~8.0 kya. Water level rose to near modern levels after 8.0 kya. A clear low stand beginning around 5.0 kya followed 3000 years of high water level. Water level fluctuated until ~1.5 kya, when the lake level gradually rose to the present high stand. Centennial-scale, analytical resolution for charcoal and fossil pollen recorded subtle changes in forest cover and in groundwater response to decreased evapotranspiration following local forest fire.

11:45-12:00

**Aquaculture-based Calibration of the Isotope Paleothermometer**

*James Hunt, Karl Kreutz, Hal Borns, Bruce Barber (School of Marine Sciences), and Douglas Introne*

Oxygen-isotope paleothermometers, based upon both inorganically and biogenically precipitated calcite and aragonite are widely used in several disciplines. There are intrinsic complexities, however, in the application of these equations to past

temperature determinations using carbonate secreting organisms. One such complication is that of the three unknown variables: water temperature, water isotopic composition and shell isotopic composition; only the latter can be measured directly. In addition, the effects of other factors such as organism vital effects and seawater salinity are often unknown. In this study, we will be culturing the important boreal bivalve species *Mytilus edulis* (Blue mussel) from early juvenile to adult stage, using a four by three factorial experiment to determine the synergistic effects of water salinity, isotopic composition and temperature on oxygen isotope fractionation during calcium carbonate shell formation. We will use a total of twelve tanks equipped with re-circulating systems capable of maintaining three tanks each at temperatures of 8, 12, 16 and 20°C. Seawater solutions of 22, 28 and 34 ppt having $\delta^{18}O$ values of -4, -2.5 and -1‰ respectively, will be made by combining Darling Center well water and seawater with an appropriate amount of sea-salt. Shell growth rate will be ascertained on a weekly basis and $\delta^{18}O_C$ determinations will be conducted monthly on new shell growth. Our goal is to develop a comprehensive calibration of the *Mytilus edulis* isotope paleothermometer that we will that will be used to investigate spatial and temporal effects on shell isotopic composition using fossil representatives of this species collected along the coasts of Greenland and Maine.

12:00-1:00pm Lunch

1:00-1:15

**A Review of Shallow-water Pockmark Distribution and Origins in the Northwestern Gulf of Maine**

*Joseph T. Kelley, Daniel F. Belknap, and Allen M. Gontz*

Seafloor depressions, called pockmarks, appear in late 19th century bathymetric surveys, and were observed as "channels" in seismic profiles in Penobscot Bay in 1959. Widespread geophysical mapping changed early beliefs that pockmarks were unusual to an appreciation that they are common. Along the Maine coast, 79 large fields of natural gas are mapped, totaling more than 300 $km^2$. Fewer than 10 fields have abundant pockmarks, but most fields are not explored. Fluid escape is the identified mechanism of pockmark formation; groundwater and methane were each postulated as driving forces. We favor methane because we have chemically measured and acoustically observed gas, and know no mechanism to deliver groundwater to existing fields. Disagreement exists over the current activity of the fields. Most gas fields lack pockmarks, and scarce observations of gas release suggest that fluid venting may be rare. Side scan images and anecdotes of gas venting in Belfast Bay, time-series maps showing the filling and creation of pockmarks, and 27 degree mean pockmark wall slopes suggest at least annual activity. Some gas fields lacking pockmarks possess breached seals; breaching of overlying seals may ultimately end pockmark activity. Pockmarks are not known from Coastal Plain estuaries, so if gas escape forms pockmarks, methane in formerly glaciated terrane requires a special source. Glacial-marine sediment and drowned wetlands are possible candidates. The upper, ice-distal "glacial"-marine sediment is often fossiliferous and organic-rich. Lakes and bogs commonly occur on this substrate on land, and presumably did so in present-day estuarine settings when sea level was lower. Lake and wetland environments commonly exist at the upper end of modern estuaries, and bays with pockmarks, like Somes Sound, were once demonstrably lakes. Thus, we believe gas and pockmark fields mark a significant transformation of terrestrial environments to marine as a result of sea level rise.

1:15-1:30

**Submerged Paleo-lakes on the Maine Coast?**

*Daniel F. Belknap, Allen M. Gontz, and Joseph T. Kelley*

There are ca. 311 $km^2$ of gas-charged Holocene sediments within coastal Maine estuarine and nearshore deposits. Well-developed pockmark fields occur in Penobscot Bay, Passamaquoddy Bay, Blue Hill Bay, and in many smaller sites. In 2001-2002 we conducted sidescan sonar surveys, seismic reflection profiling, and vibracoring designed to elucidate origins and evolution of pockmark fields. We targeted well-developed pockmark fields in Penobscot Bay, a large estuary, and Muscongus Bay, a neutral embayment. Muscongus Bay contains large areas of abundantly gas-charged sediments, but with only one or two small pockmarks known. Our initial hypothesis for the Muscongus Bay target area, an area informally named Cranberry Basin, was that bedrock ridges may have contained an early Holocene lake and/or restricted estuary at times of sea level lower than ca. 30 m. We have recovered 46 vibracores in Penobscot Bay and 10 in Muscongus Bay, in addition to 5 and 9 vibracores, respectively, from earlier projects. The upper 3-4 m of the Holocene section in Penobscot Bay are typically olive-brown, relatively well oxidized mud with water content of 40-60%, and with abundant organic content (5-7% LOI) in

the form of fine detrital organic material. Near-surface shear strengths are generally 1.5-2 kg/cm$^2$. The massive mud contains few intact mollusk fragments or foraminifera. Common zones with up to 4 cm diameter may be burrow traces, or possibly gas vent structures. Slightly indurated "pipes" in cores and dredged from the seafloor resemble published examples from known gas venting regions. Cranberry Basin cores are distinctively darker grey, reduced muds with very high organic contents (10-12%) and water contents (60-70%). Near-surface shear strength is <1 kg/cm$^2$. They contain abundant bivalves and gastropods, benthic foraminifera, with scattered sand lenses, shell hash lenses, and siliceous sponge spicules. They also contain abundant natural gas. At least one core contains detrital organic matter and abundant salt-marsh foraminifera. There is no evidence for lake sediments in the cores opened to date. The distinctly different sediments and degree of pockmark formation in the two embayments may be related to riverine inputs, paleogeography, or physical circulation. We rule out seismicity or groundwater as driving mechanisms. Paleogeographic and paleoenvironmental reconstructions allow better understanding of evolution of the Maine coastal system during Holocene sea-level rise, with implications for climate change, archaeology, and coastal land use.

