43rd International

PROGRAM & ABSTRACTS

UMass-Amherst, Massachusetts
11-13 March 2013

Arctic Workshop 2013

Cimate System Research Center
University of Massachusetts Amherst

Arctic Natural Sciences
National Science Foundation

Institute of Arctic & Alpine Research
University of Colorado at Boulder

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Students in Kongsfjord, Svalbard. Kronebreen in background.
Credit: Julie Brigham-Grette (UMass Amherst). Summer 2011.

PROGRAM AND ABSTRACTS

43rd ANNUAL INTERNATIONAL ARCTIC WORKSHOP

March 11 - 13, 2013

Amherst, Massachusetts

Climate System Research Center
Department of Geosciences
University of Massachusetts, Amherst

Organizing Committee:

Julie Brigham-Grette
Ray Bradley
Wendy Roth
David Lubinski
Gifford Miller

Introduction

Overview and history

The 43rd Annual International Arctic Workshop will be held March 11 - 13, 2013, on the campus of the University of Massachusetts, Amherst. The meeting is hosted by the Climate System Research Center, Department of Geosciences. Support is provided by the Institute of Arctic and Alpine Research (INSTAAR), University of Colorado at Boulder. This workshop has grown out of a series of informal annual meetings started by John T. Andrews and sponsored by INSTAAR and other academic institutions worldwide. In keeping with this tradition, there are no formalized topics and the workshop has been organized around themes developed from the abstracts submitted.

Web site

http://instaar.colorado.edu/meetings/AW2013

Check-In / Registration

Please check in or register on (1) Sunday evening at the Icebreaker/Reception between 7:00 – 9:30 pm, or (2) Monday morning between 8:00 – 8:30 am. At registration you will receive the Program and Abstracts, as well as other workshop information.

Posters

At registration you will receive information on where to set up your poster. Please put it up as early as possible, and leave it up as late as possible during the workshop.

Presentation Files (i.e., PowerPoint)

Please load your presentation onto our computer during the Icebreaker/Reception on Sunday 7:00-9:30 pm or the Check-In/Registration on Monday 8:00–8:30 am. Time during breaks is limited.

NSF Support

The Arctic Natural Sciences Program at the National Science Foundation's Office of Polar Programs (NSF-OPP-ARC-ANS) supports student participation in the Workshop through a grant to INSTAAR.

Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Science Foundation

Arctic Workshop 2013
Program Summary

SUNDAY 10 MARCH		
9:00 – 4:00	**Pre-workshop field trip**	*Hotel Lobby*
7:00 – 9:30	**Evening reception, Check-In, Registration** (load presentations onto computer)	*Level 11*

MONDAY 11 MARCH		
8:00 – 8:30	**Check-in & Registration** (load presentations onto computer)	*Level 2 Reading Room*
8:45	**Welcome & Introduction**	*Level 2 Reading Room*
9:00	**Paleoceanography I**	*Level 2 Reading Room*
10:10	Morning Break	*Level 1 Auditorium*
10:40	**Paleoceanography II**	*Level 2 Reading Room*
12:00	LUNCH	-
1:00 pm	**Glacial History**	*Level 2 Reading Room*
3:50	Afternoon Break	*Level 1 Auditorium*
4:00	**POSTERS I (odd-numbered posters)**	*Level 1 Auditorium*
6:00	End of session	*Level 1 Auditorium*
6:30	Non-student Dinner	*Julie B-G's house*
7:00	Student-only Pizza Party	*University Club*

TUESDAY 12 MARCH		
9:00	**Paleolimnology**	*Level 2 Reading Room*
10:30	Morning Break	*Level 1 Auditorium*
10:50	**Modelling**	*Level 2 Reading Room*
12:10	LUNCH	-
1:20 pm	**Special Talk** (Kevin Knobloch, UCS)	*Level 2 Reading Room*
1:50	**Glaciology**	*Level 2 Reading Room*
3:45	Afternoon Break	*Level 1 Auditorium*
4:00	**Chasing Ice** – documentary film	*ISB Auditorium*
5:15	Afternoon Break	*Level 1 Auditorium*
5:30	**POSTERS II (even numbered posters)**	*Level 1 Auditorium*
7:00	End of session	*Level 1 Auditorium*
7:00	**Workshop Banquet**	*Level 1 Auditorium*
	Keynote: **John H. England**	*Level 1 Auditorium*

WEDNESDAY 13 MARCH		
8:45	**Paleoclimatology I**	*Level 2 Reading Room*
10:35	Morning Break	*Level 1 Auditorium*
10:50	**Paleoclimatology II**	*Level 2 Reading Room*
12:40	**End of Meeting.** *Thanks for coming!*	*Level 2 Reading Room*

Program Details

SUNDAY 10 MARCH 2013

9:00 to 4:00 **Pre-workshop Field Trip** (*meet in Lobby of UMass Hotel*)
"*Deglacial History and Environments of the Pioneer Valley*".
Led by Julie Brigham-Grette et al. Limited space, you must sign up (online registration).
$25 (includes transportation, guidebook, coffee and box lunch)

PM - SUNDAY 10 MARCH 2013

7:00 to 9:30 **Evening Reception, Check in, & Registration** (*Level 11, Campus Center*)
Snacks and drinks will be served; cash bar for wine or beer;
load presentations onto computer; put up posters in Level 1 Auditorium.

AM – MONDAY 11 MARCH 2013

8:00 **Check-in & Registration** (*Level 2 Reading Room, Campus Center*)
(Load presentations onto our computer, put up posters in Level 1 Auditorium)

8:45 **Workshop Welcome & Introduction** (*Level 2 Reading Room, Campus Center*)

Paleoceanography I – *Level 2 Reading Room*

9:00 **WAS SEDIMENT EXPORTED FROM BAFFIN BAY ACROSS DAVIS STRAIT TO THE LABRADOR SEA DURING THE LAST GLACIAL CYCLE?**
Andrews, John T; Gibb, Olivia T; Jennings, Anne E; Simon, Quentin [pg 4]

9:30 **OCEANOGRAPHIC REGIMES IN THE WESTERN LABRADOR SEA SINCE MARINE ISOTOPE STAGE 3 BASED ON DINOCYST AND STABLE ISOTOPE PROXY RECORDS**
Gibb, Olivia T; de Vernal, Anne; Hillaire-Marcel, Claude [pg 59]

9:50 **THE ROLE OF OCEAN WARMING IN ICE SHEET-OCEAN INTERACTIONS IN EASTERN BAFFIN BAY FROM LGM THROUGH DEGLACIATION**
Jennings, Anne E; Andrews, John T; ´OCofaigh, Colm; Sheldon, Christina M; Dowdeswell, Julian; St-Onge, Guillaume [pg 63]

10:10 ☕ Morning Break (*Level 1 Auditorium*)

AM – MONDAY 11 MARCH 2013

Paleoceanography II – *Level 2 Reading Room*

10:40 **RECONCILIATION OF PHYSICAL OCEANOGRAPHIC THEORY AND PALEOCEANOGRAPHIC DATA: THE ROLE OF THE BERING STRAIT, SOUTHERN OCEAN WINDS AND THE ATLANTIC MERIDIONAL CIRCULATION**

