THIRD ANNUAL RESEARCH SYMPOSIUM
UNIVERSITY OF MAINE
INSTITUTE FOR
QUATERNARY STUDIES

WEDS-THURS.
MAY 10-11, 1995
0800-1700

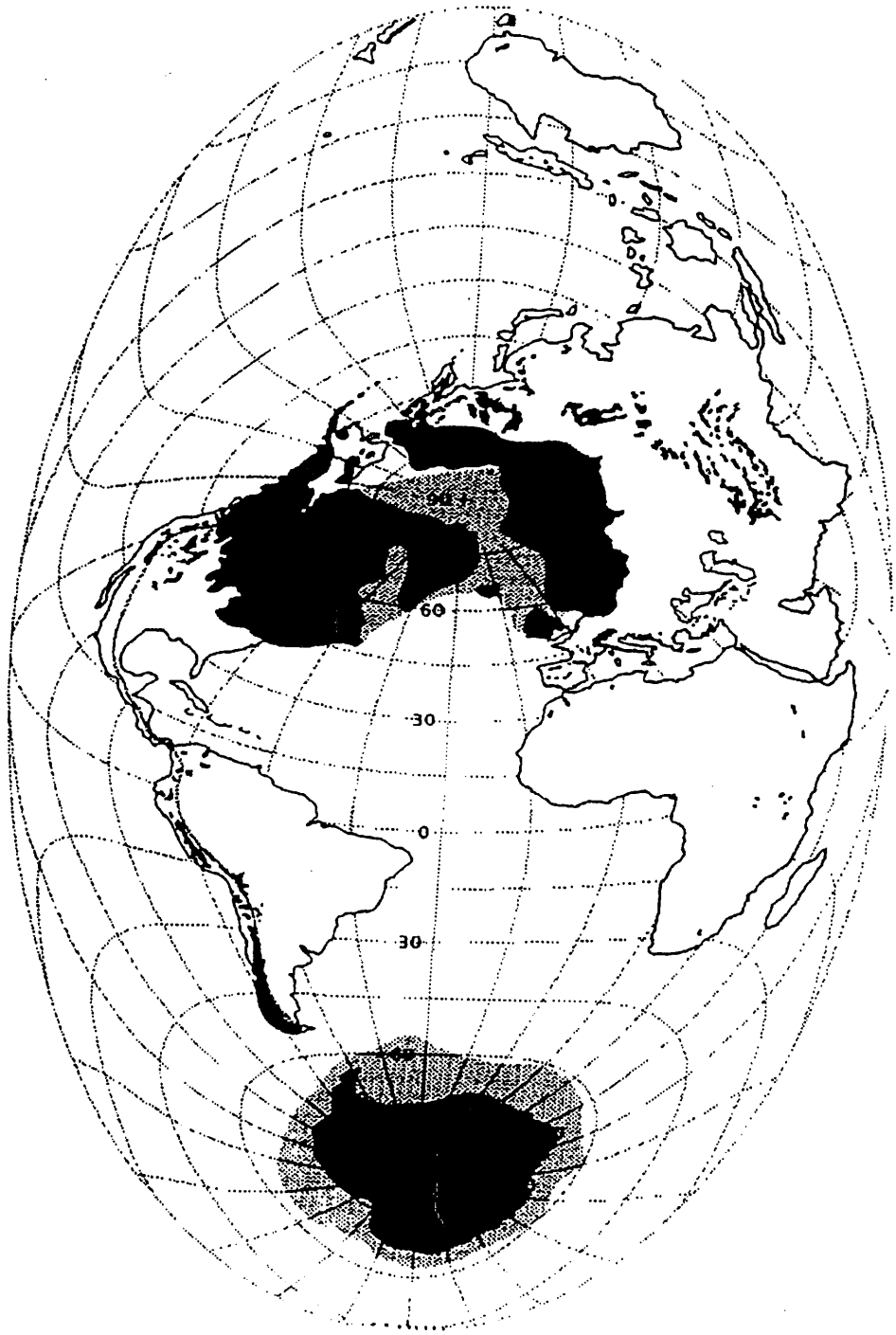
WOOLEY ROOM
COMMUNITY
CENTER

DORIS TWITCHELL
ALLEN VILLAGE

UNIVERSITY OF
MAINE

ORONO, ME

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



THIRD ANNUAL UNIVERSITY OF MAINE
QUATERNARY RESEARCH SYMPOSIUM

DORIS TWITCHELL ALLEN VILLAGE: WOOLEY ROOM
WEDNESDAY-THURSDAY, MAY 10-11, 1995

0730: **COFFEE**

0755: WELCOME AND INTRODUCTION Daniel F. Belknap

SESSION 1 - STABLE ISOTOPES, MICROFOSSILS, PALEOCLIMATE AND PALEOCEANOGRAPHY

0800: James D. Wright, SHALLOW-WATER BENTHIC FORAMINIFERAL STABLE ISOTOPES AND THE DEGLACIAL HISTORY OF LARGE ICE SHEETS: LESSONS FROM SWEDEN AND FUTURE APPLICATIONS IN MAINE

0820: I. Marianne Lagerklint, ABRUPT CLIMATE CHANGES AND SEASONALITY VARIATIONS IN THE EASTERN NORTH ATLANTIC 9,000-22,000 BP

0840: Peter L. French, MICROPALEONTOLOGIC EVIDENCE FOR CHANGES IN SEA-ICE COVER, ICE-RAFTING AND POSITION OF THE POLAR FRONT IN THE GLACIAL NORTH ATLANTIC OCEAN