1:30-1:45

**A Methodology for Paleogeographic, Paleoceanographic, and Paleoecologic Reconstructions of the Black Ledges Area, Penobscot Bay, Maine**

*Allen M. Gontz (Dept. of Geological Sciences), Daniel F. Belknap, and Beverly J. Johnson (Dept. of Geology, Bates College)*

The Black Ledges area of Penobscot Bay has been a focus of geologic research over the past 4 years. The area contains seven biogenic methane-sourced pockmark fields with densities higher than recognized anywhere else worldwide. The depth of this field lies within the zone affected by relative sea-level changes that occurred since the retreat of the Laurentide Ice Sheet. Current research hypotheses propose that the origin and evolution of these fields is controlled by the changes to the morphology, environmental settings, and oceanographic circulation of the estuary. During the summers of 2000 and 2002 over 150 km of high-resolution boomer seismic reflection data and 46 3 to 5 m vibracores were collected. Initial analysis of the seismic data suggests the Black Ledges area transitioned from a fully oceanic, ice-proximal environment through palustrine and subaerial environments to the present estuarine environment. A detailed sedimentologic and stratigraphic analysis of the vibracores is currently underway and has produced initial indications that support this hypothesis. Additional research and analysis is scheduled for the summer of 2003 involving 1) organic geochemical techniques to determine the source material of methane and its environment of deposition and 2) floral and faunal analyses to determine oceanographic and estuarine circulation and characteristics. The geophysical, geochemical, stratigraphic and sedimentologic data will be combined into a unified view to reconstruct the timing, mode and style of the evolution of the Black Ledges area since deglaciation.

1:45-2:00

**Imaging Maine from Space**

*William Sneed and Gordon Hamilton*

We are compiling a new satellite image mosaic of the state of Maine. The mosaic is composed of approximately 150 high-resolution images collected since 2001 using the ASTER instrument onboard NASA's Terra satellite. Each image contains information in fourteen spectral bands, although we only using the three visible near infrared (VNIR) bands for mosaicking. These bands have a nominal spatial resolution of 15 meters. Most of the images selected for mosaicking were acquired during the summer and early fall when cloud coverage and snow cover are minimal and when variability in vegetation coverage is least apparent. We shall describe the steps involved in the construction of the mosaic as well as some of the problems encountered. The fine spatial resolution of the imagery makes it suitable for mapping numerous features of natural and cultural interest. We plan to make the image mosaic widely available, including distributing it to Maine schools on a DVD for classroom use.

2:00-2:15

## The Life and Geological Times of John De Laski

*David Smith, Hal Borns, and Kirk Maasch*

This is the third report of progress in a four year project. It concerns the somewhat mysterious geological research work done by John De Laski, a physician from Rockland, Maine between 1840 and 1875. We have discovered ten long articles by him in the daily press of Maine, and the American Journal of Science. In addition, we have an unpublished book length manuscript by him which describes his research and his findings. In these articles, he outlines a theory of glacial geology providing an explanation for the surficial geology of Maine and Northern New England. It appears apparent that De Laski was one of true pioneers of the geology of New England. By 1860 he had identified deltas, moraines, striae, and he had collected and reported on various fossil collections. He had a considerable influence in his own time, as his work was cited and quoted by Geike, Dana, Hitchcock and others. We have begun writing a book which we hope will be published next year. We have read or scanned all the materials in the AJS (Silliman's Journal) from 1820 to 1880 which has turned out to be a significant source along with other materials from De Laski's time.

2:15-2:30

## Climatology of the NORLUN Instability Trough: Initial Development and Use in Improving New England Snowstorm Forecasts

*Gregory A. Zielinski, Daniel K. Cobb and Hendricus J. Lulofs (National Weather Service, Caribou, Maine)*

Almost every winter in New England, there is at least one occurrence of a snowstorm that was not forecasted or an "under forecasted" snowstorm that produced snowfall totals above 10 inches when the original forecast was only for 1-2 inches. In such cases, NWS warnings are often issued in the middle of the event, when heavy snow is already occurring, which limits the effectiveness of the warning. The most common cause for these problematic forecasts, particularly from the perspective of the general public, is the presence of a NORLUN instability trough (NORLUN), a trough that has the ability to focus and lift moisture to form intense and persistent snow squalls (Lundstedt, 1993). Identification of the trough as the driving force in such scenarios occurred in the early 1990s following two separate snowstorms that hit the Portland, ME, area (21 March 1992) and Cape Cod (19 February 1993) with 3-4 inch snowfall rates and total accumulations of 20-30 inches. Unfortunately, numerical models do not appear to predict consistently development of the NORLUN (QPF) nor do they appear to predict reliably snowfall amounts (QPE). Consequently, we are in the process of developing a detailed climatology of the NORLUN as a means to identify the processes involved in NORLUN formation and the parameters essential for recognizing, and thus predicting the presence and impact of the trough. An ultimate goal is the construction of a conceptual model, which would facilitate consistent prediction and provide adequate warning lead times for such events.

In addition to a re-evaluation of the storms originally assessed by Lundstedt, we initially evaluated the characteristics of two NORLUN events during the 2001-2002 winter (21 December 2001 and 16 January 2002). From these analyses we suggest that there are at least two NORLUN types. A Type I NORLUN appears to occur most frequently as a 25 to 50 mile wide band of heavy snowfall amounts with the axis of heaviest snowfall oriented NW-SE extending from the coast into the hills of interior New England. Synoptically, this type appears to be characterized by a weakening surface low moving into the St Lawrence River valley with a developing ocean storm too far to the east to affect New England directly. This situation is often associated with onshore flow of potentially buoyant air from 500 to 1500 meters above the surface ahead of a trough axis that connects the two low centers. A Type II NORLUN produces a snowfall axis that tends to mirror coastal topography in areas south of Mid-Coast Maine. In this case, there is only one low (i.e., an ocean storm passing too far to the east to directly affect New England) with a significant inverted trough extending to the northwest of the developing low center. The inverted trough appears to be the result of an advancing shortwave aloft with heavy snow along and ahead of the trough axis. However, the orientation of the snow bands tends to be parallel to the coastline and not necessarily parallel to the trough indicating that a secondary mesoscale response, such as coastal convergence induced by frictional differences between sea and land, may be more directly responsible for the maintenance of the 2 to 4 inch per hour snow rates. Consequently, geography of the coastline may be critical to development of a Type II event. We expect that these characteristics, as well as others discovered in the evaluation of additional NORLUN events, will be components of our conceptual model for the NORLUN instability trough.

