FOURTH ANNUAL RESEARCH SYMPOSIUM UNIVERSITY OF MAINE INSTITUTE FOR QUATERNARY STUDIES

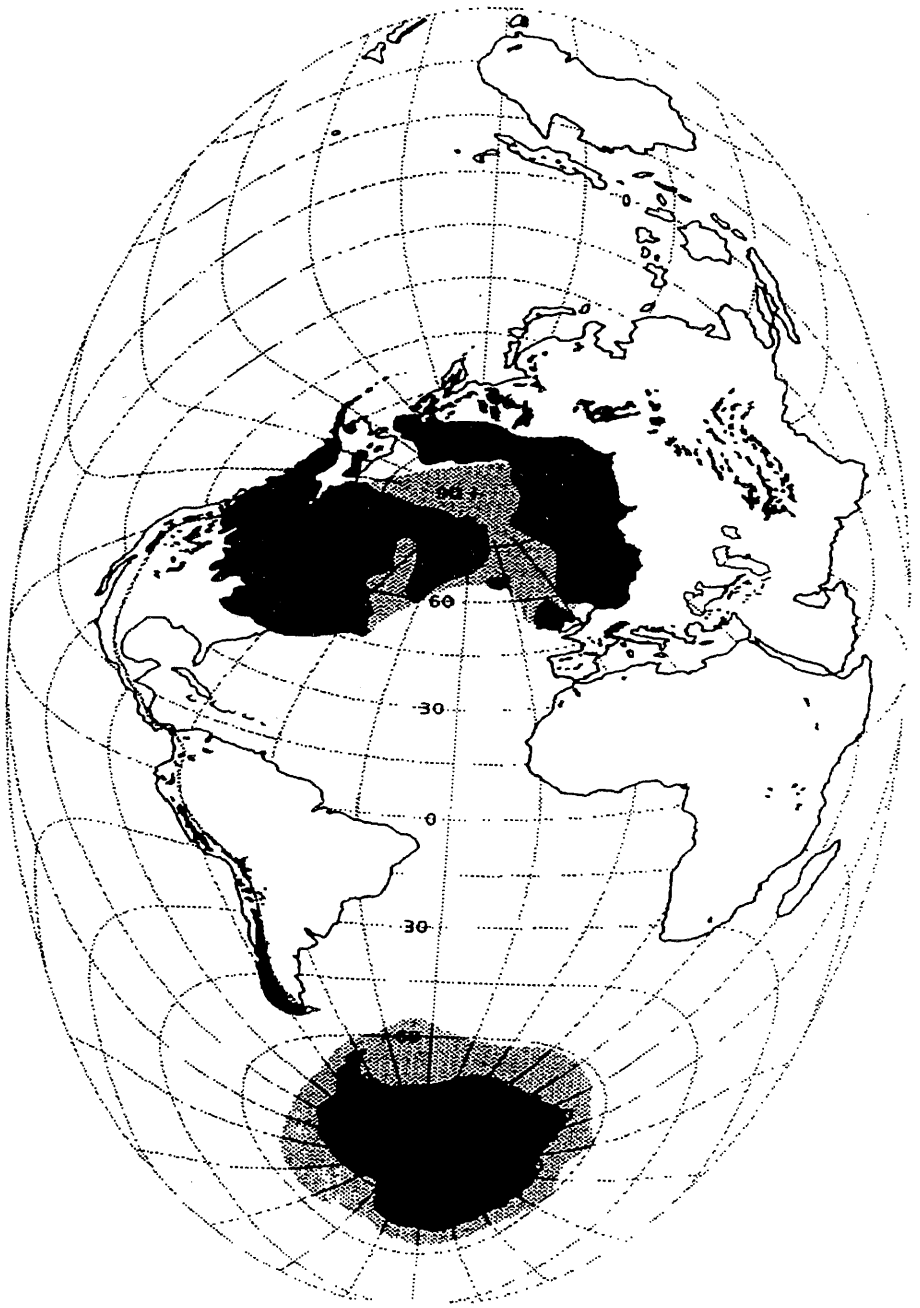
THURS. - FRI.
MAY 9-10, 1996
0830-1700 Thurs.
0730-1500 Fri.

WOOLEY ROOM
COMMUNITY
CENTER

DORIS TWITCHELL
ALLEN VILLAGE

UNIVERSITY OF
MAINE

ORONO, ME



Presentations by:
University of Maine
Faculty, Staff and
Students and
Maine Geological
Survey Scientists

KEYNOTE
SPEAKER:

ARTHUR L. BLOOM, Cornell University, Fri., 1330.

FOURTH ANNUAL UNIVERSITY OF MAINE
QUATERNARY RESEARCH SYMPOSIUM

DORIS TWITCHELL ALLEN VILLAGE: WOOLEY ROOM
THURSDAY-FRIDAY, MAY 9-10, 1996

THURSDAY, MAY 9

0830: COFFEE

0855: WELCOME AND INTRODUCTION: Daniel F. Belknap

SESSION 1 - ARCHAEOLOGY AND ANTHROPOLOGY 1

0900: Bret A. Achorn, AN OPEN DISCUSSION OF COGNITION: THE STUDY OF LEARNING PROCESSES AND ITS RELATIONSHIP TO ANTHROPOLOGICAL INTERPRETATION

0920: Daniel H. Sandweiss, MID-HOLOCENE OCCUPATION OF THE SICHES SITE, NORTHWESTERN PERU

0940: Sarah L. Nicholas, Daniel H. Sandweiss, James D. Wright, James B. Richardson and Harold B. Rollins, STABLE ISOTOPES OF MARINE SHELL AND PALEOCLIMATE ON THE NORTH COAST OF PERU

1000: Kristin D. Sobolik and Lee Cronk, ALTERNATIVE ENERGY SOURCES FOR FORAGERS OF THE EASTERN AFRICAN HIGHLANDS

1020: Catherine Chmidling, PREHISTORIC TRADE AND POPULATION MOVEMENTS IN THE NORTHERN CHIHUAHUAN DESERT: DISTRIBUTION OF APACHE CANYON CHALCEDONY, BIG BEND NATIONAL PARK, TEXAS

1040: COFFEE BREAK

SESSION 2 - PALEOCEANOGRAPHY AND BIOSTRATIGRAPHY

1100: Cinzia Spencer-Cervato, THE 'NEPTUNE' MICROPALEONTOLOGICAL DATABASE AND ITS RESEARCH APPLICATIONS

1120: James D. Wright, Thomas B. Kellogg and Marianne Lagerklint, DETECTION OF ABRUPT CLIMATE CHANGES IN NON-HEINRICH REGIONS OF THE NORTH ATLANTIC

1140: Douglas N. Reusch and Kirk A. Maasch, DID EXHUMATION OF THE NEW GUINEA COMPOSITE ARC TERRANE CAUSE CO_2 DRAWDOWN AND MIOCENE GLOBAL COOLING?

1200: LUNCH Doris Twichell Allen Village

SESSION 3 - ECOLOGY AND PALEOECOLOGY

1300: Ann Diffenbacher-Krall, MODELLING THE IMPACT OF EVAPORATION ON POTAMOGETON L. (PONDWEED) SPECIES ASSEMBLAGES AND RICHNESS IN SIX LAKES OF THE AROOSTOOK LOWLANDS, AROOSTOOK COUNTY, Maine, U.S.A. AND EXTENSION OF MODELLING TECHNIQUES TO STRATIGRAPHIC GEOCHEMICAL CHANGES

1320: Heather Almquist-Jacobson and Cinzia Spencer-Cervato, WHAT MARL LAKES IN THE NORTH ATLANTIC REGION MIGHT REVEAL ABOUT THE GLOBAL CLIMATE SYSTEM

1340: Thomas D. Henze, LATE-GLACIAL AND EARLY POST-GLACIAL PALEOENVIRONMENTS AS (YET TO BE) DETERMINED FOR SELECTED LAKES IN NORTHERN MAINE

