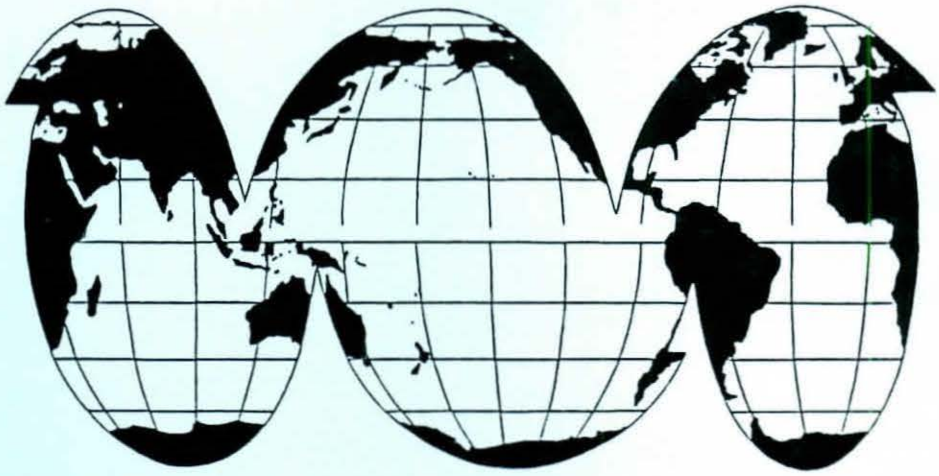
THE 23rd ANNUAL ARCTIC WORKSHOP



Bipolar Perspective on Processes and Records of Environmental Change

April 1 - 3, 1993

ABSTRACTS

BYRD POLAR RESEARCH CENTER

The Ohio State University

BPRC Miscellaneous Series M-322
Arctic Workshop Abstracts Volume

Byrd Polar Research Center
The Ohio State University
Columbus, Ohio 43210

Compiled in 1993 by the
BYRD POLAR RESEARCH CENTER

This report may be cited as:

23rd Annual Arctic Workshop Program and Abstracts, 1993. Byrd Polar Research Center Miscellaneous Series Publications No. 322, Byrd Polar Research Center, The Ohio State University, Columbus, 108 pp.

This report is distributed by:

Publication Distribution Program
GOLDTHWAIT POLAR LIBRARY
Byrd Polar Research Center
The Ohio State University
Columbus, Ohio 43210-1002

Mail order requestors will be invoiced for the cost of shipping and handling.

THE 23rd ANNUAL ARCTIC WORKSHOP

Bipolar Perspective on Processes and Records of Environmental Change

April 1-3, 1993

Byrd Polar Research Center
The Ohio State University
1090 Carmack Road
Columbus, Ohio 43210

Organizing Committee:

Amy Leventer
Steve Forman

Kathleen Doddroe
Lynn Everett
Lynn Lay

Includes: Agenda, Abstracts, Attendee List

BPRC Miscellaneous Series M-322

23rd ANNUAL ARCTIC WORKSHOP PROGRAM

Thursday, April 1, 1993

(Morning)

8:00 - 8:30 AM	Registration
8:30 - 8:50 AM	Welcome, K. C. Jezek *(Director, Byrd Polar Research Center)*

Session 1: Holocene Records of Environmental Change
Chair: Amy Leventer

		Page
8:50 - 9:10 AM	Mosley-Thompson, E., L.G. Thompson, P.N. Lin, M.E. Davis and J. Dai *"Rapid Holocene Warming and Cooling Events in Central Antarctica"*	59
9:10 - 9:30 AM	Mode, W.N., G.H. Miller and P.E. Sauer *"Robinson Lake: The Longest Lake-Sediment Pollen Record from Baffin Island"*........	58
9:30 - 9:50 AM	Galloway, J.P. and L.D. Carter *"Dune Activity on the Western Arctic Coastal Plain of Alaska Coincident with Neoglacial Cirque-Glacier Expansion in the Brooks Range"*	35
9:50 - 10:10 AM	Eisner, W.R., A.V. Lozhkin, T.P. Prokhorova, A. Oganyesyan, and A.V. Sher *"Peatlands of Beringia: A Paleoecological Quagmire or Treasure Trove?"*	32
10:10 - 10:30 AM	Sher, A. *"Global Change at the Arctic Crossroads: Current Problems of the Late Cenozoic Paleoecology of Beringia"*	70
10:30 - 10:50 AM	BREAK	
10:50 - 11:10 AM	Brubaker, L.B., C.J. Earle and P.M. Anderson *"Variations in Charcoal Content in Modern Lake Sediments: Implications to the Study of Late Quaternary Fire History in North Central Alaska"*	21
11:10 - 11:30 AM	Brown, T.A., G.W. Farwell, P.M. Grootes *"Radiocarbon accelerator mass spectrometry dating of pollen from lake sediments and peat deposits"*	18
11:30 - 11:50 AM	Retelle, M.J. *"Interpretation of Laminated Lacustrine Sediments from Northern Ellesmere Island, Canada, Based on Seasonal and Annual Sediment Trap Yields and Process Studies"*	67
11:50 - 12:10 PM	Dai, J., E. Mosley-Thompson and L.G. Thompson *"Is There a Proxy Record of Cloud Cover in Antarctic Ice Cores?"*	27
12:10 - 1:20 PM	**LUNCH (Box Lunch Provided)**	

23rd ANNUAL ARCTIC WORKSHOP PROGRAM
Thursday, April 1, 1993
(Afternoon)

Session 2: Cryospheric Processes
Chair: Christina Hulbe

		Page
1:20 - 1:40 PM	Dwyer, J. *"Studying Changes of Glacier Ablation Zones in the Kangerdlugssuaq Fjord Region, East Greenland, Using a Time Series of LANDSAT Images"*	30
1:40 - 2:00 PM	Casassa, G. *"Changes on the Ross Ice Shelf, Antarctica Derived from AVHRR Imagery"*........	25
2:00 - 2:20 PM	Hulbe, C.L. *"A Method for Determining Ice Thickness Change Using GPS"*	43
2:20 - 2:40 PM	Whillans, I.M. and C.J. van der Veen *"Mechanics of Ice Stream B, Antarctica"*	80
2:40 - 3:00 PM	Pollard, W. *"A Comparison of Ground Ice Characteristics for Two Locations in the High Arctic"*	64
3:00 - 3:20 PM	BREAK	
3:20 - 3:40 PM	Blankenship, D.D., R.E. Bell, S.M. Hodge, J.C. Behrendt, C. Finn and J.L. Brozena *"Corridor Aerogeophysics in West Antarctica"*	12
3:40 - 4:00 PM	Jeffries, M.O. *"Crystalline Structure, Isotopic Variations and Development of Pack Ice in the Pacific Sector of the Southern Ocean"*	46
4:00 - 4:20 PM	Hinkel, K.M. and S.I. Outcalt *"Identification of Heat-Transfer Processes During Soil Cooling, Freezing, and Thaw in Central Alaska"*	42
4:20 - 4:40 PM	Hardy, D.R. *"Slushflows as Sediment Transfer Mechanisms, Northern Ellesmere Island, Canada"*	41
4:40 - 5:00 PM	Ping, C.L., S. Gubin, G.G. Mazhitova and Y.L. Shur *"Soil Characteristics of the Upper Edoma Formation, NE Russia"*	63
5:00 - 5:20 PM	Nicholas, J. *"Rates of Active Layer Deepening in a Boreal Forest Setting"*........	60

23rd ANNUAL ARCTIC WORKSHOP PROGRAM
Friday, April 2, 1993
(Morning)

Session 3: **Glacial Cycles**
Chair: **Steve Forman**

		Page
8:00 - 8:20 AM	Anderson, J. *"Reconstruction of Antarctic Ice Sheet During the Last Glacial Maximum Using Marine Geological Evidence*	8
8:20 - 8:40 AM	Andrews, J.T., H. Erlenkeuser, K. Tedesco, A.E. Aksu and A.J.T. Jull *"Meltwater Events in the NW Labrador Sea and Their Association with North Atlantic Heinrich Events"*	9
8:40 - 9:00 AM	Bond, G.C. *"Near-Synchronous Century and Millennial Time Scale Events in Northern and Southern Hemispheres between 14,000 and 19,000 years ago"*............	14
9:00 - 9:20 AM	Manley, W.F. *"Late-Glacial Ice-Flow Patterns and Interactions, Hudson Strait Coast of Baffin Island"*	56
9:20 - 9:40 AM	Snyder, J.A., S.L. Forman, G.H. Miller and S. Korsun *"Preliminary Results from Quaternary Geological Investigations on the Northeastern Kola Peninsula, Russia"*.....	71
9:40 - 10:00 AM	BREAK	
10:00 - 10:20 AM	D. Lubinski, S. Korsun, S.L. Forman, A. Leventer, G. G. Matishov and G.H. Miller *"New Holocene Paleoceanographic Records from Fran Josef Land"*	52
10:20 - 10:40 AM	Forman, S.L., G.H. Miller, D. Lubinski, J. Snyder, S. Korsun, L. Polyak, G. Tarasov and G.G. Matishov *"The Last Glacial Cycle in the Russian Barents and Kara Seas"*..................	33
10:40 - 11:10 AM	Kaufman, D.S. and H.P. Sejrup *"Isoleucine Epimerization in the High-Molecular-Weight Fraction of Arctica from S.W. Norway"*	47
11:10 - 11:30 AM	Brigham-Grette, J., S. Benson, D.M. Hopkins, P. Heiser, V.F. Ivanov, and A.E. Basilyan *"Aminostratigraphy of Middle and Late Pleistocene Marine and Glacial Deposits Along the Coast of Chukotka Peninsula, Russia: Initial Interpretations and Comparisons with Alaska"* ..	15
11:30 - 11:50 AM	Bart, P. and J.B. Anderson *"Late Miocene to Plio-Pleistocene Glacial Expansions and Contractions Along the Antarctic Outer Shelf*	10
11:50 - 12:10 AM	Ishman, S.E. and PRISM Project Members *"Polar Response to Middle Pliocene Ocean Warming"*	44
12:10 - 12:30 PM	Willard, D.A. *"Northern Hemisphere Vegetation During the Mid-Pliocene: Subarctic to Subtropical Transect"*..................	81
12:30 - 2:00 PM	LUNCH AND BYRD OPEN HOUSE *(Box Lunch Provided)*	

OPEN HOUSE

Goldthwait Polar Library	**(Room 176)**
Ice Core Lab	**(Room 082)**
Polar Meteorology Lab	**(Room 041)**
Glacier Remote Sensing Lab	**(Room 047A)**
Luminescence Dating Research Lab	**(Room 216)**

23rd ANNUAL ARCTIC WORKSHOP PROGRAM
Friday, April 2, 1993
(Afternoon 2-4:00 PM)

POSTER SESSION
(First and Second Floors, Scott Hall)

continued next page

CONTINUATION - FRIDAY AFTERNOON

KEY NOTE SPEAKERS: Climate Modeling of Polar Glaciations

4:00 - 4:30 PM	R. Oglesby - *"Modeling Polar Glaciation"*	61
4:30 - 5:00 PM	Bromwich, D.H. and R.-Y. Tzeng - *"Global Climate Modeling for the Polar Regions: Capabilities and Limitations"*	17
5:00 - 5:30 PM	CONCLUDING DISCUSSION	
5:30 PM	PALEOCLIMATE OF ARCTIC LAKE AND ESTUARY MEETING	

23rd ANNUAL ARCTIC WORKSHOP PROGRAM
Saturday, April 3, 1993
(Morning)

Session 4: Marine Basin Records of Glaciation
Chair: Martyn Stoker

		Page
8:30 - 8:50 AM	Burckle, L.H., M.-A. Melieres and J.-R. Petit *"Correlation Between Northern and Southern Hemisphere for the Latest Quaternary"*..	22
8:50 - 9:10 AM	MacLean, B., G. Vilks and B. Deonarine *"The History of Depositional Environments for Late Quaternary Sediments in Hudson Strait and Ungava Bay"*	54
9:10 - 9:30 AM	Gilbert, R. *"The Glacimarine Sedimentary Environment of a High Arctic Fiord"*..	37
9:30 - 9:50 AM	Stravers, J.A. and R.D. Powell *"Glacial Debris Flow Deposits on the Baffin Island Shelf: Seismic Facies Architecture of Till-Tongue Like Deposits"*	75
9:50 - 10:10 AM	Syvitski, J.P.M. *"Seismo-Stratigraphic Facies of Submarine Moraines and Other Ice Terminus Deposits"*	78
10:10 - 10:40 AM	BREAK	
10:40 - 11:10 AM	Aarseth, I. *"Seismic Stratigraphy of Younger Dryas Ice-Marginal Deposits in West Norwegian Fjords"*	7
11:10 - 11:40 AM	Cai, J., R.D. Powell and P. Carlson *"Temperate Glacimarine Depositional Sequences Interpreted from Seismic Facies Analysis and Models of Modern Depositional Systems"*..	23
11:40 - 12:00 PM	Dowdeswell, J.A., R.J. Whittington and P. Marienfeld *"On the Formation of Diamictons and Laminated Sediments in East Greenland Glacimarine Environments"*	29
12:00 - 1:20 PM	LUNCH	

23rd ANNUAL ARCTIC WORKSHOP PROGRAM
Saturday, April 3, 1993
(Afternoon)

Session 5: Marine Basin Records and Fauna
Chair: Reed Scherer

		Page
1:20 - 1:40 PM	Stoker, M.S. *"Problems Associated with Seismic Facies Analysis of Quaternary Sediments on the Northern UK Continental Margin"*....................	73
1:40 - 2:00 PM	Gipp, M.R. *"A Numerical Model for Proglacial Sedimentation and Its Implications for Acoustic Facies Characterization"*......................	39
2:00 - 2:20 PM	Bauch, H.A. *"Significance of Size Variations in High Latitude Planktic Foraminifera for Paleoclimatic Interpretations"*..........................	11
2:20 - 2:40 PM	Brouwers, E.M. and R.M. Forester *"Continental and Shallow-Marine Ostracode Assemblages from Modern Bottom Sediments of Vitus Lake, Bering Glacier, Southeast Alaska"*..	19
2:40 - 3:00 PM	Steinsund, P.I., L. Polyak and M. Hald *"Recent Distribution of Calcareous Benthic Foraminifera in the Barents and Kara Sea"*...	72
3:00 - 3:20 PM	Lapointe, M. *"Late Quaternary Diatom Assemblages from the Gulf of St. Lawrence, Canada: Preliminary Results"*.....................................	50
3:20 - 3:40 PM	Cronin, T.M., T.R. Holtz, Jr. and R.C. Whatley *"Quaternary Paleoceanography of the Deep Arctic Ocean Based on Quantitative Analysis of Arctic'91 Ostracoda"*.........................	26
3:40 - 4:00 PM	Krissek, L.A., D.K. Rea, I. Basov and Leg 145 Shipboard Scientific Party *"Plio-Pleistocene Paleoclimatic and Paleoceanographic Evolution of the North Pacific: Preliminary Results of ODP Leg 145"*..........	49
4:00 - 4:20 PM	Scherer, R.P. *"Diatoms Beneath the West Antarctic Ice Sheet and the Global Proxy Perspective"*...	69
4:20 - 4:30 PM	**Concluding Remarks**	
7:00 P.M.	**Arctic Workshop Party at Steve Forman's House, 1970 Inchcliff, Upper Arlington Phone: 488-2740**	

For List of Attendees - see back of this volume

Inge Aarseth
Department of Geology
University of Bergen, Allégt. 41, N-5007 Bergen, Norway.

SEISMIC STRATIGRAPHY OF YOUNGER DRYAS ICE-MARGINAL DEPOSITS IN WESTERN NORWEGIAN FJORDS.

The submarine parts of Younger Dryas stadial (ca. 10 - 11 K BP) ice marginal moraines and their distal sediments have been studied in the fjords in Western Norway between 59° and 62°N. Echosounder, Sparker and Uniboom high resolution seismic profiles are used to illustrate the thickness, morphology, and seismic stratigraphy of these deposits. For some of the fjords the volume of the sediments have been calculated.

Above the marine limit the moraines of this region are discontinuous or are of limited size, but their submarine parts are incredibly large. Moraines of 100-300 m thickness are found in some of the fjords and the distal sediments may exceed 300 m.

After a mild period with extensive deglaciation in Allerød interstadial (11,800 - 11,000 B.P.) the glaciers in Western Norway advanced 30 - 50 km in some areas during the first half of the Younger Dryas stadial. In the fjords the glaciers normally stopped at bedrock sills and deposited "climbing" foreset layers with increasing slope over bottomset layers of increasing thicknesses. Maximum dip of the layers is usually 15-18°.

Evidence of several ice push events over the top of the moraines are found in some of the fjords. These oscillations may be the result of limited calving at the glacier tongue, arising from reduction in water depth asociated with the deposition of the moraines. Hower, in some fjords glacier oscillations of several kilometers are found and must be due to increased ice flow.

Between the islands on "The Norwegian Strandflat" the seismic stratigraphy of the moraines show a more complex stratigraphy with a gradual transition from a proximal sequence of high reflectivity to a distal zone of acoustic lamination. Here ice push may have resulted in the deposition of a belt of boulders on the surface of both the islands and the straits in between. Where high resolution seismic data are available traces of glaciotectonic disturbance can be seen.

Proximal to the moraines most of the the fjords have very little sediments due to a rapid deglaciation after 10,300 B.P. Some of the moraines show traces of postdepositional mass movements down the delta front.

In the context of Lateglacial climate change an understanding of the mechanism of deglaciation is important, and in the fjords of Western Norway the seismic stratigraphy of ice marginal deposits provide an unparalleled insight into these processes.

Reconstruction of Antarctic Ice Sheet During the Last Glacial Maximum Using Marine Geological Evidence

John B. Anderson
Department of Geology and Geophysics
Rice University
Houston, Texas, 77251

Piston cores and high resolution seismic reflection profiles from several portions of the Antarctic continental shelf are being used to reconstruct the extent of the ice sheet during the last glacial maximum. Former grounding line positions are interpreted from geomorphic features on the sea floor, such as morainal banks, glacial troughs and till deltas, and by mapping the distribution of subglacial seismic facies. Several sedimentological criteria distinguish basal tills from glacial marine sediments in piston cores. Results from petrographic analyses of tills were used to reconstruct ice sheet paleodrainage patterns. The combined data are summarized in a map that shows the maximum grounding line position, paleodrainage patterns, and existing radiocarbon age control.

Our results indicate that the East and West Antarctic ice sheets extended to the outer shelf during the last glacial maximum. The reconstructions and paleodrainage patterns are consistent with glacialogical models predicting an extreme advance of the ice sheets. Only in the northern Antarctic Peninsula region was the ice sheet confined to the inner continental shelf.

A key question is whether the ice sheet advances and retreats in response to climate change or eustatic rise and fall of sea-level. Unfortunately, radiocarbon dates are sparse, so the timing of ice sheet retreat from various portions of the shelf continues to be problematic. Sedimentological data indicate rapid ice sheet retreat from the shelf in all areas surveyed to date.

MELTWATER EVENTS IN THE NW LABRADOR SEA AND THEIR ASSOCIATION WITH NORTH ATLANTIC HEINRICH EVENTS

J.T Andrews[1], H. Erlenkeuser[2], K. Tedesco[1], A.E. Aksu[3] and A.J.T. Jull[4]

[1]*INSTARR and Department of Geological Sciences, Box 450, University of Colorado, Boulder, CO 80309*
[2]*C14 Laboratory, University of Kiel, Kiel, Germany*
[3]*Department of Earth Science, Memorial University, St. Johns, Newfoundland, Canada*
[4]*NSF AMS Facility, University of Arizona, Tucson, AZ*

Stable isotopic measurements have been carried out on tests of near-surface planktonic foraminifera on a series of cores from the slope and floor of the NW Labrador Sea within 50 to 120 km from the margin of the former Laurentide Ice Sheet (LIS). Core chronologies have been developed by AMS ^{14}C dates on mg samples of foraminifera. Our "type" core is HU75-009-IV-55 from 2.5-km water depth; in this core we can directly compare the association between changes in $\delta^{18}O$ and the variations in detrital carbonate. ^{14}C dates confirm that two uppermost detrital carbonate layers are coeval with Heinrich events 1 and 2 from the North Atlantic (Bond et al., 1992; Andrews and Tedesco, 1992) dated at ca. 14 and 20 ka. In HU75-009-IV-55 these two events are associated with lower stable oxygen isotopic values; however, in the case of H-2 this stands as an isolated event with higher (heavier) ratios on either side, whereas the post H-1 ocean was always significantly lower (lighter) isotopically. H-1 occurs during Termination Ia. Aksu and Mudie (1985) published detailed near-surface oxygen isotope stratigraphies for two cores in ca. 800-m water depth from a broad bench off SE Baffin Island (Imperial cores I-77-5-1 and I-77-1-2) and NE of HU75-009-IV-55. Both cores showed major fluctuations in the oxygen isotopic ratios but it was unclear whether they represented glacial/interglacial oscillations or meltwater events. Our recent AMS dating of these two cores indicates that the major oxygen isotopic excursions represent late Quaternary meltwater events. Correlations between these two cores and our "type" core are being developed on the basis of ^{14}C dating, and a variety of statistical "fitting procedures (e.g., sequence slotting and core segmentation). The data indicate significant outputs of fresh water (by meltwater and/or iceberg melt) from the Laurentide Ice Sheet at ca. 14, 20 and at times prior to 20 ka (30 ka?).

References

Aksu and Mudie, 1985. *Marine Micropaleontology*, 9: 537-557.

Andrews and Tedesco, 1992. *Geology*, 20: 1087-1090.

Bond and others, 1992. *Nature*, 360: 245-249.

Late Miocene to Plio-Pleistocene Glacial Expansions and Contractions along the Antarctic Peninsula Outer Shelf

by Philip Bart and Dr. John B. Anderson,
Rice University
P.O. Box 1892
Houston, Texas 77251

The interiors of Antarctica have probably remained polar through most of the Neogene, but the Antarctic Peninsula, the northern most extension of Antarctica, may have been particularly sensitive to climatic change. Seismic stratigraphic analyses of the western Antarctic Peninsula shelf indicates a history of several expansions and contractions of the ice sheet on the outer shelf: at least 17 times in the past.

Glacial unconformities are slightly foredeepened and have a concave-up shape on the middle and inner shelf. The oldest glacial unconformity separates finely laminated, seaward dipping, fairly continuous seismic strata from coarsely spaced, horizont seismic strata with many cross cutting relationships. No drill sites exist on the shelf, so the timing and frequency of the glacial events can't be directly constrained. However, seismic correlation of Miocene strata from DSDP drill site 325 on the Bellingshausen Sea continental rise to the adjacent continental shelf, and a 6 Ma tectonic unconformity separating the underlying active margin strata from the overlying passive margin strata roughly constrain the age of the glacial units. These correlations indicate that the period of outer-shelf glaciation initiated in the late Miocene.

SIGNIFICANCE OF SIZE VARIATIONS IN HIGH LATITUDE PLANKTIC FORAMINIFERA FOR PALEOCLIMATIC INTERPRETATIONS

Henning A. Bauch, GEOMAR, Research Center for Marine Geosciences, Wischhofstraße 1-3, 2300 Kiel, Germany.

For studying paleoclimatic changes from deep-sea sediments various approaches have been applied in the past to achieve this goal . One major contribution is based on planktic foraminifera These proved to be of essential importance because they can often be used as tracers of the ocean-climate history due to their good mode of preservation in sediments above the CCD. Among relative simple measures are e.g. coiling ratios and variations in species assemblages, which may be transferred into paleotemperatures. Others means such as $\delta^{18}O/^{13}C$-values of their calcitic tests are widely used, because the isotopic composition of the foraminiferal shells is directly tied to temperature and salinity of the ambient water masses they originally lived in as well as to the global ice volume.
The polar regions and here in particular the ice covered area of the Arctic Ocean is very apt to react to temperature changes in terms of lateral and vertical extent of the ice. This in turn has a rebound effect on atmospheric gas and energy exchange (e.g., albedo). The variability of the low salinity surface water in the Arctic Ocean -controlled by the input of freshwater from Siberian rivers- is of major significance at least for the European climate. In conjunction with the warmer and more saline Atlantic Water, surface water from the Arctic Ocean governs the the formation of North Atlantic Deep Water (NADW) within the Norwegian-Greenland Sea (NGS). Both, NADW and Antarctic Bottom Water (ABW) characterize circulation and gas exchange (O/C) in the deeper world ocean. Intensive work during the past decades led to the conclusion that the renewal of the deep water in the Norwegian-Greenland Sea strongly correlates with past global climatic changes.
Planktic foraminifera may be used to trace and better understand these global changes. Since the polar region are merely charakterized by a monospecific assemblage (*Neogloboquadrina pachyderma*) other measures than species diversity are obviously needed. One way is to deal with eco-phenotypic variants principally based on different test morphology or structure. But such methods too often depend upon subjectivity. Another method that has been employed to some extent by previous workers in the southern hemisphere is to link test size with glacial/interglacial cycles.
Latest investigations in the NGS reveal that detailed biometric analyses on *Globigerina. quinqueloba* from last glacial and modern sediments give evidence of a systematic 'size-dependence' to climatic changes. Smaller tests appear during cooler time intervals -in the Fram Strait and southeastern NGS already during Stage 2- whereas larger shells dominate during the phase of climatic optimum. Furthermore, estimates on different size-fractions show that this relation may also be applicable to older oxygen isotopic stages. Accordingly, a stable interglacial circulation system such as in the last interglacial (Eem) and the Holocene did not prevail during Stages 7, 9, 11, and 13. Moreover, two size-fractions have preliminarily been used to distinguish between two principal phenotypes of the polar species *Neogloboquadrina pachyderma* sinistral: During interglacial maxima (Substage 5.51 and Holocene) *N. pachyderma* (125-250µm) exhibits a preferred habitat in relatively cold Polar Front water masses -similar results are also known from water column samples of the Fram Strait. Thus, very high concentrations of this type observed during Stages 7, 9, and 11 in the eastern part of the investigated area, are likely due to similar oceanographic circumstances. In contrast, *N. pachyderma* (250-500µm) shows high interglacial abundances in areas with varying hydrographic conditons (e.g. ice-drift, meltwater, strong seasonal variability). Hence, these conditions may also be postulated for the time during Substage 6.5, end of 6.2, 5.4-5.1 as well as for the eastern part of the Norwegian-Greenland Sea during Stage 2.
Furture investigations for which plans are on their way will further focus on the feasibility to use test size variability for Arctic and Antarctic paleoclimatic history.

Corridor Aerogeophysics in West Antarctica

Donald D. Blankenship, Robin E. Bell, Steven M. Hodge, John C. Behrendt, Carol Finn and John L. Brozena

Understanding the lithospheric framework across the West Antarctic rift system is critical for determining the geological controls on the dynamics of the West Antarctic ice sheet, the last "marine" ice sheet, and for deciphering the evolution of the Pacific margin of Gondwana. To establish this framework we have begun an experiment entitled "Corridor Aerogeophysics of the Southeastern Ross Transect Zone (CASERTZ)". This experiment includes airborne radar and surface altimetry as well as airborne gravity and aeromagnetic measurements within a carefully chosen corridor across the West Antarctic rift system. This corridor covers the western portion of the Byrd Subglacial Basin and the easternmost portion of the Interior Ross Embayment and encompasses:

(1) the initiation point and catchment regions of several of the largest West Antarctic ice streams and the ice divide over the western Byrd Subglacial Basin which contains ice believed to hold the best record of the Southern Hemisphere paleoclimate; and

(2) the boundary between the apparent narrow and broad extension modes of the West Antarctic rift system, the north and the south flanks of this rift system as well as representative samples of Byrd Subglacial Basin and Interior Ross Embayment lithospheres.

Our experimental objectives are to characterize the distribution of sedimentary basins, volcanic rocks and important ice dynamical boundaries within the corridor.

The CASERTZ ice-penetrating radar and laser altimeter are used to establish the thickness and surface elevation of the West Antarctic ice sheet while the airborne gravity and aeromagnetics systems yield the physical properties of the underlying lithosphere. These data are collected simultaneously from a twin-engine survey aircraft we have specially modified for this aerogeophysical program. Positioning for our experiments is supplied by geodetic-quality satellite and radio navigation systems. Before CASERTZ, these geophysical and navigation systems had not been coupled successfully on a single airborne platform.

The CASERTZ ice-penetrating radar is a pulsed 60 MHz unit with 10 kW of peak power that will penetrate up to 3500 meters of the relatively "warm" ice of West Antarctica. The radar signals are digitized and stacked over 2000 sweeps which corresponds to a track-line distance of about 20 meters. This radar/digitizer combination has proven reliable and provides high quality data. The laser rangefinding system consists of a diode pumped YAG laser with 1.7 kW peak power and a single-pulse accuracy of approximately 0.1 meter. The laser returns are averaged over a track-line distance of 8 meters. The ranging capacity of this system has proven to be remarkable with 100 percent detection of returns at up to twice the designed operating limit of 1500 meters above the surface. When corrected for aircraft attitude and combined with carrier-phase satellite positioning, these laser ranges yield surface elevations that are repeatable to within 0.25 meter. CASERTZ airborne gravity is obtained with a precision of a few milligals using a marine gravity meter with its accelerometer mounted to a gyro-stabilized platform at the aircraft's center of gravity. The damping of this platform has been specially modified for airborne work. Vertical accelerations of the aircraft are calculated using displacements measured to about 0.1 m using both high-precision pressure altimetry and carrier-phase satellite positioning. Test flights over the routes of ground-based gravity traverses in West Antarctica have demonstrated that the gravity observations made with this system are valid. The aeromagnetic system consists of a proton-precession magnetometer capable of better than 1 nT precision with its sensor towed 30 m below the aircraft. In the field, there are few problems with data quality and the tow system has proven to be aerodynamically stable. Horizontal positioning of the CASERTZ survey aircraft is supplied to a 6 m precision by a UHF radio transponder system operating in parallel with pseudo-range and carrier-phase satellite positioning using the P-code. A laser-gyro inertial navigation system is used to measure aircraft attitude as well as to provide backup horizontal positioning.

At present, CASERTZ has completed three Antarctic field seasons. In the first season (1990-91), the focus was on the technical problem of adapting each geophysical and navigation system to our survey aircraft, since this had not before been attempted. By the end of the season we had "proven the principle" by flying several thousand kilometers of profiles with each geophysical system over well-known features in central West Antarctica. Our results compared well with those previously published. In the second and third seasons (1991-92 and 1992-93), we began a systematic survey of the boundary of the interior Ross embayment, the Byrd subglacial basin and the Ellsworth-Whitmore crustal block near the origins of ice streams B, C and D. We accomplished 50000 km of simultaneous ice-penetrating radar, laser altimetry, gravity and magnetics within a 120000 km^2 region due west of the Whitmore mountains. Within this region, we achieved complete coverage with a 5.3-km grid spacing. This work was accomplished in ninety-three 4-hour flights. A significant early result is the discovery of active subglacial volcanism near the critical region where ice streaming begins.

Near-Synchronous Century And Millennial Time Scale Events In Northern And Southern Hemispheres Between 14,000 And 19,000 Years Ago.

Gerard C. Bond, Lamont-Doherty Earth Observatory, Palisades, N.Y. 10964
George Denton, Inst. for Quaternary Studies, University of Maine, Orono, ME 04469-2190;Wallace Broecker, Lamont-Doherty Geological Observatory, Palisades, N.Y.

Climate records spanning the Last Glacial Maximum from both the Northern and Southern Hemispheres suggest a close correlation of sudden climate changes, probably occurring on time scales of thousands to hundreds of years. The best documented of these so far fall between about 14,000 and 19,000 years ago. In the Northern Hemisphere high resolution foram, diatom and color records from deep sea cores reveal a prominent bimodal structure, which we refer to as a "W", in sea surface temperature and in relative concentrations of ice rafted debris. The down pointing peaks of this structure are short-lived cold events dated by AMS C14 measurements at 14,3000 years and 19,400 years. The intervening up pointing peak is a warm event with an AMS C14 age of 17,000 years. The younger of the cold events corresponds to Heinrich event 1, the last in a series of six prominent discharges of Laurentide icebergs into the North Atlantic during the last glaciation. A similar bimodal structure occurs in the d O18 records from the Summit ice core in Greenland. Based on recent dating of the ice cores and conversion of calendar ages to C14 ages, the ages of the up and down pointing peaks are identical, within error, to those in the marine records. C14 ages of moraines in North America also suggest a bimodal pattern with two prominent advances that correlate closely with the cold events in the ice core and marine data.

In the Southern Hemisphere, the "W" pattern is less well defined so far in marine records, which contain evidence of only the cold event at about 14,000 years and a warm period at about 17,000 years. Ice core dust and dO18 records from Antarctica suggest that the pattern may be there but it is poorly resolved. On the other hand, C14 dating of moraine records from the Southern Hemisphere, especially from Chile and New Zealand, appear to reveal both cooling events, with ages corresponding closely, probably within hundreds of years, to those in the Northern Hemisphere.

AMINOSTRATIGRAPHY OF MIDDLE AND LATE PLEISTOCENE MARINE AND GLACIAL DEPOSITS ALONG THE COAST OF CHUKOTKA PENINSULA, RUSSIA: INITIAL INTERPRETATIONS AND COMPARISONS WITH ALASKA

BRIGHAM-GRETTE, Julie, **BENSON**, Sonja, Department of Geology/Geography, University of Massachusetts, Amherst MA 01003; **HOPKINS**, David M., **HEISER**, Patricia, Alaska Quaternary Center, University of Alaska, Fairbanks, AK 99775; **IVANOV**, Victor, F., NorthEast Interdisciplinary Scientific Research Institute, Russian Academy of Sciences, Portovaya 16, Magadan 685010, Russia; **BASILYAN**, Alexander E., Geological Institute, Russian Academy of Sciences, Moscow, Russia.

In 1991 and 1992, our research group re-examined stratigraphy and collected large suites of mollusk and microfossil samples in key sequences thought to represent middle and late Pleistocene glacial and interglacial episodes on Chukotka Peninsula. Our primary objective has been to correlate these deposits with the middle and late Quaternary sequence of coastal western Alaska using biostratigraphy and amino-acid geochronology (D-alloisoleucine/L-isoleucine, hereafter aIle/Ile). By this means we hope to establish a new stratigraphic framework for the late Cenozoic history of the Bering Strait region.

In 1991, we studied the Upper and Lower Pinakul' and the Yanrakinot suites at Cape Pinakul' near Bering Strait. In 1992 we examined bluffs between the village of Enmelen and the mouth of the Nunyamo River on the Gulf of Anadyr coast, 150 to 175 km west of Providenyia.

The Lower Pinakul'Suite (exposed thickness of about 37m) is an upward coarsening and shallowing sequence of well-bedded, fossiliferous muds and sands . The lowest exposed beds are rich in concretions and glendonite-pseudomorphs after ikkaite. The upper part of the unit is laced with burrows and other trace fossils and may have accumulated intertidally. Foraminiferal and molluscan assemblages in the lower Pinakul' suggest that Lavrentiya Bay waters were somewhat warmer than today but pollen assemblage suggest terrestrial conditions similar to today (Petrov, 1963; Ivanov, 1986),.