2:30-3:00pm Coffee Break

3-4:30pm

***El Niño-induced Floods in the Andean Desert***

Keynote Speaker, Dr. Michael E. Moseley

Professor of Anthropology, University of Florida, and Member of the National Academy of Sciences

Along the desert coast of Peru significant flash floods have only transpired in association with El Niño induced rainfall historically. Floods and debris flows accompanying the very strong El Niño events of 1982-83 and 1997-98 were very economically and demographically disruptive for populations residing in irrigated littoral valleys. However, flood deposits generated by these recent severe events are an order of magnitude smaller than numerous debris flows evident in coastal paleoflood sequences. After assessing preservation biases in paleoflood records, this presentation examines a very severe El Niño-induced paleoflood episode, the Miraflores Catastrophe, that produced flood deposits which overlie many late prehistoric occupation surfaces of the Chiribaya culture in the Río Osmore region of southern Peru (17° S. Lat.). Tentatively dated to ~ A.D.1350-1370, this devastating disaster converged with a protracted multi-decadal drought and contributed to the rapid breakdown of the coastal Chiribaya societies and the ensuing rise of the sierra Estuquiña culture.

## Friday, May 9th

8:45-9:00

### West Antarctic Climate Reconstruction Based on the 2001-2002 US ITASE Ice Cores

*Susan Kaspari, Paul A. Mayewski, Sharon Sneed, and Mike Handley*

Four ice cores collected in the Pine Island Catchment of West Antarctica during the 2001-02 US International Trans Antarctic Scientific Expedition (ITASE) were analyzed at high-resolution (15-50 samples/year) for soluble ions (Na, K, Mg, Ca, Cl, $NO_3$ and $SO_4$) using ion chromatography. The chemical time series exhibit strong seasonal signals that allow precise annual dating of the records. Correlations between the ice core time series and climate indices such as sea level pressure are explored to develop calibrated ice core climate proxies. Empirical orthogonal function (multi-dimensional principal component) analysis is used to examine the various atmospheric pathways that dominate West Antarctic climate, and spectral properties of the time series are examined for clues related to solar forcing of climate and associations with the El Niño Southern Oscillation (ENSO) and the Antarctic Oscillation. The spatial and temporal coverage of these ice cores offer potential insight into: regional trends in atmospheric chemistry, transport pathways, sources of chemical species, atmospheric circulation, variations in accumulation rates, the frequency and effect of extreme climate events (such as volcanic eruptions), and the influence of major atmospheric circulation systems (e.g. ENSO).

9:00-9:15

### Sulfur Isotopic Measurements from a West Antarctic Ice Core: Implications for Sulfate Source and Transport

*Lee E. Pruett, Karl J. Kreutz, M. Wadleigh (Dept. of Earth and Environmental Sciences, Memorial University), Paul A. Mayewski, Andrei Kurbatov*

$\delta^{34}S$ measurements covering the years 1935-1976 and including the 1963 Agung eruption were made on a West Antarctic firn core (RIDSA, 78.73° S, 116.33° W, 1804 m) and are used to assess the sulfur cycle in West Antarctica. The $\delta^{34}S$ values of xs $SO_4^{2-}$ range from -0.7‰ to 6.8‰. These values are lower than those previously reported for East Antarctica, which come from near South Pole station, and have $\delta^{34}S$ values between 18.1‰ and 9.3‰ (Patris et al. 2000). While the Agung period is isotopically distinct at the South Pole, it is not in the RIDSA dataset, suggesting differences in the sulfur cycle between these two regions. Given the relatively large input of marine aerosols at RIDSA (determined from $Na^+$ data and the seasonal sulfate cycle), there likely is a large marine biogenic sulfate influence. However, the $\delta^{34}S$ values indicate that this marine biogenic sulfate, with a $\delta^{34}S$ of 18‰, is mixing with sulfate that has extremely negative$\delta^{34}S$ values to produce the measured isotope values in the RIDSA core. We suggest that the transport and deposition of highly fractionated stratospheric sulfate in West Antarctica and local volcanic input seem to account for the variance in $\delta^{34}S$ values.

9:15-9:30

### Relationships between Crustal Records of Siple Dome Ice Core and Atmospheric Circulation

*Yuping Yan, Paul Mayeswski, and Eric Meyerson*

Using NCEP Reanalysis data, we investigate the relationships between crustal ion ($nssCa^{2+}$: non-sea-salt $Ca^{2+}$) concentrations of the Siple Dome (SDM) ice core, west Antarctica, and the climatic factors (air pressure, zonal ($u$) and meridional ($v$) wind direction and strength). Seasonal variations of $nssCa^{2+}$ show that the crustal aerosols are mainly inputted into SDM during the spring (SON). Linear correlation analyses between $nssCa^{2+}$ concentrations and SON air pressure wind fields for the recent 50 years show that $nssCa^{2+}$ concentration is positively correlated with circumpolar zonal wind ($r>0.3$, $\alpha=0.01$). Higher westerly wind speed is conducive to the transport of more crustal aerosols to the Siple Dome. Meanwhile, SDM is mostly connected to lower layer atmospheric transport. Intensified Southern Westerlies circulation enhanced transport of $nssCa^{2+}$ to west Antarctica. The contribution of Meridional circulation to $nssCa^{2+}$ concentration in SDM is not so significant.