1400: Dawn Cameron, PLATEAU BOG DEVELOPMENT IN COASTAL MAINE

1420: Molly Schauffler, THE LATE-HOLOCENE DEVELOPMENT OF SPRUCE-FIR FORESTS ON COASTAL MAINE ISLANDS - A PROGRESS REPORT

1440: Geoffrey F. Wilson and Douglas A. Maguire, SIMULATION OF EARLY REGENERATION PROCESSES IN MIXED-SPECIES FORESTS OF MAINE: GERMINATION, SURVIVAL, AND HEIGHT GROWTH

1500: COFFEE BREAK

SESSION 4 - COASTAL GEOLOGY AND SEA-LEVEL CHANGES

1520: Claire Kiedrowski, BASE MAPPING THE SALT MARSHES OF WELLS, MAINE

1540: Daniel F. Belknap, W. Roland Gehrels and David C. Smith, CHANGES IN MAINE TIDAL MARSHES, PAST 300 YEARS, DETERMINED FROM FORAMINIFERA, PLANT FOSSILS, STABLE ISOTOPES, AND RADIOMETRIC DATING

1600: Joseph T. Kelley and Daniel F. Belknap, RELATIVE SEA-LEVEL CHANGE FROM WESTERN EUROPE: THE RECORD FROM OFFSHORE OF IRELAND

SESSION 5 - ANTARCTICA

1620: Brenda L. Hall, LATE QUATERNARY HISTORY OF THE DRY VALLEYS, SOUTHERN VICTORIA LAND, ANTARCTICA: IMPLICATIONS FOR THE ROSS SEA AND WEST ANTARCTIC ICE SHEETS

1640: George H. Denton, David E. Sugden, David R. Marchant, Brenda Hall, and Thomas I Wilch, EAST ANTARCTIC ICE SHEET SENSITIVITY TO PLIOCENE CLIMATE CHANGE FROM A DRY VALLEYS PERSPECTIVE

FRIDAY, MAY 10, 1995: DORIS TWITCHELL ALLEN VILLAGE

0730: COFFEE

0755: WELCOME AND INTRODUCTION Daniel F. Belknap

SESSION 6 - CLIMATE CHANGE

0800: Todd K. Dupont and Kirk A. Maasch, THE ART OF STATISTICAL DYNAMICAL MODELING

0820: Patricio I. Moreno, George H. Denton and George L. Jacobson, ABRUPT VEGETATION AND CLIMATE CHANGES BEWTEEN 21,000 AND 9,000 14C YRS BP IN THE CHILEAN LAKE DISTRICT (41ß S)

0840: Kirk A. Maasch and Lou McNally, WHAT'S IN AN AVERAGE?: CLIMATE CHANGE IN THE NORTHEASTERN UNITED STATES

0900: David C. Smith, CHANGES IN GROWING SEASON AND OTHER CLIMATE CHANGE DETERMINED FROM HISTORICAL DIARY ENTRIES

SESSION 7 - ARCHAEOLOGY AND ANTHROPOLOGY II

0920: Jeffrey D. Sommer, INVESTIGATION OF THE FAUNAL REMAINS FROM THE TODD SITE (17-11), MUSCONGUS BAY, MAINE

0940: Robert Weber, LITHIC VARIATION AND PROCUREMENT AT THE TODD ARCHAEOLOGICAL SITE, MUSCONGUS BAY, MAINE

1000: Alice R. Kelley, Karen E. Mack and David Sanger, A GEOARCHAEOLOGICAL MODEL FOR PREDICTING PRESENCE AND PRESERVATION OF ARCHAEOLOGICAL SITES IN THE LOWER PISCATAQUIS RIVER

1020: COFFEE BREAK

SESSION 8 - DEGLACIATION OF MAINE

1040: Gregory T. Miller, MORAINES PRESERVED ON THE INNER SHELF OFF SOUTH-WESTERN MAINE

1100: Woodrow B. Thompson and Christopher C. Dorion, DEGLACIATION CHRONOLOGY AND MARINE-LIMIT REFINEMENTS IN SOUTHWESTERN MAINE

1120: Thomas K. Weddle, Joseph T. Kelley, Walter Barnhardt, Daniel F. Belknap, Christopher Dorion and Michael J. Retelle, RELATIVE SEA-LEVEL CHRONOLOGY IN THE LOWER ANDROSCOGGIN RIVER VALLEY, MAINE

1140: Harold W. Borns, Jr., Christopher C. Dorion and Michael J. Kaplan, THE PINEO RIDGE END MORAINE SYSTEM OF SOUTHEASTERN MAINE REVISITED

1200: Greg Balco, CHANGES IN LAND AND LAKE LEVEL, MOOSEHEAD LAKE, MAINE

1220: LUNCH Doris Twichell Allen Village

KEYNOTE SPEAKER

1320: Introduction by Dan Belknap, Dan Sandweiss and Hal Borns

1330: Arthur L. Bloom, MAINE (AND ELSEWHERE) FROM THE GREENHOUSE TO THE ICEHOUSE

AN OPEN DISCUSSION OF COGNITION: THE STUDY OF LEARNING PROCESSES AND ITS RELATIONSHIP TO ANTHROPOLOGICAL INTERPRETATION

Bret A. Achorn, Institute for Quaternary Studies, University of Maine, Orono, ME

Central to the issues and studies of culture(s) are the conceptual frameworks used to describe our world. Nature is seen by humans in terms of their image of nature (beliefs) and not through the actual structure of nature. A primary goal of cognition studies, relative to anthropology, is to reveal some understanding of the sources of these images (belief, knowledge, etc.) which manifest themselves as divergent cultural traits.

The anthropological position on cognition has its roots in the philosophy of Immanuel Kant who proposed that 1) cognition logically preceded action, and 2) that the individual was not free to choose his or her own cognitive system. Karl Marx and Emile Durkheim also supported similar views and the field of anthropology seems to have accepted this conception of cognitive faculties, stressing the *a priori* basis of such systems.

Cognition is not seen as a singular mechanism; there exists a functional dichotomy between its application to anthropology and to psychology. In psychology, cognitive systems are viewed as the product of some type of interaction between the subject and his or her environment. For anthropology, they are seen as products of a non-individual, historical process of transformation. When applied to a child's learning process, for example, a psychological construct would denote a gradual build-up to a coherent cognitive system, whereas in anthropology, such a system would, in essence, be handed over to that child.

Recent investigations into human behavior evidence support for the psychologically-based theories of cognition. Studies upon children indicate that some conceptual mechanisms are already in place before the development of linguistic skills. This discussion invites faculty, students, and visitors to help determine if the field of anthropology needs to re-evaluate its paradigms regarding the learning process in an effort to make more qualified statements about human behavior. A clear and defendable position on cognitive systems could be especially applicable to archaeologists. They do not have the benefit of direct observation of behavior but must often provide interpretation of behavior based on models and artifactual data.

MID-HOLOCENE OCCUPATION OF THE SICHES SITE, NORTHWESTERN PERU

Daniel H. Sandweiss, Department of Anthropology and Institute for Quaternary Studies, University of Maine

The Siches site was discovered in 1965 by Jim Richardson (U. of Pittsburgh/Carnegie Museum of Natural History); subsequently, C-14 dates from several test pits dated the occupation between 8000 and 4000 BP. Both Siches (Middle Preceramic) and Honda (Late Preceramic) components are present at this 20 ha. site. Excavations during June, 1995, uncovered stone tools, including microlithic drills, and shell bead artifacts in various stages of manufacture, indicating the presence of an early shell-bead workshop in the youngest sector of the site. In an older sector, we found a post-hole pattern showing part of a circular hut. The excavations also recovered abundant invertebrate and vertebrate faunal remains, carbonized plant parts, and uncarbonized gourd pericarp fragments. On-going studies use these materials to evaluate the hypothesis of radical environmental change at 5000 BP; this hypothesis is tentatively supported.

STABLE ISOTOPES OF MARINE SHELL AND PALEOCLIMATE ON THE NORTH COAST OF PERU

Sarah L. Nicholas , Institute for Quaternary Studies, University of Maine, Orono ME; Daniel H. Sandweiss, Department of Anthropology and Institute for Quaternary Studies, University of Maine, Orono ME; James D. Wright, Department of Geological Sciences and Institute for Quaternary Studies, University of Maine, Orono, ME; James B. Richardson III, Department of Anthropology, University of Pittsburgh, Pittsburgh, PA and Division of Anthropology, Carnegie Museum of Natural History, Pittsburgh, PA; Harold B. Rollins Department of Geological Sciences,University of Pittsburgh, Pittsburgh, PA.