0900: Cinzia Spencer-Cervato, James D. Wright and Julie K. Friez, PALEOENVIRONMENTAL RECONSTRUCTIONS OF THE SPECIATION AND MIGRATION *OF GLOBOROTALIA TRUNCATULINOIDES* : PRELIMINARY RESULTS

0920: James D. Wright, RECONCILING TROPICAL SEA-SURFACE TEMPERATURE ESTIMATES FOR THE LAST GLACIAL MAXIMUM

0940: Detmar Schnitker, SALINITY AND ISOTOPE ANALYSES OF PORE WATERS FROM GULF OF MAINE PISTON CORES - CIRCULATION CHANGES DURING THE PAST 15,000 YEARS

1000: Cinzi Spencer-Cervato, Heather Almquist-Jacobson, Julie K. Friez, Douglas Introne and Christopher C. Dorion, EARLY HOLOCENE CLIMATE CHANGES IN MAINE: PRELIMINARY RESULTS OF THE ISOTOPIC STUDY OF FISCHER LAKE, AROOSTOOK COUNTY, MAINE

SESSION 2 - GLACIAL-INTERGLACIAL CYCLES IN TWO HEMISPHERES

1020: David R. Marchant and George H. Denton, MIOCENE AND PLIOCENE PALEOCLIMATE OF THE DRY VALLEYS REGION, SOUTHERN VICTORIA LAND: A GEOMORPHOLOGICAL APPROACH

1040: George H. Denton, Patricio I. Moreno and David R. Marchant, INTERHEMISPHERIC SYMMETRY OF PALEOCLIMATE EVENTS DURING THE LAST GLACIATION

1100: Harold J. Borns, Jr. and Parker E. Calkin, WAS THE INTERIOR OF THE WEST ANTARCTIC ICE SHEET HIGHER OR LOWER AT THE LAST GLACIAL MAXIMUM?

1120: **DISCUSSION**

SESSION 5 - ARCHAEOLOGY I

1640: Bret A. Achorn, LITHIC RESOURCE UTILIZATION AND TOOL MANUFACTURE AT THE APARTMIENTIO SITE, 41BS921, BIG BEND NATIONAL PARK, TEXAS: WHAT'S THE POINT?

1700: Robert Weber, VOLCANIC SOURCES OF PREHISTORIC LITHIC MATERIALS AT THE TODD SITE (17-11), BREMEN, MAINE: QUARRY, TRADE, OR COLLECTION?

1720: Sarah Nicholas, STABLE ISOTOPES OF MARINE SHELL AND PALEOCLIMATE ON THE NORTH COAST OF PERU

1740: DISCUSSION

1800: **DINNER**: DORIS TWITCHELL ALLEN VILLAGE

THURSDAY, MAY 11, 1995: DORIS TWITCHELL ALLEN VILLAGE

0730: **COFFEE**

0755: WELCOME AND INTRODUCTION Daniel F. Belknap

SESSION 6 - CLIMATE MODELING

0800: Kirk A. Maasch, THE SPECTRUM OF CLIMATE CHANGE

0820: Douglas N. Reusch and Kirk A. Maasch, WEATHERING OF SILICATES, THE CARBON CYCLE, AND LONG-TERM CLIMATE CHANGE

0840: Todd K. Dupont and Kirk A. Maasch, A THEORY FOR GLOBALLY SYNCHRONOUS CLIMATE CHANGE ON MILLENNIAL TIME SCALES

0900: Greg Balco and Kirk A. Maasch, A TIME-DEPENDENT DYNAMICAL SYSTEM MODEL FOR GLOBAL CLIMATE VARIABILITY ON TIME SCALES FROM 10^3 TO 10^5 YEARS

0920: Robert Bear and Kirk A. Maasch, THE HISTORICAL CLIMATE OF MAINE

0940: Cindy Meservey and Kirk A. Maasch, THE QUATERNARY INSTITUTE HOME PAGE ON THE WORLD-WIDE WEB: http://iceage.umeqs.maine.edu

1000: **COFFEE BREAK**

LITHIC RESOURCE UTILIZATION AND TOOL MANUFACTURE AT THE APARTIMIENTO SITE, 41BS921, BIG BEND NATIONAL PARK, TEXAS: WHAT'S THE POINT?

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

My research focusses upon the projectile points, tools and lithic debris recovered from the 1993 excavation of the Apartimiento Rock Shelter "C", a predominantly Late Prehistoric (c.1000 AD) lithic processing site in the northeastern Chihuahuan Desert Biome. The lithic assemblage includes over 100 points or point fragments, as many tools, a dozen cores, and more than 14,000 pieces of flaking debris. Mass Aggregate Analysis of all debris, followed by the analysis of a sample of flake platforms, will help describe the 1) levels of lithic activity and technology and 2) changes in these attributes over time. Of special interest are the many styles of projectile points recovered; 10 specimens are unique and do not fall within known point types, 12 appear to be of the "Perdiz" type, 6 others are Archaic dart points, and 21 may represent variants of the "Toyah" arrowpoint. This may be the largest, single-site assemblage of this elegant and diminutive point, thereby permitting the statistical description and temporal placement of this artifact type. Minerological testing will also be conducted on samples of the lithic raw material, believed to be Burro Mesa Chalcedony - a fine-grained, cryptocrystaline metamorphosed silicate - obtained a few miles north of the shelter.

Certain evidence suggests that the inhabitants of this site exhibited an Archaic hunter-gatherer lifeway while contemporary neighbors in nearby areas possessed agriculture and other traits associated with a more sedentary village life. Examination of the geology and landscapes, biota, and climate should define the external constraints which faced the ancient inhabitants and help us to understand the reasons why they chose to maintain an Archaic subsistence strategy for hundreds of years after other inhabitants of the region had adopted, or imported, more advanced technologies.