9:30-9:45

**Volcanism in Siple Dome A Ice Core, Antarctica, Maps the History of Circulation Patterns over the Southern Hemisphere**

*Andrei V. Kurbatov, Gregory A. Zielinski, N.W. Dunbar (N.M.B.M.M.R./E&ES Department, New Mexico Tech, Socorro, NM), Paul A. Mayewski, Eric A. Meyerson, Sharon B. Sneed*

We analyzed the composition of volcanic glass shards found over the past 12 ka in the Siple Dome A (SDMA) ice core. 'Tephra fingerprinting' of these shards suggest that both local, (i.e., Antarctica: Mt. Melbourne, Buckle Island, Mt. Berlin, Mt. Takahe) and South American (i.e., Mt. Burney, Cerro Hudson) volcanic centers are sources for tephra found in the SDMA ice core. Our work identifies previously unknown eruptions from the Balleny Islands at 1791 C.E., Pleiades 1790 and 1782 C.E., Mt. Melbourne at 1764 and 358 C.E., Mt. Takahe at 1737, 6032 and 6041 B.C.E., and Mt. Berlin 7483 B.C.E. Transport of glass from these eruptions is most likely via tropospheric flow, thereby providing "snapshots" of existing circulation patterns at the time of the eruption. Interestingly, it is likely that the dominant means of transport for the tephra layer thought to originate from Mt. Birney, Chile, at 1758 B.C.E. may also have been via tropospheric flow. Similarly, the visible tephra layer found at 9090B.C.E. is compositionally close to Cerro Hudson volcano, Chile. This is the first time that tephra from South American eruptions has been found in an Antarctica ice core. Our findings provide interesting new evidence on possible air flow patterns from South America to Antarctica during the Holocene. In addition, these results assist in our interpretation of the glaciochemical volcanic time series the SDMA ice core, and in refining the existing time scale for the core.

9:45-10:00

**Bipolar Holocene Climate Variability**

*Eric A. Meyerson, Paul A. Mayewski, Andrei V. Kurbatov, Sharon B. Sneed, Kendrick C. Taylor (Desert Research Institute), Ed J. Brook (Washington State University), Eric J. Steig (University of Washington)*

Our newly developed, well dated, highly resolved ice core chemistry Holocene record from Siple Dome, West Antarctic (621 m elevation; 81.654°S, 148.808°W) is precisely dated by multi-parameter annual layer counting. Siple Dome represents an Antarctic Holocene equivalent to the Greenland Ice Sheet Project Two (GISP2) Holocene record. The instrumental calibration of the glaciochemical records from Siple Dome and GISP2 allows for the construction of accurate paleo-atmospheric circulation proxy records. The Siple Dome atmospheric circulation proxy records (sea-salt sodium, ssNa; non-sea-salt potassium and calcium, nssK and nssCa) confirm the Southern Hemisphere presence of the GISP2 Holocene events, which were first noted in worldwide glacier expansions by Denton and Karlén in 1973. A comparison of pre-Holocene and Holocene records from Siple Dome, Taylor Dome, and Dome Concordia further details the past climate history of Antarctica on a transect from the mid- to high-latitudes of the South Pacific, through West Antarctica, and up into the East Antarctica to the high southern Polar Plateau. This comparison shows that the beginning of the Amundsen Sea Low as a major influence on Siple Dome climate coincided with the ~7500 year BP start of the grounding line retreat of the West Antarctic ice sheet in the Ross Sea embayment. The influence of the Amundsen Sea Low has reached its Holocene maximum in the most recent 500 years as evidenced by the highest sustained levels of ssNa over the entire ~98,000 year record, including the Last Glacial Maximum.

10:00-10:30am Coffee Break

**Poster presenters will be present to answer questions**

10:30-10:45

**Measuring Snowfall Rates On Ice Sheets Using Ice Penetrating Radar**

*V. Blue Spikes, Gordon S. Hamilton, Steve Arcone, Paul A. Mayewski, and Daniel Dixon*

Snowfall in polar regions provides a stratigraphic record that can be traced back to determine how rates of snow accumulation have changed over time. These records can be interrupted by wind ablation and melt events, and they can also be distorted by ice flow. Ice cores provide chemical and isotopic records that can be used to determine depth to age

relationships in the ice and identify gaps in the record. However, ice cores recovered even a few kilometers apart can give very different values as a result of changes in ice flow and topographic influences on snow accumulation. Over larger distances (>50km) differing climatic regimes can dominate affecting the accumulation record. Radar is used here to fill in the space between distant ice cores in order to determine how snow accumulation changes spatially as well as temporally for large areas of West Antarctica. Before this method can be relied upon the continuous horizons identified in radar records must be shown to be isochronous. To accomplish this, results from two ice cores drilled 100km apart are coupled with a continuous radar survey between the sites. Radar horizons identified in the snow and ice at one core site are dated using snow chemistry then traced all the way to the next core where the horizon is again dated using chemical analysis. It is suggested here that if any radar horizon can be continuously traced from one core site to the next and it is found to have the same age at both core sites, the horizon is isochronal. Results from this study will be presented.

10:45-11:00

**Assessing the Performance of a Satellite-Altimeter Derived Digital Elevation Model of Antarctica using Precision Kinematic GPS Profiling**

*Gordon S. Hamilton and V. Blue Spikes*

Ice sheet surface topography is a key glaciological parameter. The pattern of undulations is an important control on the deposition of snow and so can aid in the interpretation of ice core records of climate. Surface features are formed by contrasting styles of ice flow, so the analysis of topography yields information about ice flow patterns and their history. The shape of the ice surface is also a product of ice flow over its bed, offering the possibility of inverting the surface topography to obtain maps of subglacial topography for the first time in large parts of Greenland and Antarctica. The best currently available digital elevation model (DEM) for Antarctica was developed for the Radarsat Antarctic Mapping Program (RAMP), and is a compilation of several satellite altimeter data sets. This DEM has many potential glaciological applications, but first it must be validated with ground measurements. As part of the International Trans Antarctic Scientific Expedition (ITASE) we are conducting high-precision, continuous, kinematic GPS surveys of surface topography along 1000 km or longer transects in Antarctica. These results are ideal for validating the Radarsat DEM and assessing its performance in a variety of glaciological environments (including inland flow, across ice streams, down flowlines and across ice divides). In general, the RAMP DEM reproduces the large-scale shape of the ice sheet surface quite well. However, there are significant discrepancies where are the GPS profiles cross regions of enhanced flow. In such cases the DEM fails to capture the short-wavelength (1-5 km scale) topographic features. We shall discuss the implications of our tests for the use of the DEM in several glaciological applications.