Rollins et al. published the Birth of El Niño Hypothesis in 1986 to attempt to explain the presence of thermally anomalous molluscan assemblages (TAMAs) dating to before 5000 B.P. along the north coast of Peru. These Peruvian assemblages consist of mollusks which today are limited in range to the warm tropical waters off Ecuador and more northern areas. If the isotherm separating the warm temperate water from the warm tropical water was 5š latitude farther south than it is at present, then a very different suite of resources were available to ancient peoples 5000 years ago than are present in the area today, and the El Niño/Southern Oscillation phenomenon could not have functioned in the past as it does now. 5000 B.P. marks the transition between the Siches (8000-5000 B.P.) and Honda (5000 B.P.-3500 B.P.) lithic assemblages on the northwest coast of Peru. Paleoecological data from other sites in the South Pacific rim also suggest that El Niño may not have functioned in the past as it does today. Similarity among artifact assemblages from the coast of southern Ecuador to the central Peruvian coast support the idea that these areas may be been ecologically and economically similar in the past.

The current focus for this ongoing study is the comparison of the stable isotopes of shell during modern normal (non-El Niño) conditions with those of archaeological shell. We propose that, in Trachycardium procerum and possibly in other mollusks, d18O and d13C are covariant during the normal seasonal cycle, but diverge during El Niño events. The seasonal cycle recorded by the two isotopes may be useful to archaeologists in identifying seasonality of archaeological deposits in the Andean region, where seasonality of site occupation has been difficult to address. A longer-term goal is to assess the Birth of El Niño hypothesis using stable isotopes in mollusks dating immediately before and after the proposed climate change at 5000 BP.

ALTERNATIVE ENERGY SOURCES FOR FORAGEERS OF THE EASTERN AFRICAN HIGHLANDS

Kristin Sobolik, Institute for Quaternary Studies, University of Maine, Orono, ME; Lee Cronk, Department of Anthropology, Texas A&M University

The foragers turned pastoralists of the east African highlands subsisted mainly on hunted foods supplemented by honey and a small amount of gathered plant items and traded domesticated foods. Wild game has always been considered extremely important to the diet and nutrition of these peoples, whereas the importance of honey has been considered mainly symbolic or religious in nature (Blackburn 1971, 1982). Honey mainly consists of carbohydrates, one of three sources of caloric energy. Speth (1989, 1990) has hypothesized that if more than 50% (300g) of caloric energy is provided through protein ingestion various deleterious health effects can occur. The ubiquitous combination of hunting and beekeeping in the eastern African highlands most likely has served the purpose of providing alternative energy sources with ingestion of carbohydrate-rich honey. Honey, therefore, was an essential dietary item providing a unique source of caloric energy. Combining honey and hunting in the eastern African highland region was nutritionally adaptive.

PREHISTORIC TRADE AND POPULATION MOVEMENTS IN THE NORTHERN CHIHUAHUAN DESERT: DISTRIBUTION OF APACHE CANYON CHALCEDONY, BIG BEND NATIONAL PARK, TEXAS

Catherine Chmidling, Institute for Quaternary Studies, University of Maine, Orono, ME

For this presentation I will discuss the identification and distribution of lithic sources in the Big Bend area of the northern Chihuahuan Desert. Although the area has been the subject of extensive geologic survey, little work has been done on Burro Mesa and Apache Canyon, which are among the chief areas of interest for archaeology in the region. This talk will include proposed methods of conclusively identifying different lithic sources utilized by prehistoric peoples of the area and comparison of samples from quarry sites and debitage from archaeological sites. From this information, inferences may be made regarding population movement, economics, and tool-technologies of prehistoric peoples of the area. As this work is still in the preliminary stages, I will be discussing methods and possible uses of the results, not presenting data.

The Apache Canyon quarry is a large, very high quality lithic source in the northern Chihuahuan Desert. It has been used by native peoples since Paleoindian times (approximately 12,000-10,500 BP) and (suspected) samples have been found in archaeological sites many miles away from the quarry. I have collected several samples form the canyon and been granted access to examples from some of the smaller sources in the area. From these samples, a "signature" will be determined using thin-section, microprobe, and neutron activation analyses. In addition, lithic debitage and tools from archaeological sites will be examined suing the same techniques, so that a source for the archaeological material can be ascertained. Source determination will allow for reconstruction of possible trade and migration patterns through time and across space. In this way, the economy of ancient peoples of the Big Bend are may be studied.

The quality of the varieties of chalcedony present at the source and in collections will also be studied. I hope to learn whether there was differential use of the resource, both in general and for specific tool-types, and, if so, what criteria were used in this differential selection. Studying the various qualities of chalcedony available compared with those which were selected for sue will add to current information on the tool-technologies of prehistoric peoples of the Big Bend area.

THE "NEPTUNE" MICROPALEONTOLOGICAL DATABASE AND ITS RESEARCH APPLICATIONS

Cinzia Spencer-Cervato, Institute for Quaternary Studies, University of Maine, Orono, ME

"Neptune" is a database of micropaleontological and biochronological information from over 160 Deep Sea Drilling Project (DSDP) and Ocean Drilling Program (ODP) holes. The dataset spans the Cenozoic and includes data on calcareous (foraminifera and nannoplankton) and siliceous (radiolarians and diatoms) marine plankton. To date, over half a million records are included in "Neptune."

Research on biostratigraphy (time-transgressiveness of first and last appearances), evolution (sympatric speciation of *Globorotalia truncatulinoids*) and paleoceanography (evolution of the thermocline in the Plio-Pleistocene) has originated from the database. Research on species longevity and spatial and temporal distribution of first appearances and extinctions of marine plankton species is in progress.

The first appearance of *G. truncatulinoides* as well as several other species of thermocline and deep-dwelling planktonic foraminifera occurred during the late Pliocene. Stable isotope data from benthic foraminifera and multiple species of planktonic foraminifera provide records of changes in the surface, thermocline and intermediate waters during the onset of the Northern Hemisphere Glaciation from 3.2 to 2.6 Ma. The results indicate that variations in deep-dwelling populations reflected changes in either the environmental conditions of the thermocline (temperature or salinity) or in the position of the thermocline (shallow vs. deep).

DETECTION OF ABRUPT CLIMATE CHANGES IN NON-HEINRICH REGIONS OF THE NORTH ATLANTIC

James D. Wright, Thomas B. Kellogg: Department of Geological Sciences and Institute for Quaternary Studies, and Marianne Lagerklint, Institute for Quaternary Studies, University of Maine, Orono, ME

There are two problems that are key to understanding the global implications of abrupt climate changes: (1) the geographically restricted Heinrich (H-) zone is not representative of North Atlantic surface environments; and (2) the downcore proxies are used inadequately to reconstruct paleo-environments. Because the H-zone is anomalous, high-resolution proxy records (faunal, lithic, stable isotopes) are needed that characterize the whole North Atlantic, not just the H- zone, for the last 30,000 14C yrs BP. Because stable isotope records from individual species are markedly different, a framework to better evaluate downcore proxy records is needed based on relationships between polar/subpolar planktonic foraminifera and modern hydrographic conditions.

Planktonic foraminiferal stable isotopes from the coretop assemblages are directly analogous to the downcore assemblages, and therefore it is important to document how the coretop stable isotopes relate to the overlying surface hydrography. These relationships will be used to better interpret the records of abrupt climate changes during the past 30,000 14C yrs BP from non-Heinrich zone cores in the North Atlantic.

Until recently, high-resolution climate reconstructions for the North Atlantic were limited to the H-zone and were based on stable isotope and faunal changes in from a single species, N. pachyderma (s). New data from cores outside of the H-zone show a distinct difference in the timing of deglacial warming from that recorded in H-zone cores. Furthermore, the record of ice-rafted detritus is more extensive spatially and temporally in cores outside of the H-zone and does not record the pulsed changes typical of H-zone cores. Finally, the stable isotope records of deglaciation from different species vary in timing and magnitude. These differences are persistent and replicable in different regions of the North Atlantic. These preliminary findings question whether the narrow application of proxies thus far and exclusive focus on the H-zone have portrayed accurately climate changes in the North Atlantic.