A 3-m thick layer of well-bedded, clast-supported, sandy gravel forms the base of the Upper Pinakul'. Above the gravel the Upper Pinakul'is at least 15m thick but probably much thicker and consists of poorly bedded to massive mud with dispersed shells and dropstones. The basal few meters are stony and of undoubted glaciomarine origin. Foraminifera assemblages are similar to those found in the Lower Pinakul'. Both the upper and lower Pinakul are highly folded and faulted by glaciotectonism.

Past assumptions about the age of the Pinakul' suite were based upon the unusual warm-water, south boreal mollusk fauna and on paleomagentic studies thought to indicate that except for the lowermost exposed beds, the Pinakul'suite is magnetically reversed. Ivanov (1986) interprets the basal normal section as correlative with either the Olduvai or the Jaramillo normal event within the Matuyama reversed epoch.

The northern part of the Cape Pinakul' bluffs is comprised of the Yanrakinot Beds. These are predominately glaciomarine in character, consisting of laminated to massive diamicts with dropstones up to 20 cm in diameter. Foraminifera faunas indicate water temperatures similar to the present. At one locality, a portion of the Yanrakinot is glaciotectonically overturned. The entire section is overlain by diamicton of uncertain origin, either glacial till or frost-moved colluvium. Ivanov (1986) considers the Yanrakinot beds younger than the Pinakul' Suite but in 1991, we found the field stratigraphic relationships impossible to establish due to the lack of exposures in the area of the supposed contact.

In 1992, we first studied exposures in bluffs 3.5 km long and 50-60 km high that face the Gulf of Anadyr southeast of the mouth of the Nunyamo River. There, two marine sequences separated by thick, crudely to well-stratified glaciofluvial sediments are considered by Ivanov (1986) to be of middle Pleistocene age. The outwash is assigned to the Olayon Suite. The overlying marine unit includes basal glaciomarine deposits overlain with a sharp contact by normal marine sediment which Ivanov assigns to the Mechigmen Suite. The uppermost gravel underlies two ridges oriented normal to the present coast: an alternate view is that the gravel comprises a former spit and a former outwash delta. The high bluff sequence is onlapped up to an altitude of 12 m from the northwest by marine sediments believed by Ivanov to represent the Val'katlen Interglacial (isotope Stage 5e); these beds are overlain in turn by glacial till assumed to represent the Vankarem glaciation (early Wisconsinan) which also laps onto the northwestern ridge up to altitudes of 20 m.

We then studied the type section of the Val'katlen Suite exposed in bluffs 10-15 m high that extended several kilometers northwest of the mouth of the Enmelen River. Here, fossiliferous sand and gravel is underlain by glacial and glaciomarine sediments of middle (?) Pleistocene age, and overlain by glacial deposits assigned to the Vankarem glaciation of presumed early Wisconsinan age.

Amino acid analyses of shell material from most of the units discussed above suggest an alternative interpretation to published stratigraphic schemes, but it is important to note that we have not yet analyzed material from all of the type sections for some of Ivanov's units. Table 1 provides a summary of representative material run up until Jan. 1993.

UMASS LAB #	STRATIGRAPHIC NAME	GENUS	Alle/Ile FREE	Alle/Ile TOTAL
	Gulf of Anadyr - Nunyamo/Enmelen river sections			
AGL-2098	Val'katlen beds (type)	*Mya arenaria*	ND to 0.102	0.024± 0.004 (3)
AGL-2096	Val'katlen beds (type)	*Hiatella arctica*	ND	0.019± 0.003 (1)
AGL-2094/95	Val'katlen beds (type)	*Macoma*	ND	0.040± 0.008 (2)
AGL-2097	Mechigmen beds	*Astarte borealis*	ND-0.322	0.027± 0.004 (3)
AGL-2099	Mechigmen beds	*Mya sp.*	ND - 0.286	0.017± 0.003 (4)
	Pinakul Sections, Lavrenty Bay			
AGL-2088	Upper Pinakul	*Astarte*	ND	0.028± 0.003 (2)
AGL-2089	Upper Pinakul	*Mya*	ND - 0.10	0.023± 0.006 (3)
Many AGLs	Lower Pinakul	*Astarte sp.*		0.029± 0.004 (9)
AGL- 2091	Lower Pinakul	*Macoma sp.*		0.046± 0.011 (2)
AGL-1806\1809	Yanrakinot	*Astarte*	0.228± 0.042	0.089± 0.012 (6)
AGL 1972	Yanrakinot	*Astarte*	0.380± 0.05	0.053± 0.014 (3)
AGL-1921	Yanrakinot (paired valves)	*Macoma*	0.299±0.038	0.082± 0.006 (2)

ND = not detectable; number in parentheses = number of valves analyzed.

For comparison, *Hiatella* and *Mya* from the last interglacial Pelukian beds at Nome yield ratios of 0.045 ± 0.01, while the older Anvilian beds (Stage 11) yield ratios of 0.115±0.02 (Kaufman, 1992).

Our interpretation of these data now lead us to suggest the following:

1) The Pinakul' Suite dates from parts of isotope stage 5 and the paleomagnetic data needs to be re-evaluated.

2) The Pinakul' Suite is younger, not older than beds assigned to the Yanrakinot Suite at Cape Pinakul'. Analyses from the type Yanrakinot are needed to confirm any regional pattern.

3) The Val'katlen at the type section and the Mechigmen Suite in the Nunyamo River section are probably the same age and both date from parts of isotope stage 5. This implies that the overlying glaciogenic deposits in the Nunyamo section are Vankarem (early Wisconsinan) in age, not correlative with the Kresta.

Additional analyses and tests for contamination and indigeneity are ongoing.

GLOBAL CLIMATE MODELING FOR THE POLAR REGIONS: CAPABILITIES AND LIMITATIONS

David H. Bromwich and Ren-Yow Tzeng
Byrd Polar Research Center
The Ohio State University
Columbus, Ohio 43210

The polar regions are the major energy sinks in the global atmospheric circulation. Also, many global climate model simulations project a large climatic response over these regions as a result of increased greenhouse gas concentrations. However, comparatively little effort has been devoted to evaluating the model simulations of the present climate in these two regions, which is surprising because the simulated climate is usually worse than that in the mid- and low-latitudes. Here, we primarily consider the National Center for Atmospheric Research's (NCAR) Community Climate Model Version 1 (CCM1) at R15 horizontal resolution, which is a widely used global climate model. Its capabilities and limitations in simulating polar climate are examined with a view to applying its output to climate-change problems.

The model results were compared to observations (e.g., the station data and the ECMWF global analyses) in terms of meteorological quantities (e.g., sea-level pressure and storm activity) and moisture and total energy budget analyses. The similarity and differences of biases in the simulated climate over the polar regions are summarized. For instance, in both polar regions the simulated annual precipitation is about 6 times larger than observed. In addition, the circumpolar trough around Antarctica and the storm track over the North Atlantic Ocean are poorly simulated by the model; the cyclones in these areas are primarily responsible for transporting moisture and energy to high latitudes. By contrast, the NCAR CCM2-T42 simulations are used as a sensitivity experiment to identify the causes of these biases and their differences between the polar regions. Also, these simulations illustrate the current capabilities of the CCM.

Although the dynamical processes are different, the biases in the CCM1's simulation of Arctic and Antarctic climate are found to be due to two general factors: the positive moisture fixer scheme and the topographic representation at R15 resolution. The differences are essentially caused by the geographic characteristics of these two areas. Understanding of these polar biases is particularly important for interpretation/use of climate model output for climate-change applications. For example, the predicted increase of the precipitation rate is about 10 % of the present value in the doubled CO_2 simulations but the model's biases from the present climate are more than 500 %.

RADIOCARBON ACCELERATOR MASS SPECTROMETRY DATING OF POLLEN FROM LAKE SEDIMENTS AND PEAT DEPOSITS

T.A. Brown, G.W. Farwell and P.M. Grootes
Quaternary Research Center, University of Washington, Seattle, WA

Our research project under the PALE initiative is centered on the refinement, validation and utilization of our techniques for the extraction and accelerator mass spectrometry (AMS) radiocarbon dating of pollen concentrate fractions from lake sediment and peat samples. The separation and dating of these pollen fractions from the bulk samples should significantly improve the accuracy and reliability of radiocarbon dates obtained from the lake sediments that will be the primary source of paleoclimatic data under the PALE initiative. The method we have developed is similar to procedures used in palynology studies and should be routinely applicable by palynologists in preparing their samples for submission for radiocarbon dating. The pollen concentration procedure is able to remove most (if not all) non-pollen contaminants from the samples to be submitted for dating. In the studies undertaken to date, sufficient pollen concentrate for AMS dating has been obtained from 1 cm-long samples from 5-cm diameter organic-rich lake sediment cores. Initial results obtained on a sediment core from Kachess Bog in Washington State are within the wide range of previous dates obtained on materials associated with the Mazama ash layer. In more recent measurements (that are currently being analyzed and will be presented at the workshop), we have used our radiocarbon AMS system at the Nuclear Physics Laboratory of the University of Washington to date pollen concentrate samples containing less than one milligram of carbon to an accuracy of ± 50-70 years. In the next stage of our project we will apply our method to Alaskan lake sediment cores for which inconsistent radiocarbon dates obtained by the traditional methods of β-counting radiocarbon dating have introduced significant uncertainty into the interpretation of the pollen record.

CONTINENTAL AND SHALLOW-MARINE OSTRACODE ASSEMBLAGES FROM MODERN BOTTOM SEDIMENTS OF VITUS LAKE, BERING GLACIER, SOUTHEAST ALASKA

Elisabeth M. Brouwers and Richard M. Forester
U.S. Geological Survey, Boulder, CO

Bering Glacier is the second largest glacier in North America, extending about 200 km in length from its source in the Bagley Ice Field of the Chugach-St. Elias Mountains to its terminus near the Gulf of Alaska. Bering Glacier is retreating rapidly at present, a process significantly accelerated because the southern ice margin terminates in the large proglacial Vitus Lake. Vitus Lake is 25 km long, 10 km wide, and up to 150 m deep and is drained by the Seal River, a low gradient, high discharge, tidally-influenced, southwest-flowing stream that flows about 6 km to the Gulf of Alaska (Molnia and others, 1990). The surface of Citus Lake is approximately 2 m above sea level, and tidal action affects the entire length of the Seal River. Bering Glacier has retreated sufficiently so that nearly full tidal exchange exists between the lake and the ocean; in the last decade the lake has evolved from a freshwater to a marine system.

The purpose of this study was to collect a series of bottom samples to monitor the response of the lake biota to the shift in salinity from the 1980's to 1992 and to observe the degree of exchange of organisms between the Gulf of Alaska and Vitus Lake. Twenty-nine bottom samples were taken during July, 1992 for paleontological analysis. Samples generally consisted of medium gray glacial mud, commonly with sand and gravel suspended in the mud matrix. Sample processing was qualitative because sample volume depended upon the success of the grab sampler. Initial volumes ranged from a few tens of grams to several kilograms wet weight.

Seven of the 29 samples contain ostracodes. Nine species of marine ostracodes were recovered from six of the samples. Marine ostracode-bearing samples were all collected around the periphery of a small landmass called Beringia Island just north of the beginning of the Seal River in Vitus Lake. The marine species recovered are common elements of the continental shelf in the Gulf of Alaska; the taxa are most abundant in a depth range of 20-30 m to 60-80 m. The inferred depth range of 20-80 m corresponds to inner sublittoral and shallow middle sublittoral ostracode Assemblages I and II of the Gulf of Alaska (Brouwers, 1988), which have annual ranges in temperature of 2-15°C and salinity of 30-32.5 ‰. The rarity and low species diversity of the marine ostracodes could imply that they are in the initial stage of colonization.

Two species of continental ostracodes, *Candona caudata* and *Limnocythere ceriotuberosa*, were recovered from three of the 29 samples. Two samples were collected from the northern part of Beringia Island just inside of proglacial Vitus Lake and one sample was collected from a shallow lagoon at the mouth of the Seal River. Salinity, expressed as total dissolved solids, major dissolved ion composition, water temperature, general hydrological setting, and the annual variation of physical and chemical water properties determine the biogeography and local occurrences of continental ostracodes (Forester, 1987, 1991). Continental ostracodes recovered from Vitus Lake are remarkable because they have no relationship of any known kind with either proglacial lakes or with marginal to fully marine environments. *Limnocythere ceriotuberosa* is a euryhaline ostracode that commonly occurs in inland saline to seasonally saline lakes that have a major dissolved ion composition enriched in carbonate (Forester, 1986). *Candona caudata* lives in freshwater to slightly saline lake and streams having a major ion chemistry dominated by calcium bicarbonate (Forester, 1991b). Juveniles compose most of the material, suggesting a transported assemblage. The continental ostracode assemblage must be assumed to have been reworked and then transported from some, as yet unknown, sediment in the drainage basin of Vitus Lake.

References

Brouwers, E.M., 1988, Paleobathymetry on the continental shelf based on examples using ostracodes from the bulk of Alaska, in P. DeDeckker, J.-P. Colin and J.P. Peypouquet, *Ostracode in the Earth Sciences*, p. 55-76, Elsevier, Amsterdam.

Forester, R.M., 1986, Determination of the dissolved anion composition of ancient lakes from fossil ostracodes, *Geology*, 14, 796-798.

Forester, R.M., 1987, Late Quaternary paleoclimate records from lacustrine ostracodes, in W.F. Ruddiman and H.E. Wright, Jr. (Eds.), *North American and Adjacent Oceans During the Last Deglaciation: The Geology of North America*, K-3, 261-276, Geological Society of America, Washington, D.C.

Forester, R.M., 1991a, Ostracode assemblages from springs in the western United States: Implications for paleohydrology, in D.D. Williams and H.V. Danks (Eds.), *Anthropods of Springs, with Particular Reference to Canada*, Mem. Entromol. Soc., 36 pp.

Forester, R.M., 1991b, Pliocene-climate history of the western United States derived from lacustrine ostracodes, *Quat. Science Reviews*, 10, 133-146.

Molnia, B.F., D.C. Trabant, A Post and D.G. Frank-Molnia, 1990. Bering Glacier, Alaska: Factors influencing the potential for an irreversible calving retreat, *EOS*, 71(453), 1314.

VARIATIONS IN CHARCOAL CONTENT IN MODERN LAKE SEDIMENTS: IMPLICATIONS TO THE STUDY OF LATE QUATERNARY FIRE HISTORY IN NORTHCENTRAL ALASKA

L.B. Brubaker[1], C.J. Earle[1] and P.M. Anderson[2]
[1]College of Forest Resources, University of Washington, [2]Quaternary Research Center, University of Washington, Seattle, Washington 98195

The relationship between local fires and the charcoal content of lake sediments was examined in boreal forests of northcentral Alaska by comparing sediment-charcoal concentrations among lakes in watersheds experiencing different intensities of recent fires. Image analysis techniques were used to tally the number and sizes of charcoal particles for lakes within completely burned, partially burned, and unburned watersheds in the central Kuskokwim River Drainage. Particle size-class distributions were generally similar for the three burn categories, ranging from 10^4 to $10^{7.5}$ microns. Charcoal area and particle number were significantly greater for completely burned than for partially burned and unburned watersheds; no statistical differences were found between partially burned and unburned watersheds. Similar techniques applied to a fossil sediment core from Sithylemenkat Lake, which revealed substantial charcoal input over the past 14,000 years. Charcoal accumulation rates during periods of herb and shrub tundra were comparable to accumulation rates in modern boreal forests. The only interval of low charcoal input corresponds to a period of regional expansion of alder, which is interpreted from other evidence to represent a period of increased effective moisture.

Correlation Between Northern and Southern Hemisphere For the Latest Quaternary

Lloyd H. Burckle, Lamont-Doherty Geological Observatory, Palisades, N.Y. l0964
Marie-Antoinette Melieres, Laboratoire de Spectrometre Physique, Universite Joseph-Fourier Grenoble 1, BP 96, 38402, Saint Martin d'Heres, France
Jean-Robert Petit, Laboratoire de Glaciologie et Geophysique de l'Environment, BP 96, 38402, Saint Martin d'Heres, France

We used various measures ($\partial^{13}C$, melt water pulses, dust flux, % abundance of *Eucampia antarctica*) to show that the two hemispheres are in phase, at least for the LGM and the deglacial. First we note that the $\partial^{13}C$ record in deep sea sediments reflects the global influence of North Atlantic Deep Water (NADW) and that the glacial to interglacial change in the $\partial^{13}C$ record in both the Norwegian Sea and the subantarctic region occurred during Melt Water Pulse 1A (12.6-11.8 kyrsBP). We then demonstrate that this change in the $\partial^{13}C$ record is also reflected in the percent abundance record of the Southern Ocean sea ice related diatom *E. antarctica* indicating that there is a strong causal link between Melt Water Pulse 1A (i.e. sea level), NADW, $\partial^{13}C$, % *E. antarctica* and sea ice. Finally, we present evidence to suggest that the glacial to post glacial drop in dust concentration in Vostok ice core was caused by Melt Water Pulse 1A which resubmerged some 65% of the Argentine continental shelf thus cutting off a major source of dust to the East Antarctic Plateau. The close correlation between these various measures and *% E. antarctica* permits us to use % abundance of this species to identify the glacial/postglacial transition in deep sea cores to the south beyond the range of biogenic carbonate. A number of quesions remain but two will be addressed: i.e. do we see evidence for the Younger Dryas in Southern Ocean sediments and do we observe events similar to the Northern Hemisphere Heinrich events?

Temperate Glacimarine Depositional Sequences Interpreted from Seismic Facies Analysis and Models of Modern Depositional Systems

Jinkui Cai, Ross D. Powell, Department of Geology
Northern Illinois University, DeKalb, IL 60115
Paul Carlson, USGS, Menlo Park, CA 94025

The detailed examination of single-channel, seismic reflection profiles of the sediment fill within the West Arm of Glacier Bay allows the recognition of 9 seismic facies, and 11 sedimentary facies. The seismic facies are determined by the characteristics of internal reflection configuration, reflection termination with bounding surface, and external geometry. The sedimentary facies are interpreted from these seismic facies, using the historical glacier terminal positions, paleotopographic features, sedimentation rates, and knowledge of processes, facies associations, and depositional systems at present glacier termini.

The West Arm of Glacier Bay, Alaska, has been deglaciated for only about 130 years. The glacier terminus was at the fjord mouth in 1860 where it calved icebergs into lower Glacier Bay. Since 1860, the glaciers from the West Arm have retreated, with minor fluctuations, for about 55 km to the head of Tarr Inlet (Grand Pacific Glacier), and for about 60 km to the head of Johns Hopkins Inlet (Johns Hopkins Glacier).

Careful evaluation of all seismic profiles in the study area indicates that Neoglacial deposits are not always sitting directly on the bedrock. Although the last glaciation eroded most previous deposits from within the fjord, some pre-Neoglacial sediment, stratified and unstratified, remains on the bedrock floor and on side walls of the fjord. This older sediment of more than 200 m thick has been identified locally from the seismic profiles.

During the last 130 years, the glaciers have dumped large volumes of sediment into the fjord. However, the sediment is not evenly distributed. The thickest sediment, more than 250 m, occurs in the deepest area of the deep basins. On the bedrock highs, however, the sediment cover, mostly suspension settling deposits, is only several meters thick.

Longitudinal, fjord-axial seismic-reflection profiles and sediment-thickness isopachs clearly demonstrate that the West Arm of Glacier Bay was not a single fjord basin, but was divided into several major basins by buried sediment ridges and bedrock highs. Comparison of the seismic facies of these ridges with the modern grounding-line systems forming in Muir, Tarr and Johns Hopkins Inlets, leads us to believe that the ridges are probably morainal bank deposits. These bank deposits indicate that although the glaciers rapidly uncovered this part of the fjord with an average retreat rate of more than 1.8 km per year (35 km in 19 years from known positions in 1860 to 1879), the terminus did have several short periods of quasistability.

The general vertical sedimentary sequence represented in the seismic profiles can be interpreted from our current model of glacimarine deposition by retreating tidewater glaciers. In general, slump/slide deposits occur at any level, but are more common lower in the sequences. At the bottom of the sediment sequences are morainal banks, or drape sheets of suspension settling deposits. The overlying unit in most of the study area is a relatively thick sequence (the thickest is more than 100 m) of disordered sediments. Based on its seismic characteristics, we interpret this unit as being ice-proximal to ice-distal deposits that have been subsequently disarranged by penecontemporaneous processes, such as a large earthquake inducing liquefaction and/or dewatering to produce disrupted seismic reflections. This unit changes gradually upward into ice-proximal and then ice-distal glacimarine deposits, but in some areas it is overlain by ice-distal deposits. The top of the ice-distal deposits is eroded showing some reflection truncations. This erosional surface covers about 30 km^2 and is thought to have been formed in the early 1900s when turbidity currents started to issue from a tributary fjord (Queen Inlet) where its grounding-line fan reached sea level and the glacier advanced into the newly formed ice-contact delta.

Above the erosional surface (unconformity), the dominant sedimentary facies are the ice-proximal glacimarine deposits. They have within them some clearly defined lenses and thin sheets of turbidites. These turbidites are concentrated near the erosional surface for which the turbidites are thought to be responsible, and the most significant thicknesses of turbidites are found beyond the mouth of Queen Inlet.

Based on historical terminus positions and seismic sequences, sedimentation rates within the study area can be estimated. In general, average sedimentation rates where Tarr and Johns Hopkins Inlets branch from the main trunk fjord are about 3-11 m/a for ice-contact deposits (1879-1907), about 1.4-2.4 m/a for ice-proximal deposits (1879-1907), about 25 cm/a for ice-distal deposits (1879-1907), and 10-14 cm/a for ice-distal deposits since early 1900s. The average sedimentation rates of ice-distal deposits in areas farther down the main trunk fjord since early 1900s are between 7-11.3 cm/a (with no recognizable turbidite lenses or sheets) and 38.5-60 cm/a (with a significant thickness of turbidites). These estimated rates, relative to the distance from glacier termini, are higher than those measured in sediment traps near the modern glacier termini in Tarr and Muir Inlets. The difference may be caused by turbidites not being recorded in sediment traps, or by significant decreases in glacial drainage basin area with deglaciation, or by sediment contributions from tributary glaciers and remnant ice after the main trunk glaciers had retreated.

CHANGES ON THE ROSS ICE SHELF, ANTARCTICA DERIVED FROM AVHRR IMAGERY

Gino Casassa

Byrd Polar Research Center and
Department of Geological Sciences
The Ohio State University
Columbus, OH 43210

A major part of the ice of the West Antarctic ice sheet is drained into the floating Ross Ice Shelf. The Ross Ice Shelf, with an area of 520,000 km^2, is thought to restrain the flow of the West Antarctic ice sheet. The retreat of the ice shelf could lead to the collapse of the ice sheet.

Advanced Very High Resolution Radiometer (AVHRR) satellite imagery is combined here with ancillary data to study recent changes on the Ross Ice Shelf. The approach is based on the comparison of flow stripes that appear on AVHRR imagery with present flowlines. Flow stripes are identical to flowlines only in the special case of steady flow.

The similarity of flowlines and flow stripes on the western third of the Ross Ice Shelf, fed by the East Antarctic Ice Sheet, suggests that flow conditions have not changed significantly over the past 1100 years on this sector. A large looping pattern of flow stripes which disagrees with flowlines appears west of Crary Ice Rise, on the eastern part of the ice shelf. This looped pattern is interpreted as relict flow stripes related to past activity of a major ice stream of West Antarctica which occurred about 800 years ago. A significant disagreement between velocity vectors and AVHRR flow stripes occurs downstream from Steers Head, an area fed by the West Antarctic Ice Sheet. A similar disagreement has been reported between velocity data and radar reflection data in this area. The deflection of AVHRR stripes with velocity vectors downstream from Steers Head might be related to a change in ice stream flow or a change in ice thickness occurring a few hundred years ago.

This study shows the potential of combining satellite imagery with ancillary data to derive changes on Antarctic glaciers. This method can be also applied to Arctic glaciers.

QUATERNARY PALEOCEANOGRAPHY OF THE DEEP ARCTIC OCEAN BASED ON QUANTITATIVE ANALYSIS OF ARCTIC'91 OSTRACODA

Thomas M. Cronin[1], Thomas R. Holtz, Jr.[1], and Robin C. Whatley[2]
[1]*970 National Center, U.S. Geological Survey, Reston, VA 22092*
[2]*Institute of Earth Studies, University College, Aberystwyth, Wales*

Ostracodes were studied from deep Arctic Ocean cores obtained during the ARCTIC'91 expedition of the *Polarstern* to the Nansen, Amundsen and Makarov Basins, the Lomonosov Ridge, Morris Jesup Rise and Yermak Plateau, in order to investigate their distribution in Arctic Ocean deep water (AODW), their relation to North Atlantic deep-water (NADW) assemblages, and the Quaternary paleoceanographic history of bottom water masses in the Arctic. A total of 33,000 specimens were studied from the coretop and downcore samples. The coretop assemblages from ARCTIC'91 boxcores indicate the following: (1) ostracodes are common at all water depths between 1000 and 4500 m, and species distribution is strongly influenced by water mass characteristics and bathymetry; (2) quantitative analyses comparing Eurasian and Canada Basin assemblages indicate that distinct assemblages inhabit regions east and west of the Lomonosov Ridge, a barrier especially important to species living in lower AAODW (≥ 3000 m); (3) deep Eurasian Basin assemblages are more similar to those of the Greenland Sea than those of the Canada Basin; (4) two upper AODW assemblages were recognized throughout the Arctic Ocean, one living between 1000 and 1500 m, and the other, having high species diversity, at 1500-3000 m.

Downcore quantitative analyses using the squared chord distance (SCD) coefficient of dissimilarity to identify modern analog assemblages reveal that significant Quaternary bottom water changes characterize the last deglaciation and major glacial-interglacial cycles of the last 300,000 years. During the late Pleistocene-Holocene (12 ka-present), following a period of sedimentation during the last glacial maximum in which ostracodes were rare to absent, a distinct series of abundance peaks in key indicator taxa occurs, signifying at least three distinct phases of oceanographic change during deglaciation. First, a period of very highly oxygenated water (possibly during Termination 1a) at 1500-22500 m water depths occurred characterized by high percentages of the genus *Henryhowella*. This period was followed by an interval of high organic productivity recorded by assemblages dominated by at least six species of the genus *Polycope*. Finally, a time of enhanced flow between the Canada and Eurasian Basins is indicated by the high percentages of *Cytheropteron hamatum*.

The longer term record of ostracode assemblages obtained from kastenlot core PS2200-5 (1073 m water depth) from the Morris Jesup Rise indicates a quasi-cyclic pattern of water mass changes since 300 ka. Sediments deposited during interglacial periods corresponding to oxygen isotope stages 1, 5, 7 and possibly 9 contain abundant ostracodes. Quantitative faunal analyses suggest that rapid increases in productivity and dissolved oxygen characterize each glacial-interglacial transition in a way similar to that observed for Termination 1. Preliminary interpretation of the ARCTIC'91 ostracode record is that it reflects changes in the relative proportion of AODW and NADW influencing benthic faunal assemblages of the eastern Arctic Ocean during the last deglaciation. The initial influx of high percentages of *Henryhowella* at the onset of deglaciation may signify a sudden increase in NADW during the early part of Termination 1, leading to migration from North Atlantic to the Arctic. We believe that additional high-resolution study of Arctic ostracodes can help determine the evolution of deep-water stratification in the Arctic Basin during Quaternary glacial-interglacial cycles.

Is There a Proxy Record of Cloud Cover in Antarctic Ice Cores?

Jihong Dai, Ellen Mosley-Thompson and Lonnie G. Thompson
Byrd Polar Research Center, Ohio State University, Columbus, OH 43210

Measurements of sulfate in Antarctic snow, ice and ground level aerosols have consistently shown a distinct seasonal cycle in sulfate concentrations (Legrand and Delmas, 1984; Mulvaney and Peel, 1988; Mosley-Thompson et al., 1991; Wagenbach et al., 1987; Prospero et al., 1991). Sulfate concentrations in aerosol and snow reach a maximum in the austral summer (December-February) and a broad minimum duing winter. It is generally accepted that the main source of sulfate in Antarctic aerosol and snow is marine biogenic emissions of dimethyl sulfde or DMS (Andreae et al., 1985 and 1986), which is quickly oxidized to sulfate in the free atmosphere. Volcanic eruptions contribute significant amounts of sulfate only at times of active volcanism and levels of volcanic sulfate in aerosol and snow rapidly fall after major eruptions (Delmas et al., 1988). Active volcanoes in Antarctica (Mt. Erebus and Deception Island) do not contribute significantly to the sulfur budget of Antarctic atmosphere (Radke, 1982). For most of the Antarctic and the high southern latitudes, no other major sources of sulfate in aerosol and snow have been identified.

Marine aerosol sulfate has been directly linked to DMS and methanesulfonic acid or MSA, a partial and stable product of DMS oxidation to sulfate. Ayers et al. (1991) show that coherent seasonal cycles of DMS, MSA and sulfate aerosol exist in the atmosphere over the Southern Oceans, with maximum concentrations of all species in summer. In Antarctica, a positive correlation between DMS, MSA and sulfate in aerosol has been observed in several locations (Prospero et al., 1988; Legrand and Feniet-Saigne, 1991), although the relationships are not linear.

More importantly, positive correlations are found between concentrations of DMS, sulfate and the number densities of cloud condensation nuclei (CCN). Changes in CCN number densitiies are known to affect directly the albedo of clouds and therefore the radiation property of the atmosphere over the oceans (Charlson et at., 1987). Measurements of CCN at the South Pole (Bodhaine et al., 1986) demonstrate a strong seasonal cycle similar and synchronous to that of DMS or sulfate in aerosols. In the Northeastern Pacific, DMS and CCN are found to be highly correlated (Hegg et al., 1991). Similarly, strong seasonal cycles of CCN is observed in marine aerosol in the Southern Hemisphere (Ayers et al., 1991), in sympathy with DMS and aerosol sulfate.

The conspicuous correlations between seasonal variations of CCN measured at South Pole and those of aerosol DMS and sulfate suggest that sulfate in snow may be used as a proxy for CCN and possibly cloud albedo in the high southern latitudes. Sulfate (and MSA) in aerosol and snow is much easier to measure than DMS in aerosol. Indeed, the nonlinearity of the DMS-sulfate or MSA-sulfate relationships may be overcome by a direct correlation between sulfate and CCN, because sulfate aerosol, more than DMS or its other derivatives, is responsible for CCN and consequently cloud albedo.

Charlson et al. (CLAW, 1987) have hypothesized a climate feedback system based on the linkage between oceanic phytoplanktonic production, atmospheric sulfur and cloud albedo. An increase in temperature and sunlight at the ocean surface caused by a rise in Earth's net radiation receipt may promote the abundance of oceanic phytoplanktonic algae and therefore the production and emission of DMS, which will result in increased cloud cover and therefore reduce radiation receipt at the surface of the ocean, hence completing the feedback cycle. The CLAW hypothesis can be used to explain the seasonal cycles of marine aerosol DMS and sulfate in the high southern latitude: the availability of sunlight during summer stimulates the production of phytoplankton and therefore the abundance of DMS and sulfate in the atmosphere.

The CLAW hypothesis can be tested with continuous cloud measurements over the ocean areas of the Earth (Warren et al., 1988) and sulfate concentrations in Antarctic snow. Ice cores from various Antarctic sites contain atmospheric environmental records, including aerosol sulfate records of a few hundred years. Two highly resolved sulfate records have been produced from two Antarctic ice cores (Siple Station and Dyer Plateau). The lengths of these records are estimated to be 500 years from these intermediate cores (200-300 meters). Longer records are available from deeper cores (Legrand et al., 1988). Extracting cloud data relevent to albedo, CCN and suitable for this test of the CLAW hypothesis may prove much more difficult, due to the variations of cloud type, thickness, height, shape and content. If the relationship between CCN, cloud albedo over Antarctica and the Southern Ocean and sulfate in Antarctic snow can be positively established, a history of cloud cover in the high southern latitudes may be obtained from measurement of sulfate in snow and ice preserved in the Antarctic ice sheet. This provides an important reason for testing the CLAW hypothesis: the current uncertainty about the role of clouds in climatic changes. Among the major factors of climatic change, clouds are the least understood. This is not surprising given the lack of substantial data on the history of cloud cover and the albedo of the marine atmosphere.

References

Andreae, M.O., R.J. Ferek, F. Bermond. K.P. Byrd, R.T. Engstrom, S. Hardin, P.D. Houmere, F. LeMarrec, H. Raemdonck and R.B. Chatfield. Dimethylsulfide in the marine atmosphere. *J. Geophys. Res., 90,* 12,891-12,900, 1985.

Andreae, M.O. The ocean as a source of atmospheric sulfur compounds, in *The Role of Air-Sea Exchange in Geochemical Cycling* edited by P. Buat-Menard, pp 331-362, D. Reidel, Hinham, Mass., 1986.

Ayers, G.P., J.P. Ivey and R.W. Gillet. Coherence between seasonal cycles of dimethyl sulphide, methanesulphonate and sulphate in marine air. *Nature, 349,* 404-406, 1991.

Bodhaine, B.A., J.J. Deluisi and J.M. Harris. Aerosol measurements at the South Pole. *Tellus, 32B,* 223-235, 1986.

Charlson, R.J., J.E. Lovelock, M.O. Andreae and S.G. Warren. Oceanic phytoplankton, atmospheric sulfur, cloud albedo, and climate. *Nature, 326,* 655-661, 1987.

Delmas, R.J., M.R. Legrand, A.J. Aristarain and F. Zanolini. Volcanic deposits in Antarctic snow and ice. *J. Geophys. Res., 90,* 12,901-12,920, 1988.

Hegg, D.A., R.J. Ferek, P.V. Hobbs and L.F. Radke. Dimethyl sulfide and cloud condensation nucleus correlations in the Northeast Pacific Ocean. *J. Geophys. Res., 96,* 13,189-13,191, 1991.

Legrand, M.R. and R.J. Delmas. The ionic balance of Antarctic snow: A 10 year detailed record. *Atmos. Environ., 18,* 1867-1874, 1984.

Legrand, M.R., R.J. Delmas and R.J. Charlson. Climate forcing implications from Vostok ice-core sulphate data. *Nature, 334,* 418-420, 1988.

Legrand, M.R. and C. Feniet-Saigne. Methanesulfonic acid in south polar snow layers: a recorsd of strong El Nino? *Geoph. Res. Lett., 18,* 187-190, 1991.

Mosley-Thompson, E., J. Dai, L.G. Thompson, P.M. Grootes, J.K. Arbogast and J.F. Paskievich. Glaciological studies at Siple Station (Antarctica): Potential ice-core paleoclimatic record. *J. Glaciol., 37,* 11-22, 1991.

Mulvaney, R. and D.A. Peel. Anions and cations in ice cores from Dolleman Island and Palmer Land Plateau, Antarctic Peninsula. *Ann. Glaciol., 10,* 121-125, 1988.

Prospero, J.M., D.L. Savoie, E.S. Saltzman and R. Larsen. Impact of oceanic sources of biogenic sulphur on sulphate aerosol concentrations at Mawson, Antarctica. *Nature, 350,* 221-223, 1991.

Radke, L.F. Sulfur and sulphate from Mt. Erebus. *Nature, 29,* 71-712, 1982.

Wagenbach, D., U. Görlach, K. Moser and K.O. Münnich. Coastal Antarctic aerosol: the seasonal pattern of its chemical composition and radionuclide content. *Tellus, 40B,* 426-436, 1988.