A TIME DEPENDENT DYNAMICAL SYSTEM MODEL FOR GLOBAL CLIMATE VARIABILITY ON TIME SCALES FROM 10^3 TO 10^5 YEARS

Greg Balco and Kirk A. Maasch, Institute for Quaternary Studies, and Department of Geological Sciences, University of Maine

A time dependent dynamical system model developed to account for the observed major variations (on time scales comparable to earth orbital variations) of global ice mass, atmospheric CO_2 and deep ocean properties for the past two million years is expanded to include higher frequency variability believed to be connected to millennial scale sea ice cycles. With the current availability of high resolution paleoclimate records, along with the improved age control provided by AMS ^{14}C dating, it has recently become clear that during the last glaciation (and deglaciation) significant fluctuations in climate have occurred on a time scale of roughly 1-3 kyr. One of the recognizable features of these millennial scale oscillations is repeated flooding of the North Atlantic with icebergs/meltwater. The largest of these, called Heinrich events, occur roughly every 6-10 kyr and are generally believed to be the result of ice stream discharge from the Laurentide Ice sheet. Between these Heinrich events there is evidence that discharge from many of the ice sheets around the North Atlantic is occurring. During the discharge events the sea surface is colder, salinity is lowered, and it is likely that sea ice expands. All of this evidence places yet one more constraint on any model purporting to satisfactorily account for ice age paleoclimate variations. The dynamical behavior of ice sheets and interaction with sea surface conditions not only has a direct effect on the ice sheets themselves, but they also influence other parts of the earth system which are believed to play important roles in the time evolution of global climate such as the production of North Atlantic Deep Water, and potentially the level of atmospheric CO_2. Thus, in order to assess the possible effects of millennial scale climate variability on the global climate system, we must embed such variability into a model which can also account for the time dependent variations in these quantities over glacial-interglacial cycles.

THE HISTORICAL CLIMATE OF MAINE

Robert Bear and Kirk A. Maasch, Institute for Quaternary Studies, and Department of Geological Sciences, University of Maine

Monthly mean instrumental records of temperature and precipitation for Maine have been assembled into a computer data base. Climate data from 28 stations are included in this data base. Records from 12 of these stations come from the Historic Climate Network (HCN), a data set archived at the National Climate Data Center (NCDC) in Ashville, NC, and also available via anonymous ftp from the Carbon Dioxide Information Analysis Center (CDIAC) at Oak Ridge National Laboratory, TN. Monthly averages of daily temperature and maximum/minimum temperature as well as monthly accumulation of rainfall are included. In addition, for these 12 stations the daily values for maximum/minimum temperature and precipitation along with both snowfall and snow depth were obtained directly from NCDC. The HCN monthly averages span the time each station began through December 1987. The daily records from NCDC are complete up through June 1993. The other 16 of these records are from the UMaine Agriculture Experiment Station Bulletin 771 by Baron et al., 1980. In general these records span times earlier than 1880 (the time when many of the HCN stations begin). This historical record of Maine's climate will soon be available in both digital and graphical form via anonymous ftp on **iceage.umeqs.maine.edu**, and will also be visible on the world wide web using client software such as Mosaic or Netscape at **http://iceage.umeqs.maine.edu**. It is likely that the Agriculture Experiment Station will publish a second edition of Bulletin 771.

SEISMIC STRATIGRAPHY OF MAINE LAKES - EVIDENCE FOR DEGLACIATION AND LAKE-LEVEL CHANGES

Daniel F. Belknap, Dept. Geological Sciences, CMS, Oceanography and Inst. for Quaternary Studies, University of Maine, Orono, ME

Many Maine lakes demonstrate bathymetry and Quaternary stratigraphy related to deglaciation. Seismic reflection profiling, sidescan sonar imagery, and a variety of coring techniques has provided a preliminary database for lacustrine Quaternary stratigraphy. Over the past twelve years the marine geology and sedimentology working group at UM has studied examples below the marine limit (Sebago Lake, Sebasticook Lake, Pemaquid Pond, and Biscay Pond) and one above the marine limit (Lobster Lake). Other researchers from Bates College have used similar techniques in Lake Auburn and Damariscotta Lake. We propose to conduct similar research in Moosehead Lake. Many larger lakes contain kettleholes, often in a distinct subsection of the lake. These kettleholes were ice-filled during early deglaciation, glaciomarine and glaciolacustrine phases of the lakes, then opened, allowing sediment gravity flows and draping of later lacustrine sediments into the deep holes. Major slumps are evident in Sebago Lake both as scarps at their heads and as discrete massive deposits in the deep lake basin. Large lakes studied to date also contain submerged shorelines 8-11 m lower than present lake level. These are lower than historic damming effects can account for, and appear to be the result of early Holocene dry periods. Future studies in concert with paleoecologists are planned. Finally, changing lake levels have important controls in geoarchaeology, as demonstrated at the Sebasticook fish weir site. Lowered levels of Sebasticook Lake cut a large channel at the inlet, that was used starting at least 6 ka BP as a weir site to capture anadromous fish.

Interhemispheric Symmetry ofPaleoclimatic Events During the Last Glaciation

G.H. Denton, P.I. Moreno, and D.R. Marchant, Institue for Quaternary Studies, University of Maine, Orono, ME.