Ortiz, Joseph D; Nof, Doron [pg 99]

11:00 **SEDIMENTARY RECORD IN THE CHUKCHI PLATEAU (WESTERN ARCTIC OCEAN) AND ITS PALEOCEANOGRAPHIC IMPLICATIONS**

Park, Kwang-Kyu; Khim, Boo-Keun; Ohkushi, Kenichi [pg 102]

11:20 **HOLOCENE SEDIMENT TRANSPORT FROM THE BERING SEA INTO THE CHUKCHI SHELF: MINERALOGICAL AND ISOTOPIC RECORDS**

Khim, B.K.; Keigwin, L.D.; Lee, M.J.; Cho, H.G.; Harada, N.; Uchida, M. [pg 69]

11:40 **DRIFT ICE SIGNAL AT EIRIK DRIFT (SOUTH GREENLAND) DURING THE LAST ~3000 YEARS**

Alonso-Garcia, Montserrat; Kleiven, Helga (Kikki) F.; Hollander, David; Shevenell, Amelia E. [pg 1]

12:00 **LUNCH**

See printout of food options in your registration packet

PM – MONDAY 11 MARCH 2013

Glacial History – *Level 2 Reading Room*

1:00 **DUCK HAWK BLUFFS, SW BANKS ISLAND: REVISITING THE LYNCHPIN TO A LONG-ESTABLISHED NEOGENE-QUATERNARY MODEL OF THE WESTERN CANADIAN ARCTIC**

Evans, David J A; **England**, John H; Coulthard, Roy D; Lakeman, Thomas R; La Farge, Catherine [pg 48]

1:30 **PRELIMINARY ^{10}BE AND ^{26}AL TERRESTRIAL COSMOGENIC NUCLIDE EXPOSURE DATES ON FAR-TRAVELLED (>1000KM) ERRATIC BOULDERS FROM PRINCE PATRICK ISLAND, NWT**

Coulthard, Roy D; Doupé, Jonathan P; England, John H [pg 30]

1:50 **ICE-MARGIN DYNAMICS OF CIRCUM BAFFIN BAY GLACIERS DURING THE LAST GLACIAL CYCLE**

Simon, Quentin; Hillaire-Marcel, Claude; St-Onge, Guillaume; Andrews, John T [pg 122]

2:10 **A 10BE CHRONOLOGY OF LATE PLEISTOCENE AND HOLOCENE GLACIATION IN THE ALAPAH MOUNTAIN REGION, NORTH-CENTRAL BROOKS RANGE**

Pendleton, Simon L; Briner, Jason P [pg 111]

2:30 **RECONSTRUCTING HOLOCENE ICE MARGIN FLUCTUATION IN DISKO BUGT, WEST GREENLAND**

Kelley, Samuel E.; Briner, Jason P.; Cronauer, Sandra L. [pg 66]

2:50 **REGROWTH OF LITTLE ICE AGE BRYOPHYTES EXHUMED FROM A POLAR GLACIER: THE RELEVANCE OF TOTIPOTENCY TO BIOLOGICAL REFUGIA**

La Farge, Catherine; Williams, Krista H; England, John H [pg 72]

3:10 **HOLOCENE ICE CAP DYNAMICS RECONSTRUCTED FROM RADIOCARBON-DATED MOSS AND MAMMAL BONES CURRENTLY EMERGING ALONG RECEDING ICE MARGINS ON CUMBERLAND PENINSULA, BAFFIN ISLAND**

Margreth, Annina; Kosar, Kevin; Dyke, Arthur S; Gosse, John C; Tekla, Alice [pg 83]

3:30 **COMPLEX AND HIGHLY VARIABLE CARBON ACCUMULATION AT IMNAVAIT CREEK PEATLAND**

Nichols, Jonathan E.; Peteet, Dorothy M.; Pavia, Frank J.; Karavias, John; Ouni, Souha [pg 90]

3:50 ☕ Afternoon Break (*Level 1 Auditorium*)

PM – MONDAY 11 MARCH 2013

Poster Session I (odd-numbered posters) 4:00 – 6:00 pm *Level 1 Auditorium*

1 **STRUCTURE OF RELICT ARCTIC PLANT COMMUNITIES ALONG THE NORTH SHORE OF LAKE SUPERIOR**

Edgerton, Angelique D; Pastor, John [pg 46]

3 **CONTROLS ON SLOPE-TO-CHANNEL FINE SEDIMENT CONNECTIVITY IN A LARGELY ICE-FREE VALLEY, HOOPHORN STREAM, SOUTHERN ALPS, NEW ZEALAND.**

Beel, Casey R; Orwin, John F; Holland, Peter G [pg 13]

5 **TEMPORAL ANALYSIS OF SUSPENDED SEDIMENT CONCENTRATION CHANGES IN A PROGLACIAL MELTWATER STREAM, LINNÉBREEN, SVALBARD.**

Nussbaum, Kayla E [pg 91]

7 **CAN GREENHOUSE GAS EMISSIONS FROM ARCTIC THAW POND BE DRIVEN BY THEIR GEOMORPHOLOGY?**

Negandhi, Karita; Laurion, Isabelle [pg 89]

9 **REVISION OF THE QUATERNARY STRATIGRAPHY AT MORGAN BLUFFS, BANKS ISLAND, WESTERN CANADIAN ARCTIC ARCHIPELAGO**

Lakeman, Thomas R.; England, John H. [pg 74]

11 **USING GIS AND STREAMLINED LANDFORMS TO INTERPRET PALEO-ICE FLOW IN NORTHERN ICELAND**

Moyer, Alexis N; **Principato**, Sarah M [pg 87]

13 **USING WESTERN GREENLAND ISOLATION BASINS TO CONSTRAIN MIDDLE HOLOCENE ICE SHEET AND RELATIVE SEA LEVEL CHANGES**

West, Brayton A; Kelley, Samuel E; Briner, Jason P [pgc138]

15 **SHIFTING CLIMATE STATES OF THE POLAR REGIONS (SHIFTS)**

Bakke, Jostein [pg 7]

17 **HIGH-LATITUDE NORTH ATLANTIC HOLOCENE CLIMATE RECONSTRUCTION FROM SVALBARD LAKE SYSTEMS: INSIGHTS ON THE ATLANTIC MULTIDECADAL OSCILLATION (AMO)IN THE ARCTIC NORTH ATLANTIC**

D'Anjou, Robert M.; Bradley, Raymond S.; D'Andrea, William; Bakke, Jostein; Røthe, Torgeir; Gjerde, Marthe [pg 36]

19 **HYDROCLIMATIC VARIABILITY INFERRED FROM SUBANNUAL SEDIMENT PULSES IN LAKE LINNÉVATNET, SVALBARD**

Obermeyer, Dion A; Kaufman, Darrell [pg 95]

21 **LAMINATED SEDIMENTS FROM A PROGLACIAL LAKE IN BODALEN, NORDENSKIOLDLAND, SVALBARD: IMPLICATIONS FOR LATE LITTLE ICE AGE AND 20TH CENTURY GLACIER DYNAMICS AND GLACIAL-LACUSTRINE SEDIMENT PRODUCTION**