Warren, S.G., C.J. Hahn, J London, R.M. Chervin and R.L. Jenne. Global Distribution of Total Cloud Cover and Cloud Type Amounts over the Ocean. *NCAR Technical Note TN-317+STR,* Boulder, Colorado.

ON THE FORMATION OF DIAMICTONS AND LAMINATED SEDIMENTS IN EAST GREENLAND GLACIMARINE ENVIRONMENTS

Julian A. Dowdeswell[1], Robert J. Whittington[2] and Peter Marienfeld[3]
[1]*Scott Polar Research Institute, University of Cambridge, Cambridge CB2 IER, U.K.*
[2]*Institute of Earth Studies, University College of Wales, Aberystwyth, Dyfed SY23 3DB, Wales*
[3]*Alfred-Wegener-Institut für Polar- und Meeresforschung, Columbusstrasse, D-2850 Bremerhaven, Germany*

Almost 90% of 39 m of core material recovered from Scoresby Sund and the adjacent East Greenland shelf is massive diamicton, interpreted to be formed predominantly by the release of iceberg-rafted debris and reworking by iceberg scouring. There is also likely to be a contribution from suspension settling of fines derived from glacifluvial sources. Model calculations suggest that the ^{14}C-derived Holocene sedimentation rate of 0.1-0.3 m 1000 yr^{-1} in Scoresby Sund can be accounted for mainly by iceberg rafting of debris. A further 4% of core material is of gravel or coarse sand lenses, interpreted to reflect iceberg dumping of debris. Intensive iceberg scouring, which reworks sea-floor sediments, is observed on acoustic records from over 30,000 km^2 of the Scoresby Sund fjord system and the adjacent East Greenland shelf (69-72°N and 75°N). The rate of iceberg production from Greenland Ice Sheet outlet glaciers, and iceberg drift tracks on the shelf, suggests that iceberg rafting and scouring may be important over a significant proportion of the 500,000 km^2 area above the shelf break. The relatively extensive modern occurrence of massive diamicton, formed by iceberg rafting and scouring, together with suspension settling of fines, suggests that it may also be a significant facies in the glacier-influenced geological record.

Laminated glacimarine facies make up only a few percent of the cores from East Greenland, and are found mainly in water greater than 550-m in depth on the south side of Scoresby Sund. The facies appears almost exclusively near the base of the cores at dates just prior to 10,000 yr BP. Foraminifera are largely absent from the laminated sediments. Preliminary interpretation suggests that they are formed when fast ice (sikussak) covers the fjord system for an extended period, suppressing iceberg drift over the core sites. Sedimentation continues through suspension settling of fine material derived from tidewater glaciers on the south side of the Sund. The chronology suggests that the presence of sikussak at this time may be linked to the Milne Land Stadial (Younger Dryas) cooling in East Greenland, recorded in dated moraine sequences.

STUDYING CHANGES OF GLACIER ABLATION ZONES IN THE KANGERDLUGSSUAQ FJORD REGION, EAST GREENLAND, USING A TIME SERIES OF LANDSAT IMAGES

By John L. Dwyer[1/]

Abstract

The increase in atmospheric concentrations of radiatively active (greenhouse) trace gases has stimulated much speculation regarding potential consequences for climate and environmental change. Researchers are engaged in studies to establish whether greenhouse gas emissions from anthropogenic sources will result in a detectable climate response. Arctic environments are considered particularly sensitive to climatic perturbations, and consequently, these regions have become the focus of studies of cryosphere and ecological system responses to near-term climatic change. Glacier systems in the Kangerdlugssuaq Fjord region of East Greenland are being studied using a time series of Landsat multispectral scanner (MSS) and thematic mapper (TM) images acquired in August and September of 1978-91. The objectives are to map changes in tidewater glacier terminus positions, snow cover extent, ice surface ablation area, glacier meltwater plumes, and the concentrations and patterns of ice discharge in fjords and adjacent offshore areas.

The 1:250,000-scale topographic maps for the region, available from the Geodetic Institute in Copenhagen, Denmark, contained planimetric errors of 2 to 10 kilometers, and therefore, accurate image-to-map registration and extraction of elevation values for features derived from the images were not possible. In lieu of this, a September 2, 1988, Landsat TM image was used as a reference scene to which the other TM and MSS images were registered and resampled to 30-meter pixels. Verification of the results from this scene-to-scene registration indicated a residual mean square error of less than 1 pixel (79 meters for MSS, 30 meters for TM). Various digital processing techniques (spectral albedo, principal components transformations, contrast enhancement, and spatial filtering) were used to derive image products for discriminating glacier features. Interactive image analysis tools applied to the registered images enabled interpretation and digitizing from soft-copy images, thereby ensuring precise registration of interpretation overlays with each image in the time series. The digitized features (interpretations) are topologically structured line and polygon files that can be either manipulated using a geographic information system (GIS) or rasterized for spatial overlay analysis using image processing software. GIS and image processing tools facilitate the statistical analysis of spatial and multispectral information for the identification and quantification of changes in glacier characteristics.

[1/] Hughes STX Corporation. Work performed under U.S. Geological Survey contract 1434-92-C-40004.

Preliminary results from image enhancement and analysis indicate that changes in glacier features can be delineated. Further work will evaluate changes in regional glaciation attributable to short-term variations in the regional climate as manifest by annual variations in time-series profiles of temperature and precipitation from the Angmagssalik and Scoresbysund areas. Maps depicting sea ice extent in the East Greenland Sea for the years studied will be evaluated because variations in the duration and extent of sea ice influence the interaction of ocean and atmospheric circulation, which affects temperature and precipitation along the coast of East Greenland. Results from this study may contribute to an understanding of the mass balance and glacier dynamics along the eastern margin of the Greenland Ice Sheet.

Peatlands of Beringia: A paleoecological quagmire or treasure trove?

W.R. Eisner[1], A.V. Lozhkin,[2], T.P. Prokhorova[2], A. Oganyesyan[3], and A. V.Sher[4]

1. Byrd Polar Research Center, The Ohio State University, Columbus Ohio 43210
2. Northeast Interdisciplinary Scientific Research Institute Portovaya 16 Magadan 685010
3. Institute of Biological Problems of the North, Karl Marx Street 24, 685000 Magadan
4. Severtsov Institute of Evolutionary Animal Morphology and Ecology, Russian Academy of Sciences 33 Leninskiy Prospect, 117071 Moscow,

The peatlands of the arctic are a non-renewable carbon sink which are particularly sensitive to climate change and human disturbance. The arctic tundra is under stress from increased exploitation and climatic variation. Peatlands are a major component of the tundra, accounting for 90 percent of landscape coverage in northern Alaska. Northern peatlands are the major repository of the world's terrestrial carbon; approximately 23%. Peatlands also supply the atmosphere with its principal source of methane, an important greenhouse gas. Whether northern peat is still accumulating soil carbon or may actually be losing carbon is a question with important consequences for global change scenarios.

Besides the intrinsic significance outlined above for understanding the mechanisms of peat growth, peats are also important paleoecological data. Although North American palynologists have traditionally tended to be somewhat biased against studying pollen from peat cores, pollen records from peat cores have proven valuable in North American arctic paleoecology. European and Russian studies studies depend to a much greater extent on records from peatlands, not only because of their own traditional biases, but because of logistic problems with arctic lake coring.

In some parts of Beringia: the ancient subcontinent which now includes Alaska and Northeastern Siberia (most of Chukotka and parts of northern Yakutia), peats are the most reliable source of paleoecological information. Some of these areas have been targeted for study. Material from St. Lawrence Island is currently under investigations, and material is in hand from exposures the Lower Kolyma and Anadyr, on the Okhotsk Sea, as well as a continuous peat section from eastern Chukotka. Material has also been analyzed from Wrangel Island, and future work on peats is planned. In most of these areas, no lake sediments are suitable for pollen analysis. Future research should prove the usefulness of these records in determining the vegetation history, and eventually, the paleoclimate of Beringia.

The Last Glacial Cycle in the Russian Barents and Kara Seas

Steven L. Forman[1], Gifford H. Miller[2], David Lubinski[2], Jeff Snyder[1], Sergey Korsun[3], Leonid Polyak[1], G. Tarasov[3] and G.G. Matishov[3]

[1]Byrd Polar Research Center,The Ohio State University Columbus, Ohio, [2]INSTAAR, University of Colorado-Boulder, Murmansk Marine Biological Institute, Murmansk, Russia

One of the largest uncertainties in ice volume changes during the late Quaternary are the areal and vertical extent of ice sheets over the extensive shelves bordering northern Eurasia. Field studies on Franz Josef Land (FJL), Novaya Zemlya and the adjacent seas concentrated on retrieving primary glacial and marine geologic, and relative sea-level data to provide new constraints on late Weichselian glaciation.

Deglacial of FJL and the northern Barents Sea occurred surprising early. Radiocarbon dating of shells, whalebones, and driftwood at the marine limit indicate that post-glacial emergence commenced in the central part of FJL at or prior to 10,200 yr B.P. Radiocarbon ages on monospecific forams from post-glacial marine muds demonstrate that fjords and inter-island channels were deglaciated at least prior to 9400 to 9700 yr B.P. One core retrieved from 400 m water depth from the adjacent Franz Victoria Trough contains a glacial diamict overlain by deglacial sediments. Radiocarbon ages on forams from the basal glacial-marine sediment indicates initial deglaciation of this deep trough was at ca. 11,800 yr B.P., culminating at 10,200 yr B.P. with increased North Atlantic water inflow.

Regional isobase pattern indicates that the maximum glacier loads were in the north-central Barents Sea with ice thinning onto FJL and possibly Novaya Zemlya. Strandline tilts through the Holocene are consistently to the southwest, pointing to a more dominant Svalbard/Barents Sea ice sheet than a hypothesized Kara Sea dome. Marine limits on the north island of Novaya Zemlya are consistently low, < 20 m asl and young, 4000-6000 yr B.P. We are uncertain if this low and young marine limit reflects a middle Holocene transgression or persistance of an on-land glacier carapace into the Holocene.

Examination of synthetic aperture radar images for Novaya Zemlya reveals no large scale glacial erosional features, such as orientated lakes, drift lineations and drumlin like forms. The available evidence suggests relative thin glacier coverage of Novaya Zemlya/Kara Sea, with potential early deglaciation, prior to 10,000 yr B.P..

We hypothesize that the disintegration of the Barents/Kara Sea ice sheet enhanced late glacial cooling of the North Atlantic Ocean. Much of this ice sheet (1 to 2 Greenland Ice Sheet equivalent) was discharged as icebergs into the Arctic Ocean through deep troughs that border northern Eurasia. The icebergs were entrained in the Arctic Ocean pack and eventually released into the Norwegian/Greenland Sea through Fram Strait. This increased flux of icebergs into northern seas followed closely deglaciation of the Barents/Kara Sea between 11,800 and 10,200 yr B.P., encompassing the Younger Dryas period.

Deglaciation of the Barents/Kara Sea ice sheet may have been initiated by rapid global sea-level rise ca. 13,000 yr B.P. ago. Sea-level rise would have destabilized this marine-based ice sheet particularly in the deep troughs bordering the Russian Arctic seas. Therefore we hypothesis that much of the sea-level effect of the Barents/Kara Sea ice sheet was delivered prior to

10,200 yr B.P. Currently, there is little evidence for sizable glacier/sea-level reservoir persisting in the Russian Arctic into the Holocene. The early disappearance of northern Eurasian ice sheets increases the volume of "missing glaciers", particularly in the Holocene.

Glaciers were at or behind their present limits by 8500 to 8000 yr B.P. Coincident with maximum glacier recession is the migration of thermophilous molluscan fauna into the Barents Sea, indicating mean sea surface temperature rising to 0 °C. Warmer surface waters persisted seasonally to at least 4000 to 5000 yr B.P. and probably penetrated at depth into the Arctic Ocean. A conspicuous marine escarpment dated between 8500 and 7500 yr B.P.on the western and northern part of the FJL archipelago indicates ameliorated sea-ice conditions during the early Holocene in the western Russian Arctic. A sea-level triggered deglaciation of the Barents/Kara Sea was probably enhanced by increasing summer insolation and advected oceanic heat post 12,000 yr B.P.

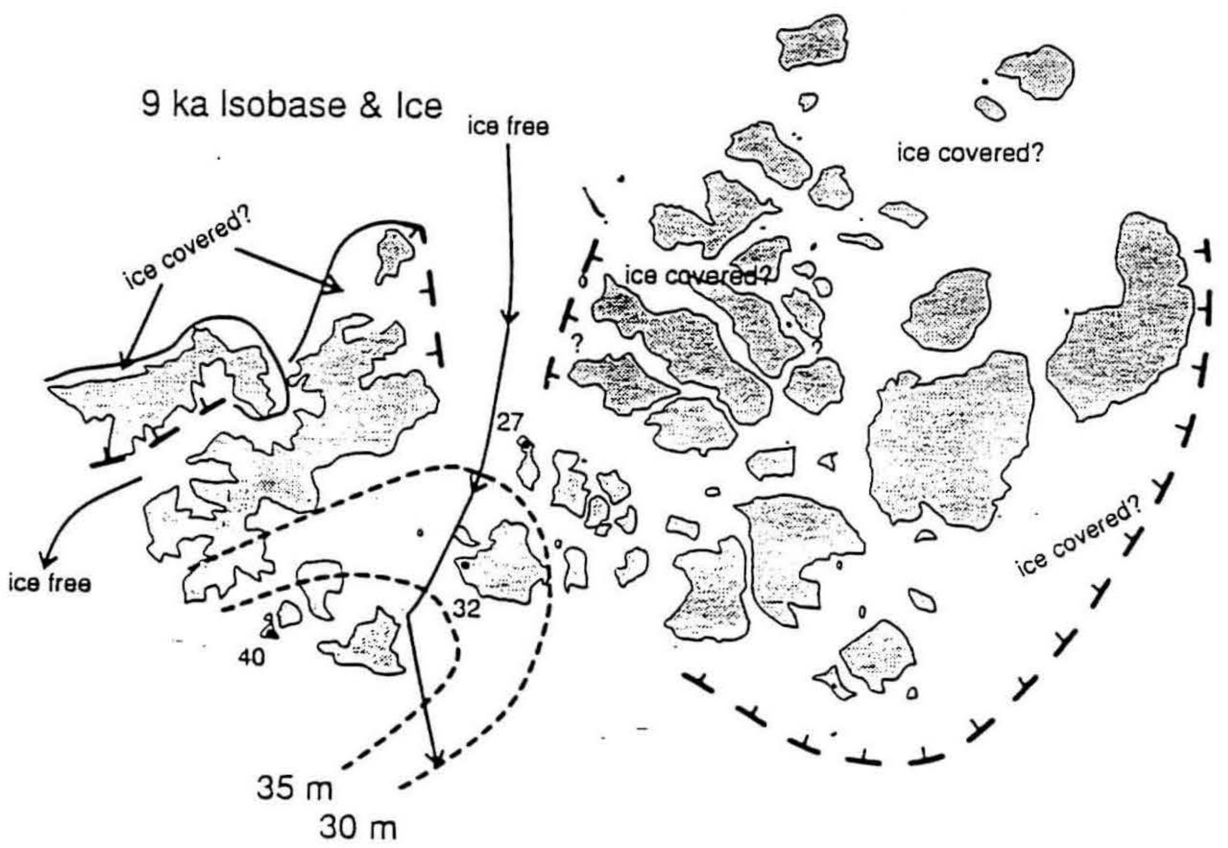


Figure 1: 9000 yr B.P. isobase and inferred coverage by remnant glaciers on Franz Josef Land, Russia. Note strong southwesterly tilt of isobases indicating maximum glacier load in the northern Barents Sea. Many of the deep channels and troughs fringing the Arctic Ocean were deglaciated by 10,000- 9000 yr B.P.

DUNE ACTIVITY ON THE WESTERN ARCTIC COASTAL PLAIN OF ALASKA COINCIDENT WITH NEOGLACIAL CIRQUE-GLACIER EXPANSION IN THE BROOKS RANGE

John P. Galloway (1) and L. David Carter (2)
(1) U.S. Geological Survey, Branch of Alaskan Geology, Mail Stop 904, 345 Middlefield Road, Menlo Park, CA 94025-3591 (2) U.S. Geological Survey, Branch of Alaskan Geology, 4200 University Drive, Anchorage, AK 99508-4667

Climatic changes during the late Holocene have caused repeated stabilization and reactivation of parabolic and longitudinal dunes and possibly sand sheets over a major portion of the landscape on the western Arctic Coastal Plain. The dunes are currently stabilized, and their abundance varies throughout the area from a few dunes to over 275 dunes for a 100-km^2 area. Dune length ranges from 320 to 2500 m, and most dunes are about 15 to 40 m wide. Field observations suggest that most dunes are 1 to 3 m thick. Modern blowouts indicate a bimodal wind regime of ENE-WSW, with the majority of the blowouts produced by easterly winds. Most stabilized parabolic and longitudinal dunes are parallel to this trend, and the parabolic dunes indicate westerly sand transport. This suggest that the late Holocene dunes formed in a wind regime similar to the present one. Twelve radiocarbon ages on peat and humic sand (paleosols) from nine locations suggests that three episodes of dune stabilization separated four periods of late Holocene sand movement (Table 1). The episodes of stabilization are dated at about 4.3 to 3.9, 2.7 to 2.0, and 1.1 to 0.7 ka. The paleosols were buried by renewed eolian transport, and dune building occurred before 4.3, 2.7 to 3.9, 2.0 to 1.1, and 0.7 ka to near the present. Each of the dune-building episodes broadly correlates with one or more neoglacial expansions of cirque glaciers in the Brooks Range (Figure 1). Reactivation of small longitudinal and parabolic dunes on the western Arctic Coastal Plain apparently occurred as a result of cooler and drier surface conditions than today.

References Cited

Calkin, P.E., 1988, Holocene glaciation in Alaska (and adjoining Yukon Territory, Canada): Quaternary Science Reviews: v. 7, no. 2, p. 159-184.

Rickert, D.A., and Tedrow, J.C.F., 1967, Pedologic investigations on some aeolian deposits of northern Alaska: Soil Science, v. 104, no. 4, p. 250-262.

Stuiver, Minze, and Reimer, P.J., 1986, A computer program for radiocarbon age calibration: Radiocarbon, v. 28, no. 2B, p. 1022-1030.

TABLE 1 - CALIBRATED RADIOCARBON AGES*

Site	Laboratory number	Radiocarbon age. (yr B.P.)	Calibrated age (yr B.P.)**
Ages for longitudinal and parabolic dunes			
1	I-10,891	2290. Â 80	2355 (2340) 2162
2	I-13,041	2420 Â 80	2713 (2455, 2434, 2419, 2379, 2367, 2364) 2349
3	I-10,890	1100 Â 80	1168 (1040, 1035, 973) 950
3	I-11,602	3690 Â 90	4219 (4082, 4030, 4020, 4009, 3989) 3907
(A)	I-1004	3840 Â 140	4503 (4264) 3996
Late Holocene paleosols in eolian sand			
4	I-11,489	890 Â 75	925 (792) 727
5	USGS-380	940 Â 110	960 (913, 808, 801) 730
6	I-12,179	2130 Â 90	2306 (2145, 2144, 2121, 2084) 2000
6	USGS-1381	2210 Â 50	2334 (2303, 2241, 2206, 2202, 2181, 2166, 2163) 2152
7	I-13,075	2200 Â 80	2338 (2301, 2244, 2179, 2168, 2162) 2078
7	USGS-185	2280 Â 50	2348 (2338) 2183
8	I-11,920	2480 Â 80	2740 (2708, 2635, 2606,2587, 2565, 2564, 2541, 2521, 2507, 2405, 2404) 2359
9	I-12,178	2500 Â 80	2743 (2712,2629, 2609, 2578, 2572, 2558, 2545) 2363

*Carter 1992, unpublished data
**Based on calibration curve of Stuiver and Reimer (1986)
(A) Rickert and Tedrow (1967)

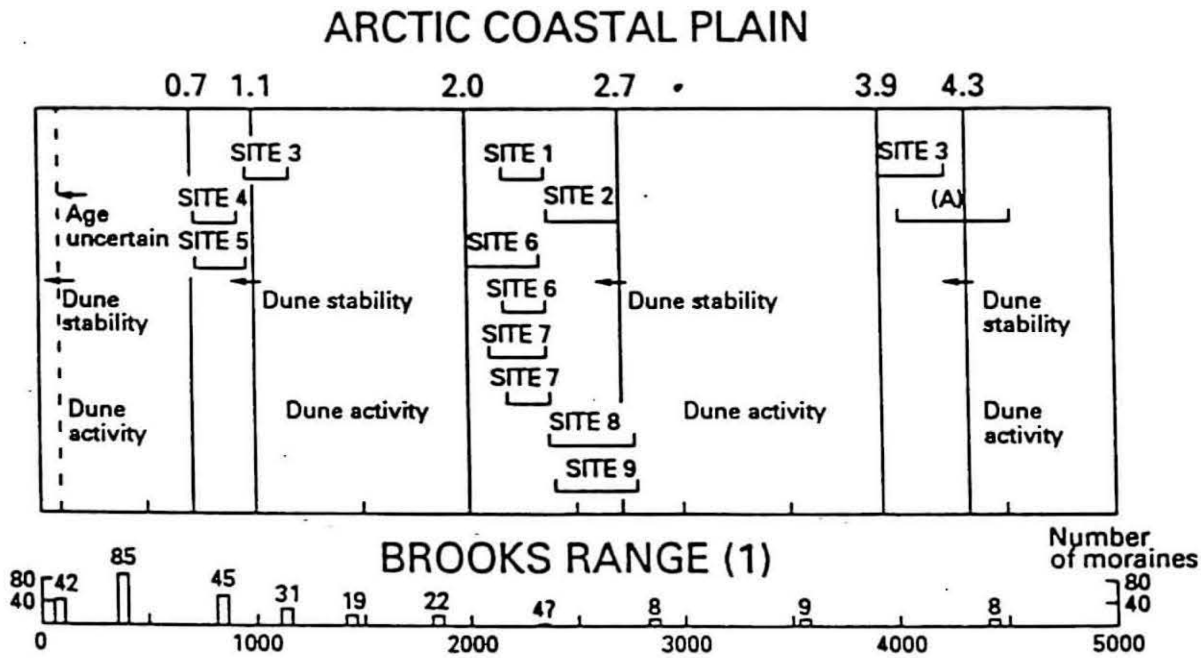


Figure 1 - Alternating episodes of dune formation and paleosol development on the Arctic Coastal Plain based on radiocarbon dates (Table 1) compared to mean ages of middle to late Holocene moraine-building events in the Brooks Range based on lichen data. (1) Modified from Calkin, 1988, table 2, pg. 163.

THE GLACIMARINE SEDIMENTARY ENVIRONMENT OF A HIGH ARCTIC FIORD

Robert Gilbert, Department of Geography, Queen's University, Kingston, Ontario, K7L 3N6, Canada. 613-545-6030. GILBERTR@QUCDN.QueensU.CA

Expedition Fiord is a small, shallow inlet on the west coast of Axel Heiberg Island near 80°N latitude in the Canadian High Arctic. It receives runoff and sediment at its head from a 1079 km^2 drainage basin, 72% of which is glacier-covered. A subbottom acoustic survey was conducted from an inflatable boat during August 1990 using a Datasonics SBP 5000, 3.5 kHz system. In June 1991, six cores, 7 cm in diameter and up to 3.03 m long, were recovered through the sea ice with a percussion gravity corer. The results described in this study are a companion to a study of the benthos of the fiord by A.E. Aitken and are also part of an assessment of the late glacial and postglacial history of a portion of western Axel Heiberg Island by D.S. Lemmen. A more complete account of the work is in press in *Marine Geology*.

Headward of a 70 m deep sill in mid fiord, the basin is divided into smaller basins with a maximum depth of 132 m. The main trough of the fiord deepens to more than 300 m near the mouth. The fiord is ice covered 10 - 12 months each year. Normally, the ice breaks up in August, especially near inflowing rivers, but frequently the fiord does not become ice free. Tides recorded from a staff gauge during field work were semidiurnal with a mean and maximum range of 0.42 and 0.56 m, respectively. During the brief summer, inflowing fresh water forms a surface layer 6 - 8 m thick which extends the length of the fiord. Temperatures and salinities above the pycnocline are up to 4°C and 12‰ while below they are about -1°C and 24 to 34‰, respectively. In the adjoining fiord a large calving glacier contributes icebergs, some of which drift into Expedition Fiord during periods of relatively open water. They scour the fiord floor and deposit rafted sediment, although only bergs of less than 70 m draft are able to pass the sill to enter the inner fiord.

The acoustic stratigraphy of Expedition Fiord shows a thin cover of well-stratified sediment with closely spaced, subparallel, laterally extensive reflectors throughout. Thickness varies from more than 30 m near the delta at the fiord head and at fans along the fiord sides to less than 5 m in places on the floor of the fiord. This is related to settling from suspension of most of the inflowing fine sediment in the immediate vicinity of the river mouths as tidal currents and wind-driven circulation are insignificant. Icebergs, slope failure, and gas have disturbed the stratified sediment in some places. Beneath the stratified sediment is an acoustically opaque material that is interpreted as either bedrock or coarse-grained, glacier-contact, or ice-proximal sedimentary deposits. This material does not have a distinctive morphology that can be related to specific geologic events, for example, the formation of recessional moraines in the fiord.

Sediment from the inner fiord is dominated by deposits of sand in discrete events. These deposits are ascribed to gravity flows, including turbidity currents, from the foreset beds of the delta associated with failures along the rapidly advancing delta front where the sediments of the river bed and bed load are composed almost entirely of sand. In addition to diurnal and seasonal fluctuations in inflow due to melting, the draining of ice-dammed lakes along the margin of the Thompson Glacier creates large, short duration pulses of water and sediment that may trigger gravity flows. No particles coarser than 2 mm were recovered from core 4, indicating that ice rafting is unimportant compared to the rate of deposition of sand and mud from Expedition River.

Sediment from the deepest region inside the sill contains silty clay, both massive rhythmically laminated, as well as coarse and fine sediment deposited from ice rafting. The massive sediments are interpreted as being slowly and quasi-continuously deposited from suspension over long time periods in the absence of other processes. The laminated sediments are interpreted as turbidites resulting from processes at the delta described above. Some may also result from dumps of sand and mud from icebergs. On warm days, we observed turbid clouds to about 20 m diameter in the sea where meltwater rivulets washed mud, sand, and small pebbles from sediment-rich bergs. When bergs are kept nearly stationary by the surrounding sea ice, these inflows might contribute sufficient sediment to generate persistent, small, vertical turbidity currents from suspended particulate matter after it had settled into the denser sea water below the pycnocline.

Although the sedimentary environment of the fiord floor is dominated by physical processes, the role of chemically controlled events may be indirectly assessed from zones 5 to 30 mm thick containing wispy black layers of reduced iron-rich sediment that quickly oxidized to red in the freshly opened core. When examined in thin sections, these red bands occur in the mud associated with the scattered sand grains attributed to ice rafting. During open water in 1988, dissolved oxygen values throughout the fiord at depths to 50 m ranged from 9.8 -11.4 mL/L. However, the benthos is depauperate below about 80 m depth, suggesting oxygen stress in the basin deeper than the sill at 70 m depth. The absence of bioturbation and of fossil remains also suggests that low values of oxygen prevailed at the fiord floor during at least some of this period. Intermittent replenishment of oxygen may have been associated with incursion of turbid plumes of surface water from the delta or from sediment-laden bergs, changing the redox conditions immediately below the sediment surface and leading to the concentration of iron in the sediment.

In the outer fiord, the much greater influence of rafting is seen in the sand which occurs as grains dispersed through the mud or as sand-rich layers that give a moderately to faintly laminated appearance to the Xradiograph images of the cores. As there are no significant sources of inflowing sandy sediments in the outer fiord, the sands are ascribed entirely to ice rafting, rather than gravity flow events. Not only are there more and larger bergs here but gelifluction directly from a number of slopes to the sea ice creates greater potential for sea ice rafting in the outer fiord.

Fragments of moss from 181 cm below the sediment surface in the basin behind the sill were dated at 3670 $\pm$ 60 BP (TO-3195). This suggests an average rate of accumulation of 0.49 $\pm$ 0.01 mm/a assuming no shortening or loss of sediment during coring, and compares with a rate of about 1 mm/a based on the acoustic data for the period since deglaciation. This rate is an order of magnitude lower than that in Disraeli Fiord on northern Ellesmere Island, but lower than rates of mid arctic fiords.

A NUMERICAL MODEL FOR PROGLACIAL SEDIMENTATION AND ITS IMPLICATIONS FOR ACOUSTIC FACIES CHARACTERIZATION.

Gipp, Michael R., Department of Geology, University of Toronto, Scarborough Campus, Scarborough, Ontario M1C 1A4, CANADA.

The geometry of proglacial sediments, observed on high-resolution seismic records, is somewhat dependent on the dominant depositional mechanism. Thus, deposits dominated by suspension rain-out or ice-rafted debris tend to be draped (upper surface mimics underlying topography); where storm-wave resuspension or creep processes dominate, the deposits are slightly thickened over topographic lows and thinned over topographic highs; and turbidites are thickly ponded in topographic lows, and thin or absent atop topographic highs.

A computationally simple method of creating two-dimensional models of proglacial basin-fill, which produces profiles which compare favourably to high-resolution seismic records collected from basins on the Scotian Shelf, is presented . The model starts off with a pre-generated bedrock surface, which may either be a digitized basin, or one generated at random. Subsequent sedimentation is added one layer of constant thickness at a time, each time generating a new seafloor. This new seafloor is then digitally filtered, using a filter with of the form e^{-kx}, where the chosen value of the constant 'k' is determined by the dominant depositional mechanism. To simulate draped muds, a low value of 'k' is chosen. To simulate ponded deposition, a high value of 'k' may be used. If desired, a Coriolis offset can be applied over topographic highs to simulate the effects of currents on deposition. Thus, the model is predicated on the assumption that each topographic surface is similar to the one which preceeded it.

This method assumes that topographic surfaces can be represented as a series of sinusoids; an assumption which is justifiable because both seafloor topography and Fourier series are self-affine. Thus, the fractal nature of the seafloor is preserved by this process.

This model has been useful for modelling the fill of basins like Emerald Basin (Scotian Shelf). Although it does not base its calculations on the physical dynamics of actual processes, nor does it incorporate irregular depositional events like debris flows, its results bear a similarity to real data. It has the advantage of being very flexible--new models can be created by changes in the input data. Additionally, by using a computationally efficient algorithm, the program only takes 2-5 minutes to run on a PC. Thus models can be run quickly, and the hardware requirements are minimal.

Since the parameter 'k' defines the geometry of the deposit, it is possible to invert this approach to deduce values of 'k' for real deposits, based on seismic data. This provides a quantitative method of characterizing acoustic facies, which is an improvement over the standard practice of characterizing them on the basis of the strenghth of the uppermost reflector, and the strenghth, spacing, and continuity of the internal reflections, all of which may be dependent on the instrument used, and the spacing between the instrument and the seafloor.

SLUSHFLOWS AS SEDIMENT TRANSFER MECHANISMS, NORTHERN ELLESMERE ISLAND, CANADA.

Douglas R. Hardy

Dept. of Geology and Geography, Univ. of Massachusetts, Amherst MA 01003

At Taconite Inlet, northern Ellesmere Island (82°50' N; 78°00' W), slushflow activity during the early snowmelt period was an important mechanism of sediment transfer from the $21 km^2$ watershed to Lake C2. Slushflow events marked the commencement of streamflow onto the lake each year between 1990 and 1992. Details of the 1992 event are presented to illustrate the sedimentological role of slushflows in the region.

Three components of slushflow sediment transfer were involved: (1) the initial, main channel slushflow; (2) subsequent slushflows, initiated elsewhere in the watershed; and (3) the delayed effects. Together, these processes were hypothesized to have partially controlled the timing and annual magnitude of sediment delivery from the watershed, and influenced sediment distribution within the lake.

The initial 1992 slushflow cleared the snow-filled stream channel, leaving lateral levees 0.5-1.5m high. Discharge of this brief pulse was the highest flow observed during the three year study period (estimated at 5.5 ± 2 m^3/sec). Large volume samples of drained, in-situ slush and sediments were collected from lateral levees and the run-out zone on the frozen lake. Sediment concentration ranged between 1.3 and 4.6 kg/m^3. Sample size distributions were remarkably consistent, with 12% gravel, 82% sand, and 6% silt/clay. The volume of slush delivered onto the ice was approximately 1100 m^3, carrying roughly 3600 kg of suspended sediment. A small amount of cobble and gravel size traction load was also transported onto the lake during the initial event. Near the distal end of the delta, the slushflow path deviated from the primary stream channel, resulting in a trajectory of water and sediment onto the ice that differed from the previous year. Although the stream later migrated back to the old channel, the deviation was significant in terms of sediment ultimately distributed and deposited in the lake.

As subsequent slushflows occurred elsewhere in the watershed, their slush and sediments became integrated with existing streamflow. At the gaging station near the lake, pulses of slush, suspended sediment, and shredded plant fragments were attributed to upstream slushflows. During one pulse, for example, discharge increased from 0.4 to 0.7 m^3/sec, and preliminary determinations of measured suspended sediment concentration (SSC) indicate a 200-300% increase.

Delayed effects of slushflow activity included elevated levels of SSC and bedload transport due to channel scour and alteration, and elevated SSC as lateral levees melted and collapsed. On the lake ice, sediments deposited during the initial slushflow altered surface albedo and the ice energy balance, thereby influencing the pattern of moat development. These sediments were then transported by ice rafting, and deposited further from the delta.

The literature documenting slushflows elsewhere indicates that in favorable geographic and topographic locations, slushflows recur frequently, perhaps even annually. Rapid snowmelt is almost always cited as the critical meteorological condition controlling slushflow initiation. Therefore, in watersheds where slushflows occur, their magnitude and spatial extent are likely to be an indicator of rapid snowmelt. Through their sedimentological effects, slushflows may serve to *amplify* the climatic signal of High Arctic sediment transfer.

Kenneth M. Hinkel
Department of Geography, University of Cincinnati
Cincinnati, OH 45221-0131 USA

Samuel I. Outcalt
Department of Geological Sciences, University of Michigan
Ann Arbor, MI 48109

IDENTIFICATION OF HEAT-TRANSFER PROCESSES DURING SOIL COOLING, FREEZING, AND THAW IN CENTRAL ALASKA

Hourly time series of temperature and a surrogate measure of the soil water ionic concentration were obtained in the upper 50 cm of soil from two proximal sites in central Alaska from August 1991 through May 1992. One site is located in a ground water seepage site and is characterized by seasonal freezing of the upper soil. The other site is located over a body of permafrost. The time series, used simultaneously, produce a unique signature diagnostic of the operative nonconductive heat-transfer process. During soil cooling in autumn, internal distillation dominates heat transfer in the active layer. A "zero curtain" develops in winter and persists for three months; maintenance of this isothermal layer is associated with water advection and internal distillation within the unfrozen zone. Conductive heat transfer is not possible in the isothermal layer during this period but dominates during the deep freezing regime which follows the closure of the zero curtain. Warming of the active layer in spring occurs nearly instantaneously and results from infiltration of snowcover meltwater and downward vapor migration. Conversely, water saturation of pore space at the seepage site inhibits internal distillation and vertical water advection; the thermal inertia of this system is much greater.