11:00-11:15

**Velocities along Byrd Glacier, East Antarctica, Derived from Automatic Feature Tracking**

*Leigh A. Stearns and Gordon S. Hamilton*

Automatic feature tracking techniques are applied to recently acquired ASTER (Advanced Spaceborne Thermal Emission and Reflection Radiometer) imagery in order to determine the velocity field of Byrd Glacier, East Antarctica. The software IMCORR tracks the displacement of surface features (crevasses, drift mounds) in time sequential images, to produce the velocity field. Due to its high resolution, ASTER imagery is ideally suited for detecting small features changes. The produced result is a dense array of velocity vectors, which allows more thorough characterization of glacier dynamics. Byrd Glacier drains approximately 20.5 $km^3$ of ice into the Ross Ice Shelf every year. Previous studies have determined ice velocities for Byrd Glacier by using photogrammetry, field measurements, and manual feature tracking. The most recent velocity data is from 1986 and, as evident in the West Antarctic ice streams, substantial changes in velocity can occur on decadal time scales. The application of ASTER-based velocities fills this time lapse, and increased temporal resolution allows for a more complete analysis of Byrd Glacier. The ASTER-derived ice velocities are used in updating mass balance and force budget calculations to assess the stability of Byrd Glacier. Ice thickness information from BEDMAP, surface slopes from the OSUDEM, and accumulation rates from Vaughan et al. 1999 are used to complete the calculations.

11:15-11:30

**Ice-core Records from Princess Elizabeth Land, East Antarctica: Preliminary Results of Chinese ITASE**

*Cunde Xiao (Laboratory of Ice Core and Cold Regions Environment, Cold and Arid Regions Environmental and Engineering Research Institute, China & CCI), Paul A. Mayewski, Dahe Qin & Mingjun Zhang (Laboratory of Ice Core and Cold Regions Environment, Cold and Arid Regions Environmental and Engineering Research Institute, China), Yuping Yan, Sharon Sneed, Ming Yan (Polar Research Institute of China)*

International Trans-Antarctic Scientific Expedition (ITASE) by the Chinese National Antarctic Research Expedition (CHINARE) has been underway since 1997. During the past six years, glaciological investigations including ice core drilling, snow radar detection, ice motion monitoring by GPS, surface mass balance, and meteorological observations have been carried out in Princess Elizabeth Land (PEL), eastern Antarctic Ice Sheet. Several shallow ice cores have been drilled along the Chinese ITASE traverse route, PEL. Based on the NCEP/NCAR re-analyses, it is found that the glaciochemical records in the DT001 ice core basically reflect the variation of SLP of a Southern Indian Ocean low (SIOL), a stationary and relatively permanent cyclone centered at approximately 62°S, 85°E. Empirical orthogonal function (EOF) analyses also verify that EOF1 series of the sea-salt ions have a high negative correlation with the variation of SLP over the SIOL. There is an obvious strengthening of the SIOL since 1970s. Another ice core, drilled at LGB69 during the 2001/02 field season, is still under analysis at the Climate Change Institute, University of Maine. Only the results of the uppermost 20 meters is discussed here.

11:30-11:45

**Recent and Abrupt Variations in Depositional Environment in Lake Fryxell, Dry Valleys, Antarctica**

*Thomas Whittaker*

Twenty-two sediment cores were retrieved from nine sites at Lake Fryxell (77°36'S, 163°08'E), eastern Taylor Valley, in the Dry Valleys region of Antarctica. Dry Valleys lakes have been shown to be extremely sensitive to variations in climate. Perched deltas and strand lines on the valley walls indicate higher Pleistocene lake levels. The area of Lake Fryxell varies due to annually fluctuating lake levels, but is generally accepted to have a surface area of approximately 7.0km$^2$. It is located within a closed basin and has 3.5-6m of permanent floating ice. Inflow occurs primarily during summer from ephemeral glacial meltwater streams. Maximum lake depth is 20-21m, but, again, this varies annually. The floating ice cap protects the lake water from the atmosphere, allowing little or no mixing. This results in a stratified water column. Algae are present, surviving within a 10 cm horizon ~10 m below the lake surface. Steep chemical gradients exist through this zone, as the algae deplete available nutrients and create conditions suitable for $CaCO_3$ precipitation. Sediments retrieved from cores were composed of alternating, thick horizons of well-sorted, organic, black sands; finely laminated, calcium carbonate-rich sands and silts; and massive, bluish-gray silts and clays. Sharp contacts between several stratigraphic units point to periods of abrupt change in depositional environment and/or climate. The sedimentary record is principally a reflection of lake level change within the basin. It may be used further to make inferences on variations in regional climate regimes.

11:45-12:00

**The Presence and Significance of Elephant Seal Skin and Remains in Victoria Land Raised Beaches, Antarctica**

*Brenda L. Hall*

Between 1995 and 2001, we discovered the presence of abundant seal skin and hair in the raised beaches of Victoria Land between Marble and Edmonson Points. Microscopic and DNA analysis of the material, as well as its concentration in sites that would have made ideal wallows, indicate that it almost certainly is from southern elephant seals (*Mirounga leonina*). This interpretation is supported by the fact that frozen and mummified remains of elephant seals occur at Inexpressible Island and Marble Point. Fifty-six radiocarbon dates of the seal skin yield ages ranging from ~530-4500 $^{14}$C yr B.P. The greatest number of sites was occupied between ~1000 and 2200 $^{14}$C yr B.P. Elephant seals are a subantarctic species and do not live in the Ross Sea Embayment today. The closest colony is over 1000 km to the north. Yet, our evidence seems to suggest the

widespread existence of such seals along the Victoria Land coast as late as about 500 years ago. The reason for the presence and subsequent disappearance of the seals is still under investigation, but may relate to changing climate conditions in the region.