Retelle, Mike; Dowey, Colin; Dulin, Ian [pg 116]

PM – MONDAY 11 MARCH 2013

Poster Session I continued (odd-numbered posters) 4:00 – 6:00 pm

23 **HIGH-RESOLUTION HOLOCENE GLACIER RECONSTRUCTIONS FROM HIGH NORTHERN LATITUDES: EVALUATING MODES OF CLIMATE VARIABILITY AND POSSIBLE INTER-HEMISPHERIC CLIMATE LINKAGES**

Wittmeier, Hella E.; Bakke, Jostein; Schaefer, Joerg M. [pg 144]

25 **PAIRED RESPONSE OF TWO HIGH-ARCTIC LAKES TO 5000 YEARS OF CLIMATE AND ENVIRONMENTAL CHANGE**

Cook, Timothy L; Balascio, Nicholas L; Bradley, Raymond S. [pg 28]

27 **1750 YEARS OF LARGE RAINFALL EVENTS INFERRED FROM SEDIMENTARY PARTICLE SIZE AT EAST LAKE, CAPE BOUNTY, MELVILLE ISLAND, CANADA**

Lapointe, François; Francus, Pierre; Lamoureux, Scott [pg 76]

29 **A HOLOCENE MIDGE (CHIRONOMIDAE) RECORD FROM FLOWER VALLEY LAKE, SOUTHEAST GREENLAND**

Francis, Donna R.; Balascio, Nicholas L.; D'Andrea, William J.; Bradley, Raymond S.; Perren, Bianca B. [pg 55]

31 **NOVEL TRI-UNSATURATED ALKENONES IN ARCTIC LAKES: IMPLICATIONS FOR PALEOTEMPERATURE RECONSTRUCTION**

Longo, William M; Dillon, James; Theroux, Susanna; Giblin, Anne E; Huang, Yongsong [pg 80]

33 **BERING/CHUKCHI SEA LATE QUATERNARY PROVENANCE AND FLOW REGIME RECONSTRUCTION THROUGH SEDIMENTOLOGIC EVIDENCE**

Pelto, Ben M; Brigham-Grette, Julie; Kocis, James J; Petsch, Steven [pg 108]

35 **ARCTIC SEA-ICE GEOCHEMICAL AND ISOTOPIC TRACERS AND ITS ENHANCED EXPORT DURING THE YOUNGER DRYAS**

Maccali, Jenny; Hillaire-Marcel, Claude; Not, Christelle; Poirier, André [pg 82]

37 **URANIUM-SERIES IN DEEP BAFFIN BAY SEDIMENTS AS TRACERS OF DETRITAL SOURCES AND SEDIMENTARY PROCESSES**

Nuttin, Laurence; Hillaire-Marcel, Claude [pg 94]

39 **ENVIRONMENTAL AND PALEOMAGNETIC SECULAR VARIATION CHANGES DURING THE HOLOCENE IN BAFFIN BAY: A HIGH-RESOLUTION STUDY BASED ON THE PHYSICAL AND MAGNETIC PROPERTIES OF FOUR PISTON CORES**

St-Onge, Marie-Pier; St-Onge, Guillaume [pg 127]

41 **OCEAN CHANGES AND THEIR RELATIONSHIP WITH GLACIER DYNAMICS IN DISKO BUGT AREA, WEST-GREENLAND, DURING THE HOLOCENE**

Ouellet-Bernier, Marie-Michèle; de Vernal, Anne; Hillaire-Marcel, Claude [pg 101]

43 **QUATERNARY ARCTIC OCEAN: SEA ICE AND OCEAN CIRCULATION VARIABILITY OVER ORBITAL TIMESCALES**

Gemery, Laura; Cronin, Thomas M; Caverly, Emma; Deninno, Lauren; Polyak, Leonid [pg 58]

PM – MONDAY 11 MARCH 2013

6:30 **Non-student Dinner** at Julie Brigham Grette's house

7:00 **Student-only Pizza Party** at the University Club. The party will be a meetup co-sponsored by the Association of Polar Early Career Scientists (APECS). Representatives from the NE USA APECS Chapter will highlight opportunities such as mentorship, collaboration, and career guidance.

AM – TUESDAY 12 MARCH 2013

Paleolimnology – *Level 2 Reading Room*

9:00 **DECIPHERING CLIMATE SIGNALS FROM THE INHERENT COMPLEXITIES OF LAKE SEDIMENTS: IT IS AS CLEAR AS MUD!**
Smol, John P. [pg 125]

9:30 **ABRUPT CLIMATE TRANSITIONS RECORDED IN SYNCHRONIZED HOLOCENE GLACIAL AND NON-GLACIAL LACUSTRINE RECORDS IN ICELAND**
Geirsdottir, Aslaug; **Miller**, Gifford; Larsen, Darren; Olafsdottir, Saedis [pg 57]

9:50 **HOLOCENE CLIMATE VARIABILITY RECONSTRUCTED FROM A LAKE SEDIMENT RECORD IN SE GREENLAND**
de Wet, Greg; Bradley, Raymond; Balascio, Nicholas; Davin, Sam; Castañeda, Isla [pg 38]

10:10 **DEFINING THE TRANSITION TO THE LATE HOLOCENE NEOGLACIAL PERIOD USING LAKE SEDIMENT RECORDS FROM SOUTHEAST GREENLAND**
Balascio, Nicholas L; D'Andrea, William J.; Bradley, Raymond S. [pg 10]

10:30 Morning Break (*Level 1 Auditorium*)

Modelling – *Level 2 Reading Room*

10:50 **A HIGH RESOLUTION ICEBERG MODEL TO UNDERSTAND HOW MELTWATER TRIGGERS ABRUPT CLIMATE CHANGE**
Condron, Alan; Bradley, Raymond S [pg 27]

11:10 **LINKS BETWEEN PERMAFROST, WATER AND CARBON CYCLING ACROSS THE TERRESTRIAL ARCTIC UNDER A WARMING CLIMATE**
Rawlins, Michael [pg 115]

11:30 **HOLOCENE EVOLUTION OF THE WESTERN GREENLAND ICE SHEET: ASSESSING GEOPHYSICAL ICE-SHEET MODELS WITH GEOLOGICAL RECONSTRUCTIONS OF ICE-MARGIN CHANGE**
Young, Nicolás; Briner, Jason [pg 147]

11:50 **MODELING THE EFFECTS OF HOLOCENE PRIMARY PRODUCTIVITY CHANGES ON ORGANIC CARBON ACCUMULATION AND STORAGE IN THE BARENTS SEA**
Pathirana, Irene; Felix, Maarten; Knies, Jochen; Mann, Ute [pg 103]

12:10 **LUNCH**

PM – TUESDAY 12 MARCH 2013

Special Talk – *Level 2 Reading Room*

1:20 **THE UNION OF CONCERNED SCIENTISTS**
Knobloch, Kevin (President, Union of Concerned Scientists)

Glaciology – *Level 2 Reading Room*

1:50 **ESTIMATES OF TIDEWATER GLACIER MELTING FROM WARMING FJORD WATERS IN SVALBARD**
Powell, Ross; Rajagopalan, Daksha; Brigham-Grette, Julie; Siegel, Rebecca [pg 113]