A method for determining ice thickness change using GPS

Christina L Hulbe
Byrd Polar Research Center and Department of Geological Sciences
The Ohio State University
Columbus, OH 43210 USA

Abstract

The development of precise differential Global Positioning System (GPS) surveying means that ice thickness change can be resolved at remote locations on an ice sheet. Vertical velocities of survey marks are used as an indicator of ice thickness change. Because observations are of sites at the surface, special account must be made for firn settling. Surface slope must also be considered. In the method now being used, a remote site is accurately positioned relative to a GPS receiver on rock. Repeat observations of the position of the remote site are used to determine its vertical velocity. To remove the settling velocity, anchors or very tall poles are placed at several depths within the firn. Relative changes in anchor positions yield a depth-settling velocity relationship which, combined with the local snow accumulation rate, is used to remove the firn settling effect. Local surface slope is also assessed and the GPS derived geocentric vertical motion is converted to surface perpendicular motion. The results of the first epoch of measurements at South Pole Station are presented. An analysis of errors indicates that the limiting measurements are long-term accumulation rate and the depth-density profile.

Polar Response to Middle Pliocene Ocean Warming

Scott E. Ishman and PRISM Project Members
U.S. Geological Survey
970 National Center
Reston, VA 22092

The cumulative results from the Pliocene Reconstruction, Interpretation, and Synoptic Mapping (PRISM) research effort conducted by the USGS and others indicate significant warming in parts of the Northern Hemisphere at ~3.0 Ma. Sea surface temperature estimates and vegetation distributions show ocean and atmospheric temperatures warmer than present temperatures in the high northern latitudes, with minimal temperature change at middle to low latitudes. Data from the Southern Hemisphere indicate elevated sea surface and atmospheric temperatures and greatly reduced ice volume on Antarctica; these conditions imply a global sea level rise of at least 25 m. In this talk, we will present a synopsis of middle Pliocene (~3.0 Ma) global climate.

Global sea surface temperature (SST) distributions have significant effects on both atmospheric and oceanic circulation. Faunal and floral SST estimates for the North Atlantic (DSDP Sites 552, 606, 607, 609, 610; Tjörnes, Iceland; Meighen Island) and the North Pacific (DSDP Sites 310, 578, 579, 580) indicate SST's significantly warmer (>7 °C) at ~3.0 Ma than present, with the greatest amplitude observed in the high latitudes (>45 °N). Similarly, middle Pliocene SST estimates for the Southern Hemisphere indicate that the high latitudes (>45 °S) were significantly warmer (4° to 10 °C) than at present. Latitudinal shifts in faunal and floral distributions along the eastern Atlantic seaboard of the United States (Tamiami Formation; Yorktown Formation) and western Pacific margin (Japan; Kamchatka) indicate atmospheric and oceanic temperatures similar to those of today in the low latitudes and warmer than present in the high latitudes. Faunal and floral data from the Arctic region indicate little to no significant land or sea ice cover in the middle Pliocene. Although still debated, abundant data exist supporting greatly reduced Antarctic ice volume in the middle Pliocene. Faunal and floral data (Ciesielski and Weaver, 1974; Abelmann, et al., 1990) also suggest reduced sea ice conditions in the southern ocean throughout the middle Pliocene (4.0 to 3.2 Ma).

Global circulation modeling (GCM) of CO_2 versus meridional heat transport in the North Atlantic (Rind and Chandler, 1991) shows that (1) doubling of atmospheric CO_2 results in an increase in temperatures at low and high latitudes or (2) increased meridional heat transport results in little or no temperature change at low latitudes, with a pronounced increase at high latitudes. PRISM middle Pliocene North Atlantic SST reconstruction strongly supports the meridional heat transport mechanism. Heat transport to the North Atlantic from intensification of the North Atlantic Drift during the middle Pliocene had a strong impact on atmospheric, as well as deep ocean conditions.

Analyses of North Atlantic benthic foraminifers and ostracodes and benthic $\partial^{13}C$ records indicate intensification of North Atlantic Deep Water (NADW) production (that is, deepening of NADW in the eastern North Atlantic basin) at ~3.0 Ma. The timing of this North Atlantic event is coincident with an increase in Antarctic ice volume as indicated by a significant positive shift (~0.25‰) in benthic $\partial^{18}O$ at ODP site 704, suggesting a decrease in bottom water temperatures, i.e., an increase in Antarctic Bottom Water (AABW) production.

Although more detailed work is needed, we suggest that, prior to the onset of Northern Hemisphere glaciation in the late Pliocene, the North Atlantic had a significant impact on Southern Hemisphere ice volume. Increased production of NADW also increased heat flow to the Southern Hemisphere via Circumpolar Deep Water (CDW).

Significant heat loss, as water vapor, provided the necessary moisture to rapidly increase Antarctic ice volume, as well as increase production of ice shelf water that mixes with CDW to produce AABW.

REFERENCES CITED

Ciesielski, P.F. and Weaver, F.M., 1974. Early Pliocene temperature changes in the Antarctic Seas. Geology, 2(10): 511-515.

Abelmann, A., Gersonde, R. and Spiess, V., 1990. Pliocene-Pleistocene paleoceanography in the Weddell Sea - siliceous microfossil evidence. In: Bleil, U. and Theide, J. (eds.), Geological History of the Polar Oceans: Arctic Versus Antarctica, 729-759. Kluwer, Amsterdam.

Rind, D. and Chandler, M., 1991. Increased ocean heat transports and warmer climates. Journal of Geophysical Research, 96(D4): 7437-7461.

CRYSTALLINE STRUCTURE, ISOTOPIC VARIATIONS AND DEVELOPMENT OF PACK ICE IN THE PACIFIC SECTOR OF THE SOUTHERN OCEAN

Martin O. Jeffries
Geophysical Institute
University of Alaska
Fairbanks, AK 99775- 0800

In order to understand sea ice and its role in air ice ocean interactions and Global Change it is necessary to know the ice growth processes that contribute to its development in both polar regions. In recent years there have been a number of investigations of pack ice development in the Weddell Sea in the Atlantic sector of the Southern Ocean. The objective of this study was to investigate pack ice development in the Ross, Amundsen and Bellingshausen Seas in the Pacific sector of the Southern Ocean.

Ice cores were obtained from floes in the eastern Ross Sea, the Amundsen Sea and the western Bellingshausen Sea during a cruise aboard the U.S.C.G.C. Polar Sea in February March 1992. The crystalline structure and stratigraphy of the cores showed that the main ice growth mechanisms were snow ice, frazil ice and congelation ice formation. There were also numerous deformation structures such as rafted nilas and blocks of congelation ice tipped on their sides. The Ross/Amundsen cores were as much as 8m long and were primarily frazil ice. The Bellingshausen cores were shorter and were primarily multiple layers of frazil and congelation ice. The large amounts of frazil ice, as well as frequent deformation structures and multiple layering reflect ice development in a turbulent environment.

Snow ice occurred at the surface of most cores. It forms when the weight of snow is sufficient to depress the floes below the waterline allowing seawater to infiltrate along the base of the snowcover, which subsequently refreezes to form snow ice at the floe surface. A number of floes were flooded at the time of sampling, probably due to the weight of the 1-2m deep snowcover. Such deep snow on pack ice has not previously been reported. The snow ice layers had del O-18 values in the range -15ppt to -18ppt. Using a simple isotopic mass balance model,it has been determined that the snow ice layers comprise an average of almost 80% snow.

In addition to the very negative del O-18 values in the snow ice, moderately negative del O-18 values, from -13ppt to -1ppt, were also found in frazil and congelation ice, sometimes as much as 2-3m below the snow ice layer. These moderately negative del O-18 values in the sub snow ice layers indicate that they also contain a snow fraction. Using the simple isotopic model it has been found that the fraction of snow in each core (snow ice layer plus sub snow ice layer) varies from 2% to 27%, with a mean value of 8%. Stable isotopes provide evidence that snow makes a moderate contribution to Antarctic sea ice development. Isotopic methods also provide a better estimate of the contribution of snow to sea ice development than using crystallographic criteria alone to identify only the surface snow ice layer.

The total contribution of snow to sea ice development in the Ross, Amundsen and Bellingshausen Seas is of the same order of magnitude as that found in Weddell Sea ice floes. The structure and stratigraphy of the ice are also similar to Weddell Sea ice. The results of this study add to the growing body of evidence that Antarctic sea ice development is significantly different from that in the Arctic.

This work was funded by NSF Grant No. 8915863 from the Ocean and Climate Program, Division of Polar Programs.

Isoleucine Epimerization in the High-Molecular-Weight Fraction of *Arctica* from SW Norway

D.S. Kaufman, Department of Geology, Utah State University, Logan, UT 84322
H.P. Sejrup, Department of Geology, University of Bergen, N-5007, Norway

Although time and temperature are dominant controls on the extent of amino acid epimerization in biogenic minerals, other factors are known to affect the overall reaction rate. These secondary effects, which can undermine the accuracy of amino acid geochronology, are embedded within the complex network of diagenetic reactions that operate in biogeochemical systems. The extent of epimerization, as is traditionally determined on the entire pool (total population) of amino acids (isoleucine in particular), is a function of the integrated effects of this reaction network. We investigated the possibility that some of the complications involved in protein diagenesis might be circumvented by isolating a single component of the reaction network and studying the extent of epimerization in that fraction alone.

We used gel-filtration to extract the high-molecular-weight (HMW) fraction of proteinaceous matter from fossil and modern molluscan shells. This fraction contains a residuum of the largest (ca. ≥16,000 MW), most-pristine indigenous proteins and peptides, that has not been affected by diagenesis to the extent of the more degraded, lower-molecular-weight fractions. The HMW molecules are relatively immune to the effects of peptide hydrolysis, which can influence the apparent rate of racemization in the total amino acid population. Because the gel fractionates macromolecules by size, we also used it to quantify the extent of protein decomposition in fossil shells by measuring the size distribution of their organic components.

As a first test of the technique, we measured the extent of isoleucine epimerization (aIle/Ile) in the HMW fraction of subsamples taken through cross sections of two *Arctica* shells from two SW Norwegian sites, Bø and Fjøsanger. The aIle/Ile ratios are uniform through each shell, despite the strong gradient in aIle/Ile measured in their total amino acid populations (Figure 1). Because there is no age difference between the intrashell samples, this finding supports the idea that the HMW fraction contains geochronologically more reliable proteinaceous matter than the total amino acid pool.

The aIle/Ile ratios in the HMW fraction of the two shells are not only spatially uniform, they are statistically equivalent. This result is consistent with other independent evidence that indicates that the deposits at the two sites are the same age, despite significantly different aIle/Ile ratios in the total amino acid population of some shells. The difference in aIle/Ile ratios in the total population is attributed to the greater proportion of low-molecular-weight, and hence, extensively epimerized, short peptides (ca. 300 MW) measured in gel-filtered samples from the Fjøsanger shell.

Analyses of shells ranging in age from early Pleistocene to modern confirm that epimerization in the HMW fraction of molluscan fossils is time dependant, but that the reaction operates at about one-fifth the rate of the total amino acid population. Although these preliminary results are encouraging, they demonstrate the limited temporal resolution of the HMW fraction for geochronology. The technique is also limited by the sample size, because older samples contain fewer intact HMW molecules.

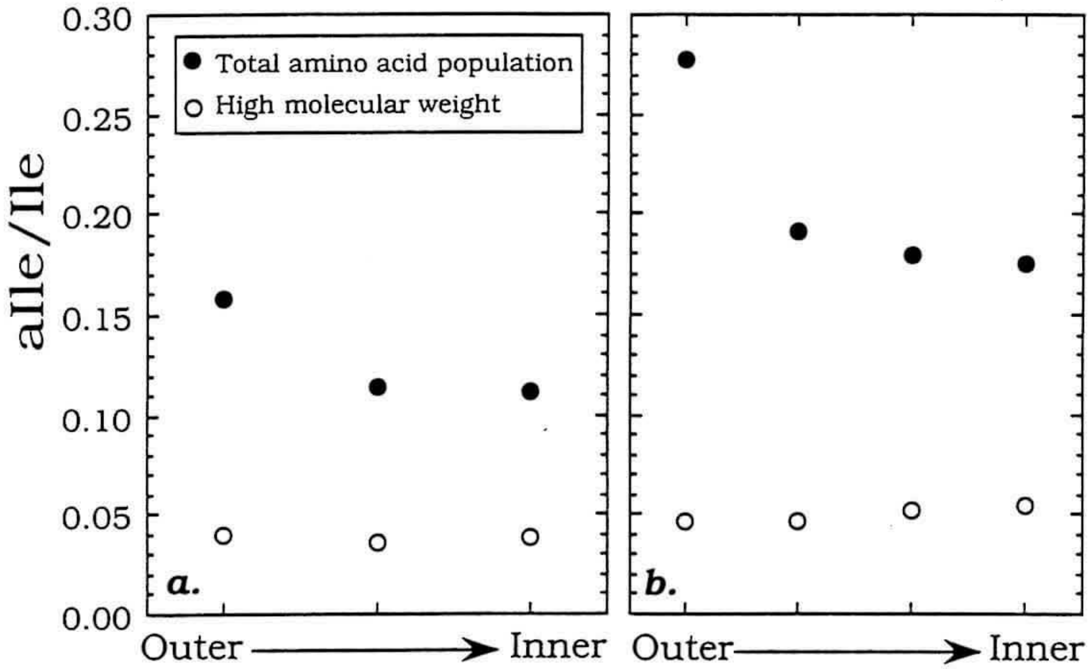


Figure 1. Intrashell variation in the extent of isoleucine epimerization in the total amino acid population and the high-molecular-weight fraction (ca. ≤16,000 MW) of *Arctica islandica* from interglacial beds at (a) Bø and, (b) Fjøsanger, SW Norway. Circles are mean values of 2-4 analyses; the ±1σ analytical errors are less than the height of the symbols in all cases. AIle/Ile ratios for the total population are from Sejrup and Haugen (in press).

Plio-Pleistocene Paleoclimatic and Paleoceanographic Evolution of the North Pacific: Preliminary Results of ODP Leg 145

Krissek, L.A. (Department of Geological Sciences, Ohio State University, Columbus, OH 43210)
Rea, D.K. (Department of Geological Sciences, University of Michigan, Ann Arbor, MI 48109)
Basov, I. (Institute of the Lithosphere, Academy of Sciences, Moscow, Russia)
and Leg 145 Shipboard Scientific Party

During ODP Leg 145 (July - September 1992), sediments were recovered from 25 holes drilled at seven sites in the North Pacific Ocean; the objectives of this drilling included: 1) obtaining high-resolution records of Miocene and younger oceanic and climatic change in this region, 2) recovering carbonate-bearing sedimentary records of the Paleogene and Cretaceous North Pacific, 3) recovering sediments from a depth transect down Detroit Seamount for study of temporal and spatial variations in North Pacific subsurface circulation, 4) examining the timing, nature, and extent of enhanced biogenic silica deposition during the middle Miocene, and 5) evaluating the proposed origin of the Meiji Tongue as a bottom current-influenced drift deposit. Shipboard observations support preliminary conclusions about the paleoclimatic and paleoceanographic evolution of the North Pacific during the Plio-Pleistocene, and will be discussed here.

Major changes in the oceanography and atmospheric circulation of the North Pacific and in the climatic conditions of adjacent landmasses at approximately 2.6 Ma are recorded by a variety of sedimentary indicators. In the northwesternmost Pacific (Site 881), the onset of current-mediated deposition at 2.6 Ma (interpreted from seismic reflection profiles) reflects enhanced bottom-water circulation. The mass accumulation rates of terrigenous clay, quartz, and coarse-grained ice-rafted debris increased significantly at 2.6 Ma in both the northwesternmost Pacific (Site 881) and the Gulf of Alaska (Site 887); these changes record the increased erosion that accompanied glacial expansion on both of the adjacent continents. Siberia, via the Sea of Okhotsk, and the southern Kamatchatka Peninsula were the major dropstone sources for the northwestern Pacific. In the northern central Pacific (Sites 885/886), the mass accumulation rate of eolian dust increased significantly at 2.6 Ma. This dust is compositionally similar to the loess deposits of China, and its increased flux to the North Pacific records the climatic deterioration that accompanied extensive Northern Hemisphere glaciation.

Both the number and the volume of volcanic ash beds increased dramatically at approximately 2.6 Ma at all sites across the North Pacific. This late Cenozoic volcanic event has been recognized and discussed previously; as demonstrated by the Leg 145 results, the size and rapid onset of this event suggest that it may be prudent to reconsider the effects of these eruptions on Northern Hemisphere temperatures.

LATE QUATERNARY DIATOM ASSEMBLAGES FROM THE GULF OF ST-LAWRENCE (CANADA): PRELIMINARY RESULTS.

Martine Lapointe, GÉOTOP, Université du Québec à Montréal, C.P. 8888, Succ. A, Montréal, (Québec), Canada, H3C 3P8.

The Gulf of St-Lawrence is a highly-stratified semi-enclosed sea that includes a wide range of environmental conditions from estuarine through oceanic. This transitional marine environment is caracterized by a strong summer gradient of salinity (28 to 34 °/oo) and temperature (8 to 15°C) and by important seasonal variations (in winter the surface water temperature drops to -1°C).

The relations between diatom assemblages and sea-surface conditions (temperature, salinity, ice cover, etc...) have been established with the analysis of 30 surface sediment samples. More then 110 taxa have been identified, most of them to the species level. In this group, the common diatoms are *Coscinodiscus bathyomphalus* (*Bacteriosira fragilaris* resting spore), *Coscinodiscus marginatus*, *Paralia sulcata*, *Thalassiosira antarctica* resting spore, *Porosira glacialis*, *Thalassiosira nordenskioeldii*, *Chaetoceros* spp, *Navicula* spp and *Nitzschia* spp. In order to perform some statistical analysis, we grouped them into 40 different sets of diatoms based on their different ecology (marine, brackish, benthic, planktonic, ice diatoms,...).

A centroid cluster analysis of the sites has been performed using these 40 sets of diatoms. The results revealed two distinct groups related to the salinity gradient. The first one defined by *Cyclotella meneghiniana* and *Stephanodiscus astrea* assemblage caracterized the estuarian conditions. The second cluster (*Paralia sulcata*, *Thalassiosira nordenskioeldii*, *Coscinodiscus marginatus* and *Thalassiosira antarctica* resting spore assemblage) represents more open marine conditions (although still epicontinental).

The close relationships between the modern assemblages and the environmental parameters will be useful to reconstruct the paleoenvironmental conditions of some Postglacial sequences from the Gulf of St-Lawrence. The preliminary results of a downcore analysis, located at the mouth of the Laurentian Channel showed that similar conditions, comparable to an actual open marine environment, lasted for about 10 000 years. Moreover, one interval related to the beginning of the Younger Dryas (*cf.* ^{18}O curve) is caracterized by a small concentration of diatoms and by a low assemblage diversification, suggesting cold environmental conditions. In general, the observed variations of the diatom assemblages appear to be consistent with those associated with the dinoflagellate cysts.

DIATOM EVIDENCE FOR LATE HOLOCENE CLIMATIC EVENTS IN GRANITE HARBOR, ANTARCTICA

Amy Leventer, Byrd Polar Research Center, Ohio State University, Columbus, Ohio 43210

Currently, little data exist concerning the response of the high latitude Southern Ocean to late Holocene climate changes. One of the problems in obtaining high resolution records from the Antarctic marine system has been the lack of well-dated core material from areas with high sediment accumulation rates. This talk presents a proxy record of climatic change from Granite Harbor, a fjord located in the southwestern Ross Sea. Downcore changes in diatom assemblages are used to interpret paleoenvironmental conditions. Time constraints on specific late Holocene events are based on traditional organic carbon C-14 dates.

First, century scale changes in species composition, as illustrated by downcore variability in relative concentration of *Nitzschia cylindrus*, indicate the influence of globally recognized late Holocene climatic change on the high latitude marine system. The trends of this species imply the existence of greater open water during **both** the Little Ice Age and the Medieval Warm Period. <u>What abiotic environmental variables drove the creation of these open water systems in the past, and were the same or different forces responsible for open water during these two very different episodes</u>? Open water can be linked to both increased windiness and / or increased temperature. Along the Antarctic coast, open water regions, or polynyas, often are associated with strong and persistent katabatic winds, which blow out thin, newly forming sea ice. Seasonal changes in sea ice extent around the Antarctic continent clearly demonstrate the role that temperature plays in the distribution of sea ice. The question is: can we distinguish between the relative importance of these two factors in driving open water conditions? I suggest that increased strength and/or intensity of winds during the Little Ice Age resulted in greater temporal and spatial extent of open water, while increased temperatures during the Medieval Warm Period was responsible for the decrease in annual sea ice cover.

Second, the occurrence of nearly monospecific layers of diatoms such as *Corethron* and *Chaetoceros* may represent individual seasons or periods of several years characterized by unusual conditions of minimal ice coverage and extreme water column stabilization. Deposition of the monospecific layers in Granite Harbor was probably aided by the frustule morphology of the species involved. The long spines and setae (spine-like extensions of the valve) characteristic of these species increase the effective size of the cells, enhancing entanglement of cells and colonies, leading to mass flocculation and sinking. These episodes may be responsible for delivery of large amounts of organic carbon and biogenic silica to the sea floor. Although the approximate timing of these episodes has been determined based on the radiocarbon-derived average sedimentation rates, the exact age of these events has not been determined, making it difficult to link any of these events to specific global occurrences. We suggest that the distribution of short-lived events such as these in the geologic record may be used to correlate between cores, and that as more high resolution cores become available from the Antarctic, the existence and age of these types of layers should be documented. In addition, the frequency with which these events occur may record the relative degree of stability/instability in the upper water column and may be important in influencing burial of organic carbon and biogenic silica at the seafloor.

Determining the relationship between these events and the longer term climatic shifts recorded by changes in the relative abundance of *N. cylindrus* is difficult since only five episodes are recorded in the longest core obtained from Granite Harbor. While the episodes of mass sediment accumulation have been linked to periods of high primary productivity (probably induced by enhanced stratification of the water column), it is not immediately obvious whether this type of oceanographic condition would occur more frequently during warm or cold periods of time. However, if, as suggested, winds were greater during the Little Ice Age, it is less likely that environmental conditions enhancing stratification would occur during this period. Since these peaks in abundance may represent single year events, however, it is still possible that they could have resulted from stratification during a generally windy period, as is demonstrated by the occurrence of a peak in *Chaetoceros* abundance during the early part of the Little Ice Age. Longer records may help to better document the frequency of co-occurrence between episodes of mass sediment accumulation and warmer versus colder climatic periods.

New Holocene paleoceanographic records from Franz Josef Land

David J. Lubinski[1], Sergey Korsun[2,3], Steven L. Forman[3], Amy Leventer[3], Gennady G. Matishov[2], and Gifford H. Miller[1]

[1] INSTAAR and Department of Geological Sciences, University of Colorado, Boulder, CO 80309-0450
email:lubinski@ucsu.colorado.edu
[2] Murmansk Marine Biological Institute (MMBI), Murmansk, Russia
[3] BPRC, The Ohio State University, Columbus, OH 43210

The recent opening of Franz Josef Land (79°to 83°N latitude, western Russian Arctic) to cooperative research among the Institute for Arctic and Alpine Research (INSTAAR), the Murmansk Marine Biological Institute (MMBI), and the Byrd Polar Research Center (BPRC) has provided an opportunity to assemble paleoceanographic records for a region of very sparse data. Franz Josef Land (FJL) is located at the boundary of the NE Barents Sea and the Arctic Ocean and consists of numerous small islands separated by deep (200-550 m) and narrow (1-20 km) channels containing Holocene sediments (Figure 1). At present the islands are heavily glaciated (>85% ice-covered), and marine conditions are dominated by Polar, not Atlantic, waters (NODC, 1991; Matishov et al., 1992).

Studies from the Greenland, Iceland, and Norwegian (GIN) seas imply that FJL might have experienced Atlantic water in the early to middle Holocene. During this period, roughly coincident with the European Hypsithermal, the GIN seas had higher sea surface temperatures (SST's) than at present (Karpuz and Jansen, 1992; Salvigsen et al., 1992) and glaciers on Norway and Spitsbergen retreated (Karlén, 1988; Lehman and Forman, 1991). This "marine optimum" was followed by decreasing SST's and Neoglacial conditions. These changes in Holocene SST's have been linked to variations in Atlantic current strength and heat input to the GIN seas (e.g. Svendsen et al, 1992). Because FJL was "down current" of the GIN seas during the Holocene, it probably experienced Atlantic water variations different in timing, magnitude and effect on terrestrial climate.

To test this hypothesis our group is using physical properties (e.g. grain size and carbonate content), faunal assemblages, radiocarbon, and foraminiferal stable isotopes preserved in marine sediments. During the 1991 and 1992 field seasons, we collected numerous grab samples and ten gravity cores from central FJL. Five of the cores are from deep (300-550 m) inter-island basins. The remaining five are from a transect of a single fjord basin (Quiet Bay, Hooker Island). We are also analyzing a piston core and a trigger core collected in 1991 by Scott Lehman (Woods Hole Oceanographic Institution or WHOI) from the Franz Victoria Trough. This deep trough lies at the western edge of the FJL region.

Work thus far has focused on lithostratigraphy, radiocarbon dating, and foraminiferal and diatom assemblages. All 12 cores have been split, X-rayed, and described. Five levels on two FJL channel cores have been dated. The inter-island channel cores are composed nearly entirely of homogeneous, bioturbated, olive-grey silty clay. The core sites were located too far from glacier margins (> 4 km) to have received much coarse glacial sediment during the last ca. 8 ka. This result is consistent with terrestrial data from Hooker island showing many Neoglacial limits within 2 kilometers of the present ice margin (Miller et al., 1992). The Franz Victoria Trough piston core and several Quiet Bay gravity cores contain sands and basal diamicts of unknown age. Foraminiferal assemblages of two FJL inter-island channel cores and one Franz Victoria trough core show a middle Holocene transition from a *Cassidulina reniforme* to a *Elphidium clavatum* zone (which exists to the present). This zone change is interpreted to reflect a regional pattern of increased benthic stress, although of yet unknown cause. *Nonion labradoricum* in one FJL core suggests that Atlantic water existed in the inter-island channels from > 3.8 to ca. 3 ka (with 425 yr marine reservoir correction). However, *Nonion labradoricum* does not occur in a 0 to 8.4 ka core taken from a site about 50 km away. The discrepancy could be due to differences in water depth or local environmental factors. Diatoms in surface and core sediments may facilitate reconstructing sea surface temperature and productivity; unfortunately a preliminary study showed very low abundances.

Future work will include additional lithostratigraphic, radiocarbon, and foraminiferal studies as well as new stable isotopic and faunal analyses. Leonid Polyak (WHOI, BPRC, and Institute for Geology and Mineral Resources of the Ocean, St. Petersburg, Russia) and Scott Lehman are assembling *Neogloboquadrina pachyderma* (s) and benthic foraminifera stable isotope records for the Franz Victoria Trough cores as part of a related, but separate, investigation. S. Korsun will use FJL surface samples to find relationships between marine environmetal factors and foraminifera. Building on preliminary FJL work by Anne de Vernal (Univ. of Montréal, Québec), A. Leventer is planning to use dinoflagellates to quantify sea surface conditions.

References

Karlén, W., 1988, Scandinavian glacial and climatic fluctuations during the Holocene, Quaternary Science Reviews, 7, 199-209.

Karpuz, N.K., and Jansen, E., 1992, A high-resolution diatom record of the Last Deglaciation from the SE Norwegian Sea: documentation of rapid climatic changes, Paleoceanography, 7, 4, 499-520.

Lehman, S.J., and Forman, S. L., 1991, Late Weichselian glacier retreat in Kongsfjorden, West Spitsbergen, Svalbard., Quaternary Research, 37, 139-154.

Matishov, G.G., Matishov, D.G., and Shaban, A.Y., 1992, New data on the role of troughs in the bio-oceanology of the Franz Josef Land and Novaya Zemlya shelves, Preprint, Russian Academy of Sciences, Kola Science Center, Apatity, 46 p. (in Russian).

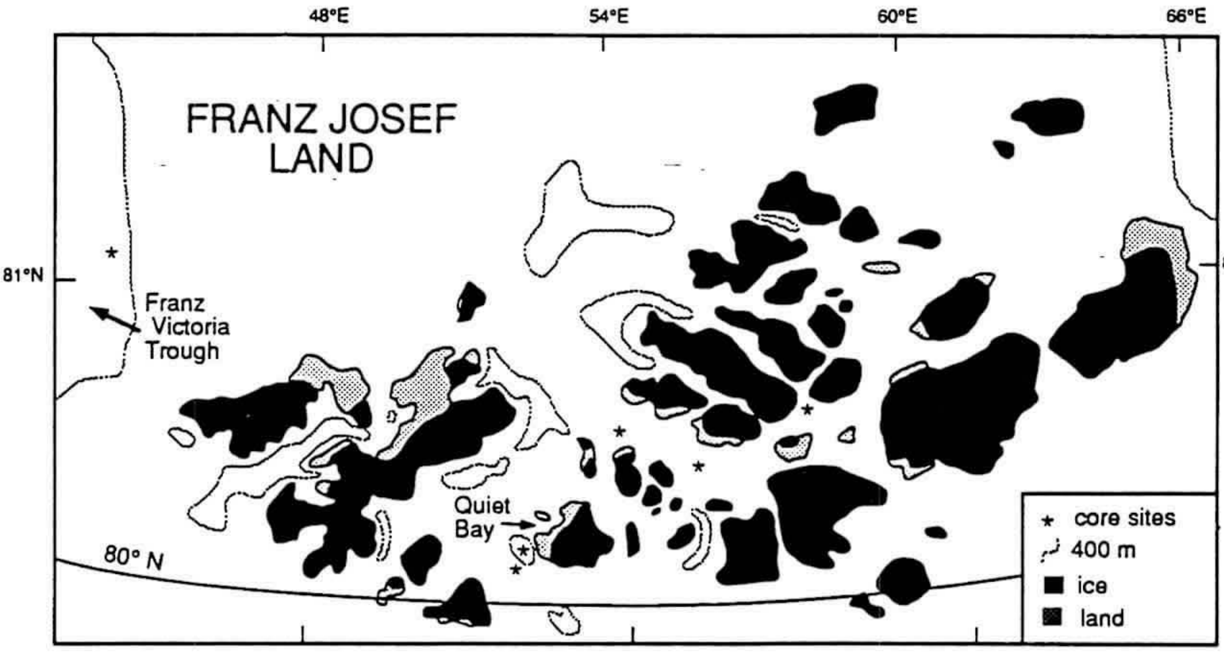
Miller, G.H., Forman, S.L., Synder, J.A., Lubinski, D.J., Matishov, G.G., and Korsun, S., 1992, Neoglaciation of Franz Josef Land, Russia, Geological Society of America, Abstracts with Programs, Annual Meeting 1992, A346.

NODC, 1991, Global ocean temperature and salinity profiles (NODC-02), Atlantic Ocean CD-ROM, National Oceanographic Data Center, Washington, D.C..

Salvigsen, O., Forman, S. L., and Miller, G.H., 1992, Thermophilous molluscs on Svalbard during the Holocene and their paleoclimatic implications, Polar Research, 11, 1-10.

Svendsen, J.I., Mangerud, J., Elverhøi, A., Solheim, and Schüttenhelm, 1992, The Late Weichselian glacial maximum on Western Spitsbergen inferred from offshore sediment cores, Marine Geology, February, 104, 1.

Figure 1. Map of Franz Josef Land and Eastern Franz Victoria Trough. Six core sites, the Quiet Bay transect, and the 400 m isobath are shown.



THE HISTORY OF DEPOSITIONAL ENVIRONMENTS FOR LATE QUATERNARY SEDIMENTS IN HUDSON STRAIT AND UNGAVA BAY

B. MacLean, G. Vilks, and B. Deonarine
Atlantic Geoscience Centre, Geological Survey of Canada, Bedford Institute of Oceanography, Dartmouth, Nova Scotia, Canada

Information on sediment distribution, depositional environments, geological history, and paleoceanographic conditions in Hudson Strait and Ungava Bay during the late Quaternary has been obtained from high resolution seismic reflection profiles and from cores.

Quaternary sequences underlying Hudson Strait and Ungava Bay include glacial drift/ice contact deposits, glaciomarine ice proximal and ice distal sediments, and postglacial sediments.

Glacial drift/ice contact sediment is widespread. Locally these sediments form moraines and include multiple sequences.

Glaciomarine and postglacial sediments mainly occur in basinal areas: in the large basin north of Ungava Bay in eastern Hudson Strait; in the basins that lie north and southwest of Charles Island; in basins along south central Hudson Strait bordering Ungava Peninsula, in adjoining bays and fiords; and in the southern part of Ungava Bay. Glaciomarine sediments dominate relative to postglacial sediments in all areas with the possible exception of southern Ungava Bay where a thicker postglacial section occurs (Vilks et al., 1989; MacLean and Vilks, 1992; MacLean et al., in press).

A transition from glacial drift to glaciomarine sediments occurs in many basin margin areas, and in the Wakeham Bay - Baie Héricart region of the south central part of the Strait where the late glacial ice margin was located offshore. This margin experienced late readvances of apparently limited extent. More extensive readvances of glacial ice appear to have occurred in the region north and northeast of Charles Island.

An AMS radiocarbon date (reservoir corrected) of 8990 ± 190 (Manley et al., in press) on foraminifera from Core 90-023-107 north of Baie Héricart provides further evidence for an early deglacial seaway along the south side of the Strait extending westward to Deception Bay. Extrapolation of sedimentation rates from dated intervals in this core to the base of the acoustically stratified section suggests that glaciomarine conditions possibly could have been present in this region as early as 11,900 BP (MacLean and Vilks, 1992; MacLean et al., in press). This is compatible with dates of 9400 - 9600 BP (Bruneau et al., 1990; Gray et al., 1992), and possibly as early as 10,700 BP (Kaufman et al., 1992), from shells in the Deception Bay area, and 11,970 BP from shell fragments in till from Akpatok Island (Gray et al., in press). The development of glaciomarine conditions probably was time transgressive from east to west.

A transition from glaciomarine ice distal to more saline early postglacial paleoceanographic conditions in the eastern basin was time transgressive from east to west between ca. 8730 and 7730. A subsequent change to relatively colder conditions occurred in the eastern basin ca. 6000 BP (Vilks et al., 1989; MacLean et al., in press).

References

Bruneau, D., Gray, J. T., and Lauriol, B., 1990. Glacial flow patterns and chronology of ice retreat in the Charles Island - Cap de Nouvelle-France sector of Hudson Strait. 19th Arctic Workshop, INSTAAR, Boulder, Colorado, March 1990, Program and Abstracts, p. 15-17.

Gray, J. T., Bruneau, D., MacLean, B. and Lauriol, B., 1992. Glacial flow patterns and chronology of ice retreat in western Hudson Strait: a terrestrial and marine record. 22nd Arctic Workshop, INSTAAR, Boulder, Colorado, March 1992, Program and Abstracts, p. 56-60.

Gray, J. T., Lauriol, B., Bruneau, D., and Ricard, J., in press. Postglacial emergence of the coastal fringe of the Ungava Peninsula, and its relationship to glacial history. Canadian Journal of Earth Sciences.

Kaufman, D. S., Miller, G. H., Gray, J. T., Stravers, J. A., Lauriol, B., Bruneau, D., and Jull, A. J. T., 1992. Chronology and configuration of late-glacial (12-8 ka) fluctuations of the Labrador dome at the mouth of Hudson Strait. 22nd Arctic Workshop, INSTAAR, Boulder, Colorado, March 1992, Program and Abstracts, p. 78-80.