A new radiocarbon chronology shows that piedmont glacier lobes in the Chilean Andes achieved maxima at 14,500 - 14,700; 21,000; 23,100; 26,900; 29,200; and at least once ≥35,000 ^{14}C years before present, all within a cold and wet Subantarctic Parkland environment. Massive glacier collapse, which began shortly before 14,350 ^{14}C years ago and was followed by an influx of North Patagonian Rain Forest species, terminated the last glaciation. In the Southern Alps of New Zealand, an additional glacial maximum is recorded at 17,700 ^{14}C years before present, along with a Younger Dryas age readvance at 11,050 ^{14}C years ago. These peaks in glacial activity in South Pacific mid-latitude mountains correlate with ice-rafting pulses in the North Atlantic Ocean. Further, the last termination began suddenly and simultaneously in both polar hemispheres prior to the resumption of the modern mode of deep-water production in the Nordic Seas. Such tight interhemispheric coupling is difficult to explain by regional North Atlantic events such as Laurentide ice-sheet surges or thermohaline switches. Rather, it implies global forcing that had its source in the atmosphere.

THE USE OF AQUATIC-PLANT POLLEN FOR PALEOCLIMATOLOGICAL STUDIES: A POSTER PRESENTATION OF A RESEARCH PROPOSAL

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

Johannes Iversen (1954) speculated that the pollen of aquatic plants should be an extremely high-resolution indicator of climate changes, especially of thermal regime, and that it should be more reliable for this purpose than the pollen of terrestrial plants because the geographic ranges of aquatic plants are able to shift more quickly than those of terrestrial plants. Since Iversen's suggestion, the pollen of terrestrial plants has been used frequently to estimate past climatic conditions but the pollen of aquatic plants has not. I propose to map the past geographic ranges of aquatic-plant taxa using the North American Pollen Database, a compilation of pollen stratigraphic data from hundreds of sites across North America. Using the maps from surface pollen samples, modern climate data, and maps of the current geographic distribution of individual aquatic-plant taxa, I will determine which species are likely to leave a pollen signal and will develop climate response surfaces associating the presence of particular pollen types with ranges of temperatures. The pollen maps and response surfaces will allow me to predict past temperatures. In addition, by determining the rate of movement of aquatic-plant geographic ranges relative to each other and to terrestrial plants, I hope to ascertain whether a time lag exists between climate change and the shifting of plant geographic ranges and whether the immigration of aquatic plants is limited by substrate-development rate.

A THEORY FOR GLOBALLY SYNCHRONOUS CLIMATE CHANGE ON MILLENNIAL TIME SCALES

Todd K. Dupont and Kirk A. Maasch, Institute for Quaternary Studies, and Department of Geological Sciences, University of Maine

Northern hemisphere paleoclimate reconstructions for the last 40 kyr based on ice cores, marine sediments, pollen, and glacial deposits indicate that large, rapid shifts in climatic conditions occurred repeatedly on two characteristic time scales, roughly 1-3 kyr and 5-10 kyr. It is now becoming clear that climatic conditions in the southern hemisphere also change on these time scales. Radiocarbon dated glacial advances from the Andes and New Zealand have been shown to be synchronous with the aforementioned northern hemisphere climate changes. This interhemispheric synchrony clearly implicates the atmosphere as the key to global climate change on this time scale. To explain the millennial scale climate variations we consider a positive feedback between CO_2 and sea ice extent, which necessitates interhemispheric synchrony. Specifically we take the dynamical systems approach. A model involving feedbacks between sea ice extent and mean ocean temperature is coupled to an ice stream model. The sea ice-ocean model contains positive (ice-albedo and CO_2) feedbacks that can drive oscillatory behavior with a period on the order of 1-3 kyr. Sea ice oscillations in both hemispheres are simultaneous because atmospheric CO_2 is well mixed. In the ice stream model an ice sheet experiences thermally regulated cyclic alternation between a binge and purge state. When forced by plausible values for the geothermal flux, atmospheric temperature, and average accumulation rate, periodic discharges of icebergs and meltwater occur approximately every 7-8 kyr. The cyclic behavior of the ice sheet in the northern hemisphere also leads to sea ice expansion, which via the CO_2 feedback occurs simultaneously in the southern hemisphere.

EXTREME ANTARCTIC CONFIGURATIONS

Dr. Jams L. Fastook, Department of Computer Science and Institute for Quaternary Studies, University of Maine, Orono, ME.

Two extreme configurations for the Antarctic Ice Sheet (AIS) are examined, first, a warm climate minimum configuration, and second a cold climate maximum configuration. The warm climate configuration uses a temperature warming of +20 degrees, the cold climate configuration uses a no-cooling case, and a -10 degree cooling case, with an additional comparison to a configuration with modified basal conditions.

In the calibration of the model a distribution of sliding is obtained by fitting the calculated surface to the present measured surface. The distribution of fitted sliding seems to match the current observations of where sliding is known to occur, but it does not match the distribution of calculated basal temperatures at the melting point. This suggests that something more complex than a simple presence or absence of a melted bed with a significant basal water layer is required to produce sliding. In addition, the calculated temperature distribution shows no melting in the Siple Coast area, suggesting that a higher geothermal heat flux is required in that area.

The minimum configuration for a 20 degree warming yields an ice sheet configuration that fails to explain the marine diatoms in the Transantarctic Mountains. It is unlikely that such warming occurred in the recent past, so either the mass balance parameterization has failed for such an extreme warming, or the source region or age of the diatoms is in error.

The maximum configuration with grounded continental shelves and present climate produces an ice sheet configuration in reasonable agreement with current thinking about the state of Antarctica during the last glacial. Thickening near the margin and grounding of the ice shelves, with little thickening in the interior matches well with data from many areas along the Transantarctic Mountains, as well as with indirect data from the dome cores.

Comparison of some limited, new field data from West Antarctica suggests that accumulation rates, at least in West Antarctica, did not decline during the last glacial.

A crude test with an extremely different distribution of sliding provides an ice sheet configuration that does not agree with field data.