12:00-1:30pm BBQ Lunch

1:30-1:45

**Changes in Atmospheric Circulation - The Key to Antarctic Climate Enigmas?**

*Paul A. Mayewski*

Northern Hemisphere instrumented records of climate offer broad spatial coverage and ~100 year duration allowing important glimpses of anthropogenic-era climate variability, but relatively minor evidence of pre-anthropogenic climate. By comparison Southern Hemisphere instrumental record coverage is extremely sparse and barely covers the last few decades. However, the Southern Hemisphere contains Earth's largest repository of buried climate records. These records can be recovered throughout Antarctica in the form of ice cores that are sub-annually resolved, continuous, and can be calibrated at least to the sparse array of instrumental records. Many of these ice cores offer evidence of climate change in extra-Antarctic regions as far north as the tropics. Interestingly the Antarctic contains several very significant climate anomalies that have thus far defied explanation. These include the presence of a so-called Antarctic Cold Reversal that is out of phase with the globally distributed Younger Dryas, a bimodal style "Little Ice Ice Age" event, a bimodal trend in recent temperature, and the "2002 austral summer from hell (Bergstrom)". Preliminary thoughts concerning the significance of these climate anomalies will be presented.

1:45-2:00

**Late Holocene Climate Variability in the North Pacific**

*Karl Kreutz, Paul A. Mayewski, Erich Osterberg, Andrei Kurbatov, and Greg Zielinski*

Rapid atmospheric and ocean temperature increases and glacier recession in the North Pacific over the past 30 years have focused attention on the mechanisms responsible for decadal-scale climate variability in the region. Coupled ocean/atmosphere processes, including the Pacific Decadal Oscillation (PDO), play a large role in regional climate, yet the long-term behavior of the PDO is not well established. In particular, the regime shift between PDO cold and warm phase during 1976, with warm phase conditions persisting into the 1990's, is a potential example of an abrupt climate change during the last 100 years. The cause(s) of the 1976 PDO regime shift remains unclear, but may be related to tropical forcing through sea surface temperature and atmospheric teleconnections. One way to test existing hypotheses is to develop annually dated multivariate paleoclimate records from the region, and assess PDO behavior during and prior to the anthropogenic period. We have several ongoing and planned ice core projects in the North Pacific, and are working with international collaborators to integrate existing Late Holocene tree ring, glacier margin, and lacustrine records. Initial oxygen isotope results from a 350-meter ice core recovered from the Eclipse Icefield, St. Elias Mountains, will be presented and discussed in relation to regional atmospheric processes.

2:00-2:15

**North Pacific Climate Change and Atmospheric Chemistry from a New Mt. Logan Summit Ice Core Record**

*Erich Osterberg, Paul A. Mayewski, Karl Kreutz, and David Fisher (Geological Survey of Canada)*

A new ice core to bedrock (190 m) was collected from the summit region (5345 masl) of Mount Logan in the Saint Elias Mountains by the Geological Survey of Canada in 2001- 2002. We are currently developing detailed time series of snow accumulation rate, major ions ($Na^+$, $NH_4^+$, $K^+$, $Mg^{2+}$, $Ca^{2+}$, $Cl^-$, $NO_3^-$, $SO_4^{2-}$), stable water isotopes ($\delta^{18}O$, $\delta D$), trace elements (Zn, Pb, Hg, Cd, Cu, V, Mn, Ni, As, Al, Fe, Se, and REEs) and tephra. Accumulation rate models and preliminary isotope data suggest that annual resolution will be possible to 1000-2000 years b.p., with multi-annual to centennial resolution for the remainder of the Holocene and possibly including the last deglaciation. The primary goal of this research is to understand North Pacific Holocene climate change and atmospheric chemistry variations over several timescales, for example: 1) annual

to decadal climatic oscillations including the Arctic Oscillation, Pacific-North American Oscillation, Pacific Decadal Oscillation, and ENSO teleconnections, 2) millennial period events such as the Little Ice Age and Medieval Warm Period, and 3) changes in atmospheric chemistry due to natural and anthropogenic contamination. In addition, we are interested in investigating links between climate change and tectonics/erosion in the Saint Elias Mountains, where pervasive temperate glaciers are responsible for extremely aggressive erosion of actively uplifting bedrock. Processing and analysis of the new Logan summit core has been proceeding since early 2003, and preliminary glaciochemical data are presented and discussed.

2:15-2:30

### Glaciochemical Records from a Mt. Everest Ice Core: Relationships to Atmospheric Circulation over Asia

*Shichang Kang, Paul A. Mayewski, Dahe Qin (Laboratory of Ice Core and Cold Regions Environment, Cold and Arid Regions Environment and Engineering Research Institute, China), Yuping Yan, Shugui Hou & Dongqi Zhang & Jiawen Ren (Laboratory of Ice Core and Cold Regions Environment, Cold and Arid Regions Environment and Engineering Research Institute, China), and Karl Kreutz*

Glaciochemical records recovered from an 80.4 m ice core in the East Rongbuk (ER) Glacier (elevation: 6450 m) on the northern slope of Mt. Everest are used to reconstruct past climate for the period AD 1846-1997. Empirical orthogonal function (EOF) analysis of the eight major ion ($SO_4^{2-}$, $Mg^{2+}$, $Ca^{2+}$, $Na^+$, $Cl^-$, $NH_4^+$, $K^+$, and $NO_3^-$) time-series reveals inter-species relations and common structure within the ER glaciochemical data. The first two EOF series (EOF1-ions and EOF2-ions) are compared with instrumental data of sea level pressure (SLP) to demonstrate that the EOF-ions series display strong connections to winter (January) and summer (July) SLP over the region of Mongolia. The positive relationship between EOF1-ions and the Mongolian High (MongHi) series suggests that enhanced winter MongHi strengthens the transport of dust aerosols southward from arid regions over central Asia to Mt. Everest. The close correspondence between EOF2-ions and the summer Mongolian Low (MongLow) indicates that the deeper MongLow and related stronger Indian Monsoon contribute to a decrease in summer dust aerosols. The ER ice core record comprises, therefore, two assemblages of crustal species, each transported from different source regions during different seasons. EOF1-ions represents the majority of the crustal species and is related to winter atmospheric circulation patterns. These species are mainly transported from the arid regions of central Asia during the winter dry season. EOF2-ions represents crustal species transported by summer atmospheric circulation from local/regional sources in the northern and southern Himalayas.