MacLean, B. and Vilks, G., 1992. New seismo-, bio-, and chrono-stratigraphic data on Quaternary sediments in Hudson Strait and Ungava Bay. 22nd Arctic Workshop, INSTAAR, Boulder, Colorado, March 1992, Program and Abstracts, p. 95-97.

MacLean, B., Vilks, G. and Deonarine, B., in press. Depositional environments and history of late Quaternary sediments in Hudson Strait: further evidence from seismic and biostratigraphic data. Géographie Physique et Quaternaire.

Manley, W. F., MacLean, B., Kerwin, M. W., and Andrews, J. T., in press. Magnetic susceptibility as a Quaternary correlation tool: examples from Hudson Strait sediment cores, eastern Canadian Arctic. *in* Current Research, Part D, Geological Survey of Canada, Paper 93-1D.

Vilks, G., MacLean, B., Deonarine, B., and Currie, C., 1989. Late Quaternary paleoceanography and sedimentary environments in Hudson Strait. Géographie Physique et Quaternaire, v. 43, p. 161-178.

LATE-GLACIAL ICE-FLOW PATTERNS AND INTERACTIONS, HUDSON STRAIT COAST OF BAFFIN ISLAND

William F. Manley
INSTAAR, University of Colorado, Boulder, Colorado 80309-0450

Research during the 1992 field season helped to clarify the timing, extent, and flow patterns of early Holocene glacial advances on southern Baffin Island. Field work concentrated on two areas: the Soper Valley, north of Lake Harbour, and the north-central Hudson Strait coast between Bond Inlet and Barrier Inlet (Fig. 1). Related field work in 1991 spanned the intervening distance from Barrier Inlet to Lake Harbour (Manley and Kaufman, 1992). Prior work in the region (Blake, 1966; Clark, 1985) had found evidence for southward flow from a late-glacial ice dome over Amadjuak Lake (210 km NNW of Lake Harbour) that abruptly merged with an ice stream flowing east-southeast down the axis of the strait. This reconstruction later conflicted with the discovery of northward flow directly across the strait onto outermost Meta Incognita Peninsula during the Noble Inlet advance, ca. 8.7-8.3 ka (Miller and others, 1988; Miller and Kaufman, 1990). Goals for the recent field seasons were to resolve this conflict, and to determine how ice from separate dispersal centers interacted along the northern margin of the largest marine outlet of the Laurentide Ice Sheet.

Striations in the Soper Valley area record southward to southwestward ice flow during the last glaciation (Fig. 1). Preserved on unweathered bedrock surfaces mantled by drift, the striations were measured mainly on plateau surfaces 140-400 m above the broad and deep floor of the valley. The striations display orientations of 178° to 233° (with common evidence for generally southward – not northward – *sense* of flow), and show that late-glacial ice originated from an independent ice divide over Meta Incognita Peninsula (not the Amadjuak Lake area). Consistent south-southwestward flow on both sides of the upper valley show that ice directly crossed the valley without being deflected, indicating that the ice mass was relatively thick. Lack of a convergent flow pattern for all reaches of the valley shows that the valley did not act as a conduit for an ice stream. Marine bivalves from glaciomarine sediment in the lowermost reaches of the valley will provide a minimum age of deglaciation. Extensive outwash terraces below the projected elevation of the marine limit (about 95 m) indicate that final deglaciation followed major emergence. Generally southward flow over the Soper Valley area agrees with 1991 observations of southward flow on the coast from Lake Harbour to Barrier Inlet (Manley and Kaufman, 1992).

Striations and simple provenance indicators on the coast east of Barrier Inlet provide new evidence for extent of the Noble Inlet advance (Fig. 1). From Bond Inlet to Wight Inlet, striations depict flow of 350° to 22°. Within this zone, marine bivalves and Paleozoic limestone are common erratics above the marine limit, supporting reconstruction of northward flow across the floor of Hudson Strait. From Wight Inlet to Barrier Inlet, both northward and southward flow are recorded (15-35° and 190-205°). Within this zone of mixed ice flow, mollusc shells and limestone erratics at sites of southward flow suggest that southward flow is younger than northward flow, and that it reworked till deposited by northward flow. A generally monotonic increase in height of the marine limit across the zones of northward, mixed, and southward flow (from 47 m at Bond Inlet to 95 m at Lake Harbour) suggests that coastal deglaciation was approximately synchronous (given a steady westward increase in average late Wisconsin ice load). Mollusc shells from both till and glaciomarine sediment will be dated to bracket the northward advance. The data show that the Noble Inlet advance extended as far west as Barrier Inlet, where it apparently abutted against southward flow from an ice cap on Meta Incognita Peninsula. Shortly afterward, the boundary between the two ice masses shifted about 30 km to the east, followed by coastal deglaciation at ca. 8.1 ka. No evidence of flow parallel to Hudson Strait was found. Field work in 1993 will focus on the Big Island area west of Lake Harbour.

The recent field work confirms that the Labradorean sector of the Laurentide ice sheet experienced major oscillations during the closing stages of the last glaciation. The striation and provenance data significantly widen the known extent of the Noble Inlet advance. Together with similar evidence for north and northeastward flow along the coast from Bond Inlet to the tip of the peninsula (Stravers, 1986; Miller and others, 1988; Miller, unpub.), the data attest to a rapid flow of ice directly across the deepest portion of Hudson Strait. Indirectly, the data document a massive discharge of icebergs into the Labrador Sea. Like older northward advances of the Labradorean sector (at ca. 11 ka and 9.9-9.6 ka; Miller and Kaufman, 1990; Stravers and others, 1992), the Noble Inlet advance may have been triggered by regional climate changes (Miller and de Vernal, 1992). Furthermore, by discharging icebergs and meltwater, the advance may have altered suface ocean conditions and circulation (cf., Andrews and Tedesco, 1992; Bond and others, 1992).

References:

Andrews, J. T., and Tedesco, K., 1992, Detrital carbonate-rich sediments, northwestern Labrador Sea: Implications for ice-sheet dynamics and iceberg rafting (Heinrich) events in the North Atlantic: Geology, v. 20, p. 1087-1090.

Blake, W., Jr., 1966, End moraines and deglaciation chronology in northern Canada with special reference to southern Baffin Island: Geological Survey of Canada Paper 66-26, 32 p.

Bond, G., and twelve others, in press, Evidence for massive discharges of icebergs into the North Atlantic ocean during the last glacial: submitted to Science.

Clark, Peter, 1985, A note on the glacial geology and postglacial emergence of the Lake Harbour region, Baffin Island, N.W.T.: Canadian Journal of Earth Sciences, v. 22, p. 1864-1871.

Manley, W. F., and Kaufman, D. S., 1992, Late-glacial patterns of ice flow, glaciomarine sedimentation, and sea-level change near Lake Harbour, southernmost Baffin Island: 22nd Arctic Workshop, University of Colorado, Boulder, p. 98-100.

Miller, G. H., and de Vernal, A., 1992, Will greenhouse warming lead to Northern Hemisphere ice-sheet growth?: Nature, v. 355, p. 244-246.

Miller, G. H., and Kaufman, D. S., 1990, Rapid fluctuations of the Laurentide ice sheet at the mouth of Hudson Strait: New evidence for ocean/ice-sheet interactions as a control on the Younger Dryas: Paleoceanography, v. 5, p. 907-919.

Miller, G. H., Hearty, P. J., and Stravers, J. A., 1988, Ice-sheet dynamics and glacial history of southeasternmost Baffin Island and outermost Hudson Strait: Quaternary Research, v. 30, p. 116-136.

Stravers, J. A., 1986, Glacial geology of outer Meta Incognita Peninsula, southern Baffin Island, Arctic Canada [Ph.D. Disser.]: Boulder, University of Colorado, 231 p.

Stravers, J. A., Miller, G. H., and Kaufman, D. S., 1992, Late glacial ice margins and deglacial chronology for southeastern Baffin Island and Hudson Strait, eastern Canadian Arctic: Canadian Journal of Earth Sciences, v. 29, p. 1000-1017.

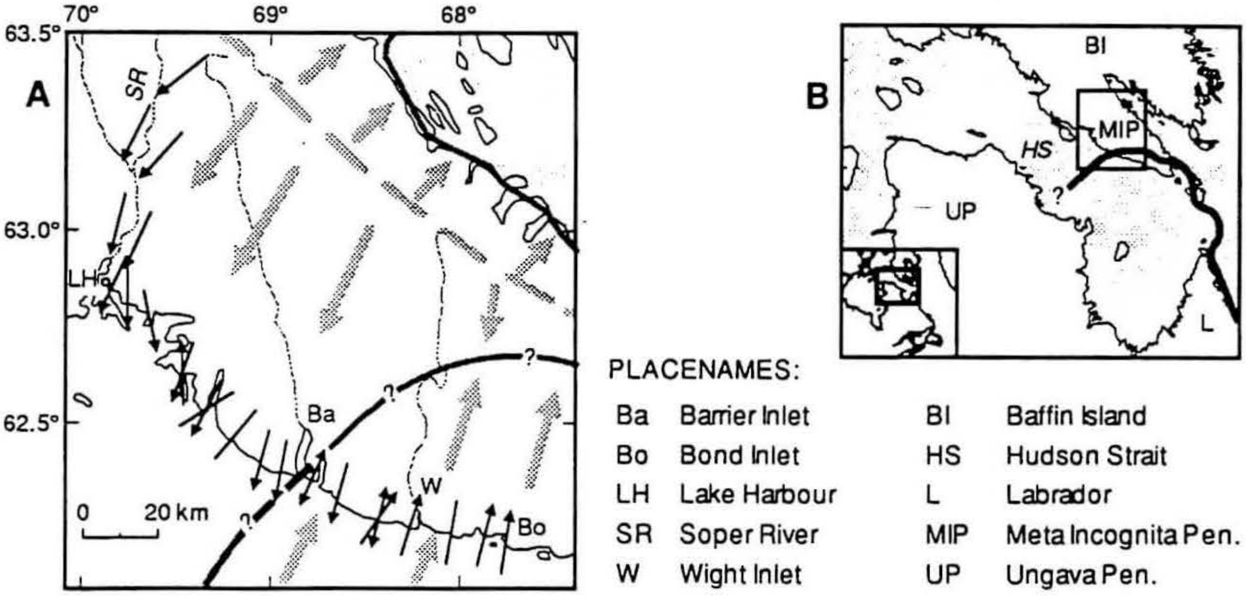


Fig. 1. A) Striations and inferred flow history for south-central Baffin Island ca. 8.5 ka. Each arrow represents several striation measurements. Stippled arrows depict inferred flow directions. Queried line marks boundary between ice masses. B) Location map showing maximum probable extent of Noble Inlet advance, ca. 8.5 ka (cf., Stravers and others, 1992).

ROBINSON LAKE: THE LONGEST LAKE-SEDIMENT POLLEN RECORD FROM BAFFIN ISLAND

William N. Mode[1], Gifford H. Miller[2], and Peter E. Sauer[2]
[1]*Department of Geology, University of Wisconsin-Oshkosh, Oshkosh, WI 54901-8649*
[2]*INSTAAR and Department of Geological Sciences, University of Colorado, Boulder, CO 80309-0450*

Robinson Lake, located in southeastern Baffin Island, was cored in May, 1991, using a Nesje corer. Fourth lithologic units were recovered beginning (at the base) with diamict, overlain by lake sediment, overlain by another diamict, finally overlain by lake sediment. The Nesje corer employs a weight for hammering directly on the coring head, and this allowed penetration and recovery of this variety of sediments. This paper concerns only the uppermost, postglacial lake sediments (117 cm) which have a radiocarbon age at the base of about 10,000 years B.P. Prior to recovery of the Robinson Lake core, the oldest lake sediments from Baffin Island were 9,200 years (Iglutalik Lake; Davis, 1980), and most lakes yield basal ages of 7,000 to 8,500 years.

The pollen stratigraphy is generally the same four assemblage-zones that have been identified in other postglacial pollen diagrams in Baffin Island:

Zone 1 (basal zone):	pioneer herb zone
Zone 2:	shrub tundra zone
Zone 3:	shrub tundra zone with exotic alder dominating
Zone 4:	shrub tundra zone

While none of these zones is well dated in any single pollen diagram, our preliminary geochronology suggests the following: 1) that replacement of pioneer vegetation (Zone 1) by shrub tundra (Zone 3) was time-transgressive and occurred earliest at Robinson Lake; and, 2) that the boundaries of Zone 3 (dramatic rise and decline in exotic alder) are synchronous, at least throughout southern Baffin Island.

References

Davis, P.T., 1980, Late Holocene glacial, vegetational, and climatic history of Pangnirtung and Kingnait Fiord area, Baffin Island, N.W.T., Canada, Ph.D. dissertation, University of Colorado, Boulder, 366 pp.

Rapid Holocene warming and cooling events in central Antarctica

E. Mosley-Thompson, L.G. Thompson, P.N. Lin, M.E. Davis, J. Dai
Byrd Polar Research Center
The Ohio State University

A 200-meter core from the Plateau Remote site (84°S; 43°E) on the high central Plateau of East Antarctica has been analyzed for oxygen isotopic ratios ($\delta^{18}O$) and dust concentrations. A total of 5603 samples representing the entire length of the core were analyzed for total dust concentration, size distributions and liquid conductivities. A total of 3578 samples, including every sample from 0 to 100 meters and every third sample from 100 to 200 meters, were analyzed for $\delta^{18}O$.

The use of $\delta^{18}O$ as a paleothermometer for East Antarctic precipitation has been well established by both the Soviet-French analyses of the very long Vostok core (>180,000 year) and the French analysis of the 900-meter Dome C core (≈32,000 years). The 4000 year Plateau Remote record discussed here has been analyzed in very high resolution. Near the top the sampling scheme allows three to four samples per year while near the bottom each sample represents approximately one year. These analyses provide the highest resolution histories currently available from any East Antarctic ice core and thus provide the first such look at the last half of the Holocene in this high, remote and cold region.

The isotopic record reveals a long, gradual cooling trend from ≈4000 yr.B.P. to the present. However, this 4000 year trend is punctuated by alternating multi-century long warming and cooling trends of at least $4^{\circ}/_{\infty}$. Note that the glacial to interglacial transition in the Dome C core was characterized by a $\delta^{18}O$ change of $6^{\circ}/_{\infty}$. In addition, the Plateau Remote oxygen isotopic record reveals at least ten abrupt (one to two decade) transitions between isotopically warmer and cooler conditions. These decadal-scale variations have magnitudes up to $6^{\circ}/_{\infty}$, persist for 30 to 80 years, and exhibit rapid rates of onset and offset. The longest and most pronounced warm episode occurred about 3500 yr.B.P., lasted nearly 200 years, and terminated abruptly with a $6^{\circ}/_{\infty}$ depletion in ^{18}O.

This paper will explore these warm/cool episodes in East Antarctica and their relationship to the corresponding dust and electrical conductivity records from this core. In addition, comparisons are made with temporally correlative Holocene histories available from a limited number of East Antarctic ice cores. The reconstruction of a more precise history of climatic conditions over the East Antarctic Plateau for the last half of the Holocene might help identify the mechanisms responsible for these rapid changes near the middle of East Antarctica.

Submitted for the 42nd Arctic Workshop to be held at The Ohio State University on April 1-3, 1993.

James Nicholas
Department of Geography, University of Cincinnati
Cincinnati, OH 45221-0131

RATES OF ACTIVE LAYER DEEPENING IN A BOREAL FOREST SETTING

Hourly measurements of soil temperature and a surrogate index of soil water ion concentration were obtained from the active layer over a permafrost body located in central Alaska. The data were collected at eight evenly spaced probes ($\Delta Z = 7$ cm) from near the surface (1 cm) to a depth of 50 cm, over the period 5 May-4 August 1992, which includes snow meltout and active layer development in summer. The high spatial and temporal resolution of the data set enables monitoring of active layer deepening over the entire thaw season. In addition, daily precipitation and air temperature were recorded.

The temperature data were contoured and presented as a time -depth temperature field. The zero degree isotherm on the contour plot represents the active layer-permafrost interface. Using this method, the active layer depth at any point along the time axis can be estimated and correlated to the degree days accumulated since snow meltout.

Using a modified form of the Stefan equation ($Z = \mathbf{B} \sqrt{\mathbf{ADDT}}$), the depth of the active layer was plotted against the $\sqrt{\mathbf{ADDT}}$. In this model, Z is active layer depth (cm), **b** is the slope of the regression line, and **ADDT** is the accumulated degree days of thaw since snow meltout. The correlation coefficient of 0.98 confirmed that the deepening of the active layer is largely a function of air temperature.

There are, however, variations in the rate of development as reflected by residuals from the best-fit line. These perturbations are probably linked to the transport of sensible heat down the soil column by precipitation infiltration, but may include downward transport of vapor from the atmosphere into the soil. Several heavy summer rainfall events are isolated, and clearly show the downward dilution of soil water associated with percolation. Concurrently, the temperature was observed to increase near the base of the thawed zone; rates of soil temperature change are increased by an order of magnitude above the primarily conductive rates.

Most general circulation models predict enhanced warming at high latitudes associated with increased concentrations of anthropogenic radiatively-active trace gases, and some suggest a significant increase in summer precipitation. The relationship illustrated here, if verified by further studies at similar sites, may enable standard meteorological data to be used to estimate seasonal active layer depth, impact of atmospheric warming on permafrost degradation, and the effect of precipitation on active layer development. The constant **b** should be similar for other boreal forest settings characterized by sparse forest underlain by permafrost and possessing a thick organic mat.

Modeling Polar Glaciation

Robert J. Oglesby
Department of Earth and Atmospheric Sciences
Purdue University

Understanding the nature and causes of polar glaciation is of fundamental importance to the study of past earth climates and possible future climatic change, as the cryosphere is a basic component of the climate system. Understanding the presence or absence of these massive continental ice sheets is important in its own right but also of considerable interest are the possible effects that these ice sheets might have on hemispheric or even global weather and climate.

A key measure of our understanding is the ability to model the initiation, maintenance, and elimination of glaciation over Antarctica and high latitude land masses in the northern hemisphere. For example, why is Antarctica glaciated at present, while we are currently in an interglacial northern hemisphere state, with ice sheets outside of mountainous regions restricted to Greenland and islands of the High Arctic. Was Antarctica largely or completely deglaciated early in the Cenozoic? What are the causes and implications of massive continental ice sheets over much of Canada, Scandinavia, and Siberia that occurred during the last glacial maximum?

A hierarchy of climate models, ranging from simple energy balance models to much more complex general circulation models (GCMs) has been applied to the study of polar glaciation. These studies will be reviewed briefly, emphasizing both the methodologies employed and the major implications of the results. I will then describe in some detail my own previous studies of Antarctic glaciation (Oglesby 1989; 1991; Prentice et al 1993) which address questions of Cenozoic Antarctic glaciation, with implications for the effects on southern hemisphere climate. I will next discuss studies that address questions of Pleistocene glaciation in the northern hemisphere (Oglesby 1990; Verbitsky and Oglesby 1992; Marshall and Oglesby 1993), again emphasizing both the effects of climate on glaciation, and glaciation on climate.

Among the key results and implications of these studies are:

(1) Important conclusions regarding Antarctic glaciation are that to first order the topography and polar position of the continent are most important in explaining the presence or absence of large ice sheets, while SST play a more secondary role, acting to modify the extent of glaciation but not its occurrence. Continentality (that is, the size of the continent without regard to geographic, or polar, position) appears to play a tertiary role at best; in particular this means that the attachment of Australia to Antarctica prior to about 40-50 Ma has little effect. This last result, based on GCM studies, is in contradiction to earlier EBM studies. At present, Antarctica is climatically 'detached' in large part from the rest of the southern hemisphere climate, although it serves as a tremendous heat sink. The southern hemisphere climate at mid and high latitudes is very much different when Antarctica is unglaciated, although it is difficult to separate effects due to the ice sheets from effects due to the factors that acted to eliminate the ice sheets.

(2) Important conclusions regarding northern hemisphere glaciation are that atmospheric CO_2

concentration has a significant effect on the location and extent of continental ice sheets, but that the total ice volume involved is small compared to the total amount observed at present or inferred to exist during the Pleistocene Ice Ages. Furthermore, snow cover as an initial condition plays a key role in determining model determined glaciation, suggesting the importance of a few consecutive years of abnormally heavy winter snowfall. A study under way by Felzer at Brown is investigating systematically the effects of northern hemisphere ice sheets on climate. Preliminary results suggest large local effects, but relatively small downstream effects unless the ice sheet is large enough and positioned properly to split the polar jet stream, a result also suggested by previous studies. The results also suggest that cold dry winds blowing from the ice sheets over warm ocean currents may have an impact on the circulations of both the atmosphere and the ocean.

All of these previous modeling studies suffer from use of crude models that in many ways are inadequate to the task at hand. The EBM can give a reasonable simulation of surface temperature but lacking a hydrologic cycle it cannot compute explicitly the net mass snow balance. The GCM can provide such acalculation, but current models suffer from (i) deficiencies in the simulation of the present-day observed climate, affecting the accuracy to which they can compute the large-scale convergence of water vapor; (ii) coarse resolution, meaning that topographic features and meso-scale climates cannot be adequately simulated; and (iii) simplifications and deficiencies in the treatment of snow physics, especially with regard to snow melt. The newest generation of climate models will have significantly higher resolution and with improved physics packages will hopefully better simulate the present-day climate. Also of potential importance is the coupling, or nesting, of a mesoscale model within a GCM. Marshall and Oglesby (1993) give a first step towards an improved snow physics paramaterization.

Soil Characteristics of the Upper Edoma Formation, NE Russia

C.L. Ping[1], S. Gubin[2], G.G. Mazhitova[3], and Y.L. Shur[4]

Edoma is a Yucutia term referring to remnants of terraces, which were dissected by thermokarst and erosion. It occurs mainly in some parts of Russian permafrost regions and mainly along coastal regions between the Kolyma and Yana Rivers. The term has been adapted by Russian scientists for describing thick series (up to 50-60m) of ice-rich syngenetically formed soil which is penetrated throughout by ice wedges. Soil material ranges from silty loam to sand. Edoma formation refers to late Pleistocene and there are a lot of evidences of wide distribution of similar deposits in the Northern Hemisphere in that time. The whole Edoma is a gigantic fossil soil, which was turned into permafrost during its formation layer by layer. The Edoma formation has received wide interest among scientists.

The modern soil is formed in the recent active layer, which depth in Northern Yakutia ranges from 30 to 60 cm. Between the active layer and relatively homogeneous typical Edoma there are two layers: first of them (transient layer) is about 10-15 cm thick, gleyed and characterized by mainly vertical shaped ice lenses. The second one (intermediate layer) with thickness to 1-1.5 m is also gleyed with stratified ice lenses and very distinct cryogenic structure (ataxitic). This layer is referred to as Holocene transformation, and is the result of the active layer depth decrease. In this Pleistocene transformation, many well-preserved fine roots penetrated throughout the horizon suggesting the syngenesis of rising permafrost and steppe succession. Below this layer, massive ice wedges interspaced with frozen soil materials. The ice wedges have alternate clear vertical bands of clear ice and ice with soil material. The ice wedges contain 5 to 10% minerals. The frozen soil mass contains up to 80% water in very fine ice lenses. Organic debris, plant residues, and woody fragments and fossils are common in this frozen soil mass. The organic carbon contents on a dry base vary little with depth, ranging from 1.2 to 1.8%. There are also many preserved fine roots extending to a greater depth, and the moderate fine to medium platy structure suggests the syngenetic process in which the permafrost rises with each increment of deposits, likewise the vegetation succession.

The surface of the Edoma in both the forest and tundra zone is characterized by hummocks and polygons, and the soils thus formed have varying drainages. Soils on the mounds have a thin organic layer (<5 cm) and thin A horizons (<2 cm), whereas soils along the frost cracks have thicker humus (Oa) and A horizons. The Bw horizons have moderately to strongly developed granular structure and pockets of frost churned Oa and A material, indicating the cryopedogenesis, including cryoturbation. Within the Bw horizons there are slightly gleyed pockets indicating seasonal saturation. The BCgf horizon is at the lower active layer and is gleyed. The frozen substratum (Cf) has characteristics of slier formation and the upper slier layer changes its status periodically between permafrost and seasonal thawed conditions dependent on short periods of climate changes. The thawed upper part of this horizon has strong coarse angular blocky structure breaking into moderate medium platy structure, indicating its cryogenic nature. The strongly gleyed BCgf or Cf horizons are buried soils because of reduced active layer depth during Holocene. The relatively constant depth of the active layer under the tundra and forest vegetation, and the thick exposure of the Edoma formation along drainages, rivers and sea cliffs provide an excellent opportunity for paleoenvironmental studies.

[1]School of Agriculture and Land Resources Management, University of Alaska Fairbanks, Palmer Research Center, Palmer, AK, USA.

[2]Institute of Soil Science and Photosynthesis, Russian Academy of Science, Pushchino, Moscow, Russia.

[3]Institute of Biological Problems of the North, Far Eastern Branch of the Russian Academy of Science, Magadan, Russia.

[4]Visiting Faculty, University of Alaska Fairbanks, Palmer Research Center, Palmer, AK, USA.

A COMPARISON OF GROUND ICE CHARACTERISTICS FOR TWO LOCATIONS IN THE HIGH ARCTIC.

WAYNE POLLARD
Department of Geography, McGill University, 805 Sherbrooke Str. W., Montréal, Québec, Canada, H3A 2K6

Ground ice is a significant component of surficial sediments in many permafrost areas of the world. The aggradation and degradation of ground ice contributes to the unique geomorphic nature and evolution of permafrost landscapes. Knowledge about the distribution, origin, and nature of massive ground ice and ice-rich sediments is necessary to assess potential terrain response to both natural and anthropogenic disturbance of permafrost. Ground ice studies may also provide useful proxy information on arctic palaeoclimates and palaeogeomorphology. This paper summarizes recent ground ice research for several sites on the Fosheim Peninsula, Ellesmere Island and Expedition Fiord, Axel Heiberg Island. The primary aim of this paper is to describe the nature and range of massive ground ice occurrence in these areas. In view of recent suggestions that buried glacier ice may form a significant component of ground ice in the western Canadian Arctic (French and Harry, 1989), a secondary aim of this paper is to describe differences between buried glacier ice and intrasedimental ice in high arctic permafrost. The term intrasedimental has recently been recommended for massive ice formed in place by freezing of groundwater (Mackay and Dallimore, 1991).

Ground ice is common in fine-grained marine sediments on the Fosheim Peninsula (Pollard 1991). Natural sections created by retrogressive thaw slumps and stream bank erosion expose ice masses ranging from 2 to 6 m high and 10 to 30 m wide. In the past three years 53 exposures of massive ground ice have been documented (Figure 1), they occur primarily in poorly bedded sandy silt and silty clay, and massive silty clay. The elevation of exposed ground ice bodies range from 10 to roughly 80 m a.s.l., and are all below the Holocene marine limit (Hodgson, 1985). Complete shells (*Mya truncata* and *Hiatella arctica*) are found at several locations in marine sediments directly overlying massive ice. On the Fosheim Peninsula massive ground ice tends to occur either as shallow layered bodies of dark coloured ice and sediment beneath 1-3 m of massive clayey silt (Type A), or as thick horizontally foliated white ice with clear ice bands beneath 5-10 m of laminated silty clay and massive sandy silt (Type B). Ice has also been documented as concordant layers up to 1 m thick in poorly lithified bedrock (Type C). The gradational and conformable nature of upper contacts of Type A ice and the concordant nature of Type C ice support a segregation and segregation-injection origin. The foliated appearance and whitish colour of Type B massive ground ice together with unconformable upper contacts make identification more problematic. Accordingly, the characteristics of Type B massive ice are described in more detail.

The Type B occurrence of massive ice includes layers of dark and white coloured ice, dark layers are composed of clear ice containing fine sediment laminae and randomly distributed small gas and sediment inclusions. The white ice contains high concentrations of small gas inclusions. In clear ice gas inclusions range from 1 to 5 mm in length with their long axes inclined roughly 10-15° from vertical. Sediment inclusions are limited to a few randomly distributed clumps of silty clay 1-2 mm long and silt particles. The foliated white ice contains layers of small (< 1 mm) vertically oriented elongated bubbles and bubble trains. Both ice types are composed of large anhedral to subhedral crystals that range from 1-15 cm^2. Crystal size is fairly uniform but shape is highly variable, the white ice bands display slightly more regular crystal shapes. Grain boundaries are predominantly straight with minor dislocations. In both, ice crystal fabrics display weak maxima inclined roughly 10-15° from vertical but approximately normal to the internal layering.

A $\delta^{18}O$ profile from a Type B site reveals a negative shift with depth and no distinct break between the massive ice and ice from the overlying sediments. For example, clear massive ice immediately below marine sediments and the reticulate vein and lens ice from the sediment had $\delta^{18}O$ values ranging from -29.7‰ to -30.7‰, while the white (bubble-rich) ice, which occurred deeper in the massive ice unit, ranged from -32.5‰ to -34.4‰. This pattern suggests that the ice occurring in the marine sediments and the clear ice at the top of the massive ice unit have a common origin, the negative shift that occurred with depth may reflect fractionation. Conductivities range from 180 to 1750 μmhos/cm. Ice at the base of the active layer had low conductivity values (180 -250 μmhos/cm) while reticulate vein and massive ice had conductivities from 900 to 1750 μmhos/cm. The conductivity of the deep white ice varied from 300 μmhos/cm to 650 μmhos/cm.

By comparison, the buried glacier ice studied occurs as a continuous core in the White Glacier moraine. A channel cut by meltwater has exposed a layer of massive ice and icy till 250 m long and 7-12 m thick. The massive and dirt-rich ice units can be traced laterally to exposures of basal ice in the terminus of the White Glacier. The identification of separate stratigraphic units is complicated by a lack of lateral continuity and the deformed nature of these materials. Based on ground ice characteristics and structure, 5 cryostraigraphic units can be delineated, this discussion focuses on a deformed massive ice section near the base of the moraine. Ice samples taken from the glacier are translucent to whitish in appearance and faintly foliated. The white colour and foliated appearance result from layers of gas inclusions corresponding to seasonal accumulation layers. Gas inclusions tend to be small (1-3 mm) and irregularly shaped, in many cases two or more bubbles coalesce to form complex shapes. The buried glacier ice has much the same appearance except it includes considerably more sediment and gas inclusion layers are highly deformed. Sediment inclusions can be grouped into 2 categories; first, a random distribution of fine sediment particles, and second, clumps of silty clay 1.0-2.5 cm wide loosely grouped into steeply dipping bands. The buried glacier ice displays medium to large subhedral ice crystals ranging in size from 2 to 5 cm^2. Crystal size and shape are relatively uniform through oriented block samples. Crystal boundaries are relatively short and straight. Most of the c-axes are clustered in two maxima inclined roughly 45° to the vertical. A zone of deformed ice displays a bimodal texture consisting of a few large crystals 3-8 cm^2 in a matrix of small to medium crystals 0.4-1.4 cm^2. The larger crystals are anhedral in shape with irregular grain boundaries and minor dislocations. The small grains are euhedral to subhedral in shape and have short straight boundaries. The fabric diagrams display no obvious preferred pattern but a series of weak horizontal maxima oriented roughly normal to the internal sediment bands. The conductivity of the glacier ice ranges from 90-140 μmhos/cm^2 while the buried glacier ice ranges from 110-200 μmhos/cm^2.

French, H.M. and Harry, D.G., (1989) Observations on buried glacier ice and massive segregated ice, Western Arctic Coast, Canada. Permafrost and Periglacial Processes, 1, 31-44.

Hodgson, D.A. (1985). The last glaciation of west-central Ellesmere Island, Arctic Archipelago, Canada. Canadian Journal of Earth Sciences, 22, 347-368.

Mackay, J.R. and Dallimore, S.R., (1992). Massive ice of the Tuktoyaktuk Peninsula Area, Canada. Canadian Journal of Earth Sciences, 29. 1235-1249.

Pollard, W.H. (1991). Observations on massive ground ice on Fosheim Peninsula, Ellesmere Island, Northwest Territories. <u>in</u> Current Research, Part E; Geological Survey of Canada, Paper 90-1E, p. 223-231.

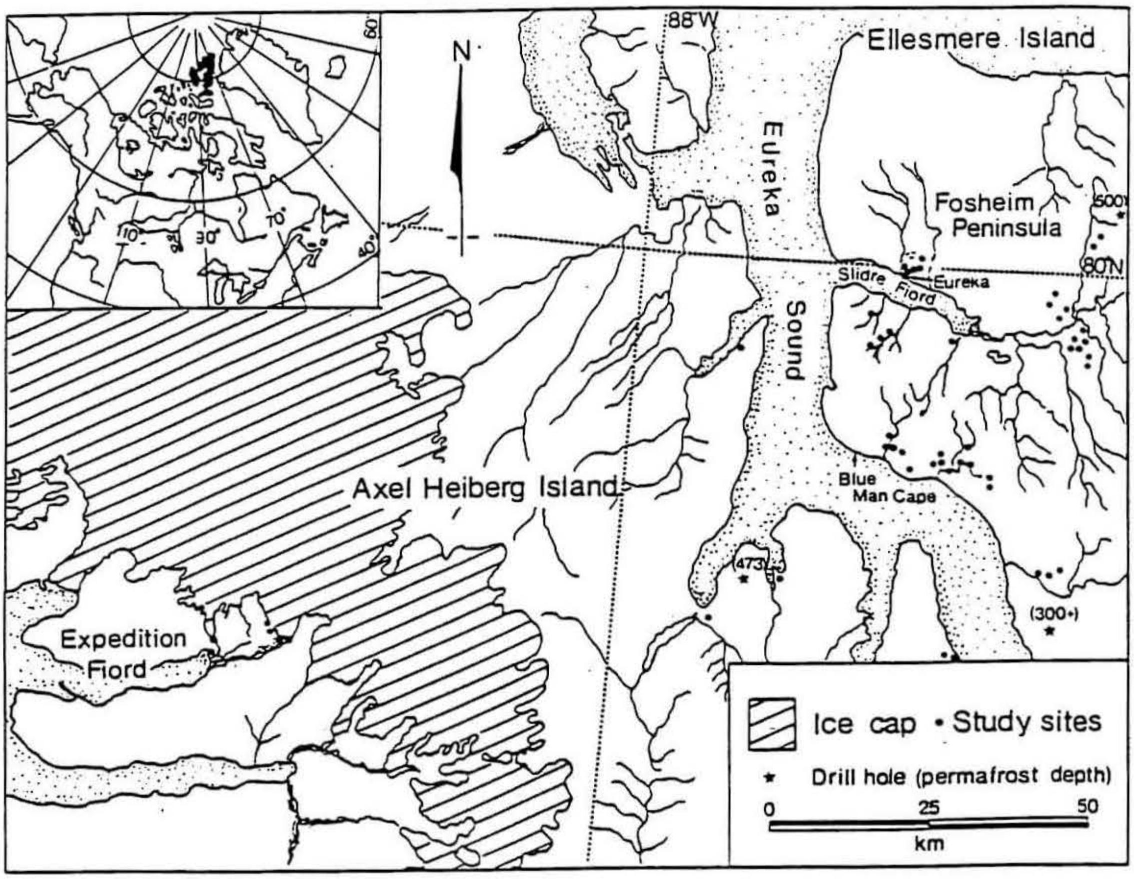


FIGURE 1: Distribution of massive ground ice exposures.