DID EXHUMATION OF THE NEW GUINEA COMPOSITE ARC TERRANE CAUSE CO_2 DRAWDOWN AND MIOCENE GLOBAL COOLING?

Douglas N. Reusch and Kirk A. Maasch, Department of Geological Sciences, University of Maine, Orono, ME

During the subduction of oceanic crust and aggradational phase of magmatic arc growth, thermal degassing reactions result in a large flux to the atmosphere of CO_2, an influential greenhouse gas. Conversely, silicate weathering reactions consume atmospheric CO_2, especially during the exhumation of magmatic arcs, which are large reservoirs of fine-grained, soluble CA and Mg silicate minerals and glass. We hypothesize that the curtailed degassing, increased silicate weathering, and enhanced organic carbon burial triggered by arc-continent collision lead to atmospheric CO_2 drawdown, global cooling, and distinctive geochemical/isotopic signatures in coeval marine precipitates. Dissolution of the New Guinea composite arc terrane, exhumed after accreting to Australia, may have increased the carbon flux from the atmosphere by 10^{17} to 10^{18} moles per myr and caused the rate of increase of marine $^{87}Sr/^{86}Sr$ to drop from over 80 x 10^{-6} per myr to near zero just before the prominent middle Miocene $\delta^{18}O$ shift and global cooling event. Similar global cooling events correlate with the exhumation of arc rocks during the early Oligocene Trans-Himalayan, late Ordovician Taconic, and late Precambrian Pan-African orogenies. The marine $^{187}Os/^{186}Os$ record should reflect arc-continent collisions because ultramafic rocks, exhumed with the arc rocks, are a major reservoir of Os with very low $^{187}Os/^{186}Os$ values. Accordingly, the marine $^{187}Os/^{186}Os$ record constrains the carbon flux related to the weathering of mafic rocks, a flux which we argue must be incorporated into carbon cycle models.

MODELLING THE IMPACT OF EVAPORATION ON POTAMOGETON L. (PONDWEED) SPECIES ASSEMBLAGES AND RICHNESS IN SIX LAKES OF THE AROOSTOOK LOWLANDS, AROOSTOOK COUNTY, MAINE, U.S.A., AND EXTENSION OF MODELLING TECHNIQUES TO STRATIGRAPHIC GEOCHEMICAL CHANGES

Ann C. Dieffenbacher-Krall, Department of Plant Biology and Pathology, University of Maine, Orono, ME.

Six lakes in the Aroostook Lowlands, Maine, U.S.A., were sampled for water chemi
stry (major cations, anions, and pH) and surveyed for aquatic plant species. Water chemistry values resulting from different amounts of evaporation were projected by concentrating the modern water chemistry values to mimic a lowered water balance. Alkalinity and pH were subsequently calculated by the chemical equilibrium software MINEQL (Schecher and McAvoy 1992, Westall et al. 1976). These results were compared with the pH and alkalinity tolerance
ranges of 28 Potamogeton species to determine which species could survive in each lake under different levels of evaporation.

Although the application of MINEQL to this evaporation exercise has limitations, computer modelling can help predict changes in lake chemistry resulting from aquatic flora changes. The modelling of chemical equilibria from lake sediment may promote improved interpretation of marl sediment sequences by providing information about the potential presence of aquatic plant species that may be largely responsible for marl production within these systems.

WHAT MARL LAKES IN THE NORTH ATLANTIC REGION MIGHT REVEAL ABOUT THE GLOBAL CLIMATE SYSTEM

Heather Almquist-Jacobson and Cinzia Spencer-Cervato, Institute for Quaternary Studies, University of Maine

Paleoclimatic records from across the North Atlantic region show coherency in the pattern and timing of glacial and late-glacial climatic events. The glacial period was characterized by high-magnitude, millennial-scale climate oscillations that are revealed in both ice-core and marine records. The late-glacial period included several abrupt adjustments in climate conditions that are revealed by ice-core, marine, beetle, and pollen records. In contrast, oxygen-isotope records from Greenland ice cores and North Atlantic sediment cores demonstrate that Holocene climate has been comparatively quiescent. Thus, the cryosphere itself has been implicated as the primary controller of climate variation at sub-orbital time-scales during the glacial period.

However, recent analyses of dust content in the GISP2 ice core suggest that the Holocene may also have been characterized by millennial-scale climate changes that, although smaller in amplitude, were of similar frequency to those of the glacial world. If that is true, the mechanism(s) controlling millennial-scale climate oscillations during glacial time must have continued through the Holocene, and therefore could not involve large ice sheets, except perhaps as a signal amplifier. Ultimately, a logically-constructed matrix of refined paleoclimate records from both northern and southern hemispheres will be required to determine the relative role(s) of various factors in instigating and amplifying millennial-scale climate fluctuations. We suggest that if a coherent pattern in the amplitude, timing, and rate of Holocene climate changes cannot be detected in the North Atlantic region, which appears so strongly linked during late-glacial time, it is unlikely to be detected anywhere.

Thus far, a coherent pattern of millennial-scale Holocene climate variability is not apparent from pollen records of the North Atlantic region. However, late-Glacial stable-isotope records from marl lakes in Switzerland appear to be much more sensitive than pollen records. Thus, high-resolution Holocene stable-isotope records from those lakes, which we propose to obtain, may provide useful insights. Two recent (unpublished) records from the northeastern U.S. do show millennial-scale fluctuations. At one marl lake in northern Maine, which we have selected for preliminary analysis, shifts in carbon- and oxygen-isotope values appear to coincide with changes in lake level as interpreted from independent (macrofossil) evidence. This Holocene record will be further developed and compared with new isotope records from marl lakes in Switzerland and from North Atlantic sediments in order to establish the trans-Atlantic pattern.

LATE-GLACIAL AND EARLY POST-GLACIAL PALEOENVIRONEMTNS AS (YET TO BE) DETERMINED FOR SELECTED LAKES IN NORTHERN Maine

Thomas D. Henze, Institute for Quaternary Studies, University of Maine, Orono, Me

The Acadian Region—which includes Maine, the Gaspé, and southern maritime provinces—was deglaciated during late-glacial and early post-glacial time. The geography of that deglaciation is better defined than its temporal development. Paleoenvironmental changes, suggested to correlate with climate changes in Europe, are neither sufficiently constrained with stratigraphic information nor well enough radiocarbon dated to be compared extraregionally. It is unknown if the paleoenvironmental changes in northern Maine were coeval with those in other parts of the Acadian region. The character of the late-glacial and early post-glacial paleoenvironments, especially whether they were wetter or drier, is also unknown. Hydrologic conditions would have directly influenced glacier expansion or contraction, vegetation, soil development, erosion. Atmospheric flow patterns inferred from temperature and hydrologic information together, might be used to reconstruct climate change or to test predictive models.

I propose to study late-glacial and early post-glacial lacustrine sediments from selected lakes in northern Maine, in order to determine the timing, magnitude, and character of local paleoenvironmental changes. I will establish the basin configuration and lithostratigraphy for each lake by applying a variety of field and laboratory techniques, including loss-on-ignition, and x-ray image analyses. I will use terrestrial and aquatic plant macrofossils to infer the ecological conditions, local paleohydrology, and limnic conditions. Stable carbon isotopes may be used to reveal more about erosion, lake productivity, or hydrology. With radiocarbon dating, I can determine when the significant biostratigraphic or lithostratigraphic transitions occurred and correlate them with events at other sites. The relative rate of sedimentation inferred from the lithostratigraphy, based on bedding, grain-size, and grading, can also be refined with radiocarbon dating, such that an approximate rate (cm/yr) may be assigned.

PLATEAU BOG DEVELOPMENT IN COASTAL MAINE

Dawn Cameron, Institute of Quaternary Studies, University of Maine, Orono, ME

Plateau bogs are a type of raised bog distinguished by unique morphometry, hydrology and plant communities. In Maine, this type of bog occurs in coastal areas east of Penobscot Bay. Several different hypotheses exist regarding development of domed raised bogs, but there are limited field studies providing tests of these hypotheses. The proposed project will investigate the timing and factors influencing development of plateau bogs and their current plant communities. Determining what factors lead to the unique morphometry of these bogs has implications for understanding the mechanisms of raised bog development, which is key to predicting the long-term stability of these ecosystems.