2:15 **SERMILIK FJORD OUTLET GLACIERS, SOUTHEAST GREENLAND: COHERENT BEHAVIOR OR A DRUNKARDS WALK?**
Miles, Victoria; **Miles**, Martin W.; Johannessen, Ola M. [pg 85]

2:35 **EXAMINING THE PAST DYNAMICS OF THE NORTHEAST GREENLAND ICE SHEET THROUGH RADAR INTERNAL STRATIGRAPHY**
Keisling, Benjamin; Christianson, Knut; Jacobel, Robert; Anandakrishnan, Sridhar; Peters, Leo; Alley, Richard [pg 65]

2:55 **UTILITY OF SATELLITE DERIVED TRANSIENT SNOWLINE MIGRATION RATES IN MASS BALANCE ASSESSMENT ON ARCTIC GLACIERS**
Pelto, Mauri; Mernild, Sebastian; Malmros, Jeppe [pg 104]

3:15 **CONNECTING THE ATLANTIC-SECTOR AND THE NORTH PACIFIC (MT LOGAN) ICE CORE STABLE ISOTOPE RECORDS DURING THE HOLOCENE: THE ROLE OF EL NIÑO AND THE GREAT 4.2 KA BP EVENT**
Fisher, David A [pg 54]

3:45 End of Session

Chasing Ice - Award-winning documentary film (*ISB Auditorium*)

4:00 to 5:15

"*Chasing Ice* is the story of one man's mission to change the tide of history by gathering undeniable evidence of climate change. Using time-lapse cameras, his videos compress years into seconds and capture ancient mountains of ice in motion as they disappear at a breathtaking rate."

http://www.chasingice.com/

Film sponsored by UMass Department of Geosciences.

PM – TUESDAY 12 MARCH 2013

Poster Session II (even-numbered posters) 5:30 -7:00 *Level 1 Auditorium*

2 **BIOAVAILABILITY OF METHYLMERCURY TO ARCTIC CHAR ON CORNWALLIS ISLAND, NUNAVUT**

Hudelson, Karista E; Barst, Benjamin D; Drevnick, Paul E [pg 62]

4 **A GEOMORPHIC AND SEDIMENTOLOGICAL STUDY OF THE PERIGLACIAL PROCESSES AND ENVIRONMENTS, VARDEBORGSLETTA, WESTERN SPITSBERGEN, SVALBARD**

Farnsworth, Lauren B; Retelle, Michael J; Christiansen, Hanne; Cohen, Sara M [pg 51]

6 **ICE-MARGINAL AND PROGLACIAL FLUVIAL CHARACTERISTICS OF A HIGH-ARCTIC GLACIER, LINNÉBREEN, SVALBARD**

Whiting, John; Carson, Robert; Bader, Nicholas; Roof, Steven; Retelle, Michael [pg 142]

8 **THE GLACIOTECTONIC HISTORY OF THE WORTH POINT STRATIGRAPHIC SEQUENCE, BANKS ISLAND, NT, CANADA.**

Vaughan, Jess M; England, John [pg 132]

10 **USING GIS TO RECONSTRUCT PALEO EQUILIBRIUM-LINE ALTITUDES FROM CIRQUES IN NORTHWEST ICELAND**

Lee, Jessica F; Principato, Sarah M [pg 78]

12 **RECONSTRUCTING HOLOCENE ICE SHEET MARGINS IN CENTRAL WESTERN GREENLAND: WHAT IS THE AGE OF THE DRYGALSKI MORAINES?**

Cronauer, Sandra L; Briner, Jason P; Kelley, Samuel E [pg 32]

14 **HOLOCENE FLUCTUATIONS OF LINNÉ GLACIER: CONSTRAINING ITS PRE-LITTLE ICE AGE HISTORY USING COSMOGENIC RADIONUCLIDE EXPOSURE DATING**

Reusche, Melissa M; Windsor, Kelsey; Carlson, Anders; Rood, Dylan H; Novak, Anthony; Marcott, Shaun; Roof, Steven; Retelle, Michael [pg 118]

16 **INTEGRATING CONTEMPORARY ARCTIC RESEARCH INTO SECONDARY EDUCATION CURRICULUM: EXPERIENCE, OUTREACH, AND CURRICULUM BUILDING THROUGH A FIELD SEASON IN SVALBARD**

Frost, Daniel S [pg 56]

18 **LATE HOLOCENE PALEOCLIMATE RECONSTRUCTION FROM VARVED SEDIMENT RECORD, LINNÉVATNET, SVALBARD, NORWAY**

Dowey, Colin W; Retelle, Michael J [pg 41]

20 **USING CLAY MINERALOGY TO ANALYZE SEDIMENT CONTRIBUTIONS TO LINNÉVATNET, SPITSBERGEN, SVALBARD**

Tiedmann, Helena R [pg 129]

22 **HOLOCENE GLACIER FLUCTUATIONS RECONSTRUCTED FROM THE DISTAL GLACIER-FED LAKE KLØSA AT MITRAHALVØYA, SPITSBERGEN**

Røthe, Torgeir; Bakke , Jostein; Hormes, Anne; Gjerde, Marthe; D'Anjou, Robert; D'Andrea, William; Bradley, Raymond [pg 121]

PM – TUESDAY 12 MARCH 2013

Poster Session II continued (even-numbered posters) 5:30 -7:00

24 **RECONSTRUCTING CLIMATE AND ENVIRONMENTAL CHANGE OVER THE LAST 9000 YEARS BASED ON A PEAT BOG RECORD FROM NORTHERN NORWAY**

Kelly, Michael P; Balascio, Nicholas; Anderson, Scott; Bakke, Jostein [pg 68]

26 **MORPHOSTRATIGRAPHIC STUDY OF THE PINGUALUIT CRATER LAKE, NUNAVIK: INITIAL LIDAR RESULTS**

Desiage, Pierre-Arnaud; St-Onge, Guillaume; Lajeunesse, Patrick [pg 39]

28 **A 7000 YEAR RECORD OF CLIMATE CHANGE FROM AMMASSALIK, SE GREENLAND**

Davin, Samuel H; Bradley, Raymond S; Balascio, Nicholas [pg 37]

30 **A 10,800 YEAR XRF DERIVED LAKE LEVEL RECORD SPANNING THE LATEGLACIAL TO MIDDLE-HOLOCENE FROM OTTER LAKE, SOUTHCENTRAL ALASKA**

Bochicchio, Chris J; Yu, Zicheng [pg 17]

32 **DISTRIBUTION OF BRANCHED AND ISOPRENOIDAL GDGTS IN RELATION TO MODERN SSTS AND ENVIRONMENTAL VARIABLES IN THE BERINGIAN GATEWAY**

Kocis, James J; Castañeda, Isla S; Petsch, Steven T; Finkelstein, David B; Brigham-Grette, Julie [pg 70]

34 **PALEOMAGNETIC STUDY OF HOLOCENE SEDIMENTS FROM THE MACKENZIE RIVER TROUGH IN THE BEAUFORT SEA**

Barris, Elissa C; St-Onge, Guillaume; Rochon, André [pg 11]