2:30-2:45

### Do Terrestrial Archives Preserve Chemical Signals from the Ocean?

*Steve Norton (Dept. of Geological Sciences)*

Landscapes near the ocean receive substantial fluxes of marine salts. Inputs of major elements are not directly recorded in lake or peat accumulations, primarily because of their high solubility and concentrations in excess of biological needs. Other components are also transported from the ocean including Se (as $SeO_4^{2-}$ and methylated Se), Br (as $Br^{1-}$ or possibly organo-Br), and I (as $I^{1-}$, methyl-I, or other organo-I compounds). These compounds are deposited in modern mosses and accumulate in peat (Roos-Barraclough et al., in review; Shotyk et al., in preparation) and lake sediments (Norton et al. 2002). Concentrations and accumulations vary as much as 100%, are cyclic, and correlate with each other. Interestingly, Br and Hg correlate through time. Oxidation of $Hg^0$ by seasonally high Br may enhance Hg deposition. Alternatively, emissions of Hg from the ocean may be variable (Vandal et al., 1993). Collectively, these observations of lake and peat sediments suggest that oceanic conditions may control the flux of Br, Hg, I, and Se to lake and peat sediment.

2:45-3:00

### A Century of Retreat: An Interhemispheric Comparison of the Collapse of Mountain Glaciers Since the Little Ice Age

*Colby Smith*

Historical records in the Northern Hemisphere show glacier retreat since about 1860-1890 AD. Is there a corresponding glacier retreat in the Southern Hemisphere of similar timing and magnitude? Comparison of the timing and magnitude of glacial retreat in the two polar hemispheres over the past century elucidates the mechanisms driving global climatic change.

In order to determine the retreat patterns of Murchison, Hooker and Tasman glaciers in the Southern Alps of New Zealand, geomorphic maps were constructed and recent glacial deposits were dated using lichenometry. Since the mid-to-late nineteenth century, each glacier terminus has retreated about 1.5 km. The timing and magnitude of this retreat of New Zealand glaciers are similar to that of the recent glacial retreat in the European Alps and elsewhere in the Northern Hemisphere. The recent glacial retreat is, therefore, a result of global not hemispheric warming. Mechanisms other than the Broecker ocean circulation model and the bipolar see-saw must be used to explain the synchronous retreat of glaciers in both polar hemispheres. It is possible that some of the recent warming is linked to decreased albedo, increased concentrations of trace gases in the atmosphere, and variations in solar activity.

3:00-3:15

**Predicting the Source of Meltwater Pulse 1A**

*Sean Birkel*

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. $^{18}O$ analyses of corals from Barbados, Tahiti and the Sunda Shelf indicate that 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 meltwater pulse (MWP-1A) caused eustatic sea level rise of as much as 16 m, whereas the second meltwater pulse (MWP-1B) was less significant. The collapse of the Laurentide Ice Sheet is a potential source for MPW-1A. However, preliminary studies also have shown the importance of a freshwater contribution from the Antarctic. Determining the source of MWP-1A is an important step in understanding abrupt climate change, and the transition from glacial to interglacial conditions. This research will use the University of Maine Ice Sheet Model (UMISM) to predict the source for MWP-1A by evaluating freshwater contributions from both the northern and southern hemisphere ice sheets during the last deglaciation.

## POSTERS

Posters will be up on the walls both days. Please take a moment at the coffee breaks or at lunch to look at them. All of the authors will be present to answer any questions at the coffee break on Friday morning, 10-10:30am.

### Lake Formation by Volcanic Dam, Lake Modification by Human Dam, and Possible Hurricane Impacts on Freshwater Lake, Dominica, W.I.

*Ronald B. Davis*

A 9.76 m long, 10 cm diameter piston core was obtained in 1997 from Freshwater Lake on the West Indian island of Dominica. The 4.1 ha, 15 m deep lake is located at 750 m above sea level. It is surrounded by young montane rain forest that has regenerated since Hurricanes David and Allen in 1979 and 1980. The lake sits in a moat between the eastern rim of a 2 km wide volcanic crater and a massive dacite dome that rises 470 m above the lake. Excessive rainfall (~8 m/yr), rapid weathering of dacite rock, non-anthropogenic and anthropogenic disturbances, and steep slopes above the lake result in intense erosion, high sediment accumulation rates in the lake, and an exceptionally detailed record of disturbances and landscape conditions over the past millennium. At 8.90 m sediment depth, the core tube encountered an upright stump of a charred tree fern, cored 0.26 m through it and then through 0.6 m of compacted, washed sand and gravel to rejection on rock at 9.76 m. Carbon-14 dates on the trunk and a wood fragment from the gravel, and sediment properties suggest that a stream and forest occupied the moat, and that the stream was dammed around 980 AD. In this volcanically active area, it is likely that a pyroclastic flow blocked the drainage. After lake formation, continued catchment instability and high sediment input to the lake resulted in deposition of ~3.5 m of dacitic silts and fine sand at the coring site. This rapidly (<100 yr; >3.5 cm/yr) deposited material is nearly devoid of clay minerals and aquatic microfossils. The ensuing 5.4 m of sediment accumulated much more slowly (~0.5 cm/yr), and consisting of lake sediments rich (25-65%) in organic matter including abundant well-preserved remains of terrestrial and aquatic biota. The profiles of LOI and total plant debris display several major peaks which I postulate [for prehistoric time (pre-1493)] were caused by hurricane defoliation of adjacent rain forest. More recent peaks correlate with documented historic hurricanes. This approach has considerable potential for chronicling prehistoric hurricanes. These montane rain forests have undergone frequent disturbances, maintaining an abundance of early successional species. Starting in 1961, a series of power dams and diversion to the lake of runoff from an adjacent catchment have raised lake level, quadrupled lake area, and increased inflow. Lead-210 dating and $^{137}Cs/^{241}Am$ chronostratigraphic markers indicate that since these disturbances began, mean sediment accumulation rate has been 4.4 cm $yr^{-1}$ at the coring site. Analyses of this sediment and soil cores from the catchment indicate extreme high inventories of $^{210}Pb$, commensurate with the extremely high rainfall.