SPATIAL AND TEMPORAL VARIABILITY IN LATE-GLACIAL VEGETATION OF THE GREAT LAKES - NEW ENGLAND REGION

George L. Jacobson Jr. and Molly Schauffler. Institute for Quaternary Studies, University of Maine, Orono ME.

Landscapes of the Great Lakes -- New England region changed rapidly and differentially with the demise of the Laurentide ice sheet. Paleovegetational reconstructions using mapped pollen data reveal strong differences from east to west throughout the period from 12,000 to 9000 BP, with open tundra-like conditions and spruce woodland persisting latest in northern New England and the Maritime provinces. Spruce forests and woodlands were important in some parts of the region as late as 9500 BP. Pine became abundant in southern New England by 12,000 BP, spreading westward coincident with the expansion of birch after 11,000 BP. Although stratigraphic data from sites in eastern Maine and the Maritime provinces may indicate reversion to cooler conditions between 11,000 BP and 10,000 BP, mapped records of four major pollen taxa west of the strong maritime influence show no evidence of reversal during the Younger Dryas chronozone. Possible reasons include insensivity of the data and continentality of climate.

SIDE-SCAN SONAR IMAGES OF SEBAGO LAKE, MAINE: EVIDENCE FOR A POSTGLACIAL INLAND MARINE LIMIT

Robert A. Johnston, Stephen M. Dickson, Joseph T. Kelley, Maine Geological Survey, Augusta, ME and Daniel F. Belknap, Dept. Geological Sciences, Univ. Maine, Orono, ME

Comparisons of western Gulf of Maine physiographic regions with those flooring Sebago Lake, 30 km inland of Maine's coast, indicate a similar Quaternary depositional history. Sebago Lake, in southwestern Maine, is a 123 km^2 bedrock-framed, glaciated lake basin located along the postglacial marine limit. Over 52 km^2 of side-scan sonar tracks (over 40% of the lake floor) have been collected since 1992 in an attempt to accurately locate the marine limit, shown to cross the lake on the 1985 Surficial Geologic Map of Maine.

Work by Kelley and Belknap (1991) divided the glaciated, western Gulf of Maine into four physiographic areas and Sebago Lake shows similar provinces: nearshore basins, outer basins, rocky zones, and shelf valleys. Nearshore basins contain sand or mud with intermittent bedrock outcrops. Paleoshorelines rim the nearshore basins, indicating a lower lake level at -11 m, well below the pre-dam level of the early 1800's. Outer basins, greater than 50 m in depth, contain mud. Rocky zones are either solid bedrock or bouldery ledges. Deep springs (>60 m) are seen on the side-scan images to emit from the ledges. Shelf valleys lead from the modern river inlets, are framed by bedrock, and grade from sand along the inshore regions to mud offshore.

Side-scan sonar images indicate that submarine debris flows are common in the sedimentary environment. Images of the recent debris flows detail the morphology of the slumps. Seen in side-scan records are longitudinal debris in the deep basin covering up to 0.8 km^2. Fine-grained muds appear to be winnowed from the shallow, nearshore areas filling the deep bedrock-controlled basins. These side-scan sonar records support the hypothesis that the entire Sebago Lake basin was an active depositional environment along an inland glacial margin during the late Quaternary.

THE SPECTRUM OF CLIMATE CHANGE

Kirk A. Maasch, Institute for Quaternary Studies, and Department of Geological Sciences, University of Maine

Climatic change on time scales ranging from millennia to millions of years is examined with an eye toward developing a theory to explain why it occurs. On tectonic time scales (10-100 Myr) the movement of continents and building of mountains has a profound influence on the global climate. Ice ages occur roughly every 200-300 Myr in coincidence with continental collision and subsequent uplift of mountains. On earth orbital time scales (20-100 kyr) the global climate oscillates between glacial and interglacial conditions over the last 2-3 Myr. It is only during the last 900 kyr of this time span that the 100 kyr cycle is dominant. On millennial time scales (1-10 kyr) a rapidly growing body of paleoclimate evidence indicates that rapid shifts in global climatic conditions during the last glacial/interglacial cycle occur on two characteristic time scales, roughly 1-3 kyr and 5-10 kyr. All of this information forms a basis for constructing dynamical systems models for global climate change over these time scales. These models, which are a closed set of statements that describe the time dependent variations of climate variables (i.e., global ice mass, atmospheric CO_2 , ocean circulation ...) represent a theory for climate change on geologic time scales ranging from thousands to millions of years.

MIOCENE AND PLIOCENE PALEOCLIMATE OF THE DRY VALLEYS REGION, SOUTHERN VICTORIA LAND: A GEOMORPHOLOGICAL APPROACH

David R. Marchant and George H. Denton, Institute for Quaternary Studies, University of Maine, Orono ME 04469