36 **PALEOMAGNETISM AND ENVIRONMENTAL CHANGES FROM SOUTHWESTERN HUDSON BAY HOLOCENE SEDIMENTS: PRELIMINARY RESULTS**

Duboc, Quentin; St-Onge, Guillaume; Lajeunesse, Patrick [pg 44]

38 **LEAD CONCENTRATIONS AND ISOTOPIC COMPOSITIONS OF EASTERN AND NORTHERN BAFFIN BAY SURFACE SEDIMENTS.**

Pujol, Nicolas; Poirier, André; Hillaire-Marcel, Claude [pg 114]

40 **HOLOCENE SEDIMENTARY ENVIRONMENTS IN SMEERENBURGFJORDEN, SPITSBERGEN**

Velle, Julie H.; Forwick, Matthias; Hass, H. Christian; Laberg, Jan Sverre; Vorren, Tore O.; Vogt, Christoph; Nielsen, Tove; Solheim, Anders [pg 133]

42 **A GCM COMPARISON OF MARINE ISOTOPE STAGES 1, 5E, 11C AND 31 IN RELATION TO LAKE EL'GYGYTGYN NE RUSSIA**

Coletti, Anthony J; DeConto, Robert M; Melles, Martin; Brigham-Grette, Julie; Minyuk, Pavel S [pg 26]

44 **THE EFFECT OF ORBITAL FORCING ON POLAR CLIMATE**

Roychowdhury, Rajarshi; Robert, DeConto M [pg 120]

PM – TUESDAY 12 MARCH 2013

Workshop Banquet and Keynote (*Level 1 Auditorium*)

7:00 **WORKSHOP BANQUET & KEYNOTE**

John H. England
Professor Emeritus
Dept. of Earth and Atmospheric Sciences
University of Aberta, Canada

"My Arctic Camino of Forty-eight Years and Counting: stories of remarkable friends, calamities and adventures that ultimately eclipse the splendour of science"

AM – WEDNESDAY 13 MARCH 2013

Paleoclimatology I – *Level 2 Reading Room*

8:45 **MILLENNIAL SCALE CHANGE FROM LAKE EL'GYGYTGYN, NE RUSSIA: DID WE STEP OR LEAP OUT OF THE WARM PLIOCENE INTO THE PLEISTOCENE?**
Brigham-Grette, Julie; Melles, Martin; Minyuk, Pavel; , El'gygytgyn Science Team [pg 19]

9:15 **COLOR REFLECTANCE SPECTROSCOPY AND MINERALOGICAL ANALYSIS FROM LAKE EL'GYGYTGYN, NE SIBERIA, DURING MARINE ISOTOPE STAGES 8 - 12**
Wei, Jeremy H.; Brigham-Grette, Julie; Castañeda, Isla S.; Finkelstein, David B.; Nowaczyk, Norbert [pg 137]

9:35 **DID NORTHERN HEMISPHERE GLACIATION BEGIN WITH THE NORTH PACIFIC OCEAN?**
Venti, Nicholas L; Billups, Katharina; Herbert, Timothy D [pg 134]

9:55 **REVERSING THE IMPACT OF THE HAUGHTON CRATER, DEVON ISLAND, CANADA**
Gosse, John; Rybczynski, Natalia; Stubner, Konstanze [pg 61]

10:15 **EXAMINING GLACIAL-INTERGLACIAL CONTINENTAL TEMPERATURE VARIABILITY IN THE BERINGIAN ARCTIC DURING MARINE ISOTOPE STAGES (MIS) 1-7, MIS 9-11 AND MIS 31: INSIGHTS FROM AN ORGANIC GEOCHEMICAL INVESTIGATION OF LAKE EL'GYGYTGYN**
Castañeda, Isla S.; Finkelstein, David B; Wei, Jeremy; D'Anjou, Robert M; Phu, Victoria; Urann, Ben; Wilkie, Kenna; Brigham-Grette, Julie [pg 23]

10:35 Morning Break (*Level 1 Auditorium*)

AM – WEDNESDAY 13 MARCH 2013

Paleoclimatology II – *Level 2 Reading Room*

10:50 **SEDIMENT CORE AND GLACIAL ENVIRONMENT RECONSTRUCTION – A METHOD REVIEW**

Bakke, Jostein [pg 9]

11:20 **NORTH-ATLANTIC HOLOCENE CLIMATE VARIABILITY REFLECTED IN THE DYNAMICAL RESPONSE OF NORWEGIAN MARITIME GLACIERS**

Vasskog, Kristian; Bakke, Jostein; Førre, Erlend; Tolo, Annbjørg; Nielsen, Pål R; Birks, H.J.B; Kvisvik, Bjørn C; , et al. [pg 131]

11:40 **AMINO ACID RATIOS IN REWORKED MARINE BIVALVE SHELLS CONSTRAIN GREENLAND ICE SHEET HISTORY DURING THE HOLOCENE**

Briner, Jason P; Kaufman, Darrell S; Bennike, Ole [pg 20]

12:00 **CLIMATE IMPACTS ON HUMAN SETTLEMENT AND AGRICULTURAL ACTIVITIES IN NORTHERN NORWAY REVEALED THROUGH SEDIMENT BIOGEOCHEMISTRY**

D'Anjou, Robert M.; Bradley, Raymond S.; Balascio, Nicholas; Finkelstein, David B; Castañeda , Isla S. [pg 34]

12:20 **MODELING HABITAT USE BY BOWHEAD WHALES IN RESPONSE TO PAST AND FUTURE ARCTIC CLIMATE CHANGE**

Pendleton, Dan; Zhang, Jinlun; Ferguson, Megan; Holmes, Elizabeth [pg 110]

12:40 **END OF MEETING – THANKS FOR ATTENDING!**

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Notes

DRIFT ICE SIGNAL AT EIRIK DRIFT (SOUTH GREENLAND) DURING THE LAST ~3000 YEARS

Alonso-Garcia, Montserrat [1]; **Kleiven**, Helga (Kikki) F. [2]; **Hollander**, David [3]; **Shevenell**, Amelia E. [4]

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The area of Eirik Drift (off South Greenland) is a very sensitive region in terms of ocean circulation and climate in the subpolar North Atlantic. This area is influenced by the cold and low salinity water of the East Greenland current (EGC) as well as by the Irminger current (IC), a branch of the North Atlantic current which transports warm and high salinity water from low to high latitudes (Fig. 1). The amount of sea ice and icebergs transported by the EGC to southern Greenland has been linked to several factors including temperature, atmospheric conditions in the polar/subpolar area (which induce changes in the speed of the EGC and sea ice production and export), the type of glaciers in East Greenland coast and their calving rates. Enhanced Arctic ice export has been related to the atmospheric conditions of the North Atlantic Oscillation (NAO) positive phase (Kwok and Rothrock, 1999). Moreover, the location and strength of a low-pressure system near Svalbard as well as the phase of the Arctic Oscillation (AO) is known to affect the Arctic sea ice production and the amount of ice moving through Fram Strait to the south (Rigor et al., 2002). Additionally, it has also been suggested that the atmospheric conditions in the Arctic may be forced by solar irradiance (see Bond et al., 2001, and references therein). Low solar irradiance intervals may induce changes in the stratosphere which cool the high northern latitude atmosphere and shift the northern subtropical jet southward, triggering oceanic feedbacks that spread the cooling effect and boost Arctic ice export via Fram Strait and the EGC.