INTERPRETATION OF LAMINATED LACUSTRINE SEDIMENTS FROM NORTHERN ELLESMERE ISLAND, CANADA, BASED ON SEASONAL AND ANNUAL SEDIMENT TRAP YIELDS AND PROCESS STUDIES

RETELLE, M.J., Department of Geology, Bates College, Lewiston, Maine, 04240

During summers of 1990 through 1992, sediment coring and process studies were undertaken on a series of lakes at Taconite Inlet on northern Ellesmere Island, Canada. The main purpose of the research program is to recover records of laminated sediments preserved in meromictic lake basins and to interpret the paleoenvironmental significance of the records through detailed studies of modern climatology, hydrology, and sedimentology in one of the lake basins. The meromictic lakes contain finely laminated sediments due to density-stratification and anoxia in the bottom waters caused by isostatic uplift of these coastal basins from the adjacent marine waters. Preliminary ^{210}Pb and ^{137}Cs dating of the sediments suggests that the laminae are indeed annual deposits (unpublished data from Zolitschka, 1992a) and may provide a high resolution record of environmental change for the late Holocene of northern Ellesmere Island where high resolution records are distinctly lacking (Bradley, 1990).

Cores were recovered from all three lake basins in the study area and baseline limnological measurements were made in the lakes (Ludlam, 1992) and the adjacent fiord however the most detailed coring and process work was done on Lake C2, the central of the three lakes. Sediment traps were deployed in a grid pattern and included traps that were recovered daily and traps that were recovered at the end of the field season and redeployed to measure sediment accumulation over the intervening fall/winter season (Retelle and Child, 1992). Water column measurements were made twice daily early and late in the season and at 4 hour intervals during peak runoff using a Seacat CTD equipped with transmissometer and a dissolved oxygen meter. The laminated sediments were studied in detail by Zolitschka (1992a,b). Petrographic thin sections were made from undisturbed surface cores from Lake C2 and revealed that the sediments are finely laminated siliciclastic sediments with laminae thickness ranging from 0.1 to 1.0 mm. Other laminae up to 30 mm thick occur at intervals downcore and invite several preliminary interpretations.

Suspended sediment may be transported to the basin at various stages through the meltwater season. Sediment transport is initiated into the basin when thick slushflows carry sediment to the delta front and adjacent delta proximal area of the lake surface (Hardy, this volume). At late stages of the slush flow event and early thereafter, sediment may enter the water column through cracks and cylindrical holes in the ice up to 1 meter in diameter. The holes and cracks at the margin of the lake adjacent to the inlet stream are eventually enlarged to form a tongue-shaped moat that elongates parallel to the inlet stream jet by current erosion of the lake ice. Suspended sediment concentration in the water column generally builds and peaks during this phase of the season as the snowmelt freshet crests (Retelle and Child, 1992). One possible explanation for thicker than normal varves is that sustained radiation and warmth in the spring combined with thick snowcover causes greater than normal snowmelt and runoff.

A second explanation for thick laminae may be turbidite sedimentation. These episodic deposits represent sediment transported basinward either down the prodelta slope or from other slopes in the basin after sediment accumulates above the angle of repose on the steep slopes and may even be triggered loose by a shock from an earthquake or avalanche, for example.

A third probable explanation is that a second, large suspended sediment peak results from a late season precipitation event. In contrast to the early season snowmelt freshet, the landscape may be significantly free of snowcover and thawing of the surface may provide access to sediment from loose unfrozen surficial deposits. In 1991, sediment traps in Lake C2 yielded as much as twice the concentration of sediment from the late season (July 1991 to May 1992) than during the early phase (June to July 1991). This large amount of sediment is probably related to a significant late season precipitation (rain) event that occurred after the field party left the lake site in late July.
Several lines of evidence support the latter interpretation for a late season event that may produce a thick lamination in the sediment record:

(1) Significant sediment was found at all levels of traps within the water column from the surface to 80 meters depth and was not limited to the bottom trap, which would be expected if this late season sediment flux was due a turbidite slumping event.

(2) The sediment was not the seasonal accumulation of fine sediment that had not yet settled from the spring snowmelt freshet as it consisted of as much as 74% sand-size particles in delta proximal sediment traps and as much as 20% sand in the more distal trap sites. This coarse fraction would have settled from the water column almost instantaneously after the event that introduced it into the basin.

(3) Although the field party was not on site during the late season a sustained and drenching mid-August rainstorm has been detailed from several field stations on northern Ellesmere and adjacent Axel Heiberg Islands.

References Cited

Bradley, R.S., 1990, Holocene paleoclimatology of the Queen Elizabeth Islands, Canadian High Arctic, Quaternary Science Reviews, volume 9, p. 365-384.

Ludlam, S.D., 1992, The comparative limnology of the Taconite Inlet lakes, Ellesmere Island, N.W.T.: The 22nd Arctic Workshop, Program and Abstracts, Institute of Arctic and Alpine Research, University of Colorado, Boulder, Colorado, p. 92-93.

Retelle, M.J. and Child, J.K.,1992, Suspended sediment transport and deposition in a high arctic meromictic lake, northern Ellesmere Island, Canada; The 22nd Arctic Workshop, Program and Abstracts, Institute of Arctic and Alpine Research, University of Colorado, Boulder, Colorado, p. 117-119.

Zolitschka, B., 1992a, Sedimentation in a high arctic lake- first results: The 22nd Arctic Workshop, Program and Abstracts, Institute of Arctic and Alpine Research, University of Colorado, Boulder, Colorado, p. 150.

Zolitschka, B. , 1992b, Sedimentation in nonglacial arctic lakes at Taconite Inlet, Ellesmere Island, Canada: unpublished report to NATO Science Fellowships Programme, University of Massachusetts, Amherst-Abteilung Geologie, Universitat Trier.

DIATOMS BENEATH THE WEST ANTARCTIC ICE SHEET AND THE GLOBAL PROXY PERSPECTIVE

Reed P. Scherer
Byrd Polar Research Center, The Ohio State University
Columbus, Ohio 43210, USA

Controversy persists regarding the Plio-Pleistocene history of the marine-based West Antarctic Ice Sheet (WAIS). Glaciological measurements, theory and modeling show that the ice sheet is highly dynamic, and predict that it may be susceptible to rapid mobilization and periodic disintegration due to some combination of atmospheric and/or oceanic warming, sea level rise, and internal and basal ice sheet dynamics. Proxy records of sea level and ice volume have traditionally been interpreted as indicating a relatively stable ice sheet in West Antarctica since the late Miocene. However, West Antarctic contribution to global sea level and the oceanic oxygen isotope reservoir is relatively small. Furthermore, records of this kind cannot indicate the source of ice volume changes. Microfossils recovered from beneath the WAIS provide direct evidence of marine sedimentation in the West Antarctic interior. Till samples from three regions in the southern Ross Embayment contain abundant evidence of late Miocene and earlier marine deposition, supporting the view that the West Antarctic marine basins were largely unglaciated through the Miocene. Samples from one region (Upstream B) contain rare post-Miocene diatoms of probable Pliocene and late Pleistocene age, which represent marine incursions to at least 83° south latitude, subsequent to the initial formation of marine ice sheets in West Antarctica. Despite relatively broad chronostratigraphic control (~ 1-2 Ma), Plio-Pleistocene-age diatoms beneath the WAIS demonstrate a history of dynamic behavior of this ice sheet. In contrast, global proxy records of ice volume and water mass changes, which generally have good chronostratigraphic control, provide no specific geographic control on ice sheet changes.

With the new paleontologic data from beneath the WAIS, and assuming that climate cyclicity is the major control on the ice sheet, it becomes possible to identify specific intervals that are most likely to have undergone ice sheet collapse, by evaluating detailed proxy records of global ice volume and sea level. Recent oxygen isotope studies from the Southern Ocean (Hodell, in press) show that surface waters were warmer during isotope stages 7, 9 and 11 than at any other time during the last 2.5 million years. During these intervals, North Atlantic Deep Water penetrated deep into southern latitudes. Climatic and sea level records throughout the world suggest that Stage 11 (400,000 years ago) was a period of unusual warmth and climatic instability. Based on the occurrence of diatoms beneath the WAIS that are less than 2 million years old, coupled with the diverse global proxy evidence, I speculate that the WAIS may have disintegrated during Oxygen Isotope Stage 11. The possibility of collapse of the WAIS during subsequent interglacial stages appears possible but, at this stage, seems more conjectural.

Global Change at the Arctic Crossroads: Current Problems of the Late Cenozoic of Beringia

Dr. Andrei Sher
Severtsov Institute of Evolutionary Animal Morphology and
Ecology, Russian Academy of Sciences, Moscow

The Arctic is and was very sensitive to the global climatic changes, and Beringia, as the area of Arctic land and marine crossroads, is considered to be one of the best test areas for paleoecological research. Moreover, Beringia preserves the best paleoenvironmental record of the Late Cenozoic in the whole Arctic. The aim of this contribution is to outline the most important events in the terrestrial environment and biota of Beringia, which were certainly related on a major scale, i.e. global, changes in the Northern Hemisphere during the last 3 Ma (million years BP). Some of these events can be already traced across the whole Beringia (Asian and American), the other are still to be recognized on the other side of the present Bering Strait.

1. By the middle of the Pliocene boreal forests were essentially impoverished. They had lost their broadleafed components and most of the Miocene diversity of the coniferous plants. Reference sections: Begunov in the Lower Kolyma, Lava Camp in Alaska.

2. Progressive cooling had resulted in the establishment of rather low-temperature permafrost and appearance of lowland tundra plant, insect and mammal communities in the continental areas of West Beringia by 2.5 Ma. Reference site: Kutuyakh member of the Krestovka section, Lower Kolyma, probably correlative with the Fishcreekian of Arctic Alaska (cf. Repenning & Browsers, 1992, the First Cooling Cycle, 3.0-2.0 Ma).

3. The further cooling was accompanied by progressive continentalization of climate. By approx. 2.0-1.5 Ma the first insects, related with the modern steppe species, had appeared at the Lower Kolyma. Reference site: Loc. 8 in the Krestovka Valley.

4. Increasing continentality resulted in the development of treeless grassland and open parkland vegetation, further permafrost aggradation, and evolution of rich fauna of grazers (Olyorian Fauna). A possible period of maximum aridization in the Kolyma area straddles the Matuyama/Brunhes transition. It coincides with the important evolutionary changes in some Beringian mammal lineages, such as Dicrostonyx and Microtus. Reference site: Cape Deceit Formation in Alaska, Olyorian in Siberia and Old Crow Basin (Yukon). This stage corresponds to the Second Cooling Cycle of Repenning & Browsers, 1992 (2.0-0.85 Ma).

5. The extinction of many Olyorian mammals is not dated with a desirable accuracy. They are substituted by the faunal complex hardly separable from the typical Late Pleistocene mammal communities. This event can be probably correlated with the "beginning of the Ice Ages" of Repenning & Browsers (1992), but in the Siberian terms it is usually referred to as the Middle Pleistocene. However, during this period one very important paleoenvironmental event must be mentioned. Prior to this event only ice-wedge casts(though very numerous and large) can be found in Beringian sections. Since that time true ice wedges have been preserved, that means that there were no complete or major permafrost degradation later on. At present, this important event cannot be dated precisely, but it almost certainly took place during the Middle Pleistocene.

6. The fully developed cryoxerotic environment existed in Beringia during the late part of the middle and the whole late Pleistocene, being represented by the famous Mammoth Fauna (sensu stricto), tundra-steppe plant and insect communities, and enormous growth of the syngenetic ice wedges. The age of this environment corresponds to the development of the most prominent continental glaciation in the Northern Hemisphere. Contrary to the temperate latitudes, in Arctic Beringia the periods of relatively mild climate and higher temperature were not marked by important changes in faunal composition. There were no sharp shifts of latitudinal zones, documented in Europe or southern North America, and the tundra-steppe communities were able to survive through these "interglacial" stages.

7. The most radical change in the environment and community structure took place around the Pleistocene/Holocene boundary, when the Pleistocene communities (and some species) became extinct, being substituted by new communities, which very shortly after produced the present-day Arctic biota.

Each of these seven environmental history landmarks requires thorough study and comparison with possible correlatives in the temperate latitudes to recognize the most important global changes. The corresponding time-slices seem to deserve an intense international joint research focused on the Arctic Crossroads.

PRELIMINARY RESULTS FROM QUATERNARY GEOLOGICAL INVESTIGATIONS ON THE NORTHEASTERN KOLA PENINSULA, RUSSIA

SNYDER, J. A., FORMAN, S. L., Byrd Polar Research Center, The Ohio State University, Columbus, OH 43210; MILLER, G. H., INSTAAR, University of Colorado, Boulder, CO 80309; KORSUN, S., Murmansk Marine Biological Institute, Dal'nie Zelentsy 184631, Murmansk Region, Russia.

The extent of late Weichselian glaciation on the Barents Sea shelf and surrounding landmasses has long been a subject of controversy. The northeastern Kola peninsula is particularly important area to understand glaciation in the southeastern Barents Sea region. The scarcity of data concerning post-glacial emergence, ice-flow direction, and timing of deglaciation leads to vastly different ice reconstructions for the area. Particular controversy exists regarding the presence of ice centered in Novaya Zemlya or the Barents Sea extending to the Kola peninsula in late glacial times. In 1991 a joint Russian/American research project was initiated to study the history of glaciation in the region.

Preliminary field investigations conducted from Dal'nie Zelentsy (69°08'N; 36°05'E) to Vostochnaya Litsa (68°37'N; 37°50'E) have concentrated on the post-glacial relative sea-level history and indicators of ice flow direction. Two shore line levels are particularly well developed along the northern Kola peninsula. The lower shore level (12-16 masl) is dated by radiocarbon to 6500 yr BP and is correlated to the Tapes transgression in Scandinavia. Dating of the higher shore level (35-45 masl) is more problematic because of the absence of organics preserved on shore surfaces and the absence of sections containing marine fauna at this level. However, limited C-14 evidence from other parts of the peninsula suggest that the higher shore level is greater than 9500 yr BP. The trend of the Tapes isobase and other assumed synchronous shore levels suggests lesser ice load toward the eastern part of the peninsula. Based on radiocarbon dates collected so far, a preliminary emergence curve is constructed for the area. The presence of generally north-northeast trending striations on hilltop areas indicates dominant ice flow from the peninsula toward the Barents Sea. No evidence is observed for ice flow from the Barents Sea onto the Kola peninsula in the field area. Observed trends in post-glacial emergence and ice flow are all consistent with a sizeable ice mass centered on the Kola peninsula during deglaciation.

Future investigations will focus on early post-glacial deposits in the region. In particular, we plan to initiate a lake coring project in the next year. We will attempt to recover both marine and lacustrine sediments from basins below the late Weichselian marine limit. We anticipate that these records will provide a chronology of deglaciation and early postglacial emergence for the area. In addition, these deposits may provide a record of post-glacial marine and vegetative conditions for the region.

RECENT DISTRIBUTION OF CALCAREOUS BENTHIC FORAMINIFERA IN THE BARENTS AND KARA SEA.

Per Ivar Steinsund*, Leonid Polyak** and Morten Hald*
* Department of Geology, IBG, University of Troms , 9037 Troms Norway
** VNII Okeanogeologia, Maklina pr. 1, St. Petersburg 190121, Russia and
Byrd Polar Research Center, The Ohio State University, Columbus, OH

We have been mapping the recent distribution of benthic calcareous foraminifera using 520 surface sediment samples from this area. The Barents and Kara Seas have a steep climatic gradient with summer bottom water temperature ranging from -1.8 to 6.0 °C.

The reason for using only the calcareous foraminifera, is that this avoids problems assosiated with disintegrating agglutinated foraminifera and the result is more comparable with older sediments.

A factor-analysis has divided the samples into five different faunas. The result shows that the different faunas reflect the present watermasses and bottom sediments. Most of these species and faunas are well known from deglaciation sequences during the late Quaternary in northern Europe.

The distribution of the different faunas and most important species (Nonion barleeanum, Cibicdes lobatulus, Elphidium excavatum, Cassidulina reniforme, Islandiella norcrossi, Cassidulina teretis, Buccella frigida and Trifarina fluens) will be presented and discussed.

PROBLEMS ASSOCIATED WITH SEISMIC FACIES ANALYSIS OF QUATERNARY SEDIMENTS ON THE NORTHERN UK CONTINENTAL MARGIN

M S Stoker
British Geological Survey, Murchison House, West Mains Road, Edinburgh, EH9 3LA, Scotland

The interpretation of seismic facies in terms of specific lithological and geotechnical characteristics is a problem of very general interest. There is a common expectation that laterally persistent, acoustically homogeneous seismic units are associated with relatively consistent lithologies and geotechnical properties. Conversely, it is generally supposed that lateral or vertical changes in seismic texture necessarily indicate a change of sediment type or character. Although these expectations may be fulfilled in some locations, I believe that they are not infallible, and that reliance on seismic data without adequate groundtruth calibration can be shown in certain areas to lead to an unsatisfactory interpretation of the sedimentary succession.

On high-resolution seismic reflection profiles, the Quaternary succession is largely expressed in terms of units displaying either "structureless to chaotic" or "layered" acoustic signatures. The "structureless to chaotic" reflection configuration is characteristic of diamicton-dominated units which form regionally extensive, sheet-like sequences over most of the shelf area. Existing depositional models constructed for similar sequences on the mid-Norwegian and east Canadian shelves have been developed on the basis that this acoustic signature is indicative of subglacial till, even extending onto the upper slope. However, borehole and shallow core data from acoustically similar deposits on the northern UK continental margin indicate that glaciomarine deposits, including debris flows and turbidites, are also likely to be present.

The "layered" reflection configuration is typical of proglacial basin-fills such as the Witch Ground Basin in the central North Sea, as well as deep-water, slope and basin-plain deposits to the west of Shetland and the Hebrides. These sediments were deposited by a variety of mass flow, suspension and bottom current mechanisms. Despite the often lateral persistence of reflectors across the width of these basins, sediment cores have proved vertical and lateral, lithological and geotechnical variations associated with this seismic facies. However, examples are also presented from areas where the acoustic layering may locally fade or lose expression, laterally and/or vertically, but for which no significant change in lithology or geotechnical property has been recorded.

A striking example of the seismic facies problem is provided by the sediments preserved on the Hebrides Slope, west of Scotland, where the entire preserved section of the Plio-Pleistocene succession has been penetrated by BGS borehole 88/7, 7A (Fig. 1). On seismic profile, this 89m - thick sequence displays a marked vertical change in acoustic character; a strongly layered lower unit is overlain by a much weaker layered middle unit, in turn overlain by a stronger reflecting upper unit although there is loss of reflection towards the sea bed. The lower part of the lower unit locally downlaps and onlaps onto an irregular, eroded Miocene surface, whereas the upper part of the unit shows a laterally continuous draped reflection configuration. In borehole 88/7, 7A this unit correlates with sand-dominated, preglacial, marine deposits of Pliocene to early middle Pleistocene age, whereas the middle and upper units consist of homogeneous, mud-dominated, glaciomarine sediments of middle to late Pleistocene age. Despite the change in acoustic signature there is no discernible change in the lithology of the glaciomarine section. However, the change does appear to have some chronological significance, in that the weakly reflective middle unit broadly correlates with the Anglian glacial stage (about 440 to 350Ka), whereas the upper unit equates with the Devensian (Wisconsin) glacial stage (about 120 to 10Ka). Although there is apparent conformity of the units at the borehole site, a disconformity must separate the middle and upper units. Fossil evidence suggests a hiatus of up to 150,000 years. Significantly, when these units are traced back up slope evidence of erosion is observed on the seismic profile. Similarly, there is also erosion at the contact of the lower and middle units, which is clearly not observed at the borehole site.

The lack of lithological and acoustic correlation is very evident at this location. The lower and upper units are acoustically similar, but the former is sandy whilst the upper is muddy. However, the homogeneous, muddy, glacial section displays very obvious changes in acoustic signature. Moreover, the identification of at least one intra-Pleistocene erosion surface of substantial duration, within a seismically continuous section, may have some effect on the geotechnical parameters above and below this level.

The erosion of the uppermost part of the Hebrides Slope coincides with the loss of the layered character of the Plio-Pleistocene section, which becomes increasingly chaotic upslope. This lateral change in acoustic character may reflect the increased influence of glacially-related processes, in shallower water depths, on the deposition of the sediment. Additionally, the irregular nature of the intra-Pleistocene erosion surface provides a good wave scattering surface, which presumably increased the level of backscatter with a loss of acoustic stratification in the units, on the upper slope. These surfaces are interpreted to represent buried levels of iceberg ploughmarking further implying some physical disruption and turbation of the sediment.

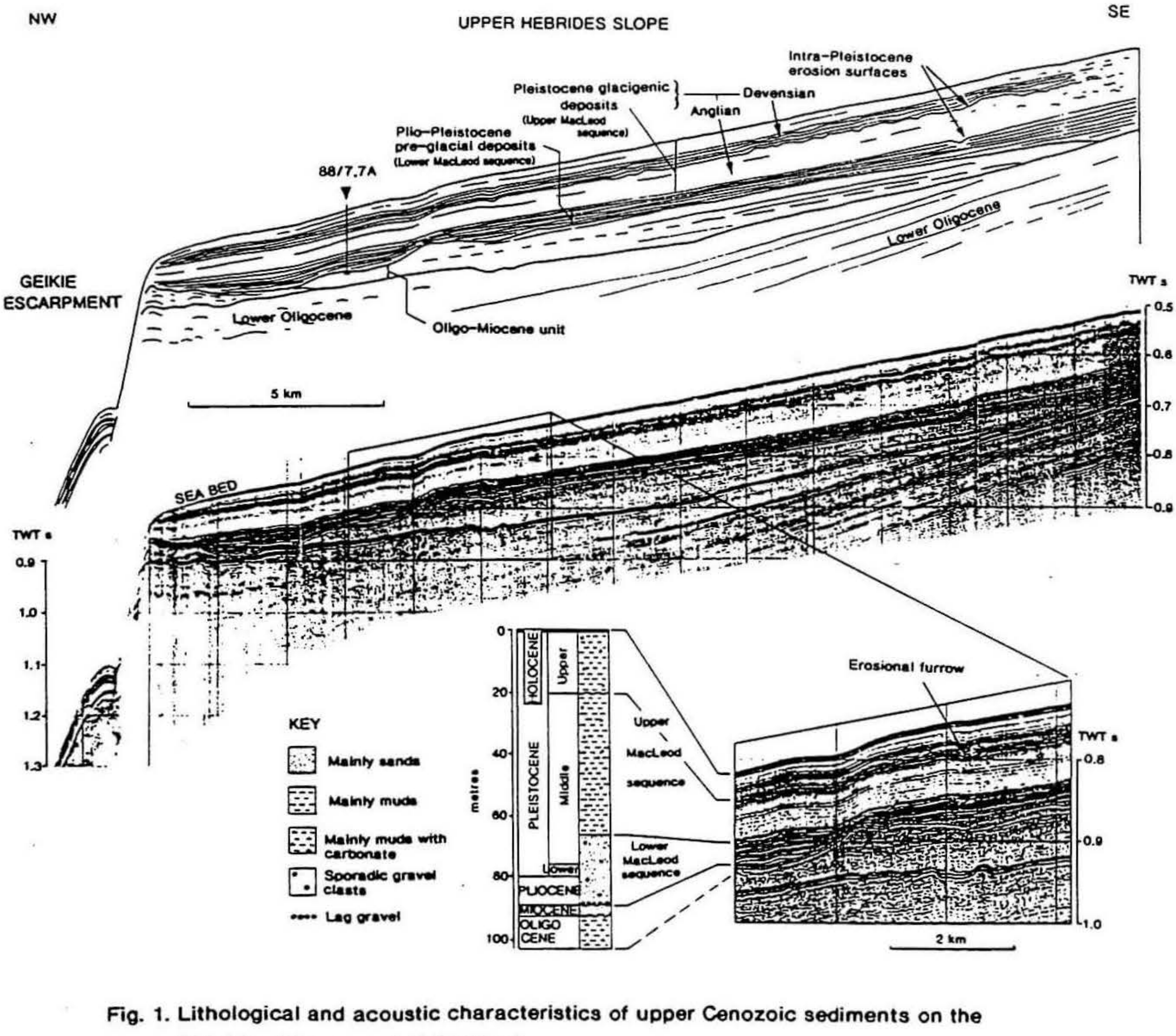


Fig. 1. Lithological and acoustic characteristics of upper Cenozoic sediments on the Hebrides Slope, west of Scotland

Glacial debris flow deposits on the Baffin Island shelf: seismic facies architecture of till-tongue like deposits.

Jay A. Stravers and Ross D. Powell
Department of Geology, Northern Illinois University, DeKalb, Illinois 60115.

Extensive seismic reflection coverage of late Foxe/Wisconsin glacial deposits in the Savage Basin enables us to model seismic facies distribution in 3-D. These data provide important new information concerning the morphology and origin of acoustically unstratified seismic units.

The southern portion of the basin is underlain by a thick sequence (locally over 110 m) of morainal bank deposits (Unit II) that are very similar to moraines and "till tongue root" deposits described from the Scotian and Norwegian Shelves and Gulf of St Lawrence. In 2-D longitudinal cross-section, Unit II thins and differentiates northward into two acoustically unstratified wedges or "till tongue" like deposits (Unit IIAw and IIBw) which are observed to interbed with stratified glacialmarine sediments (Unit I) displaying continuous parallel reflectors. The sense of sediment transport is to the northeast, consistent with the known ice flow out of Hudson Strait during the late glacial.

Both unstratified wedges are lobate in plan view with the thickest portion (5 to 50m) lying along the lobe axis. The upper unstratified wedge (Unit IIBw) consists of three distinct lobes labeled A, B, and C in Figure 1. Upper surface contours are convex to the north and mimic the lobate margin (Figure 1). Southward, at the transition to the morainal bank, the contours become concave to the north. This morphology is consistent with that of lobate viscous debris flow deposits with the concave contours defining a zone of sediment failure. Slump blocks are not observed along the distal margin of the moraine indicating cohesionless materials which deform completely upon failure. Slope gradients over which the debris flows travelled are very small and the distal portion of the lobes moved up slope against a gentle incline.

Lithological data for "till tongue" like deposits are rare however similar wedge shaped seismostratigraphic units in the Barents Sea have been sampled by Gataullin et.al. (in press) using shallow drilling techniques with continuous core recovery. Low sediment density and shear strength, high water content, and clast fabric all suggest a "flow till" or "water lain" origin for the wedge shape units.

In the Savage Basin sequence, multiple sediment failure escarpments and coalescing debris flow lobes are observed along the entire distal slope of the morainal bank. Without 3-D geometry, the complex lobate morphology cannot be resolved. The data indicate sediment failure within deposits which accumulated near the terminus of a temperate ice sheet (Figure 2).

Truncations of Unit I reflectors against the lower surface of the debris flows indicate that the wedges were deposited episodically and that they remobilized or eroded some of the underlying Unit I sediments. This unconformable relationship gives the same stratigraphic sequence that would develop under the proposed model of "till tongue" formation from subglacial meltout beneath neutrally buoyant ice in contact with the seabed.

Gataullin, V., Polyak, L., Epstein, O., and Romanyuk, B., (in press), Glacigenic deposits of the central deep: a key to the late Quaternary evolution of the eastern Barents Sea. Boreas, in press, 1993.

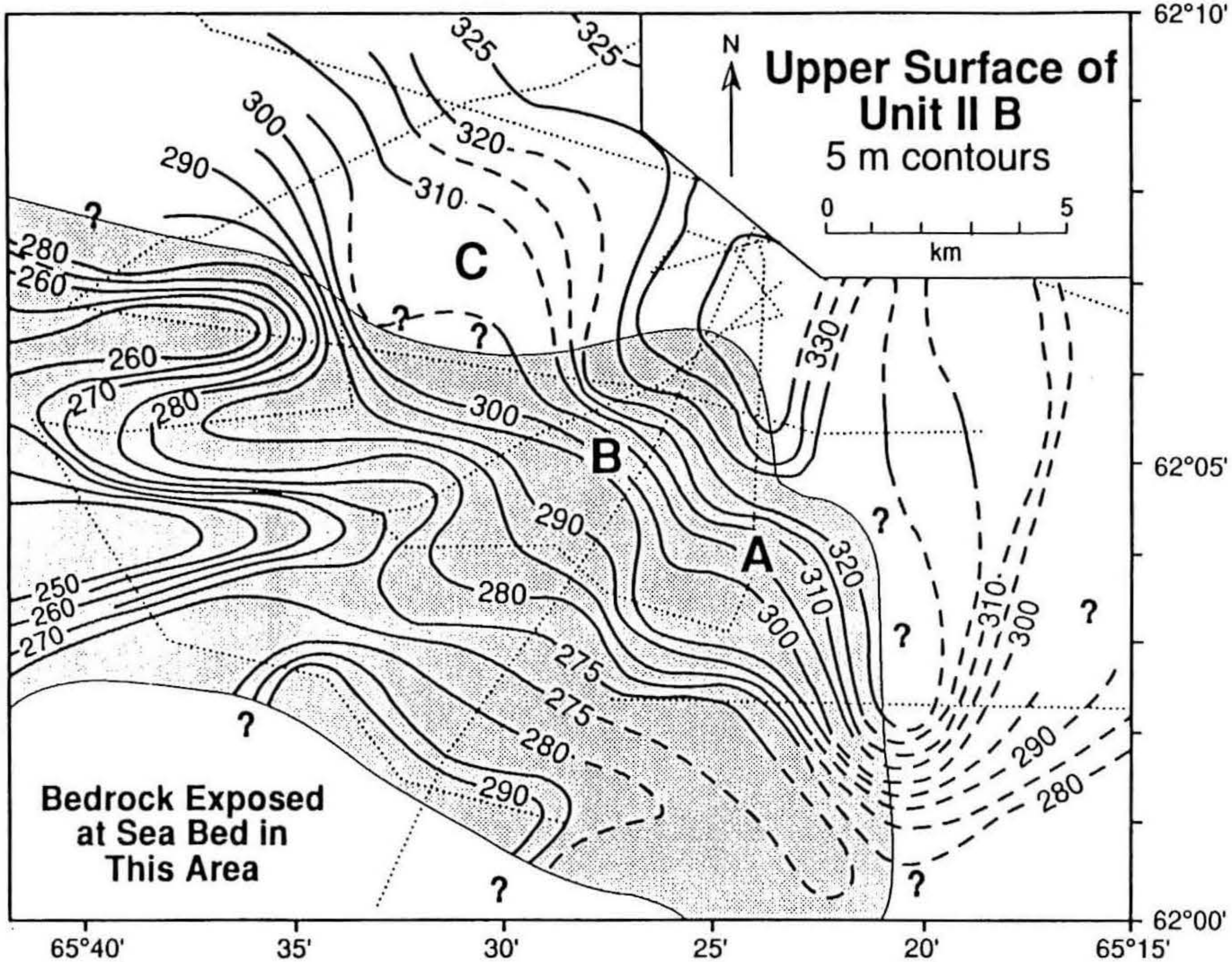


Figure 1: Paleobathymetric map of the seabed reconstructed for the time period just after the deposition of Unit IIB. Contours define the surface of Unit IIB and depths to equivalent stratigraphic horizons in the surrounding stratified glacialmarine sediment. The stippled pattern outlines the extent of Unit IIB deposits as defined by the seismic data. Dashed contours show regions of sparse seismic coverage where we are less certain of the paleo-bathymetry.

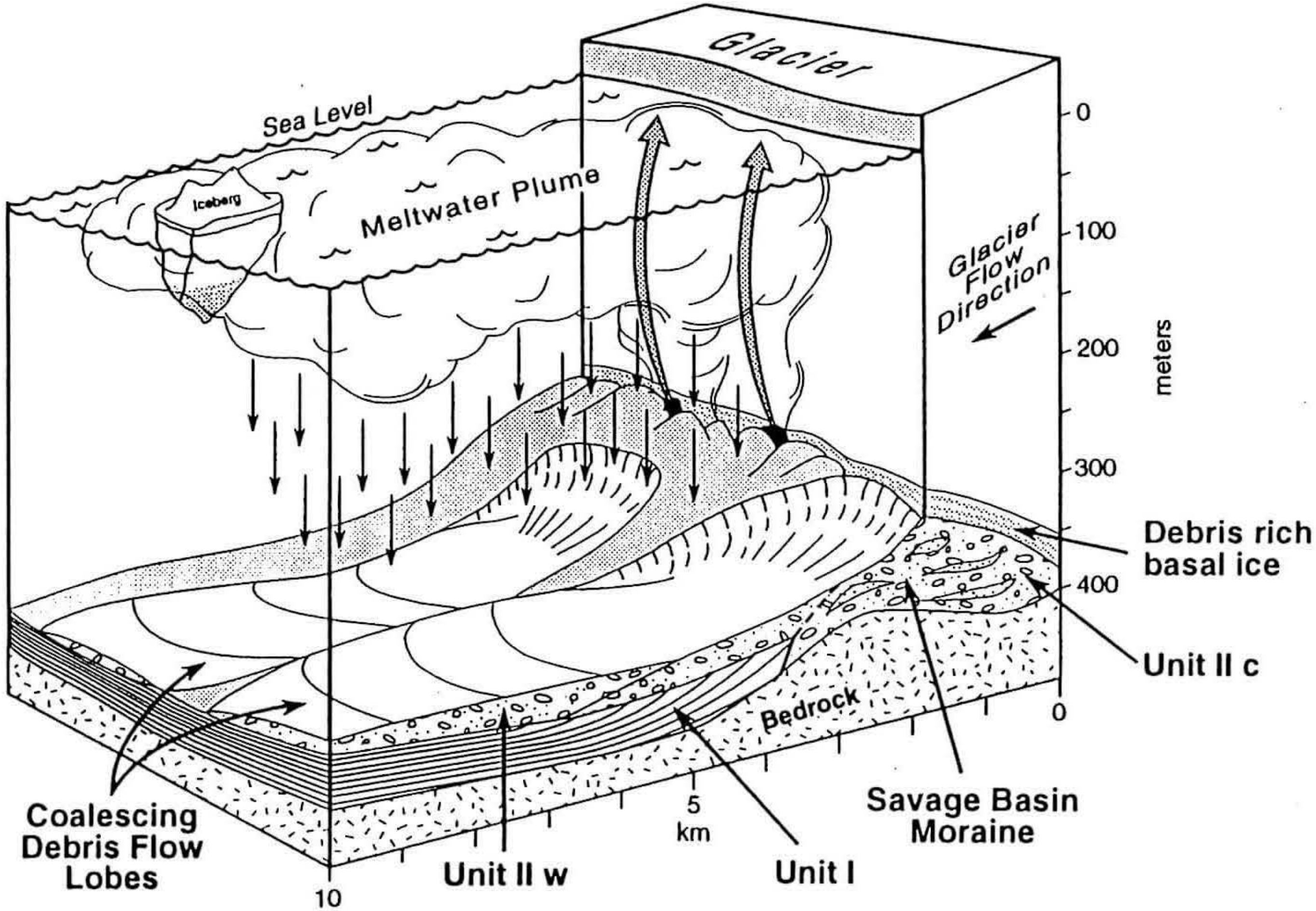


Figure 2: Model for the development of a "till tongue" like stratigraphy from sediment failure and viscous debris flow at the terminus of a temperate ice sheet.