Paleoecological methods, including macrofossil analysis of multiple peat cores, will be used to create a detailed reconstruction of plant communities and environmental conditions in a single bog. Plateau bogs are characterized by a unique plant assemblage, including Scirpus cespitosus, Empetrum nigrum and several Sphagnum species. Combined with well-developed chronologies and other stratigraphic changes, macrofossils of these and other species from several cores will be used to indicate the timing of plateau initiation and rate of expansion. Preliminary results from two plateau bogs will be presented.

THE LATE-HOLOCENE DEVELOPMENT OF SPRUCE-FIR FORESTS ON COASTAL MAINE ISLANDS -- A PROGRESS REPORT

Molly Schauffler, Institute for Quaternary Studies and Department of Plant Biology and Pathology, University of Maine, Orono, ME.

Regional pollen records throughout Maine indicate that spruce and fir became dominant in the region only in the last 1000 years. This recent expansion appears to be part of a large regional expansion of southern populations of spruce across NA, presumably as the climate cooled. How was the regional expansion of spruce manifested on local landscapes? What species did it replace when its population expanded? Are there stands where spruce persisted throughout the Holocene? Are there any patterns in the timing of spruce expansion along a north-south coastal gradient? Did its expansion accompany changes in disturbance regime? This is a progress report of my analysis of local pollen records from forested hollows on coastal Maine islands and peninsulas in attempt to address these questions.

SIMULATION OF EARLY REGENERATION PROCESSES IN MIXED-SPECIES FORESTS OF MAINE: GERMINATION, SURVIVAL, AND HEIGHT GROWTH

Geoffrey F. Wilson and Douglas A. Maguire, Department of Forest Ecosystem Science,University of Maine, Orono ME.

The natural regeneration processes of seeding, germination, and early establishment are closely tied to the surrounding biotic and abiotic environment. The biotic environment often mediates extremes in the physical environment of young seedlings, yet also defines the competitive environment for site resources. Understanding the complex role of the biotic environment in early regenerative processes is essential toward understanding the responses of plant communities to a fluctuating physical environment because the biotic community itself is controlled by climate and the physical substrate. Plots were established to study these early regeneration processes in mixed-species stands consisting of a diversity of stand structures. Germinant density and first-year survival of *Abies balsamea* and *Tsuga canadensis* were modeled with Poisson and binomial regression models, respectively, revealing the effects of stand structure and substrate type on these processes. Height growth of established *Abies* seedlings was modeled as a function of vegetation structure by application of weighted nonlinear least squares. *Tsuga* appeared to germinate preferentially on wood, whereas *Abies* germinated on different substrates more or less in proportion to substrate availability. However, survival of both of these conifer species was highest on moss. Height growth of Abies seedlings was controlled on fine spatial scales by the density of other seedlings and at coarser scales by the density of overstory trees. The prediction models reflected a complicated interplay of substrate and stand structure effects.

BASE MAPPING THE SALT MARSHES OF WELLS, MAINE

Claire Kiedrowski, Institute for Quaternary Studies, University of Maine, Orono, ME

Many researchers have mapped the salt marshes of Wells, ME in the course of geological and ecological studies. However, a comprehensive base map with surveying accuracy is required to document changes in the landscape and vegetaqtion zones through time, as revealed in air photos, maps, and historical survey records. An ongoing UMaine study of human alteration of the marsh, as well as recent controversies over issues of alteration or remediation around Wells harbor, are the justification for this combined surveying and coastal geological study. To begin mapping this area, data from the following sources were collected and compiled: scanned aerial photographs, USGS Digital Elevation Models, and horizontal and vertical control files from USGS, Federal Emergency Management Agency (FEMA) and Maine Department of Transportation (MDOT). In addition, GPS was used to occupy known control points and to expand the control to the marsh area. Future plans include identifying imagery signatures of specific features such as high tide and low tide plant associations on the marsh, which will enable researchers to identify these zones in archived black-and-white airphotos. All of this information will be used to produce an orthophotomap with topographic and planimetric vectors overlying digital imagery. In produciong the orthophotography, questionable elevations on the marsh produced by previous surveys will be reconciled. The map will be used as a foundation for further research in the Wells marshes, and as a resource for the Wells National Estuarine Research Reserve.

CHANGES IN MAINE TIDAL MARSHES, PAST 300 YEARS, DETERMINED FROM FORAMINIFERA, PLANT FOSSILS, STABLE ISOTOPES, AND RADIOMETRIC DATING

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Human impact on marshes ranges from local disturbance, to regional alteration of sediment transport, to global increase in rate of sea-level rise. We are studying such alteration of natural systems in the extensive tidal marshes of Wells in southwestern coastal Maine. These marshes range from back-barrier salt marshes 5 km along-coast by 1 km broad, to marginal brackish and freshwater marshes of a few hectares in incised valleys. The marshes are connected to the Gulf of Maine through inlets at Wells Harbor and the Little River. Tidal range is 2.62 m mean and 3.02 m spring. Most of this system is presently protected in the Wells National Estuarine Research Reserve (WNERR) and Rachel Carson National Wildlife Refuge. Historically, human impacts have included disposal of dredge spoil on the Webhannet Marsh (12.3 hectares, 300,000 m3), construction of causeways and tidal flapper, and encroachment of buildings and harbors. Marshes were cored along both disturbed and relatively unaltered transects. Cores were sampled for sediments, plant fossils, foraminifera, pollen, 210Pb and 137Cs, accelerator mass spectrometry (AMS) 14C, and stable isotopes (d13C). Transects and vegetation zones were mapped and leveled using a Total Survey Station. Historic maps, charts, airphotos, and detailed field notes from C.A. Davis (1914) were compared to modern maps to quantify changes in vegetation related to the local stratigraphic record and local tide-gauge records of sea-level change. Foraminiferal data and plant macrofossils demonstrate a recent transg-ressive overlap of fresh- and brackish marsh by high marsh zones in the upper 10-20 cm of cores from the Little River Marsh. This may be the result of recent acceleration of sea-level rise. Within the 30-Acre Marsh, confined between two artificial causeways, plant communities are altered, foraminifera and thecamoebians demonstrate an abrupt shift to freshwater conditions, and leveling confirms 80 cm or more lowering of the marsh surface in historic times. We have also observed a process of drastic alteration of brackish and freshwater marsh by tidal creek and low marsh invasion, that may be an important process in New England marshes. A specific comparison of vegetation maps from 1914 and the present, at Pemaquid Beach, demonstrates profound changes from a brackish and freshwater marsh to a high marsh, tidal creek, and altered transitional zone, within the 81 year period over which local relative sea level rose some 17 cm. Radiometric and stable isotope analyses are in progress.

RELATIVE SEA-LEVEL CHANGE FROM WESTERN EUROPE: THE RECORD FROM OFFSHORE OF IRELAND

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The relative sea-level-change record from offshore of Maine varies in its rate of change through the Holocene. We have interpreted the variations in relative sea-level rise as evidence for forebulge migration through the coastal zone. Data from Nova Scotia and Quebec generally support our interpretation of a non-linear isostatic crustal response to glacial unloading which has important implications for numerical models simulating such phenomena.

Like Maine, Western Europe (specifically the British Isles) is located near the terminus of the last glaciation. Considerable speculation exists regarding regional relative sea-level changes in western Britain and Ireland, and numerical models offer conflicting possibilities for the isostatic response of the land to deglaciation. One model (Lambeck, 1991) that supports our view of a migrating forebulge predicts profoundly different sea-level records from around Ireland. As yet there are few offshore data to support or contradict any models of relative sea-level change for the region, however. We are proposing to collect side-scan sonar and seismic reflection data from offshore northeastern, northern and western Ireland to establish the depth(s) of the lowstand of the sea in late Pleistocene/early Holocene times. In addition, we hope to examine terrestrial sites for data concerning the timing of a possible mid-Holocene, higher-than-present stand of sea level. Only by finding records of sea-level change similar to Maine's from geologically similar areas around the world can we be confident we understand the vertical changes in Maine's crust we have proposed.