In this work, we studied the occurrence of ice-rafted debris (IRD) at Eirik Drift as a proxy to evaluate the drift ice frequency and its linkage to ocean-atmosphere and solar irradiance forcings. The forcing records used in this study include reconstructions of solar irradiance (from the cosmogenic isotopes 10Be and 14C) and NAO. In addition, we compared our record with temperature reconstructions from ice cores, ocean and lake sediment cores from Northern Hemisphere sites. This study was carried out in two stages, first we generated a high resolution IRD record of the last ca. 1200 yr to evaluate the correlation between our ice rafted debris record and the forcing records at a multi-decadal scale. Second, since we also aimed to assess that correlation at a centennial-to-millennial-scale, a similar study has been performed using a lower resolution record which covers a longer time interval. We used sediments from the multicore GS06-144, located at Eirik Drift (57° N, 48° W; 3432 m water depth), for the high resolution study, and the sediment core MD03-2665, from the same location, for the long term record. The occurrence of IRD has been studied using the sediment size fraction between 63 and 150 μm. This fraction not only contains smaller grains, easier to study under the microscope, but also they are mostly mono-mineral allowing a good identification of the main IRD tracers such as the quartz/feldspar hematite stained grains (HSG) and volcanic glass (VG). An aliquot of each sample containing about 200-300 lithic grains (200 minimum) was studied using a high magnification stereomicroscope provided with transmitted and reflected lights. The benefit of using aliquots instead of preparing smear slides is that we can obtain IRD concentrations as well as relative abundances of each lithic component.

The high resolution record shows that IRD deposition at Eirik Drift during the last 100 yr has been significantly lower than during the last 1200 yr, even lower than during the Medieval Warm Period (MWP). Stronger IRD deposition occurred during the intervals AD 1000-1250, AD 1400-1450 and AD 1650-1800. The last two intervals coincide with the timing for the two main cooling phases of the Little Ice Age (LIA) described at close locations (eg. Larsen et al., 2011). However, the strong IRD accumulation events recorded between AD 1000 and 1250 are intriguing because this period corresponds to the MWP. The relative abundance of the petrologic tracer VG shows similar trends to the IRD concentration curve. In contrast, the relative abundance of HSG shows a first interval from AD 800 to 1150 of low values (between 5 and 15 %), then an interval of very low values (on average below 8 %) between AD 1150 and 1400, and after AD 1400 the record shows and increasing trend reaching values higher than 20 % during the XVI, XIX and XX centuries. The concentration of the HSG also shows the lowest values between AD 1150 and 1400 and an increasing trend after AD 1400, but after AD 1900 the concentration of HSG decreases. In addition, at the multi-decadal scale the relative abundance of HSG and the total IRD concentration are consistently opposite.

The changes in abundance and concentration of the HSG are most likely linked to variability in the sources of the ice drifted to Eirik Drift. The geological sources of HSG, the so-called red beds, are located in NE Greenland and the Arctic surroundings (Bond and Lotti, 1995). Although in these places the glaciers develop floating ice platforms which are commonly blocked by fast-ice and, as a consequence, most of the IRD are dropped in the fjords by bottom melting (Reeh, 2004, and references therein), the glaciers and sea ice may also contain wind-blown fine sand grains in the top. The periods of higher HSG abundance suggest, therefore, a higher input of IRD from the Arctic ice via the EGC. The increase in HSG after AD 1400 may be related to the LIA cooling. If sea surface temperature (SST) was colder the icebergs and sea ice coming from the Arctic had more possibilities to survive longer timer and reach Eirik Drift. The opposite may have occurred during the MWP. However, it seems that during the MWP less Arctic ice reached Eirik Drift area but there was greater input of IRD. This fact contrasts with the warm temperatures suggested by records from Greenland ice and Iceland sediment cores. It is likely that warmer SST were inducing higher rates of calving in SE Greenland increasing the input of IRD from this area, as it has been observed with recent global warming. If this is the case, the icebergs coming from SE Greenland may be carrying more IRD because they were not blocked by fast-ice in the fjords. Therefore, the higher IRD input during this period may not be associated with extreme iceberg discharges and Arctic sea ice export but with iceberg calving close to Eirik Drift (SE Greenland) and the low presence (or even absence) of fast-ice in those glaciers. A multi-proxy study of sediment input at West Denmark Strait shows higher input of Arctic IRD associated with warmer conditions, when the fast-ice was seasonal and allowed the drift of ice carried by the EGC to the studied area (Alonso-Garcia et al., in prep). Permanent sea ice conditions may have played a major role in the delivery of IRD preventing either iceberg rafting in the fjords or the drift of sea ice/icebergs in certain areas. Thus, the interpretation of events of high IRD deposition must be carefully analysed bearing in mind the dynamics of the area of study.

The preliminary results from the correlation and empirical orthogonal functions (EOF) analysis have been evaluated in this work. The first EOF explains the 22.3 % of the variance shows a significant negative correlation between the HSG (relative abundance and concentration) and the solar irradiance proxies. The second EOF explains the 18.3 % of the variance and shows a significant positive correlation between the total IRD concentration and the NAO index as well as a negative correlation between the relative abundance of HSG and total IRD concentration. The eigenvalues of each EOF show three different periods in agreement with the intervals described above. The long term record seems to show similar correlations in the centennial-millennial scale.

Alonso-Garcia, M., Andrews, J.T., Belt, S.T., Cabedo-Sanz, P., Darby, D., Jaeger, J. (in prep). A comparison between multi-proxy and historical data (AD 1990-1840) of drift-ice conditions on the East Greenland shelf (~66°N).

Bond, G., Kromer, B., Beer, J., Muscheler, R., Evans, M.N., Showers, W., Hoffmann, S., Lotti-Bond, R., Hajdas, I., Bonani, G., 2001. Persistent Solar Influence on North Atlantic Climate During the Holocene. Science 294, 2130-2136.

Bond, G.C., Lotti, R., 1995. Iceberg Discharges into the North Atlantic on Millennial Time Scales During the Last Glaciation. Science 267, 1005-1010.

Kwok, R., Rothrock, D.A., 1999. Variability of Fram Strait ice flux and North Atlantic Oscillation. J. Geophys. Res. 104, 5177-5189.

Larsen, D.J., Miller, G.H., Geirsdóttir, Á., Thordarson, T., 2011. A 3000-year varved record of glacier activity and climate change from the proglacial lake Hvítárvatn, Iceland. Quat. Sci. Rev. 30, 2715-2731.

Reeh, N., 2004. Holocene climate and fjord glaciations in Northeast Greenland: implications for IRD deposition in the North Atlantic. Sediment. Geol. 165, 333-342.

Rigor, I.G., Wallace, J.M., Colony, R.L., 2002. Response of Sea Ice to the Arctic Oscillation. J. Clim. 15, 2648-2663. Schmitz, W.J., McCartney, M., 1993. On the North Atlantic Circulation. Rev. Geophys. 31, 29-49.