Seismo-stratigraphic facies of submarine moraines and other ice terminus deposits

James P.M. Syvitski
Geological Survey of Canada
Bedford Institute of Oceanography
Box 1006, Dartmouth, NS
Canada, B2Y 4A2

There are no morainal types recognized on land that could not have their marine counterparts. Submarine moraines may have deposited subaerially and then later become submerged during a marine transgressive event, such as the early Holocene post-glacial eustatic rise of the ocean surface. More commonly, submarine moraines would have been deposited directly within the marine environment concommitant with the advance or retreat of ice sheets across the continental shelf. In the latter case, glacimarine processes would replace the styles of sedimentation associated with glacifluvial action. Glacimarine processes include the effects of iceberg calving, river plume dynamics, and turbidity currents, and would produce different types of debris flows and ice stagnation deposits than found on land. On land, the position of an ice terminus is largely a function of ice flow and ablation, and thus dependent on fluctuations of the equilibrium line altitude (ELA) of the ice mass. In the marine environment, the position of an ice terminus is less affected by ELA fluctuations, and more controlled by iceberg calving dynamics and water depth.

Extensive high-resolution r seismic eflection surveys of the Canadian continental margin have revealed a large variety of glacigenic deposits arguably formed at quasi-stable ice front termini. These morainal deposits often have a radical assymetry to their cross-sectional form. The seaward side is often a thinning wedge of stratified deposits that extends for many kilometres (in the St. Lawrence Estuary the morainal wedge extends for 200 km: Syvitski and Praeg, 1987). This is in contrast with steeply convex deposits located on the landward side of the morainal crest, which are often acoustically unstratified and extend for much shorter distances. It is not uncommon for the landward side of the morainal crest to have failed and slumped.

Occasionally, the crests of submarine moraines extend on land (Stravers and Syvitski, 1991; Hein et al., in press) where they have been interpreted as paleo-ice front deposits. Some moraines have ridge crests hundreds of kilometres long, particularly where the paleo-ice front was unconstrained by bathymetry and ice flow lines may have diverged (Hein et al., in press). In such cases the morainal surface is relatively smooth, like the surface of a submerged fan-delta. The base of such moraines may cross paleo-bathymetric contours, although the crest remains roughly parallel to bathymetry.

Where a paleo-ice front was a site of converging flow lines, such as the case for an ice stream, the moraine#s crest is generally the width of the confining basin. Such moraines are typically very thick (50 to 500 m) as a result of the nature of confined sediment accumulation. Associated high rates of sedimentation commonly lead to slope instabilities and debris flow deposition. Stacked moraines are common to some fjords, for example in Maktak Fiord, Baffin Island, where the positions of eight paleo-ice margins can be observed. Stacked moraines differ somewhat from the thrust moraines described for Chaleur Bay (Syvitski, in press) and Itirbilung Fiord (Syvitski and Hein, 1991) in that massive sediment deformation of the seaward glacimarine strata is not observed.

In Hamilton Inlet (Lake Melville), Labrador, stacked moraines account for over 500 m of glacimarine sediments. Paleo-ice front positions of the Melville Ice Stream would have occurred during the rapid ice ablation period of the early Holocene. Nearby gravel pits have uncovered rounded boulders in excess of 10 m in diameter, attesting to the high volume of water draining off of the ice sheet and into the coastal basin.

Other morainal forms, such as push moraines, and supraglacial (medial, lateral, frontal dump) moraines have also been recognized in the offshore. Push moraines often appear as ribbed clusters, are seldom in excess of 10 m in height, are commonly interfingerred with ice proximal sediments, and occasionally show evidence of ice tectonics. Marine push moraines are associated with relatively shallow water depths, thus reflecting the retreat phase of an ice sheet and the influence of terrestrial ice dynamics. In contrast, supraglacial moraines can be volumetrically large and appear stratigraphically unrelated to the overlapping glacimarine sediments and the underlying bathymetry. Stagnation moraine deposits are seldom discernible in the offshore, although their presence may be inferred from the presence of features indicating a collapse of overlying sediments through thaw of buried ice masses.

SYVITSKI, J.P.M. and PRAEG, D.B. 1989. Quaternary sedimentation in the St. Lawrence Estuary and adjoining areas. An overview based on high-resolution seismo-stratigraphy. Geographie physique et Quaternaire, 43(3): 291-310.

SYVITSKI, J.P.M. and HEIN, F.J. 1991. Sedim entology of an arctic basin:Itirbilung Fiord, Baffin Island, Canada. Geological Survey of Canada Prof. Paper 91-11, 67#pp.

STRAVERS, J.A. and SYVITSKI, J.P.M. 1991. Early Holocene land-sea correlations and deglacial evolution of the Cambridge Fiord basin, Northern Baffin Island. Quaternary Research 35: 72-90.

SYVITSKI, J.P.M., 1992. Marine Geology of Baie Des Chaleurs. Geographie physique et Quaternaire. 46(3): in press.

HEIN, F.J., SYVITSKI, J.P.M., Long, B. and Dredge, L 1993. Quaternary sedimentation in the Sept-Illes area, Quebec North Shore: Potential for marine placer. Canadian Journal of Earth Sciences (in press).

MECHANICS OF ICE STREAM B, ANTARCTICA

I.M. Whillans and C.J. van der Veen
Byrd Polar Research Center, The Ohio State University

Measurements of surface velocity on ice stream B indicate that this rapidly-moving glacier is controlled from the sides. Velocity and surface slope have been determined over two transects across ice stream B by repeat photogrammetry. In addition, more widely-spaced velocities along the entire ice stream are available by repeat photogrammetry. The data show that the nearly stagnant interstream ridges provide most of the resistance to motion, and the ice moves almost without friction over the bed. Resistance from gradients in longitudinal tension or compression, as advanced in some earlier models, is comparatively unimportant. No important basal obstructions to flow (sticky spots) of horizontal dimension between 1 and 20 km are found. This means that fast ice-stream flow is enabled by a well-lubricated bed, but controlled from the sides. The dynamics of the margins, and hence the evolution of the entire ice stream, are tied to strain heating, crystal fabric development, advection of ice from the interstream ridges, and stress transmission from the ice stream to the interstream ridges.

Northern Hemisphere Vegetation during the mid-Pliocene: subarctic to subtropical transect

Debra A. Willard, U. S. Geological Survey, 970 National Center, Reston, VA 22092

Middle Pliocene pollen assemblages from sites from 27° - 67° N were analyzed to study the latitudinal distribution of vegetation during the middle Pliocene warm interval and to determine which mechanism for warming is fit best by vegetation data.

Pollen assemblages from ODP Site 642 in the Norwegian Sea and the Tjörnes Sequence of Iceland are dominated by *Pinus* and *Picea* pollen. *Quercus, Alnus, Betula,* and *Ilex* pollen also are present at both sites, as well as *Castanea* (Tjörnes), *Sciadopitys,* and *Pterocarya* (642). The presence of pollen from plants presently found in more temperate regions suggests that Pliocene temperatures were warmer than today at both sites; Tjörnes probably had winter temperatures at least 4° C warmer than those of today.

Samples from deep-ocean sediments from ODP Site 646 in the Labrador Sea are dominated by *Pinus* pollen, with *Picea* subdominant and *Abies, Betula, Alnus, Quercus, Sciadopitys,* and *Tsuga* present in most samples. These assemblages were compared to modern samples using the Modern Analog Technique (MAT) of dissimilarity coefficients, and the closest modern analogs are from Newfoundland and Nova Scotia. If the source area for pollen at Site 646 is Labrador or Quebec, as suggested by present wind patterns, then these data indicate an expansion of the northern hardwood forest into Labrador and Quebec and indicate that Pliocene temperatures in those regions were at least 3.5° C warmer than today with higher precipitation levels.

Pollen assemblages from the shallow-marine sediments of the Yorktown Formation in southeastern Virginia are dominated by *Pinus* , with *Quercus, Carya,* and *Sciadopitys* pollen commonly present. The closest modern analogs are from North Carolina and South Carolina, indicating Pliocene temperatures about 2° C warmer than today and higher precipitation levels. The Pinecrest Beds of southwestern Florida also are dominated by *Pinus* pollen, with *Quercus* and taxodiaceous pollen also abundant. These assemblages are analogous to modern assemblages from sites along the coast of Florida that represent the longleaf/slash pine forests that cover much of the Atlantic coastal plain and indicate no significant differences between Pliocene and modern temperatures in this subtropical region.

The presence of vegetation characteristic of temperatures much warmer than present at high latitudes grading southward to present-day temperatures at low latitudes is similar to patterns shown by marine invertebrates in both degree and timing of change. The relatively greater amplification of temperatures at subarctic sites is consistent with predictions by climate models using increased meridional heat transport as the mechanism for middle Pliocene warming in the northern hemisphere. The northern expansion of both the boreal forest and northern hardwood zone is consistent with the existence of little or no land ice on Greenland during the middle Pliocene.

POSTER SESSION

(Listed Alphabetically)

The plankton environment of the Archipiélago de Magallanes, Chile

David M. Anderson[1] and Richard B. Archer[2]

1. NOAA Paleoclimatology Program, Boulder, Colorado
2. Department of Evolutionary, Population, and Organismic Biology, University of Colorado, Boulder, Colorado

Marine plankton shells found in the rapidly accumulating sediments of the Chilean fjords provide a potential high-resolution record of climate in a region where marine paleoclimate data coverage is poor. To improve our understanding of how climate is recorded by the plankton in sediments from this region, we sought to characterize the marine plankton environment using hydrographic observations. Along the southern coast of Chile, annual-mean sea surface temperatures (SST) indicate a steep zonal gradient that decreases from 14°C at 40°S to less than 5°C at the southern end of Chile. The amplitude of the seasonal cycle is largest (6°C) at 40°S, and decreases southward. Compared to surface waters farther offshore, coastal SSTs are slightly cooler, reflecting the influence of the Humbolt current that advects cold water into the region from the Southern Ocean. This region traverses the subtropical to subpolar habitat of planktonic foraminifers, and we found abundant *Globigerina bulloides* and *N. pachyderma* right-coiling in sediment samples from the southern continental margin. Within the fjords, surface salinity's are affected by the abundant precipitation that occurs in this region- in the upper fjords off the Estrecho de Magallanes, salinity's drop to less than 14 psu because of the fresh water input. We expect to test the hypothesis that the change in salinity is accompanied by a change in the $\delta^{18}O$ content of the surface ocean reflecting the input of ^{18}O-depleted runoff, providing an index of precipitation that may be preserved in the plankton shells. Along the Estrecho de Magallanes, surface water properties are homogeneous, probably because of strong tidal currents that exist there. While additional observations are necessary, these measurements provide a preliminary view of the physical processes that influence plankton sedimentation within the region.

Time Series Animations of Co-registered Digital Elevation Models and SSM/I Brightness Temperature Data Over Greenland and Antarctica

D. Anderson, K. C. Jezek

Abstract:

During the past decade, long time series of passive microwave data sets have become available over the polar regions. These data can be used to study important glacial, atmospheric and oceanic processes. However, the data volume is large and the data area is extensive, requiring researchers to develop methods that need to be able to easily manipulate and visualize these data sets. Further more, a key attribute of these data is their sequential format, which can be used to develop unique intuitions about changes in the dynamical processes with time.

In order to inspect the data over Greenland and Antarctica and to retain the basic temporal information provided by the passive microwave data, we have developed a tool that can easily create images of consecutive days of data and then combine them to form animations. In order to help visualize the glaciologic aspects of the data, the images in the animations consist of two distinctive data sets; a Digital Elevation Model on which is overlaid the Passive Microwave Data, providing a 3D image. We are presenting synchronized animations of Antarctica and Greenland with 37 GHz channel data over a period of time from 9/87 to 3/91.

So far four polar processes can be identified in the animations; surface melting, sea ice coverage, temperature variances, and weather fronts and patterns. Analyzing these processes is aided by the animations in that they allow the researchers to see spacial and temporal interactions. The weather patterns, in particular, influence the surface melting seen on the icesheets. The seasonal ebb and flow of the sea ice is a dramatic event that can cover hundreds of kilometers in only a few months that also corresponds to a change in the temperature on the icesheets themselves.

The animations themselves provide a unique view of both poles simultaneously, side by side: winter at one pole, summer at the other.

ARE YOU BEING SERVED?

Martha Andrews
Institute of Arctic and Alpine Research
University of Colorado
Boulder, CO 80309

Are the needs of polar information users being met adequately?

A project is currently underway by the author to rationalize bibliographic control of the published results of polar regions research.* The purpose of this project is to improve secondary sources of information (indexes, bibliographies, etc.) so that the user has the widest possible access to polar information.

But, do the providers of information to the polar research community give adequate consideration to the concerns of the user? In order to gain insight into this question, a poster is presented raising awareness of what happens to a research paper once it is published. For instance, what journals are likely to reach the widest audience? Some journals are indexed completely, and even in duplicate, by one or more access services (Cold Regions Bibliography Project, Scott Polar Research Institute, etc.) while other journals or individual papers are not selected for inclusion. Some subjects (glaciology, geology) are better covered by the access services than others (palynology, botany). Are conference papers adequately indexed? Book chapters are notably under-represented on indexing services, as is the ever elusive "gray" literature.

Yet for the information provider, there is a lot we can learn about where the user finds information references in a typical published paper, since nearly 40% of the references cited are not found readily in secondary information sources (bibliographies, indexes, etc.). How are these identified by the scientist who references them, and can we serve the scientific community better?

These concerns, and an open-ended interaction regarding them, can help both the user and the provider of polar research information operate more effectively. The results of this poster session will be incorporated into future planning for access to polar information resources.

---

*"Distributing responsibilities for accessioning and indexing polar regions information." Supported by Council on Library Resources Grant 897.

STRATIGRAPHIC AND GROUND PROBING RADAR INVESTIGATIONS OF GROUND ICE ON THE FOSHEIM PENINSULA, ELLESMERE ISLAND, N.W.T.

Peter Barry, MSc.
McGill University Geography Department, Montreal, Quebec, Canada H3A 2K6.

ABSTRACT

Stratigraphic investigations of twenty-eight retrogressive thaw slumps near Eureka, west central Ellesmere Island, were conducted in 1991. Ground ice was found to occur in two general settings: 1) as shallow ice-rich silt with pure ice layers several centimetres thick at depths of one to five metres, overlain by silt and silty sand containing shell fragments; and 2) as deep massive ice at depths of approximately ten metres, overlain unconformably by massive clay and silty clay containing shells (Figure 1). In many cases, massive ice contains laminae of silt and/or gas bubbles which show varying degrees of folding. Gravimetric ice contents from slump headwalls were used to produce an ice content profile which reflects the two ice settings. Given the distribution of retrogressive thaw slumps in the region, ground ice appears to be widely distributed in sediments of marine origin.

Ground Probing Radar surveys conducted at 50 MHz at Hot Weather Creek, 30 km east of Eureka, reveal the presence of a layer approximately four metres thick at a depth of two metres (Figure 2). This layer extends for at least several hundred metres across a rolling lowland plain featuring ice wedge polygons. Natural exposures in a three metre high retrogressive thaw slump headwall and an eroding creek bank, as well as shallow drill cores, indicate that the layer is composed of ice-rich fine sandy silt and clay containing some massive ice. The top of this layer is defined by a strong radar reflector which appears to mimic the surface topography. This reflector may represent a thaw unconformity which lies well below the tops of ice wedges exposed in the creek bank (.5 to 1 m below surface), implying that the ice-rich layer and the thaw unconformity both predate the ice wedges.

Common Mid Point (CMP) surveys conducted at 50 MHz reveal a radar wave velocity profile of .10 m/ns (apparent dielectric constant $K_a = 9$) extending from the surface to a depth of approximately 6 metres. Below this the radar wave velocity increases to .15 m/ns ($K_a = 4$) to a depth of 10 metres where it increases again to .16 m/ns ($K_a = 3.5$). Below six metres, 25 MHz profiles show a cross-bedded structure which, combined with the velocity profile, may suggest the presence of sand and possibly ice. As yet, no holes have been drilled to this depth in the area.

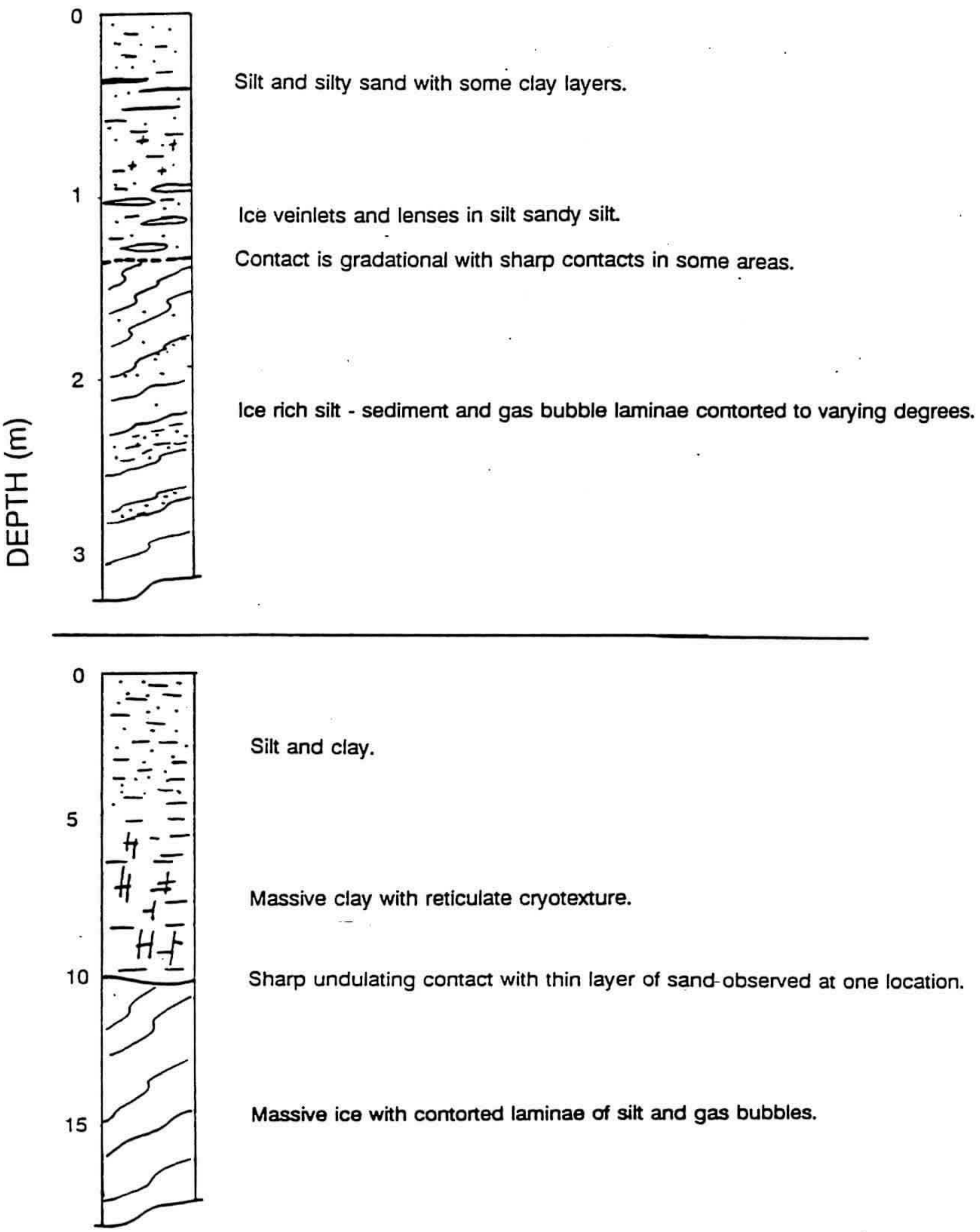


Figure 1 Ground ice occurs in two general settings: 1) As shallow ice-rich silt overlain by silt and silty sand (top), and 2) As deep massive ice overlain by massive clay topped with silt (bottom).

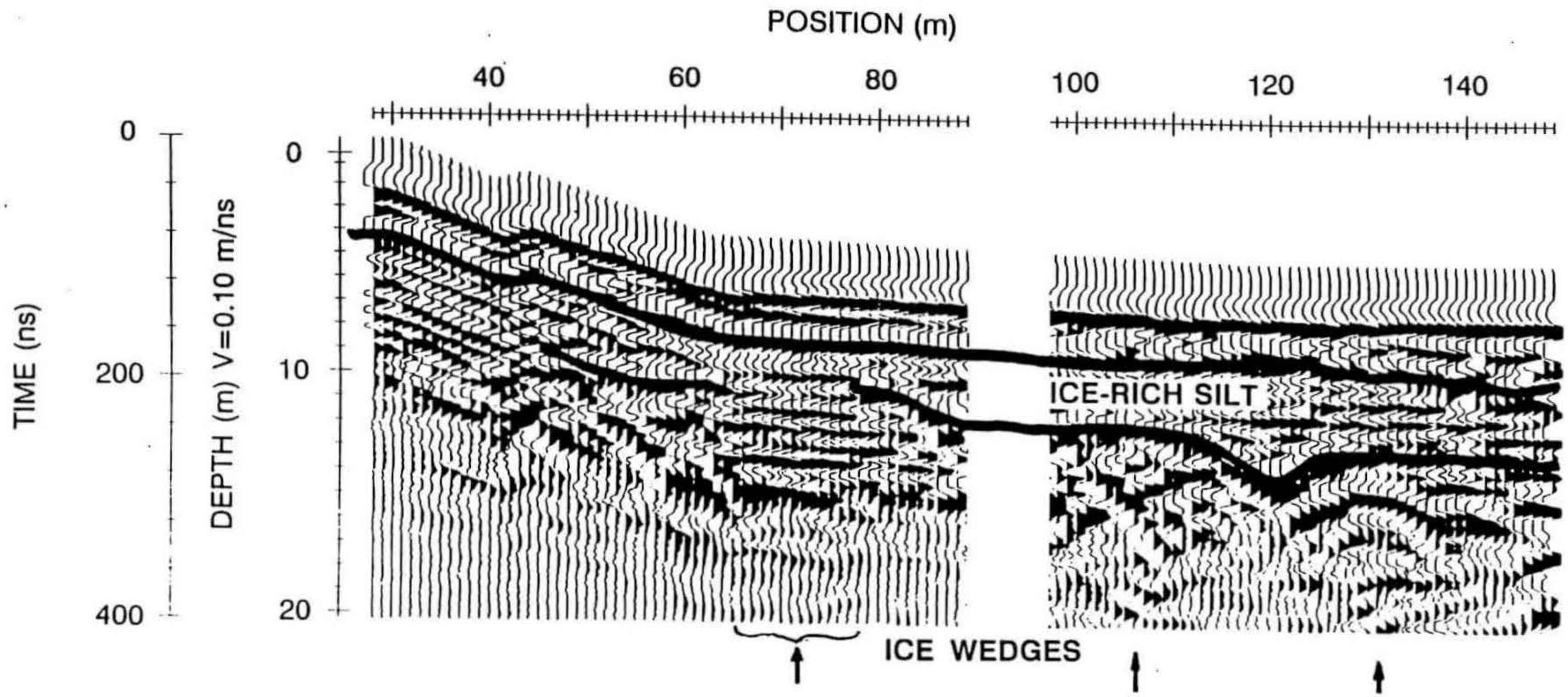


Figure 2 50 MHz profile at Hot Weather Creek showing ice-rich layer at a depth of 2 metres which follows the topography. Reverberant effects due to ice wedges can also be seen in this profile.

Preliminary Seismic Stratigraphy of Sediments in McMurdo Sound, Ross Sea: Implications for Glacially Influenced Early Cenozoic Eustatic Change

Louis R. Bartek [1], *Stuart A. Henrys* [2], *John B. Anderson* [3], and *Peter J. Barrett* [2]

1 Dept. of Geology, University of Alabama, P O Box 870338, Tuscaloosa, AL

2 RSES, Victoria University, P O Box 600, Wellington, NZ

3 Dept. of Geology and Geophysics, Rice University, Houston, TX

Glacial and glaciomarine sedimentary sequences in McMurdo Sound, Antarctica, have been mapped seismostratigraphically. Twenty unconformity-bound, seismic-stratigraphic sequences are identified on seismic data (600 km) collected by the Polar Duke in 1990. These pre-Pliocene sequences are labeled A through T.

Interpretation of the seismic stratigraphic units to CIROS-1 has been assisted by the computation of synthetic seismograms. This correlation reveals that units A-O are older than Pliocene and younger than the early Miocene strata of CIROS-1. Portions of units A-O may have been cored by MSSTS-1. Units P and Q correlate to the late Oligocene portion of the CIROS-1 core and units R, S, and T appear to correspond to the early Oligocene interval.

Analysis of the stratigraphic sequences of the CIROS-1 drill core (Barrett et al., 1989) produced evidence of glacial advances and retreats some of which match the timing of global eustatic falls and rises in sea level. The CIROS-1 drill site is located in a shallow area of McMurdo Sound and the seismic data show evidence of glacial erosion, but the erosional events produced a greatly condensed section at this location. Therefore, it is difficult to distinguish the individual events identified by Barrett et al. (1989). However, seismic units P and Q appear to correspond to the interval where Barrett et al., (1989) identified 3 late Oligocene glacio-eustatic events.

EXTENSIVE GLACIATIONS OF ELLESMERE ISLAND: TENTATIVE AGE ESTIMATES BASED ON AMINO ACID RATIOS AND PALEOENVIRONMENTAL IMPLICATIONS

TREVOR BELL
Department of Geography, McGill University, Montreal, Quebec, Canada H3A 2K6
JOHN ENGLAND
Department of Geography, University of Alberta, Edmonton, Alberta, Canada T6G 2H4

Beyond the last glacial limit on western Fosheim Peninsula, there is abundant evidence of older, more extensive glaciations. Erratics are widely distributed and were deposited by ice that covered the entire peninsula. Erratic dispersal patterns document former ice flow direction whereas amino acid ratios from ice-transported shells differentiate discrete glaciations. The pattern of ice retreat is inferred from the distribution of moraines, meltwater channels and glaciofluvial and glaciomarine deposits.

Amino acid ratios from shell fragments in till demonstrate that two populations, with mutually exclusive ratios, can be identified according to sample location. The highest ratios (Group I, Table 1) and consequently, the oldest shells, are associated with till on the northwestern and southwestern corners of the peninsula (Fig. 1). Lower ratios (Group II, Table 1) are confined to till on the western fringe of the peninsula and eastern Axel Heiberg Island, roughly coincident with north-central Eureka Sound. Mixed shell populations (Group III, Table 1) were found at the northeastern corner of the peninsula and in east-central Eureka Sound. The occurrence of two tills containing ice-transported shells with discrete relative ages is best accounted for by at least two glaciations. These are provisionally named *Group I* and *Group II* glaciations for the oldest and youngest events, respectively.

Table 1: Summary group statistics for aIle/Ile ratios[1] from the study area

	GROUP I		GROUP II		GROUP III	
	Free	Total	Free	Total	Free	Total
range	0.372 - 0.741	0.089 - 0.185	0.146 - 0.355	0.047 - 0.086	0.285 - 0.417	0.041 - 0.090
$\bar{x}$	0.547	0.127	0.232	0.065	*na*	*na*
S_x	0.102	0.032	0.049	0.011	*na*	*na*
CV	19%	25%	21%	17%	*na*	*na*
n	19	17	17	20	4	4

na = not applicable
CV = coefficient of variation ($S_x/\bar{x}$)

Group I glaciation inundated Fosheim Peninsula and was responsible for the deposition of erratics on the highest summits, adjacent to Greely Fiord. The extent of this advance northward into Greely Fiord is unknown but it was at least 800 m thick on the northern peninsula. Fossiliferous till associated with the Group I glaciation contains shells that have amino acid ratios similar to those collected from the oldest marine sediments of the Kap København Formation, northern Greenland, dated 2.4-3.2 Ma (Funder *et al.* 1985). Member A of this formation was deposited

[1] Some amino acid ratios were not used in data reduction or analysis because of (1) taxonomic differences, (2) anomalously high ratios from 'old' shells, or (3) inconsistent free and total ratios suggesting analytical error.

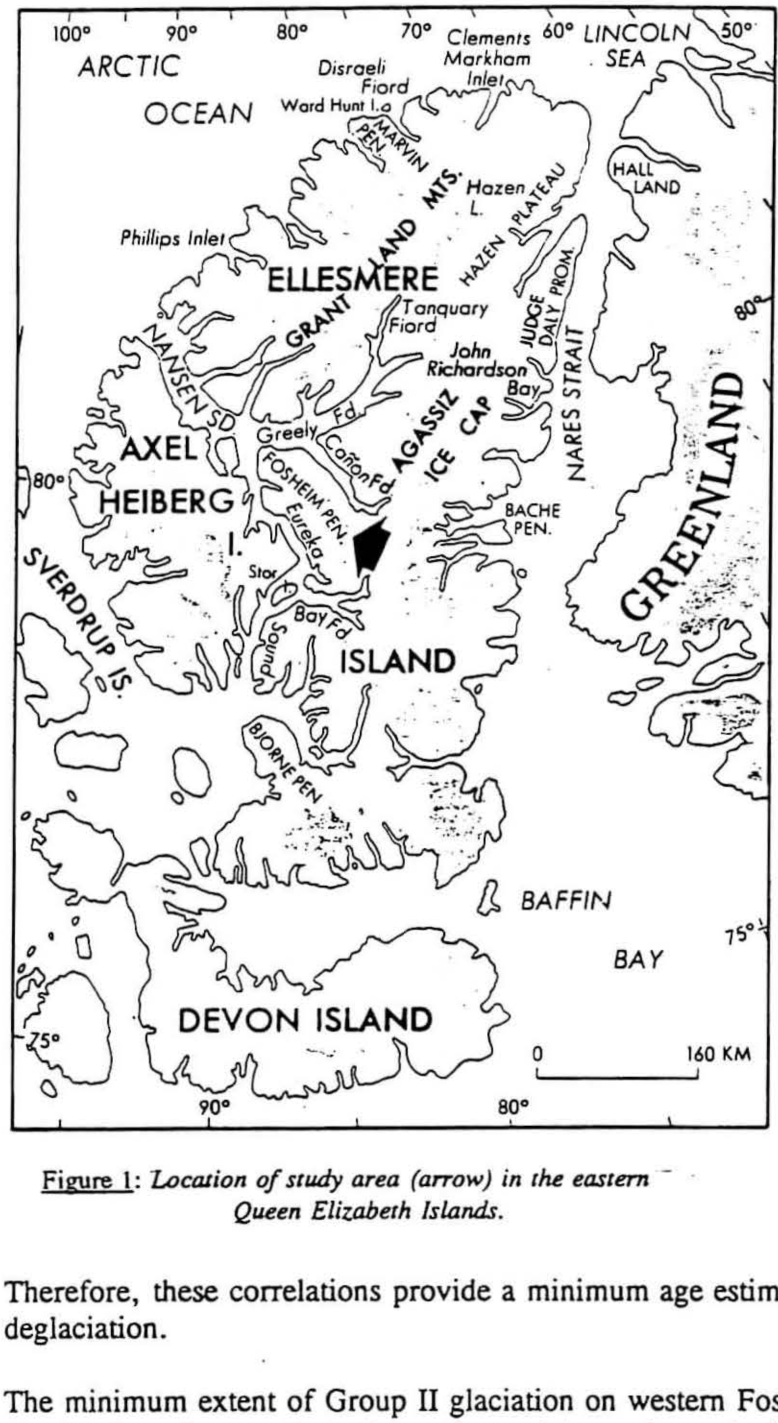


Figure 1: *Location of study area (arrow) in the eastern Queen Elizabeth Islands.*

during the advance of the Greenland Ice Sheet. These ratios are also similar to shell fragments from granite-rich till deposited by the maximum advance of the Greenland Ice Sheet onto northeastern Ellesmere Island (Lemmen and England 1992). Based solely on the correlation of amino acid ratios, it is suggested that Group I glaciation was coeval with the maximum advance of the northwestern Greenland Ice Sheet and that this advance redeposited shells related to the preceding marine episode, tentatively dated 2.4-3.2 Ma. Therefore, the maximum age of Group I glaciation is possibly as old as 2.4 Ma.

Retreat of Greenland ice from northeastern Ellesmere Island allowed the oversteepened Ellesmere Island ice to advance from the point of previous coalescence. Deglacial shorelines along Nares Strait may be equivalent to the Member B marine transgression (2 Ma) of the Kap København Formation, based solely on elevation (285 m *vs.* 230 m; England *et al.* 1981 and Bennike and Böcher 1990, respectively). Moreover, marine sediments associated with these higher sea levels contain shells with amino acid ratios similar to Group II shells on western Fosheim Peninsula. Therefore, these correlations provide a minimum age estimate of *ca.* 2 Ma for Group I deglaciation.

The minimum extent of Group II glaciation on western Fosheim Peninsula is outlined by the distribution of group II shell samples which consist exclusively of lower amino acid ratios. This limit is tentatively positioned along the northern third of the peninsula. Group II glaciation must postdate Group II shells and therefore its maximum age is estimated to be 2 Ma; however, it may be as young as 0.4-0.7 Ma based on paleoclimatic considerations. Lemmen and England (1992) recognized a second (pre-Wisconsinan) glaciation on northeastern Ellesmere Island which postdated the maximum advance of the Greenland Ice Sheet and may be younger than 0.4 Ma.

Older, extensive glaciations of western Fosheim Peninsula (perhaps similar to a former Innuitian Ice Sheet; Blake 1970, 1992) represent a significant departure from the last glacial maximum. Because precipitation is regarded as the critical climate control on modern glacier growth, it has been argued that more extensive glaciations must have been favoured by much greater precipitation (Bradley and England 1978; Miller and de Vernal 1992). The proposed relationship between regional glaciation of the high arctic and a greatly reduced Arctic Ocean sea ice cover (*cf.* Lemmen and England 1992) appears to be consistent with the geological evidence for Group I glaciation. However, we are at an early stage in the development of a chronology for older glaciations in the high arctic and consequently, our correlations require further verification.

The glacial history of the study area is used to constrain landscape evolution models for west-central Ellesmere Island (England 1987; Ricketts 1987). Group I shells demonstrate that Greely Fiord and parts of Eureka Sound existed as marine embayments prior to Group I glaciation; therefore, regional glaciation must postdate the breakup of a contiguous Fosheim Basin (*i.e.* at least nascent fiords and marine channels predate extensive glaciation of this area). It is proposed that the detailed mapping and dating of Neogene fluvial sediments, which record the late Tertiary drainage on the peninsula, will provide a maximum age for the evolution of the surrounding fiords and marine channels which may have begun not long before the advent of regional glaciation.

Bennike, O. and Böcher, J. 1990. Forest tundra neighbouring the North Pole: plant and insect remains from the Plio-Pleistocene Kap København Formation, North Greenland. Arctic, **43**: 331-338.

Blake, W., Jr. 1970. Studies of glacial history in Arctic Canada. I. Pumice, radiocarbon dates, and differential postglacial uplift in the eastern Queen Elizabeth Islands. Canadian Journal of Earth Sciences, **7**: 634-664.

Blake, W., Jr. 1992. Holocene emergence at Cape Herschel, east-central Ellesmere island, Arctic Canada: implications for ice sheet configuration. Canadian Journal of Earth Sciences, **29**: 1958-1980.