MIDDLE TO LATE WISCONSINAN CHRONOLOGY AND PALEOENVIRONMENTS IN NORTHERN MAINE AND ADJACENT CANADA:

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The landscape of Maine reflects multiple glaciations during the Quaternary Period. In northern Maine, a palimpsest topography preserves the imprints of 3 periods of glacial activity. The oldest event is dated at 41,200 + 1,400 ^{14}C yrs. B.P. and is tentatively correlated with the extensive ice contact stratified drift composing the cores of drumlinoid hills. It is proposed that this outwash surface blanketed northern Maine during this time and was deposited near the margin of a large ice mass. Riverine evolution during the middle Wisconsinan modified and/or removed parts of this surface. At 24,300 ^{14}C yrs. B.P. the Laurentide ice sheet advanced through northern Maine. At 24,500 ^{14}C yrs. B.P. the advance had reached Jo Mary Pond in central Maine and at 25,280 + 1,100 ^{14}C yrs. B.P. (Anderson et al., 1992) the margin was advancing into a shallow nearshore marine environment at Gould Pond at a present elevation of 90 masl. After 12,000 ^{14}C yrs. of ice sheet coverage, recession again uncovered Maine beginning 14,000 14C yrs. B.P. By 12,800 ^{14}C yrs. B.P. northeastern Maine was deglaciated yet southeastern Maine was covered by residual ice masses for an additional 500 ^{14}C years until the onset of the Bolling warming. Calibration to the calendar year chronology of Stuiver et al. (1995) and GISP2 records shows that the large moraine, delta, and sandur deposits of eastern Maine that mark significant stillstands occurred 2,000 to 1,500 years before the Bolling warming, in conditions similar to the last glacial maximum (LGM). Oxygen isotope (δ^{18}O) data, from Kreutz (1994), and microfaunal assemblages confirm the polar to sub-polar marine conditions prevailing until 13,000 ^{14}C yrs. B.P. in the Gulf of Maine. During Bølling and Allerød time the remainder of Maine was deglaciated except the north-central and northwest uplands. During Younger Dryas time glacial ice expanded across northern Maine flowing from the St. John uplands (elevation 300 m), damming large glacial lakes in the Aroostook and St. John valleys. Ice advance over proglacial outwash on which moss/sedge/grassland thrived near Oxbow occurred at 10,500 ^{14}C yrs. The Younger Dryas cold period is seen as a distinct marker horizon of minerogenic deposition in lake cores ringing the northern Maine ice cap and generally dates to between 11,400 and 10,500 ^{14}C yrs. B.P. The onset of the Holocene terminated all glacial activity in northern Maine.

THE CHANGING FROST-FREE SEASON IN NEW ENGLAND

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Historic and instrumental records have been analyzed for the fifteen climate zones of New England from early colonial times until the Weather Bureau changed its method of recording freezing temperatures. Curves have been plotted which indicate a high degree of fluctuation typical of the end of the ice age environments. Recent changes (since 1880) differ from zone to zone. Some of the results will be presented.

LATE QUATERNARY HISTORY OF THE DRY VALLEYS, SOUTHERN VICTORIA LAND, ANTARCTICA: IMPLICATIONS FOR THE ROSS SEA AND WEST ANTARCTIC ICE SHEETS

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The extent and chronology of the Antarctic Ice Sheet during the last glaciation is critical to understanding the Antarctic contribution to ice-age sea-level and oxygen-isotope changes. Recent work indicates that Antarctic ice extent has not been significantly greater than that reached at the last glacial maximum for at least the last 15 Ma. Therefore, the size of the late Wisconsin ice sheet can be used to limit the potential Antarctic effect on sea level since the mid-Miocene.

During the last glaciation, the greatest ice volume change took place in the Ross Sea, a large embayment presently fed by ice streams from West Antarctica and by outlet glaciers from East Antarctica. The extent - and even existence - of an ice sheet in the Ross Sea (Ross Sea ice sheet) has been hotly debated, with estimates of the Antarctic contribution to sea-level variation ranging from 0.5 to 29 m. In addition, the timing, cause, and pattern of deglaciation, so crucial to understanding the behavior of the West Antarctic Ice Sheet, remain poorly defined.

The most complete record of the former Ross Sea ice sheet comes from the Dry Valleys and other ice-free areas of the McMurdo Sound region (77-78 °S). Here, ice flowed onto land, depositing glacial and glaciolacustrine sediments. Detailed geologic mapping, coupled with over 300 radiocarbon dates on lacustrine algae and carbonates, indicates that there was an extensive Ross Sea ice sheet during the last glaciation. A lobe of this ice blocked the mouth of Taylor Valley between at least 8340-23,800 ^{14}C years B.P. The Ross Sea ice sheet did not flow into Wright and Victoria Valleys. Instead, the coastal Wilson Piedmont Glacier thickened substantially and advanced to merge offshore with the Ross Sea ice sheet. Large lakes up to 450 m deep occupied all three major valleys between about 26,000 and 7900 ^{14}C years B.P. These lakes formed because of increased melting ablation in the Dry Valleys. The Ross Sea ice sheet probably prevented summer storms from the Southern Ocean from reaching the Dry Valleys. Today, snow from these storms restricts glacial meltwater production, which is highly sensitive to local radiation balance. Early results show that all three lakes underwent simultaneous surface-level variations with periodicities of about 2000-3000 years. Marked lake-level lowering shortly after 7900 ^{14}C years B.P. probably relates to initial phases of Ross Sea deglaciation. This timing is consistent with dates from Taylor Valley that place deglaciation there between 8340 and 6650 ^{14}C years B.P. (uncorrected for the approximately 1200 year marine reservoir effect), and from the adjacent Scott Coast where the oldest dated raised marine sediments are 6550 ^{14}C years old (uncorrected). Overall, data from the Dry Valleys and Scott Coast suggest that deglaciation of the Ross Sea began late in the deglacial cycle in mid-Holocene time. If this is the case, then the West Antarctic Ice Sheet grounding line may have been retreating slowly since that time.

EAST ANTARCTIC ICE SHEET SENSITIVITY TO PLIOCENE CLIMATIC CHANGE FROM A DRY VALLEYS PERSPECTIVE

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A case is made for the stability of the East Antarctic Ice Sheet during Pliocene time from landscape development and surficial sediments in the Dry Valleys sector of the Transantarctic Mountains. The alternate hypothesis of Pliocene meltdown requires atmospheric temperatures 20°C above present values, late Pliocene ice-sheet overriding of the Transantarctic Mountains, and possible rapid late Pliocene mountain uplift of 1000-3000 m. The geomorphological results suggest that these conditions were not met in the Dry Valleys region. Rather, Pliocene mean annual atmospheric temperatures were at most only 3° to 8°C above present values; ice-sheet overriding occurred in Miocene time (>13.6 Ma); Pliocene glacier expansion was limited; and Pliocene surface uplift was only about 250 to 300 m. These conclusions are based on field studies in Taylor and Wright Valleys, in the western Asgard Range, and in the Quartermain Mountains. The chronology comes from numerous $^{40}Ar/^{39}Ar$ dates on *in-situ* volcanic ashes that occur in stratigraphic association with unconsolidated diamictons in the western Dry Valleys, basaltic lava flows interbedded with widespread tills in Taylor Valley, and reworked basaltic clasts in alpine moraines in east-central Wright Valley. The combined evidence from the Dry Valleys region indicates that slope evolution was severely restricted throughout Pliocene time, and has been so since at least the middle Miocene. The implication is that most of the Dry Valleys landscape is relict and that it reflects ancient erosion, possibly under semi-arid climate conditions, prior to middle-Miocene time.

THE ART OF STATISTICAL DYNAMICAL MODELING

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What qualifies as a climate model varies from a lone elementary diagnostic equation to an intricate web of so-called "primitive" equations. The class of climate models referred to as Statistical Dynamical Models (SDMs) fall midway in this spectrum of complexity. SDMs borrow from the realms of both deductive and inductive physics, using the hallowed physical "Laws" as well as empirical parameterizations that the "art" of statistical dynamical modeling comes into play. This "art" lies in using intuition and plausibility to create or hypothesize an inductive "law." Testing the SDM against the physical world also serves to test the skill of the "artist."