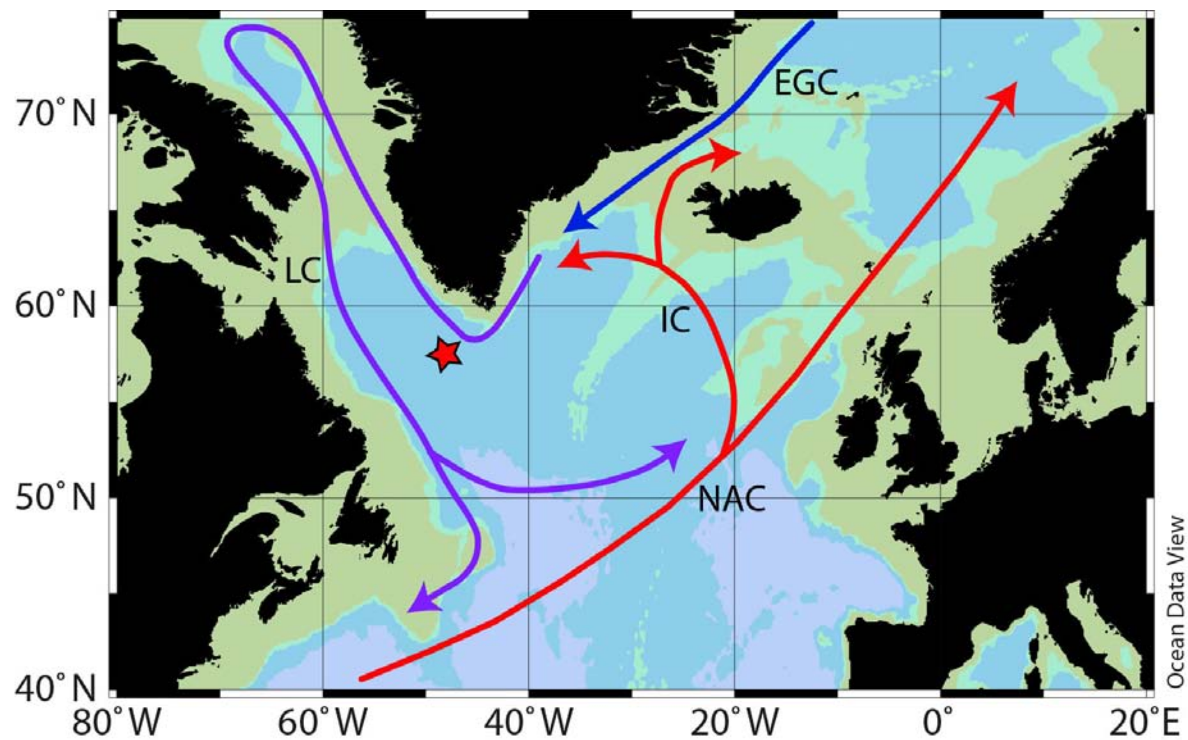

Fig 1. Location of the site studied in this work (red star) and sketch of the surface circulation in the subpolar North Atlantic (Schmitz and McCartney, 1993). EGC=East Greenland current, NAC=North Atlantic current, IC=Irminger current, LC=Labrador current.

WAS SEDIMENT EXPORTED FROM BAFFIN BAY ACROSS DAVIS STRAIT TO THE LABRADOR SEA DURING THE LAST GLACIAL CYCLE?

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Quaternary glacial marine sediments in both Baffin Bay and the Labrador Sea contain units that are dominated by detrital carbonates, eroded from mainly Paleozoic outcrops that floor many of the large grabens (e.g. Hudson Strait, Lancaster Sound), which were the product of early Tertiary rifting. In the Labrador Sea, these detrital carbonate-rich sediments (DC sediments or events), define the widely studied North Atlantic Heinrich (H-)-events. On the slope and floor of the Labrador Sea the DC sediments in the < 2 mm fraction are dominated by calcite versus dolomite in ratios ~6:1 and as a result magnetic susceptibilities within H-events are troughs. The DC-rich sediments thin along the transport path toward W/NW Europe where the carbonate in H-events is mainly dolomitic and where H-events are peaks in magnetic susceptibility. In contrast to Labrador Sea, DC sediments in Baffin Bay are marked by high weight %s of dolomite and low calcite, often with iron substituting into the crystal structure, which gives the sediment a buff, brownish color. As a consequence, the question that has been raised is whether Baffin Bay DC events (BBDC) and H-events are coeval, and if not, whether there are demonstrable leads and/or lags in the two areas? A corollary question is whether the DC events are associated with the importation of “warm” Atlantic Waters (Hiscott et al., 1989)? And yet another important question is whether, as has been suggested, an ice shelf ever existed in Baffin Bay and the Labrador Sea during the LGM interval, and is indeed a necessary condition for ice stream collapses?

To attempt an answer to these questions we undertook a study of a site cored during the HU2008029 cruise (Andrews et al., in press) and which recovered a box core (0006BC), and trigger and piston cores (0008TC, 0008PC) from a site in ~ 840 m of water and just to the south of the 600 m deep Davis Strait sill (Fig. 1). The main proxy for sediment export and provenance is the quantitative mineralogy of the < 2 mm sediment fraction, obtained from X-ray diffraction analysis using the methods developed by Eberl and used in Baffin Bay by Andrews and Eberl (2011). We compare the records from this site to a detailed record constructed by Simon et al (2012) from HU2008029-016PC from the deep central basin of Baffin Bay, and a series of cores from the slope and sea floor of the Labrador Sea, including HU2008029-0004TC and PC. A radiocarbon-based chronology for the 0008 site, based on 12 dates on planktonic foraminifera, had to be rejected, and an alternative depth/age model was developed based on correlation of DC events in Baffin Bay (016PC) and on the Labrador Sea slope (HU97049-007PC). Site 0008TC/PC shows a series of 5 dolomite-rich DC (Fig. 2) events derived from outcrops north of Baffin Bay and one (basal) calcite-rich event (probably originated from Hudson Strait). However, the bulk of the sediment is associated with two large West Greenland ice streams that reached the shelf break (Jennings et al., subm.; O'Cofaigh et al., in press). It appears that there is no evidence for collapse of the northern ice streams coeval with H-1 (~16 cal ka BP) nor H-2 (~24 cal ka BP).

Andrews, J.T., Eberl, D.D., 2011. Surface (sea floor) and near-surface (box core) sediment mineralogy in Baffin Bay as a key to sediment provenance and ice sheet variations. Canadian Journal of Earth Science 48, 1307-1328.
Andrews, J.T., Gibb, O.T., Jennings, A.E., Simon, Q., in press. Variations in the provenance of sediment from ice sheets surrounding Baffin Bay during MIS 2 and 3 and export to the Labrador Sea: Site HU2008029-0008 Davis

Strait. Journal of Quaternary Science.
Jennings, A.E., Walton, M.E., O Cofaigh, C., Killfeather, A.A., J.T., A., Ortiz, J.D., de Vernal, A., Dowdeswell, J.A., subm. Paleoenviroments during Younger Dryas-early Holocene Greenland ice retreat from outer Disko Trough, central West Greenland. Journal of Quaternary Science.
O'Cofaigh, C., Dowdeswell, J.A., Jennings, A.E., Hogan, K.A., Killfeather, A.A., Hiemstra, J.H., Noormets, R., Evans, J., McCarthy, D.J., Andrews, J.T., Lloyd, J.M., Moros, M., in press. An extensive and dynamic ice sheet on the West Greenland shelf durting the last glacial cycle. Geology.
Simon, Q., St-Onge, G., Hillaire-Marcel, C., 2012. Late Quaternary chronostratigraphic framework of deep Baffin Bay glaciomarine sedimentts from high-resolution paleomagnetic data. Geochemistry, Geophysics, Geosystems, 13, Q0AO03, doi:10.1029/2012GC004272 .