The Dry Valleys region is a hyper-arid, cold polar desert. Modern climate varies systematically with increasing elevation and distance from the coast. We distinguish three microclimate zones on the basis of varying precipitation, wind direction, relative humidity, temperature, and soil-moisture content. Zone 1 represents coastal, Zone 2 intermediate, and Zone 3 far-western areas of the Dry Valleys region. Soil-moisture content and relative humidity are the key parameters that control the areal distribution of solifluction terraces, gelifluction lobes, polygonal ground, scree slopes, and soil development in Zones 1, 2 and 3. The coastal Zone 1 shows active solifluction terraces, gelifluction lobes, levees, streams, debris flows, mudflows, and subxerous soils. The intermediate Zone 2 contains little evidence for modern downslope movement; here active gelifluction lobes, debris flows, and streams are largely restricted to north-facing slopes with high moisture content. The inland Zone 3 lacks evidence for significant modern downslope movement. There are no active solifluction terraces, stream channels, debris flows, or levees in Zone 3. Instead, Zone 3 shows Miocene- and Pliocene-age sand wedges, avalanche cones, and desert pavements. The mid-Miocene landsurface of Zone 3 is preserved to a remarkable degree. The antiquity and longevity of paleoforms in Zone 3 can be readily demonstrated by the topographic position of dated ashfall deposits. The lack of gelifluction lobes, solifluction terraces, rills, levees, and stream channels on in-situ Miocene- and Pliocene-age deposits in Zone 3 indicates that here mean-annual air temperature, soil moisture content, and relative humidity did not reach levels that now occur in Zones 1 and 2. The present mean-annual air temperature and relative humidity of Zones 1 and 2 are about -17°C/ 75% and -27°C/ 45%, respectively. The implication is that climatic warming of the magnitude necessary for East Antarctic Ice Sheet deglaciation predicted by some glaciological models and growth of vascular vegetation in the Transantarctic Mountains could not have occurred during Pliocene time.

LATE GLACIAL CLIMATE, FIRE, AND PALEOINDIANS(?) IN THE CHILEAN LAKE DISTRICT (42°S).

Patricio I. Moreno. Dept. of Plant Biology & Pathology and Inst. for Quat. Studies
University of Maine, Orono ME

The high-resolution pollen record from Lago Condorito (42°S), shows a low-elevation Valdivian/North Patagonian community between 12.3 and 12 ka, including the thermophilous Myrtaceae, the conifer *Pilgerodendron*-type, southern beech (*Nothofagus*), and understorey trees (*Lomatia/Gevuina*). This assemblage suggests wet/temperate conditions similar to the modern climate in the area. Charcoal shows maximum abundances at 12 ka. A major vegetation change occurred after 12 ka featuring the decline of the thermophilous taxa, and the abrupt increase of the cold-resistant *Podocarpus* and *Pseudopanax*, at the same time charcoal decreases to consistently low values. I infer climate cooling beginning at 12 ka; these wet/cooler conditions suppressed the occurrence of natural fires. At 11 ka, *Weinmannia* and *Tepualia* rose rapidly while *Podocarpus* and *Pseudopanx* decreased slowly, implying an opening of the forest under wet conditions. Charcoal concentrations increased rapidly at 11 ka, and remained high until 9 ka. Shortly after 10 ka, moisture-demanding *Weinmannia* and *Tepualia* declined, while thermophilous Valdivian taxa began to increase.

The cooling beginning at 12 ka in Lago Condorito (42°S) is also observed in the Puerto Octay record (41°S), however **the rise of *Weinmannia*, and charcoal abundances between 11-10 ka do not fit the COOL/WET climate inferred in both records**. *Weinmannia* is a cold-resistant, low/mid elevation tree favored by volcanic disturbance. I suspect that the rise in *Weinmannia* at 11-10 ka was induced by fire disturbance of non-climatic origin. My argument is that no other thermophilous tree taxa increased between 11-10 ka, but after 10 ka. Lago Condorito is 20 km SE of the Monte Verde site, which shows paleoindian remains as old as 13 ka(?!). I suggest that the vegetation changes between 11-10 ka were the result of human-set fires.

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

Sarah Nicholas - Institute for Quaternary Studies, University of Maine, Orono, ME.

The presence of warm water mollusk shells on the north coast of Peru suggests that there may have been permanent warm water and moist tropical conditions along the Peruvian coast before 5000 B.P., unlike modern conditions which are characterized by cold water and no precipitation except during El Niño events. If this climate change were confirmed, it would have implications for human adaptations in the area. My research is intended to test the climate change hypothesis. I will refine and expand upon the protocol designed by Rollins et al (1987). $\delta^{18}O$ and $\delta^{13}C$ values measured along the increment of maximal growth of bivalves which survived the 1982-1983 El Niño will be used to provide a gauge which can be used to assess the environmental conditions (including El Niño events) recorded in mollusk shells within archaeological sites. If the differences in shell composition between molluscan assemblages, from the Siches site in northern Peru, before and after 5000 B.P. are similar to the differences between El Niño and non- Niño periods within individual shells which survived the 1982-83 ENSO event, then the research would tend to support the idea that permanent moist tropical conditions were in effect along the Peruvian coast before 5000 B.P.

WEATHERING OF SILICATES, THE CARBON CYCLE, AND LONG TERM CLIMATE CHANGE

Douglas N. Reusch and Kirk A. Maasch, Institute for Quaternary Studies, and
Department of Geological Sciences, University of Maine

The greenhouse theory of climate and carbon cycle models imply that imbalances between the rates of planetary degassing and silicate weathering drive long term climate change. Major glaciations have coincided with continental collisions, which exhume old sialic crust and contribute radiogenic strontium to the oceans. While less abundantly exposed than sialic materials, simatic crust, rich in labile Ca and Mg silicates, disproportionately influences the weathering flux (11.0×10^{12} moles CO_2 removed/km^3 "dissolved" basalt versus 1.3×10^{12} moles /km^3 for granite). Maximal weathering fluxes would be expected when simatic rocks are subaerially exposed in hot, wet regions (e.g., Papua ophiolite). In convergent settings, the degassing-weathering flux ratio plummets at the transition from subduction to collision when active magmatic arcs and ophiolites are obducted. Likewise, in extensional settings, the ratio plummets at the termination of terrestrial basalt floods. Significant weathering of simatic rocks coincident with glacial periods took place during the Vendian, late Ordovician, Permo-Carboniferous, and Cenozoic periods. Using a geochemical cycle model we will compare and contrast the relationship between tectonics and climate for two of these glacial periods, the Varanger ice age which occurred at around 600 Ma and the late Cenozoic which culminated with the late Pleistocene ice ages.