ABRUPT VEGETATION AND CLIMATE CHANGES BETWEEN 21,000 AND 9000 ^{14}C yr B.P. IN THE CHILEAN LAKE DISTRICT (41°S)

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We report high-resolution, radiocarbon dated pollen and charcoal records from sediment cores taken from an abandoned meltwater spillway near Puerto Octay (40°57'09"S, 72°54'18"W), Lago Condorito (41°45'S, 73°07'W), and from Huelmo (41°31'S, 73°W) in the Chilean Lake District. Our results indicate the presence of Subantarctic parkland and Magellanic Moorland communities between 20,200 and about 14,400 ^{14}C yr B.P. with cooler temperatures (6°C lower than present) and higher precipitation (twice the modern values), suggesting a permanent year-round influence of the westerly winds. Minor climate amelioration between 20,200 and 15,800 ^{14}C yr B.P. was interrupted by a cooling event at 19,200 ^{14}C yr B.P. Subsequent pulses of cooling occurred at about 15,800 and 15,000 (?)^{14}C yr B.P., and lasted until 14,400^{14}C yr B.P. The abrupt expansion of thermophilous Valdivian/North-Patagonian rain forests that began at 14,400 ^{14}C yr B.P. constitutes the most significant vegetation change identified in this study. This was followed by an abrupt increase of thermophilous species at about 12,900 ^{14}C yr B.P. We interpret this event as a second pulse of climate warming. This was followed by a general reversal in trend with cooling events at about 12,000 ^{14}C yr B.P. and 11,000 ^{14}C yr B.P., that lasted until 9800 ^{14}C yr B.P. Vegetation disturbance is evident in the Lago Condorito record between 11,000 and 10,000 ^{14}C yr B.P., accompanied by abrupt increases of microscopic charcoal particles at about 11,000 ^{14}C yr B.P. However, the timing, trends, and abundance of microscopic charcoal in Puerto Octay and Huelmo are quite different from Lago Condorito, suggesting that fire and vegetation disturbance were most prominent in the vicinities of the Monte Verde Paleoindian site (41°30'S, 73°15'W), at times when cool/wet climate might have suppressed the occurrence of natural fires.

WHAT'S IN AN AVERAGE?: CLIMATE CHANGE IN THE NORTHEASTERN UNITED STATES

Kirk A. Maasch and Lou McNally

Climate is an average. The present-day "climate" is typically defined as the mean value of instrumentally derived meteorological variables calculated over some 30 year interval. The 30 year interval currently used to determine the so-called "norms" is from 1961-1990. In recent years considerable attention has been given to the possibility that earth's climate is warming due to the an anthropogenic increase of greenhouse gases in the atmosphere (primarily CO2). Although in theory an increase in greenhouse gas concentration will warm the surface of the planet, the complicated nature of the climate system has prevented any conclusive answer to the global warming question.

Several issues arise concerning climate change over the last few centuries. If climate is defined as the mean, then a change in the mean would constitute climate change. However, if higher order moments, like variance, are considered then it is possible to have a change in the climate with no change in the mean. In many instances it is extreme events that pose problems (or even threats) to society, and not the mean. Hence, in some ways it makes more sense to use the variance calculated from daily weather as an indicator of climate change rather than the changes in (or departures from) the mean.

In order to assess possible climate change in the northeastern United States we begin with daily meteorological observations at five evenly spaced times spanning the last 200 years:

(1) For the year 1785, when instrumental records were scarce, descriptive accounts are used to augment our knowledge of daily weather.

(2) In the early 1830's observations were made in a more systematic manner, but spatial coverage was still rather sparse.

(3), (4) and (5) For the late 1890's, 1940's, and 1990's spatial data coverage is much better.

INVESTIGATION OF THE FAUNAL REMAINS FROM THE TODD SITE (17-110, MUSCONGUS BAY, MAINE

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In this paper I will discuss the objectives of a proposed study of the faunal remains excavated from the Todd site (17-11), Muscongus Bay, Maine. In addition, I will discuss the research strategy and methods that will be used to meet the stated objectives. The preliminary nature of the research precludes any discussion of results at this time.

The main objective of the proposed study is to gain insights into the subsistence base and human/environment interactions of Ceramic Period populations at the Todd site. Other objectives are as follows: 1) determine what faunal species were being used; 2) determine what habitats were being exploited; 3) determine season(s) of occupation; 4) identify taphonomic issues that may have affected the faunal assemblage; 5) identify possible implications of the sampling procedure; 6) identify differential use of space within the site; 7) identify and interpret changes in the faunal assemblage through time. The ultimate goal is to gain an understanding of the regional settlement-subsistence and socio-economic systems of the Ceramic Period. This study will provide a basis for achieving that goal by presenting important data concerning aspects of Ceramic Period subsistence economies and seasonality of maritime adapted people on the coast of Maine.

LITHIC VARIATION AND PROCUREMENT AT THE TODD ARCHAEOLOGICAL SITE, MUSCONGUS BAY, Maine

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The Todd Site is a shell midden located on the central coast of Maine. Within the midden refuse are zones interpreted as representing living floors that have been radiometrically dated to the Ceramic Period (~2725-400 BP). Detailed micro-analyses were performed on the lithic débitage derived from these floors using petrographic descriptions of hand specimens, complemented by thin section analysis. The analyses show that a variety of distinct volcanics are present in changing amounts at different times in prehistory. Bedrock lithic sources suitable for producing the tools in the Todd assemblage do not occur locally. The presence of flaked cobble cortex shows that some materials were obtained from glacial drift. However, a shoreline survey with a radius of 1 km from the Todd site reveals a near total absence of volcanic rocks similar to those in the assemblage either on beaches or eroding from glacial drift, and inspections of nearby gravel pits show a similar lack. This deficiency implies that extensive lithic acquisition required either relatively long distance trade, or procurement forays.

A GEOARCHAEOLOGICAL MODEL FOR PREDICTING PRESENCE AND PRESERVATION OF ARCHAEOLOGICAL SITES IN THE LOWER PISCATAQUIS RIVER VALLEY

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Investigations of the margins of the Howland Reservoir in the lower Piscataquis River Valley suggest that consideration of past and present geological processes should be included in the planning of the reconnaissance level archaeological survey (Phase 1). This process allows the initial stages of survey and subsurface testing to be done in a more cost effcient and timely manner. Geology and geomorphology influence both the location and preservation of archaeological sites. The geological/geomorphological setting may control the original occupation of an area through its proximity to a resource and/or suitability for living space. Geological processes also affect the preserva- tion or destruction of archaeological sites. For these reasons, it is important to consider geology/geomorphology when planning the first stages of an archaeological investigation. Phase 1 or reconnissance level archaeological survey of an area is concerned with the identificationand location fo all potentially significant archaeological sites. This involves a literature search, interviews with local collectors and landowners, as well as a walk-over survey of the shoreline and subsequent subsurface testing at regular intervals.

Geological analysis of topographic maps and aerial photographs of the study area indicated a variety of geological environments, such as bedrock-controlled rapids, abandoned meander channels, oxbow lakes, and areas of recent sediment deposition. Each of these environments has potential for preservation or destruction of preexisting sites. The initial field effort in the lower Piscataquis River Valley used traditional method of Phas 1 survey. The results of this survey were then compared with predictions of site locations based upon geological analysis. As excepted, sites were found in areas identified as geologically stable or aggrading. Remnants of sites were located in areas experiencing erosion. Sites were not found in areas of extreme erosion. On the basis of these findings the sampling plan for this summer's field work has ranked portions of the study area using the geologic model of site preservation potential. This model is then incorporated into previously established models of prehistoric land use to form a geoarchaeological model. This model,in turn, will allow us to focus our investigations on areas of highest potential (both geologically and archaeologically) while excluding areas with lowest potential.