### Holocene Water-Balance Changes of Whited Lake, Northeastern Maine

*Ann Dieffenbacher-Krall*

Existing paleoecological records from across the eastern half of North America indicate that major changes in Holocene water balance are time transgressive or out of phase across the region. As part of an ongoing objective to resolve Holocene water balance changes across the northeastern United States, we analyzed the organic content, mineral grain size, and plant macrofossil assemblages of six sediment cores from Whited Lake, a carbonate lake in Bridgewater, Maine. The water level of Whited Lake rose gradually during the early Holocene period until about 8590 cal yrs BP. A low stand from 8591 to 8175 cal yrs BP may correspond with the 8200 cold event reported from the GISP2 Greenland ice core. A second dry period occurred from 7280 to 6810 cal yrs BP. The water level was at its lowest from 4244 to 3185 cal yrs BP. A rapid rise to the modern water level occurred within the past 2000 years. Water balance changes of Whited Lake vary considerably in timing, magnitude, and number from those of Mansell Pond, Alton, Maine. Carbonate content of the Whited Lake deep-water core corresponds with the lake-level curve suggesting that high resolution carbonate analysis and radiocarbon dating of the core may provide a decadal-scale record of Holocene water-balance changes. Chironomid analysis (in progress), and carbon and oxygen isotope analysis (proposed), should allow us to separate the effects of temperature, precipitation, and seasonality of major precipitation on Holocene water balance.

## The Late-glacial Climate History of Pennington Pond.

*Geneva Chase*

The late-glacial climate history of Pennington Pond (T15 R6, Aroostook County, Maine) was calculated through the analysis of subfossil non-biting midge (Diptera: Chironomidae) assemblages. The data from both Pennington Pond and Whited Lake (Bridgewater, Maine) will be compared with the late-glacial records from lakes across the Atlantic Provinces of Canada, Maine and New Hampshire. Also of importance is the lake's role in determining the margin of the residual ice cap in northern Maine. In addition, a midge found in Pennington may be the first record of the genus in North America.

## Marine and Terrestrial Proxy Records of Holocene Climate Conditions in the Gulf of Maine Region – proposed research

*Marianne Lagerklint, Ann Dieffenbacher-Krall, Debbie Eustis-Grandy (University of Maine at Fort Kent)*

The proposed research will develop a dual record of Holocene changes in temperature and water balance on the northeastern rim of the Gulf of Maine, and Holocene changes in temperature and salinity of ocean waters in the Gulf itself. Changes in the position of the warm, northward-flowing Gulf Stream reflect decadal movement of the atmospheric North Atlantic Oscillation, which affects climate in the circum-North Atlantic region. Shifts in the cold, southward-flowing Labrador Current are indicative of changes in the Labrador Sea, an important site for North Atlantic heat exchange. The two currents meet and interact at the mouth of the Gulf of Maine. Relative degrees of current mixing affect temperature and humidity distribution in the northeastern United States and Canadian Maritime Provinces through associated atmospheric circulation, and ocean temperatures in the Gulf of Maine.

Fossil pollen data suggest, but do not directly measure, Holocene temperature and water balance differences between sites along the rim of the Gulf of Maine and inland sites in Maine. In a multi-proxy study, the researchers will determine temperature and water balance changes in Eastern Coastal Maine for the past 12,000 $^{14}$C years (~14,000 cal years) at a centennial scale. Holocene changes in the lake level of Norse Pond, a small lake in eastern Maine located 1 km from the Gulf shore, will be determined through examination of plant macrofossils, mineral grain size, organic content, and gross sediment composition of six sediment cores from a transect of water depths. Rhizopod analysis of a peat core from a coastal island will be used to corroborate overall changes in Holocene water balance. Holocene temperature changes will be inferred by chironomid and biogenic silica analyses of the Norse Pond deep-water core. Through analysis of a transect of cores from beneath the Eastern Maine Coastal Current into Jordan Basin in the Gulf of Maine, researchers will determine the correspondence between terrestrial and marine Holocene climate changes, the changing mixture of Slope Water (composed of Gulf Stream and Labrador Slope Water) inflow into the Gulf of Maine, and the presence or absence of the Eastern Maine Coastal Current (created by mixing of surface and bottom water). Holocene ocean surface water temperatures will be inferred through alkenone analysis, and bottom water temperature and salinity will be determined by changes in the oxygen isotopic composition of benthic foraminiferal shells.

## Red Cherts, Jaspers, and Chalcedonies in the Maine-Quebec-Maritimes Region

*Adrian L. Burke*

Red-colored, highly siliceous, lithic raw materials with varying degrees of translucency are regularly found on prehistoric sites in the Northeast. These are variably referred to as cherts, jaspers, or chalcedonies when they are not of igneous origin. In the Maine-Quebec-Maritimes region of the Northeast the sourcing of these raw materials is crucial to our understanding of regional trade and interaction, as well as emerging tribal territories of the late prehistoric to historic period. This poster presents various red knappable lithic sources and how we can accurately distinguish these using macroscopic, microscopic, and chemical methods.

## Embedded Ice Sheet Models: Application to Maritime Canada

*James L. Fastook*

Atmospheric modelers have had considerable success with high-resolution regional models whose boundary conditions are defined and controlled by the output of a lower-resolution global circulation model. This sort of embedded model allows for resolutions that would not be feasible if the entire domain were digitized at high resolution. A similar problem exists for ice sheet modeling. Important dynamic features such as ice streams are poorly resolved at the low resolutions (20-100 km grid spacing) necessary to include an entire ice sheet, and yet migrating ice divides and changing catchment areas make modeling of a whole ice sheet necessary to capture large-scale changes which must have occurred during the LGM and the ice sheet's subsequent collapse to its present configuration. Current Antarctic databases such as BEDMAP offer 5 km resolution of the bed, while surface DEMs are approaching 200 m resolution. Bed-topographic DEMs on which Northern Hemisphere paleo-ice sheets are reconstructed are available at similar resolutions. Details of implementing such an embedded model are described and an application of the embedded model to Maritime Canada, with particular attention to the distribution of basal water and consequent sliding and ice streaming, is discussed.

## Ice Cores: From Collection to Analysis

*Sharon B. Sneed, Michael J. Handley, Paul A. Mayewski, Gregory A. Zielinski, Karl J. Kreutz, Andrei V. Kurbatov, Douglas Introne*

Environmental conditions may be reconstructed from a variety of records such as tree rings, historical records, instrumental data, sediments, and ice cores. Climate change in ice cores is documented by a wide range of parameters. The Institute is well equipped to collect, process, and analyze many components used to reconstruct climate change. Capabilities include major ions by ion chromatography, trace metals by inductively-coupled plasma - mass spectrometry, stable isotopes by mass spectrometry, and optical microscopy for particulates. Institute facilities also include a large storage and processing freezer as well as many ice coring drills, some of original design.