CLIMATIC CHANGE OR GEOGRAPHIC VARIATION IN THE MID-HOLOCENE OF NORTHERN PERU: ARCHAEOLOGICAL AND PALEOCLIMATIC EVIDENCE

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

The Ostra Site is located near the Santa River on the Peruvian north coast (ca. 9° S latitude) and dates to the mid-Holocene (ca. 6250 to 5400 BP). Vertebrate and invertebrate faunal assemblages from the Ostra Site and an associated paleoshoreline are dominated by species now found in warm-tropical waters north of ca. 5° S latitude, while the Ostra region today has a typical warm-temperate fauna. Other mid-Holocene sites south of 5° S latitude also have warm-tropical faunas. Models to account for the anomalous fauna of mid-Holocene northern Peru have stressed either regional climate change or local geographic alterations. These models are considered in the context of other sources of climate data, and their differential implications for regional prehistory are discussed.

SALINITY AND ISOTOPE ANALYSES OF PORE WATERS FROM GULF OF MAINE PISTON CORES - CIRCULATION CHANGES DURING THE PAST 15,000 YEARS

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Pore water was extracted from four Gulf of Maine piston cores and analyzed for its salinity and oxygen-isotope composition. It is expected that these waters are true remnants of ancient Gulf of Maine bottom waters. All records of paleo-salinity and oxygen isotopes are relatively noisy, making comparisons with modern oceanographic data difficult. Late-glacial glaciomarine pore waters were 2‰ to 2.5‰ less salty than post-glacial, especially late Holocene pore waters, indicating dilution with fresh water during late glacial times. Late Holocene pore water salinities approach present-day bottom-water salinities of ~33‰ to 34‰. The isotopic ratios of late-glacial pore water are usually significantly lighter than those of post-glacial age, reflecting the greater degree of dilution with isotopically light fresh water. Salinity/$\delta^{18}O$ regression demonstrates that the diluting fresh water was probably equivalent to modern rainwater ($\delta^{18}O$ = -7‰ to -10‰), rather than isotopically extremely light glacial meltwater. Regression intercepts of less than -7‰ were encountered for several early Holocene core sections, suggesting that the diluting freshwater came from melting sea ice. Only the last glacial bottom waters of Jordan Basin were probably diluted with continental ice meltwater ($\delta^{18}O$ = -37‰).

LATE WISCONSINAN STRATIGRAPHY AND DEGLACIATION CHRONOLOGY OF THE LOWER AROOSTOOK RIVER VALLEY, MAINE

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Evidence exists for a Younger Dryas climatic oscillation in southern New England and the Canadian Atlantic provinces, and associated glacial readvances are documented in Quebec and high elevations in the Atlantic provinces. This work investigates the deglaciation chronology of Northern Maine in an effort to determine whether evidence exists there for a climatic oscillation. Cores from 12 lakes suggest a late-glacial return to ice proximal conditions, and a ubiquitous stratigraphy of till overlying stratified drift exists in numerous locations, however no clear morphological evidence exists for a late-glacial readvance. Ice marginal moraines between Mars Hill and Easton indicate progressive northward retreat of active ice. Radiocarbon-dated terrestrial organics from Echo Lake indicate ice-free conditions in the Presque Isle vicinity by 11,950±190 yr. B.P., and the stratigraphy up-section from this date reflects warmer conditions interrupted by a cooler period followed by resumed warming, similar to cores from nearby sites (Deevey, 1951) and from New Brunswick (Cwyner et al., 1994).

Outwash gravels in excess of 10m thick are overlain by till in the lower Aroostook Valley, with the contact lying approximately 21m above the present river elevation. These gravels grade downstream to similar exposures in the St. John River valley in New Brunswick and are erosional remnants of a thick valley train sequence which existed prior to the Late Wisconsinan advance. A similar outwash deposit was cored in Number Nine Lake and dated at 41,200±1400 yr. B.P. The till in the Aroostook River Valley correlates with till and ice marginal diamicton elsewhere in the region, implying that underlying stratified gravels observed in specific locations are pre-Late Wisconsinan in age. This chronology is consistent with the Late Wisconsinan chronology in New Brunswick (Rappol, 1989; Cwyner et al., 1994).

DEGLACIATION SEQUENCE IN SOUTHWESTERN MAINE

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The Maine Geological Survey (MGS) is compiling a deglaciation chronology map of SW Maine. End moraines, submarine fans, and glaciomarine deltas mark successive positions of the late Wisconsinan ice margin in the area of late-glacial marine submergence. Inland from the marine limit, deglaciation progressed by continued northward recession of the glacier margin. End moraines are uncommon in the mountainous terrain of western Maine, and usually occur in areas that were topographically favorable for late ice flow. The pattern of ice retreat in this region is reconstructed from meltwater channels and the ice-contact heads of glaciolacustrine and glaciofluvial deposits. The morphosequence concept has been used successfully to document ice-margin positions based on these deposits. Although the ice flowed SE to SSE during maximum glaciation, striae and ice-marginal deposits indicate a widespread late-glacial shift in flow toward S-SSW in the part of western Maine that lies south of the Mahoosuc Range. Striae and glaciotectonic structures show that locally dynamic ice flow persisted during retreat. Field work in the northern White Mountains of New Hampshire likewise indicates systematic retreat of the ice margin and continued ice flow during late stages of deglaciation. Uncorrected AMS radiocarbon dates on marine shells collected by MGS and University of Maine investigators indicate that coastal southwestern Maine was deglaciated beween 15,000 and 14,000 yr B.P. Recently obtained AMS dates from central Maine suggest that the interior region was generally ice-free by 13,000 B.P., but additional lake coring is needed to develop a deglaciation chronology for the area extending from the marine limit north to the Canadian border.