MORAINES PRESERVED ON THE INNER SHELF OFF SOUTHWESTERN Maine

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Interpretation of 150 km of new side-scan sonar (SSS) profiles and 100 km of seismic reflection profiles within the Wells Embayments, southwestern Maine depicts a series of end moraines subparallel to the present coastline. The SSS records show that the Wells Embayment is a sand-covered, rocky basin with gravel areas associated with the moraines. The moraines are highly variable in size, ranging in length from 10 m to 800 m, widths from less than 5 m to 100 m, and heights of 1 m to 12 m. A typical moraine is 70-150 m long, 25 m wide and 2-5 m high, with large moraines in deep water. The moraines are associated with bedrock, which strikes parallel to the coast within the embayment. In addition, seismic reflection data reveal that the moraines are often rock cored. These moraines were deposited in a marine environment as the ice margin retreated from the continental shelf ca. 14,000 BP and are presently within 10-40 m water depth. These small-scale moraines are identical in form to fields of similar features found on land nearby. As the ice retreated, partially or completely draping the moraines with the glaciomarine Presumpscot Formation mud. Isostatic uplift exposed the moraines ca. 11,000-9,000 BP before the ongoing transgression rapidly submerged them. On two brief occasions (during uplift and later submergence) the moraines were probably islands, and partially reworked into barrier island systems. The rapid rise in sea level between 9,000 and 7,000 BP, the temporary protection by glaciomarine mud cover, and coarse lag armoring appear to have preserved these features on the inner shelf. Identification of these features provides a continuity between processes acting on the present inner shelf and present coastal lowlands during deglaciation in Maine, and provides a means for examining degree of preservation versus reworking of pre-Holocene sediments on the inner shelf.

DEGLACIATION CHRONOLOGY AND MARINE-LIMIT REFINEMENTS IN SOUTHWESTERN MAINE

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The Natural Resources Information and Mapping Center (NRIMC) has compiled a digital map showing end moraines and other ice-contact features that can be used to trace the retreat of the late Wisconsinan glacier margin in southwestern Maine. The EPSCoR terrestrial working group from NRIMC and the University of Maine's Institute for Quaternary Studies are combining these data with a statewide synthesis of radiocarbon dates that limit the time of deglaciation, to produce an updated map showing the chrology of ice retreat. In 1995 the authors cored several ponds in western Maine and the northern White Mountains, and have obtained four new AMS radiocarbon dates from basal organic material recovered from the late-glacial portions of the cores. These dates are progressively younger from south to north, ranging from 13.2 ka in the hills north of Fryeburg to 11.5 ka near the Quebec border. The coring sites were selected to provide some limitation on ages of large moraine systems in the region, including the Androscoggin and Frontier Moraines. One of the cores very clearly shows what is probably the Younger Dryas climate event. Recently surveyed elevations of glaciomarine deltas in southwestern Maine have been used to refine the profile of the upper limit of late-glacial marine submergence in this part of the state. A plot of both old and new data indicate a uniform marine-limit gradient of 0.50 m/km, projected to a profile line that includes points from Sanford to Augusta. The elevation profile is surprisingly straight considering that crustal uplift was occurring as the area was deglaciated and the deltas were deposited.

RELATIVE SEA-LEVEL CHRONOLOGY IN THE LOWER ANDROSCOGGIN RIVER VALLEY, MAINE

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A relative sea-level curve, determined locally for the lower Androscoggin River Valley in Maine, is similar to the regional sea-level curve for the state of Maine as originally proposed by Belknap et al. (1987), and most recently refined by Barnhardt et al. (1995). The local relative sea-level curve differs from the state-wide curve because it infers deglaciation and emergence of this area in southwestern Maine occurred earlier than previously reported. The lower Androscoggin River Valley curve can be used as a comparative model for local curves and isostatic chronologies in other valleys within the marine limit in Maine.

THE PINEO RIDGE END MORAINE SYSTEM OF SOUTHEASTERN MAINE REVISTED

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The Pineo Ridge end moraine system is composed of closely spaced, subparallel grounding line moraine segments and occasional ice-contact marine deltas. The system is approximately 2 km wide extending in a nearly straight line northeastward from the Cherryfield, to Lubec, Campobello Island and probably across Passamaquoddy Bay at least to Pennfield Ridge, New Brunswick, a distance of at least 140 km.

In comparison with the adjacent and earlier recessional grounding-line moraines, the Pineo moraine segments are generally larger, averaging 20 m high, 200 m wide and up to 6 km long. They are primarily composed of packages of basal till, submarine outwash and glacial-marine mud. The cross-cutting relationship of the Pineo system and the earlier recessional moraines is demonstrated at many locations along its length.

Clearly the geographic pattern, crosscutting relationships and sedimentary composition demonstrate that the Pineo system marks the termination of a readvance of a melted bed glacier in ocean depths up to 85 m. The presence of ice-contact deltas preclude the presence of an ice shelf.

Presently the age is constrained between approximately 13,150±250 years B.P. and 13,800±80 years B.P. radiocarbon years (uncorrected). The system may be the correlative of the Port Huron readvance of the midcontinent (as predicted by Borns & Hughes, 1977) and the beginning of the onset of the Bölling warmth recorded, for example, in the GISP (Greenland Ice Sheet Project) core and the records of N.W. Europe.

CHANGES IN LAND AND LAKE LEVEL, MOOSEHEAD LAKE, MAINE

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The advance and retreat of large ice sheets causes corresponding crustal depression and rebound in areas beneath and marginal to the ice, as the crust and upper mantle seek isostatic equilibrium with the changing ice load. These glacioisostatic changes in level are usually reconstructed from relative sea-level curves in ice-marginal regions, but this method is limited to coastal areas. I propose a method by which differential changes in level of moderately-sized lakes in glacially-scoured regions can be used to reconstruct deglacial isostatic rebound in inland areas, and apply this method to Moosehead Lake, a 40-km long lake in north-central Maine. By assuming that the ice-proximal crustal depression and ice-distal forebulge associated with an ice sheet travels across the landscape as a wave that follows the retreating ice front, I calculate the predicted changes in relative water level at various locations in the lake basin. I then present seismic-stratigraphic, morphological, and stratigraphic studies of Moosehead Lake that expose evidence for both relative highstands and lowstands of lake level in various parts of the lake. An early deglacial highstand in the north end of the lake, and corresponding lowstand in the south end, is recorded by an abandoned outlet channel in the north, abandoned shoreline features throughout the lake basin, and an unconformity in the south end of the lake. An AMS date on basal sediment from the outlet channel suggests that it was abandoned before 8370±40 ybp (OS-6794), which agrees with the predicted timing of this event. Seismic-stratigraphic evidence also suggests that a lowstand occurred in the north end of the lake at some time. All the available evidence for changes in lake level can be explained by differential glacioisostatic rebound, without the need to invoke climatic drawdown of the lake, although this process cannot be ruled out. I have numerous radiocarbon dates in progress in an effort to establish age control on the various lake-level phases.

MAINE (AND ELSEWHERE) FROM THE GREENHOUSE TO THE ICEHOUSE

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In the greenhouse of late Mesozoic and Paleogene times, Maine must have experienced year-around warm temperatures. While early Cenozoic mammals roamed the warm Arctic coast, a deep regolith accumulated on the crystalline rocks of the Canadian Shield and the northern Appalachians. The "rotten rock" noted in many Maine geological studies is probably the remnant of a Tertiary regolith that may have been 100 m thick. Many large crystalline erratics are probably core stones from within the regolith, and were not plucked and abraded by glacial processes. Early glaciations may have denuded the Canadian shield by only 6 m each; subsequent glaciations may have removed only an additional 1 m each (Kaszycki and Shilts, 1987, p. 158). Maine glacial erosion may have been comparably light.

Jahns (1943) demonstrated that the rock-cored drumlins of the Boston region were only slightly abraded, plucked, and over-steepened preglacial landforms. Matthew (1975) proposed that the volume of Cenozoic sediment in the western Atlantic Ocean requires denudation in the northern Appalachians of only about 300 m in the last 60 million years, or only tens of meters in the Quaternary. All this evidence leads to the conclusion that the present topography of Maine is very old, and largely relict from the greenhouse, with a light touch of glacial erosion and stripping of the former regolith.

Relict on a shorter timescale is the Maine shorezone. Abundant intertidal glacial striations demonstrate that Holocene shorezone erosion has had a negligible role in shaping the hard-rock coast, which is fundamentally a set of glacially plucked rock knobs.