Bradley, R.S. and England, J. 1978. Recent climatic fluctuation of the Canadian High Arctic and their significance for glaciology. Arctic and Alpine Research, **10**: 715-731.

England, J. 1987. Glaciation and the evolution of the Canadian high arctic landscape. Geology, **15**: 419-424.

England, J., Bradley, R.S., and Stuckenrath, R. 1981. Multiple glaciations and marine transgressions, western Kennedy Channel, NWT, Canada. Boreas, **10**: 71-89.

Funder, S., Abrahamsen, N., Bennike, O., and Feyling-Hanssen, R.W. 1985. Forested Arctic: Evidence from North Greenland. Geology, **13**: 542-546.

Lemmen, D.S. and England, J. 1992. Multiple glaciations and sea level changes, northern Ellesmere Island, high arctic Canada. Boreas, **21**: 1-16.

Miller, G.H. and de Vernal, A. 1992. Will greenhouse warming lead to a Northern Hemisphere ice-sheet growth? Nature, **355**: 244-246.

Retelle, M.J. 1986. Glacial geology and Quaternary marine stratigraphy of the Robeson Channel area, northeastern Ellesmere Island, NWT. Canadian Journal of Earth Sciences, **23**: 1001-1012.

Ricketts, B.D. 1987. Evolution of the eastern Arctic landscape and the Tertiary - Quaternary transition, Queen Elizabeth Islands. International Union for Quaternary Research, XII International Congress, Ottawa, Ontario; Program with abstracts, p.52.

Synthetic Seismogram Generation - A Study in the Antarctic Peninsula Region

Bissell, D.M. and Manley, P.L., (Middlebury College, Department of Geology, Middlebury, VT, 05753)

Many reflectors on high resolution profiles result from the interference of fine-scale sediment layers rather than distinct lithologic horizons. Synthetic seismograms allow a detailed correlation between these high resolution seismic records and observed or measured physical properties of core sediments. Such a correlation provides insight into both the nature of the reflectors as well as the characteristics of the insonified sediments. In this study, high resolution seismics from a 3.5kHz Deep Tow Huntec system were correlated with six 9m piston cores taken in and around the Antarctic Peninsula. To generate the synthetic seismograms, impedance and reflection coefficient profiles were calculated from sediment velocity and bulk density analyses measured every 5 cm on the cores. The reflection coefficient was convolved with the seismic source signature and the resulting synthetic seismogram compared with the actual seismic records. In addition, one core was analyzed for biogenic and terrigenous silica, and calcium carbonate content to determine whether density changes might be the result of biogenic peaks. The resulting data are used to help interpret climatic trends and cycles in the region and to investigate regional depositional processes occurrring there.

PHYSICAL LIMNOLOGY OF ROMULUS LAKE, WEST CENTRAL ELLESMERE ISLAND

Gillian Davidge, Dept. of Geography, Queen's University, Kingston, Ontario, Canada K7L 3N6

Romulus Lake is located on the Fosheim Peninsula, West Central Ellesmere Island, approximately 4 km southeast of the head of Slidre Fiord and at 8 m above sea level. The lake is approximately 4 km^2 in area with a maximum depth of 60 m and a drainage basin of 31 km^2. Surface inflow consists of short, intermittent streams that are largely controlled by snow melt. During the summer of 1992, a study of the physical limnology of the lake in relation to the patterns of lake ice deterioration and surface inflow was undertaken to assess the role of various mechanisms in the origin of Romulus Lake and how the modern hydrologic environment is determining its characteristics.

Romulus Lake is a chemically-stratified, meromictic lake consisting of three distinct layers: (1) a brackish surface layer (mixolimnion) at 0-17 m; (2) a layer of rapidly changing salinity (chemocline) at 17-24 m; and (3) a hyper-saline bottom layer (monomolimnion). Over the field season salinity and temperature changes occurred within the upper few meters of the mixolimnion due to freshwater inputs from lake ice melt and stream inflow, increased solar inputs, and wind mixing effects. Below 5 m depth, the temperature profile remained stable between +0.5 and -1°C.

The monomolimnion is not completely anoxic as is the case in other high arctic chemically-stratified lakes. From late June to mid July a zone of dissolved oxygen supersaturation between 4 and 12 m may be attributed to excessive algal photosynthesis due to continuous sun light. The presence of an algal bloom is consistent with low Secchi disk readings recorded from the center of the lake during this period.

Sediment influx occurs through stream inflow and eolian storms. The majority of stream input is confined to the short snow melt season, which in 1992 occurred while the lake was still almost completely ice covered, confining most of the sedimentation to the outer edges of the lake. During and following lake ice break-up, sediments along the shallow outer edges were reworked and transported further out into the lake through wind and wave action and ice transport. Short cores reveal laminated sediments within the deeper portions of the lake. However, it is not clear whether these are annual or event layers.

The saline water within Romulus Lake was initially derived from trapped sea water due to isostatic rebound. Subsequent processes to explain its present density structure are solute migration from surrounding ground to lake during uplift and permafrost aggradation and/or solute rejection from seasonal ice growth.

LATE QUATERNARY PERIGLACIAL MARINE SEDIMENTS ON THE OUTER CONTINENTAL SHELF OFF NEW JERSEY: CHARACTERIZATION FROM HIGH RESOLUTION 3-D HUNTEC® REFLECTION SURVEYS AND CORES

Thomas A. Davies and James A. Austin, Jr (Institute for Geophysics, The University of Texas, Austin, Texas)
Martin B. Lagoe (Department of Geological Sciences and Institute for Geophysics, The University of Texas, Austin, Texas)

ABSTRACT

Regional seismic reflection surveys have delineated a wedge of late Quaternary sediment extending 150 km south from the Hudson apron along the edge of the continental shelf off New Jersey. Present water depths in the area occupied by the sediment wedge range from 130 m in the north to 65 m in the south. The bottom of the sediment wedge is defined by a prominent reflector (R), which has been assumed to represent an erosional surface carved during the last lowstand of sea level (Wisconsin Maximum).

To investigate subtle changes in the regional acoustic stratigraphy, a 3-D reflection survey of a 5 km X 0.5 km area of the southern part of the wedge was carried out in October 1989, using a deep-towed Huntec® system. Frequency of operation was 500-3,500 Hz; sampling rate was 0.1 msec. Line spacing was 10 m and shot spacing 2.5 m. Navigation was provided by Starfix®, a commercial system employing constellations of geostationary communications satellites to achieve position accuracies to < 5 m.

The survey shows that the southern part of the outer shelf sediment wedge has a complex internal structure which is unrelated to the present seafloor morphology. Two prominent, mappable reflectors occur between R and the sea floor. A structure map of the upper reflector shows a system of meandering channels apparently draining toward the shelf edge, indicating that the depositional history was interrupted by at least one episode of erosion.

Piston and gravity cores show that both the channel-fill and sub-R sediments are generally sandy. Sediment into which the channels are cut is a clayey mud, in places extremely stiff, suggesting sub-aerial exposure. Associated microfaunal studies of the cores provide information on paleobathymetry, water mass variations, current energy and relative sediment accumulation rates. To date our sampling of the sediment wedge indicates shallower water depths than present and no evidence for deposition at shallower than mid-shelf depths. Sand below the modern sediment veneer was deposited under moderate current energies, at rates much higher than the modern sand layer. The clayey mud also appears to represent mid-shelf deposition, under low energy conditions, an environment with no modern analog on the New Jersey shelf.

Based upon correlations with late Quaternary glacial history developed from studies on land, we conclude that the sedimentary sequence was formed as a result of a series of rapid depositional events, probably related to glacial melting, and interrupted by one or more erosional episodes, as implied by the channels.

Additional fieldwork planned for 1993 will extend the existing 3-D Huntec® survey with the objective of better defining the geometry of the channel system and its relationship to ancestral Hudson River drainage. A series of precisely located vibracores collected in conjunction with the planned survey will permit us to better characterize the sedimentological, microfaunal and acoustic properties of units insonified, sampled, and mapped. These studies, one element of a long-term program of shelf corridor studies off New Jersey being carried out with ONR support, are also planned to complement the Mid-Atlantic Transect to be drilled by the Ocean Drilling Program (ODP Leg 150) to sample Neogene and Paleogene sediments across the New Jersey margin.

CO_2 disequilibrium in Antarctic sea ice and surface water: evidence from $^{13}C/^{12}C$ ratios in organic C

Robert B. Dunbar*, Amy Leventer**, Jennifer C. Rogers*, & David A. Mucciarone*

*Geology and Geophysics, Rice University, Houston, Texas 77251, USA
**Byrd Polar Research Center, The Ohio State University, Columbus, Ohio 43214, USA

Marine organic matter $\delta^{13}C$ is increasingly used in the study of carbon fluxes and CO_2 partitioning between ocean, atmosphere, and terrestrial reservoirs. An important isotopic trend observed in modern marine organic carbon is a decrease in plankton $\delta^{13}C$ with latitude, from -19 to -22‰ near the equator to -26 to -31‰ in polar regions. ^{13}C depletion in high latitude plankton was initially attributed to the influence of temperature on intra-cellular metabolic processes responsible for isotopic fractionation but has recently been ascribed to the greater availability of dissolved molecular CO_2 (e.g. $[CO_2]_{aqueous}$) in cold surface waters. This has led to suggestions that $\delta^{13}C$ in sedimentary organic matter can be used to estimate past ocean/atmosphere CO_2 levels. We began a survey of $\delta^{13}C$ in sinking, suspended, and ice-bound organic matter in the Ross Sea to assess the degree and uniformity of ^{13}C depletion in a polar "end-member" setting. We expected low and highly uniform $\delta^{13}C$ values since Ross Sea surface water temperatures range from 0° to -2°C and the modern input of terrestrial C is negligible.

We have analysed >600 samples of particulate organic carbon (POC) collected by sediment trapping, SIPRE coring (basal sea ice), and water column filtration in the Ross Sea and McMurdo Sound between 1986 and 1992. We observe a range in POC $\delta^{13}C$ of 26‰ (from -8‰ to -34‰), more than the entire latitudinal range observed in surface water plankton and the largest yet reported within any single marine ecosystem. The largest enrichment in ^{13}C occurs within sea ice algal communities. We also observe a seasonal cycle in plankton $\delta^{13}C$ within annual fast ice as well as ^{13}C enrichment within the products of an open water phytoplankton bloom during summer. We attribute ^{13}C enrichment to the production of organic matter in seawater with low $[CO_2]_{aqueous}$ caused by photosynthetic uptake and maintained by reduced gas exchange with the atmosphere and deep water. Gas exchange between the sea ice community and the underlying seawater is limited by the physical properties of the sea ice and brine channel fluids. We postulate restricted gas exchange in surface seawater during periods of strong stabilization induced by sea ice melting or strong solar warming coupled with low wind shear. In this scenario, ^{13}C enrichment may be produced in two ways: 1) phytoplankton utilization of CO_2 enriched in ^{13}C by the removal of ^{12}C (Rayleigh process); or 2) the direct effect of low $[CO_2]_{aqueous}$ on the phytoplankton isotopic fractionation factor (ε_p). Preliminary analysis of direct measurements of CO_2 concentration and ΣCO_2 $\delta^{13}C$ in conjunction with isotopic analysis of the associated POC suggest that each mechanism is of roughly equal importance in producing the observed ^{13}C enrichment during bloom events.

Our results are consistent with the concept of CO_2 availability controlling phytoplankton $\delta^{13}C$ but suggest that CO_2 availability during high productivity events is controlled by bloom dynamics and physical mixing processes rather than equilibrium exchange with the atmosphere. It is likely that large amounts of organic matter in the Southern Ocean are produced within CO_2 reservoirs out of equilibrium with the atmosphere. These observations may well extend to lower latitude systems and suggest the need for caution in the use of marine POC $\delta^{13}C$ as a CO_2 paleobarometer. With further development, $\delta^{13}C$ of marine POC preserved in sediments might serve as an indicator of past sea ice coverage and/or wind-linked stabilization of surface waters.

HIGH RESOLUTION SEISMIC STRATIGRAPHY AND SEDIMENTOLOGICAL ANALYSIS OF HOLOCENE GLACIAL MARINE SEDIMENTS IN THE PALMER DEEP BASIN. BELLINGSHAUSEN SEA, ANTARCTICA.

KIRBY, Matthew E., Geology Dept., Hamilton College, Clinton, N.Y. 13323; DOMACK, Eugene, W., Geology Dept., Hamilton College, Clinton, N.Y. 13323; McClennen, Charles E., Geology Dept., Colgate University, Hamilton, N.Y. 13346

In order to determine the nature and history of deep basin sediments along the Antarctic Peninsula continental shelf a series of high resolution HUNTEC seismic profiles and piston cores were collected from the Palmer Deep during the R.V. Polar Duke 92-2 cruise. The Palmer Deep actually consists of three separate basins each of which retains unique sedimentological character and seismic signature. The deepest basin (1435 m) is characterized by an acoustically transparent layer above an acoustically stratified layer. Piston cores show that the majority of this fill consists of 0.5 to 1.0 meter fine grained gravity flows recognized by thick homogenous diatomaceous muds. Thin, stratified, diatomaceous muds with ice rafted debris separate the flows and are thought to represent the synchronous pelagic and ice rafted record. The AMS C-14 chronology, magnetic susceptibility and gravel grain count confirm this situation.

The shallowest basin reaches depths of just over 1000 m and is characterized by an acoustically laminated sequence recognized on the scale of tens of cm. An analysis of piston cores collected from this basin show an alternating pattern of hemipelagic and pelagic sediments characterized by finely stratified diatom muds with ice rafted debris and diatom oozes. Gravity flow sequences were not observed in this basin.

These results show the complexity of glacial marine sediments within a confined and proximal area in a modern depositional environment and serve as a foundation for other seismic and sedimentological studies conducted along the Antarctic Peninsula.

Limitations of Infrared Stimulated Luminescence (IFSL) to Date High Arctic Glacial-Marine Sediments

Kenneth Lepper, Steven L. Forman, and James Pierson
Byrd Polar Research Center and Dept. of Geological Sciences
The Ohio State University, Columbus, Ohio 43210-1002

There is a clear need for the development of a technique that can accurately determine the timing of environmental events during the middle and late Quaternary in the Arctic. This study was designed to ascertain the potential and limitations of IFSL to date Arctic waterlain sediments. Specifically, we focussed on gaining a better understanding of the factors controlling the reduction of the IFSL signal with deposition of sediments, and determining if sediments in near-shore marine environments receive sufficient light exposure to yield accurate IFSL ages. All the sediments studied are from modern glacial-genic environments, or analogous late Quaternary sediments with radiocarbon and biostragraphic time control.

Waterlain sediments are probably exposed to lower energy infrared-red light rather than higher energy green or blue light with deposition. Thus, the infrared excitation light is more appropriate in reference to the depositional spectral conditions. A ring of thirty infrared diodes (880 ± 80 nm), similar to the construction of Spooner et al., (1990) was used to excite the sample. The estimated delivery of energy is about 20 mw/cm^2. We examined both the resultant ultraviolet and blue signal from the sediments;the background count rate is low at 20 and 80 counts/second, respectively. The IFSL properties were examined for the fine-grained polymineral and quartz extracts for these sediments.

The reduction in the IFSL signal with exposure to filtered sunlight (wavelengths below 570 nm blocked) is similar to previous investigations. There is approximately a 50-60% reduction in the IFSL signal, for most samples, within the first minute of sunlight exposure. After 5 to 10 minutes of light exposure most sediments have achieved a residual level, with little change in the IFSL signal after 60 minutes. However, we document surprising variations in the response of the blue and ultraviolet signal to sunlight exposure, that remains to be investigated.

Changes in the natural IFSL signal of modern and Holocene tills, glacial-marine, and sublittoral sediments parallel variations in the TL signal for these sediments. Tills and glacial-marine sediments have the highest natural IFSL levels, in contrast sublittoral sediments have lowest IFSL values. However, the reduction in the IFSL signal for sublittoral sediments is 2 to 3 times lower then compared with the coressponding TL signal.

IFSL age estimates are computed using modified total bleach procedure. A variety of residual levels were used to ascertain the sensitivity of the IFSL signal to solar resetting. Background-signal residual level yielded in most case overestimates in age. For example, modern sediments yielded ages of 3 ka, and radiocarbon dated sediments of 10 ka yielded IFSL age of 22-109 ka. The residual level after 60 minutes sunlight exposure yielded similar, though somewhat less, overestimates. Apparently accurate ages can be obtained with light exposures between 10 to 60 minutes. This cautious approach yields preliminary age brackets of 5-25 ka, 56-95 ka and 105-130 ka for the last three deglacial cycles.

IFSL geochronology is a step forward in dating high Arctic glacial-genic sediments that receive rather brief and wavelength restricted light exposure prior to deposition. However, we are still constrained by variations in sediment dynamics that control the solar setting of IFSL signal.

LATE PLEISTOCENE STRATIGRAPHY ON JAMESON LAND, EAST GREENLAND

A. Lyså (Institute of Biology and Geology, University of Tromsø, N-9037 TROMSØ, NORWAY, temporary adress: University of Colorado at Boulder, Institute of Arctic and Alpine Research, 1560 30th Street, Campus Box 450, BOULDER CO 80309-0450) and
J.Y. Landvik (Agricultural University of Norway, Department of Soil Sciences, P.O. Box 5028, N-1432 ÅS, NORWAY)

This is a presentation of preliminary results from part of the PONAM (Polar North Atlantic Margin- Late Cenozoic Evolution) 1990 and 1992 field work on East Greenland.

On coastal Jameson Land, more than 70 m of raised Quaternary sediments reflect the climatic changes and relative sea-level fluctuations during the last interglacial-glacial cycle (last 130 ka). The deposits comprise deltaic, shallow marine and fluvial sediments that appear interbedded with diamictons. These are interpreted as tills and glaciomarine muds and serve as markers representing glacial advances.

Three glacial advances have occurred after the last interglaciation, and the sedimentation between seems to follow a cyclic pattern caused by changes in the relative sea-level. TL-ages of the non-glacial sediments indicate that the deposition took place mainly during isotope stage 5 and probably during early stage 4, however a subdivision has not yet been possible.The successive higher relative sea-level during the deposition of the sequence indicate that isotope stage 5 on Greenland has been characterized by a long period of ice sheet growth.

Erika Meyer
Department of Geography, University of Cincinnati
Cincinnati, OH 45221-0131

Analysis of Soil Temperature and Solute Concentration using Power Law Methods

Hourly observations were obtained from eight temperature/ electric potential probes at two proximal sites in the Caribou-Poker Creeks Research Watershed, approximately 50 km north of Fairbanks, AK. The probes were placed at depths from 1 to 50 cm at 7-cm intervals. Measurements of temperature and C-index (a surrogate of soil water solute concentration) were made hourly over a calendar year.

Thirty-day segments were isolated from the time series for a mid-level (29 cm) probe. These periods represent thermal regimes during which specific nonconductive heat transfer processes are known to predominate, and include active layer development in summer, active layer cooling in autumn, development of the zero curtain in early winter, and deep soil freezing in late winter.

Following Fourier transformation of the time series, the slope of the best-fit line to the variance spectra is used to calculate the fractal dimension. This metric varies between thermal regime periods in a manner consistent with the dominant mode of heat transfer, and reflects the impact of soil conditions at the dissimilar sites.

By accumulating the deviations from the mean of the recorded time series, a rescaled vector **Xd** of **d** observations is obtained. The rescaled range **R(d)** is derived from max(**Xr**)-min(**Xr**). This range, divided by the standard deviation, yields **Q(d)** which is used to compare time series through the Hurst equation (log **Q(d)**/log(**d**)). This method can also be used to calculate the fractal dimension, and results are compared to those obtained using variogram analysis. The Hurst method is a simple yet powerful tool for the analysis of 1-dimensional time series.

MELTWATER AND SUSPENDED SEDIMENTS IN GLACIMARINE ENVIRONMENTS: DIGITAL ANALYSIS OF LANDSAT IMAGERY

Anne-Marie Nuttall and Julian A. Dowdeswell
Scott Polar Research Institute, University of Cambridge, Cambridge CB2 1ER, U.K.

Fresh water surface plumes containing suspended sediment are a characteristic feature of fjords, and some more open marine settings, where glaciers reach the sea or are present over significant parts of the catchment. The suspended material is derived from sediment-laden meltwaters discharged from glaciers in which all or part of the glacier bed is at the pressure melting point. These glacier-derived suspended particulates are introduced to marine waters in two main ways: (a) directly, from subglacial meltwater streams entering the water column at the base of tidewater glacier termini; (b) indirectly, via glacier-fed meltwater streams which enter the sea at its surface. Turbid subglacial waters upwell to sea level and surface stream waters remain there because, despite their suspended sediment load, they are almost always less dense than sea water.

High-resolution visible-band satellite imagery can be used to monitor both the extent and relative turbidity of such meltwater plumes, and variations in these parameters through time. The blue band (0.5-0.6 μm) of the Landsat multispectral scanner (MSS) is particularly useful in this context, since energy at this wavelength will penetrate the surface of clear water, whereas water becomes progressively more opaque as wavelength increases towards the infra-red. We have systematically examined relative pixel brightness levels from a number of Landsat MSS computer compatible tapes imaging the waters around Svalbard and East Greenland. These data have been transformed into real physical values of reflectance using an algorithm taking into account internal satellite calibrations and corrections for atmospheric haze and solar elevation. The reflectance values are then analyzed in order to monitor the distribution of suspended sediment plumes of each image and plume dynamics through time. The relative concentrations of suspended sediments are also analyzed.

We are presently investigating a number of problems concerning the distribution of glacier-derived suspended sediments around the Svalbard archipelago and East Greenland from almost 40 MSS images, each covering an area of 185 by 185 km. Questions include the following. (a) What is the importance of suspended sediment delivery from subglacial streams draining tidewater glaciers, as opposed to meltwater-fed subaerial rivers? (b) Are there differences in turbid meltwater production linked to differences in the dynamic regime of the parent ice mass (e.g., tidewater glacier, fast-flowing outlet glacier, surge-type glacier in the quiescent or active phase, slow-moving ice wall)? (c) Is there a gradient with latitude in the production of suspended sediments, and hence of subglacial meltwater, derived from tidewater glaciers in East Greenland?

MASSIVE GROUND ICE IN THE VICINITY OF HOT WEATHER CREEK, FOSHEIM PENINSULA, ELLESMERE ISLAND, N.W.T., CANADA.

Stephen D. Robinson - Department of Geography, Queen's University, Kingston, Ontario K7L 3N6.
e-mail: robinsos@qucdn.queensu.ca

Massive ground ice has been noted as an important component of the unconsolidated surficial sediments of the Fosheim Peninsula, Ellesmere Island, N.W.T., at elevations below local marine limit. The presence of multiple active retrogressive thaw slumps and stabilized slump scars suggest the presence of sizable or multiple ice bodies.

Geophysical and geomorphological studies were conducted in 1991 and 1992 to examine the massive ice and enclosing sediments in the vicinity of the Geological Survey of Canada's Hot Weather Creek Global Change Observatory. Mapping the distribution and characteristics of massive ground ice is important to a better understanding of the permafrost and climatic conditions under which the ice formed. Potential terrain response to future climatic changes can also be assessed.

Geophysical surveying involved both electromagnetic and gravity techniques. The electromagnetic instruments (Ground Penetrating Radar and EM31) were severely affected by the presence of highly conductive salts in the upper sediments, and yielded little information concerning the underlying massive ice. Preliminary gravity survey results show maximum massive ice thickness of at least 14 m.

Geomorphological investigations suggested the present retreat of retrogressive thaw slumps is between 3 and 7 m per year and is influenced by climate, ice face orientation, local topography, and overburden thickness. The polycyclic nature of slumping is well preserved and can be reconstructed based upon aerial photographs, field observations, and revegetation patterns. Shallow drilling indicated the presence of massive ice in the near surface at most of the study sites. Ground ice sills up to 57 cm thick were also found to occur within the bedrock of the poorly consolidated Eureka Sound Group.

LIST OF ATTENDEES

Inge Aarseth
Department of Geology
University of Bergen
Allégt. 41, N-5007 Bergen
NORWAY

David M. Anderson
NOAA Paleoclimatology Program
Boulder, Colorado

Donald Anderson
Byrd Polar Research Center
The Ohio State University
1090 Carmack Road
108 Scott Hall
Columbus, Ohio 43210

Douglas Anderson
Brown University
Department of Geological Sciences
Providence, Rhode Island 02912

John B. Anderson
Department of Geology and Geophysics
Rice University
Houston, Texas 77251

John T. Andrews
INSTARR
University of Colorado
Box 450
Boulder, Colorado 80309

Martha Andrews
Institute of Arctic and Alpine Research
University of Colorado
Boulder, Colorado 80309

James Austin
Institute for Geophysics
University of Texas
8701 Mopac Boulevard, Suite 301
Austin, Texas 78759-8345

Peter Barry
McGill University
Geography Department
Montreal, Quebec
Canada H3A 2K6

Philip Bart
Rice University
P.O. Box 1892
Houston, Texas 77251

Henning A. Bauch
GEOMAR-Research Center
for Marine Geosciences
Wischhofstraße 1-3
2300 Kiel
GERMANY

Robin Bell
Lamont-Doherty Earth Observatory
Columbia University
Palisades, New York 10964

Trevor Bell
Department of Geography
McGill University
Montreal, Quebec
Canada H3A 2K6

D.M. Bissell
Middlebury College
Department of Geology
Middlebury, Vermont 05753

Donald D. Blankenship
Institute for Geophysics
University of Texas
8701 Mopac Boulevard, Suite 301
Austin, Texas 78759-8345

Gerard C. Bond
Lamont-Doherty Earth Observatory
Columbia University
Palisades, New York 10964

John D. Bossler
Center for Mapping
1216 Kinnear Road
The Ohio State University
Columbus, Ohio 43212

Julie Brigham-Grette
Department of Geology and Geography
University of Massachusetts
Amherst, Massachusetts 01003

David H. Bromwich
Byrd Polar Research Center
The Ohio State University
1090 Carmack Road
108 Scott Hall
Columbus, Ohio 43210

Thomas A. Brown
Quaternary Research Center
University of Washington
Seattle, Washington 98195

Linda B. Brubaker
College of Forest Resources
University of Washington
Seattle, Washington 98195

Lloyd H. Burckle
Lamont-Doherty Geological Observatory
Columbia University
Palisades, New York 10964

Jinkui Cai
Department of Geology
Northern Illinois University
DeKalb, Illinois 60115

Gino Casassa
Byrd Polar Research Center
The Ohio State University
1090 Carmack Road
108 Scott Hall
Columbus, Ohio 43210

G. Michael Clark
University of Tennessee
Department of Geological Sciences
Knoxville, Tennessee 37996-1410

Thomas M. Cronin
U.S. Geological Survey
970 National Center
Reston, Virginia 22092

Jihong Dai
Byrd Polar Research Center
The Ohio State University
1090 Carmack Road
108 Scott Hall
Columbus, Ohio 43210

Gillian Davidge
Department of Geography
Queen's University
Kingston, Ontario
Canada K7L 3N6

Thomas A. Davies
Institute for Geophysics
The University of Texas
Austin, Texas 78759-8345

Michèle A. De Sève
134 Outremont, #4
Montréal, P. Québec
CANADA H2V 3N1

Eugene Domack
Geology Department
Hamilton College
Clinton, New York 13323

Julian A. Dowdeswell
Scott Polar Research Institute
University of Cambridge
Cambridge CB2 1ER
United Kingdom

John L. Dwyer
Land Sciences Section
Hughes STX Corporation
EROS Data Center
Sioux Falls, South Dakota 57198

W.R. Eisner
Byrd Polar Research Center
The Ohio State University
1090 Carmack Road
108 Scott Hall
Columbus, Ohio 43210

Steven L. Forman
Byrd Polar Research Center
The Ohio State University
1090 Carmack Road
108 Scott Hall
Columbus, Ohio 43210

Charles Fowler
Department of Geology
and Applied Earth Sciences
University of Colorado
Box 7150, Austin Bluffs Parkway
Colorado Springs, Colorado 80933-7150

Clark Freise
Naval Research Laboratory
4555 Overlook Avenue, S.W.
Washington, D.C. 20375

John P. Galloway
U.S. Geological Survey
Branch of Alaskan Geology

Robert Gilbert
Department of Geography
Queen's University
Kingston, Ontario
K7L 3N6 Canada

Michael R. Gipp
Department of Geology
University of Torono
Scarborough Campus
Scarborough, Ontario M1C 1A4
Canada

Douglas R. Hardy
Department of Geology and Geography
University of Massachusetts
Amherst, Massachusetts 01003

Stuart A. Henrys
RSES
Victoria University
P.O. Box 600
Wellington, NZ

Fran Herlihy
Miami University
Department of Geology
Oxford, Ohio 45056

Kenneth M. Hinkel
Department of Geography
University of Cincinnati
Cincinnati, Ohio 45221-0131

Christina L. Hulbe
Byrd Polar Research Center
The Ohio State University
1090 Carmack Road
108 Scott Hall
Columbus, Ohio 43210

Scott E. Ishman
U.S. Geological Survey
970 National Center
Reston, Virginia 22092

Martin O. Jeffries
Geophysical Institute
University of Alaska
Fairbanks, Alaska 99775-0800

Kenneth C. Jezek
Byrd Polar Research Center
The Ohio State University
1090 Carmack Road
108 Scott Hall
Columbus, Ohio 43210

Leonard Johnson
Office of Naval Research
Attention Code 1125
Ballston Tower 1
800 North Quincy Street
Arlington, Virginia 22217-5000

D.S. Kaufman
Department of Geology
Utah State University
Logan, Utah 84322

Matthew E. Kirby
Geology Department
Hamilton College
Clinton, New York 13323

Sergey Korsun
Murmansk Marine Biological Institute
Murmansk, Russia

Marilyn Kressel
Department of Geological Sciences
The Ohio State University
Columbus, Ohio 43210

L.A. Krissek
Department of Geological Sciences
The Ohio State University
Columbus, OH 43210

Martine Lapointe
GEOTOP
Université du Québec à Montréal
C.P. 8888, Succ. A.
Montréal, Québec, Canada H3C 3P8

Kenneth Lepper
Byrd Polar Research Center
The Ohio State University
1090 Carmack Road
108 Scott Hall
Columbus, Ohio 43210

Amy Leventer
Byrd Polar Research Center
The Ohio State University
1090 Carmack Road
108 Scott Hall
Columbus, Ohio 43210

Richard Levy
Department of Geology
University of Nebraska
Lincoln, Nebraska 68508

Craig Lingle
SAR Facility
Geophysical Institute
University of Alaska
Fairbanks, ALaska 99775

David J. Lubinski
INSTARR
University of Colorado
Boulder, Colorado 80309-0450

A. Lyså
Institute of Biology and Geology
University of Tromsø
N-9037 Tromso, NORWAY
(temporarily at Institute of Arctic
and Alpine Research,
University of Colorado at Boulder
1560 30th Street, Campus Box 450
Boulder, Colorado 80309-0450)

Brian M. MacLean
Atlantic Geoscience Centre
Geological Survey of Canada
Bedford Institute of Oceanography
Dartmouth, Nova Scotia
Canada

Pat Manley
Middlebury College
Department of Geology
Middlebury, Vermont 05753

William F. Manley
INSTARR
University of Colorado
Boulder, Colorado 80309-0450

G. Matishov
Murmansk Institute of Marine Biology
Murmansk, Russia

Erika Meyer
Department of Geography
University of Cincinnati
Cincinnati, Ohio 45221-0131

William N. Mode
Department of Geology
University of Wisconsin-Oshkosh
Oshkosh, WI 54901-8649

Bruce Molnia
U.S. Geological Survey
Office of International Geology
MS-917
Reston, Virginia 22092

Ellen Mosley-Thompson
Byrd Polar Research Center
The Ohio State University
1090 Carmack Road
108 Scott Hall
Columbus, Ohio 43210

James Nicholas
Department of Geography
University of Cincinnati
Cincinnati, Ohio 45221-0131

Anne-Marie Nuttall
Scott Polar Research Institute
University of Cambridge
Cambridge CB2 lER
UNITED KINGDOM

Robert J. Oglesby
Department of Earth and Atmospheric Sciences
Purdue University
West Lafayette, Indiana 47904

Sam Outcalt
Department of Geological Sciences
University of Michigan
1006 C.C. Little Building
Ann Arbor, Michigan 48109

Julie Palais
Program Manager, Glaciology
Division of Polar Programs
National Science Foundation
1800 G Street, N.W.
Washington, D.C. 20550

Dennis Peacock
National Science Foundation
Polar Science Section, Room 620D
1800 G Street, N.W.
Washington, D.C. 20550

Chien-Lu Ping
School of Agriculture and
Land Resources Management
University of Alaska
Palmer Research Center
Palmer, Alaska 99645

Wayne Pollard
Department of Geography
McGill University
805 Sherbrooke Street, West
Montréal, Québec
Canada H3A 2K6

Leonid Polyak
Byrd Polar Research Center
The Ohio State University
1090 Carmack Road
108 Scott Hall
Columbus, Ohio 43210

Michael Prentice
University of Maine
Department of Geological Sciences
110 Boardman Hall, Long Road
Orono, Maine 04469

M.J. Retelle
Department of Geology
Bates College
Lewiston, Maine 04240

Stephen D. Robinson
Department of Geography
Queen's University
Kingston, Ontario
Canada K7L 3N6

Donald Rodbell
Byrd Polar Research Center
The Ohio State University
1090 Carmack Road
108 Scott Hall
Columbus, Ohio 43210

Ted Scambos
National Sea Ice Data Center
NOAA
Boulder, Colorado 80309

Reed P. Scherer
Byrd Polar Research Center
The Ohio State University
1090 Carmack Road
108 Scott Hall
Columbus, Ohio 43210

Geoff Seltzer
Byrd Polar Research Center
The Ohio State University
1090 Carmack Road
108 Scott Hall
Columbus, Ohio 43210

Andrei Sher
Severtsov Institute of Evolutionary
Animal Morphology and Ecology
Russian Academy of Sciences
Moscow, Russia

J.A. Snyder
Byrd Polar Research Center
The Ohio State University
1090 Carmack Road
108 Scott Hall
Columbus, Ohio 43210

Aradhna Srivastav
Department of Geology
University of Nebraska
Lincoln, Nebraska 68508

Per Ivar Steinsund
Department of Geology
IBG, University of Troms
9037 Troms
NORWAY

Martyn S. Stoker
British Geological Survey
Murchison House
West Mains Road
Edinburgh, EH9 3 LA
SCOTLAND

Jay A. Stravers
Department of Geology
Northern Illinois University
DeKalb, Illinois 60115

James P.M. Syvitski
Geology Survey of Canada
Bedford Institute of Oceanography
Box 1006, Dartmouth
Nova Scotia, Canada B2Y 4A2

G. Tarashov
Murmansk Marine Biological Institute
Murmansk, Russia

Pat Webber
Kellogg Biological Station
Michigan State University
East Lansing, Michigan 48824

Diane Winter
Department of Geology
University of Nebraska
Lincoln, Nebraska 68508

I.M. Whillans
Byrd Polar Research Center
The Ohio State University
1090 Carmack Road
108 Scott Hall
Columbus, Ohio 43210

Debra A. Willard
U.S. Geological Survey
970 National Center
Reston, Virginia 22092

Hermann Zimmerman
Atmospheric Sciences/Climate Dynamics
National Science Foundation
1800 G Street, N.W.
Washington, D.C. 20550