SHALLOW-WATER BENTHIC FORAMINIFERAL STABLE ISOTOPES AND THE DEGLACIAL HISTORY OF LARGE ICE SHEETS: LESSONS FROM SWEDEN AND FUTURE APPLICATIONS IN MAINE

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The marine $\delta^{18}O$ record of the most recent deglaciation is often inferred from locations far from the ice sheets themselves. The observed $\delta^{18}O$ changes in these cores are usually small and cannot be unequivocally identified as meltwater events. Planktonic foraminiferal $\delta^{18}O$ records in cores proximal to the ice sheets do not record a large meltwater signal. The absence of this signal in $\delta^{18}O$ records is because most planktonic foraminifera cannot tolerate large salinity changes. Planktonic foraminifera move either laterally or to deeper depths to avoid fresh water pulses. One exception comes from the Gulf of Mexico where one species, *Globigerinoides ruber*, recorded at least a 5‰ salinity change in the Gulf of Mexico during a glacial discharge event down the Mississippi. Unfortunately, this species is limited to the tropics and subtropics, and therefore, it is not found in regions proximal to the ice sheets. An unlikely recorder of the freshwater plumes is the benthic foraminifera *Elphidium excavatum forma clavata*. Because these organisms are benthic they cannot avoid the fresh water; they either tolerate the freshwater or die. In a previous study, *E.excavatum forma clavata* $\delta^{18}O$ records from southwestern Sweden indicate that this species recorded the release of fresh water from the Baltic Ice Lake at 9.5 kyr. The benthic foraminiferal $\delta^{18}O$ change during the meltwater event indicates that *E. excavatum forma clavata* lived in water as fresh as 15‰ in salinity. This species is common in most of the marine sections found on-shore in Maine and off-shore in the Gulf of Maine. High sedimentation rates in these cores provide an excellent opportunity to determine not only the timing, but also, the nature of deglaciation in Maine (i.e., was it a one time event or a series of events over several years?).

SPATIAL PATTERN IN SEED BANK COMPOSITION AND DENSITY

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Current models of forest response to climate change assume that seed of all simulated species is ubiquitous. Given the degree of future climate change predicted by general circulation models, however, the ability of plant species to disperse seed to climatically suitable sites at the rates at which these sites may become available is questionable at best. Uncertain effects of habitat fragmentation further complicate our predictions of plant response to global change on a biogeographical scale. The objective of the present research is to assess landscape-level spatial patterns in seed bank dynamics and to begin constructing models for simulating the dispersal of plant seed across landscapes with varying habitat patterns. Seed bank composition and density have been assessed by sampling soil in 10 different landscape units, followed by germination tests under different greenhouse and growth chamber conditions. The germination tests show that germination percentage under artificial light in the greenhouse (16 h day, 8 hr night), and under summer conditions in the growth chamber (16 h day, 30 °C; 8 h night 20 °C) is substantially greater than under natural light in the greenhouse and under fall conditions in the growth chamber (12 h day, 15 °C; 12 h night, 10 °C). The major taxa are *Rubus idaeous*, *Oxalis europea*, *Betula*, *Carex*, *Tsuga* and graminoids. Work will continue during the coming field season with further seed bank sampling, vegetation measurement, and seed rain assessment. This work will take place along twenty five 100 m transects across boundaries between different landscape units. All subsequent germination tests will be conducted under artificial light in the greenhouse. The spatial patterns in seed banks and seed rain will be tested against a general null model of random distribution on the landscape. Under the expectation of rejecting the null hypothesis, models of seed dispersal and survival in the seed bank will be assembled for tree species and the more common shrub and herb species. Distance from seed source will be a driving variable in the dispersal models and vegetation/habitat type will be a driving variable for seed survival. The spatial arrangement of vegetation units on the landscape will therefore influence the simulated dynamics of seed dispersal and persistence. Efficient computing environments for retaining the spatial features of the model will be explored over the next academic year.

Diatoms in Antarctic Ice Cores and Snow Pits: Implications for Mechanisms of Diatom Emplacement in Ancient Glacigenic Deposits

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ABSTRACT

The presence and nature of diatoms in PICO South Pole Ice Core #1 are key to resolving the decade-long debate among paleoclimatologists over the occurrence of a hypothetical Pliocene warming event 3.0-3.5 myBP in Antarctica. According to this hypothesis, a narrow ice-free seaway opened in the Wilkes and Pensacola subglacial basins due to elevated Pliocene temperatures, raising global sea level in excess of 25m. Marine diatoms deposited in this seaway were subsequently carried by a later glacial advance and reworked forming glacigenic Sirius Group deposits at high elevations in the Transantarctic Mountains. Hence the validity of this low-abundance Pliocene diatom assemblage is the keystone for the hypothetical warming. If Pliocene diatoms in the Sirius Group are not in place but reworked, as suggested by many workers, there is no reason to postulate a Pliocene warming event.

Over 40 species of diatoms, both marine and non-marine, Antarctic and possibly extra-Antarctic, occur persistently but in low abundance throughout the South Pole ice core, spanning the last 2000 years. As there are no local sources for the diatoms entrained in South Pole ice, these must have been carried from coastal or extra-Antarctic sources by atmospheric transport. Together with diatom assemblages in snow pits and ice cores from other remote interior sites including Dome C, and the Taylor and Siple Domes, the South Pole diatoms argue strongly that aeolian processes could easily have been involved in diatom emplacement in Sirius Group sediments long after these sediments were deposited.