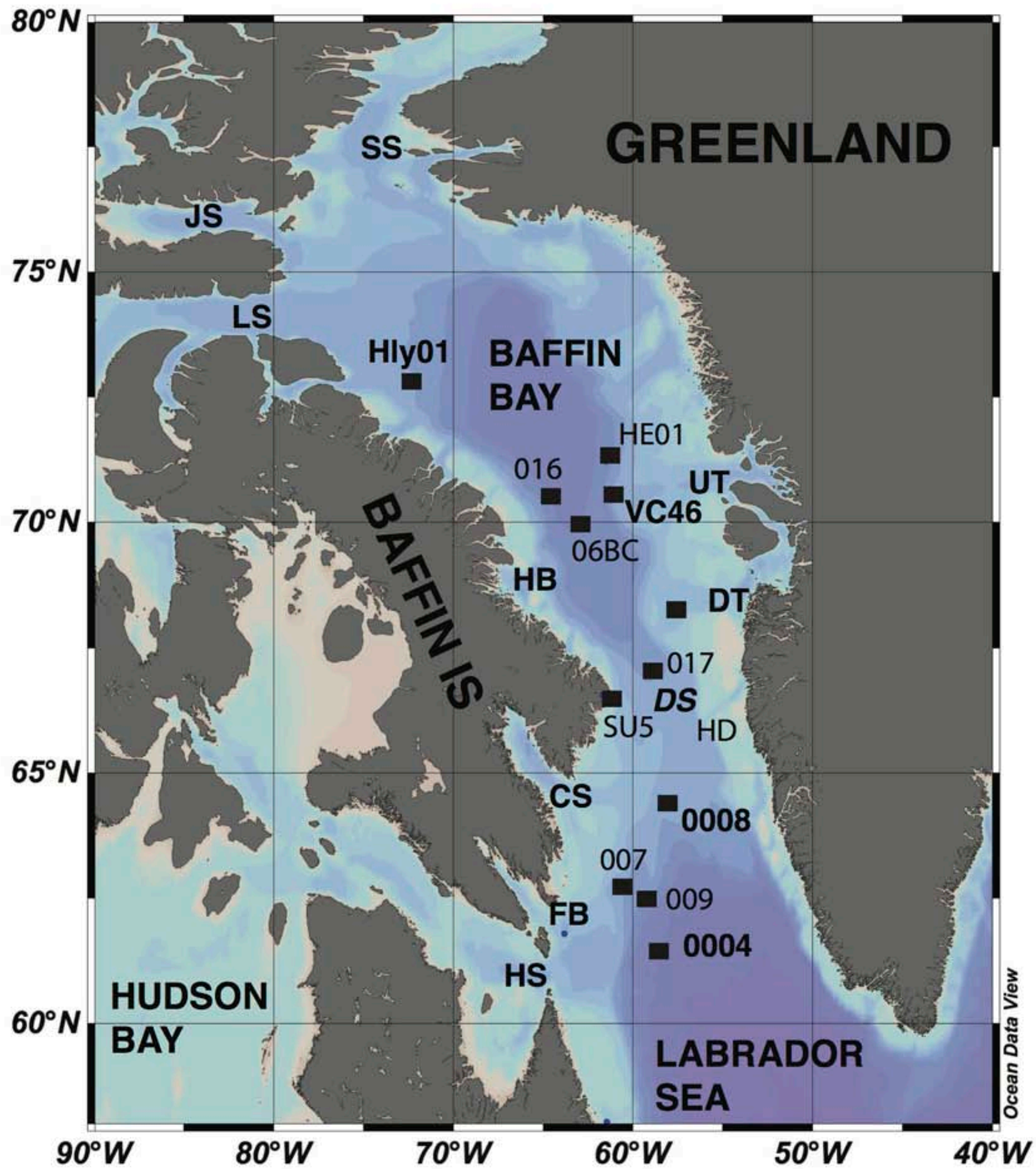

Fig 1. Map of the Davis Strait area and location of relevant core sites.

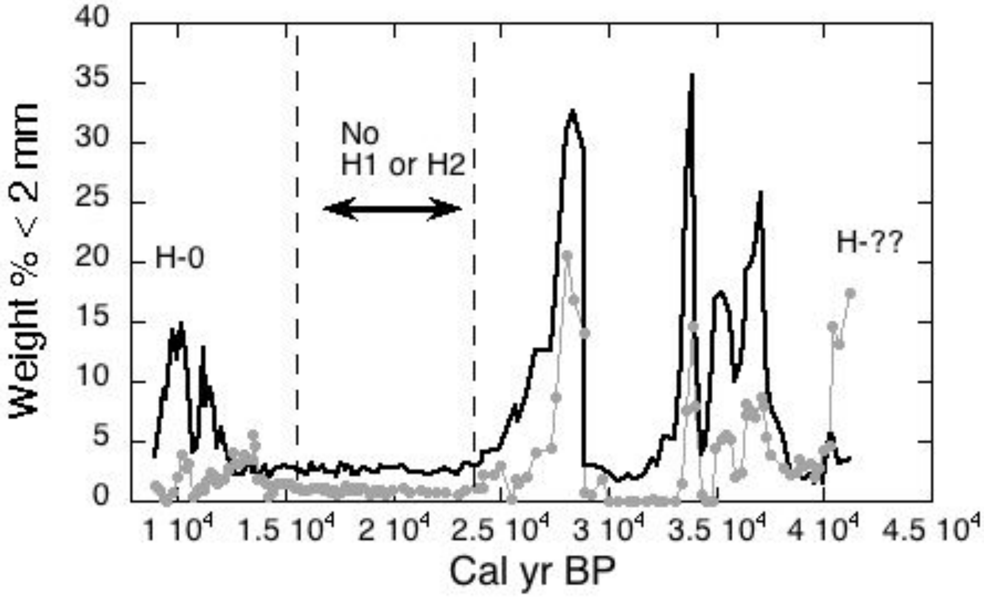

Fig 2. Graph of the down-core variations in dolomite (black line) and calcite weight % (grey line with filled circles) in HU2008029-0008PC on a chronology tied to HU97049-007PC (See Fig. 1)

SHIFTING CLIMATE STATES OF THE POLAR REGIONS (SHIFTS)

Bakke, Jostein [1]

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SHIFTS is a five year research program (2011-2016) aiming to produce high resolution climate reconstructions covering the Holocene time epoch from the two polar regions. Few approaches in palaeoscience have the potential to portray the spatial, temporal, and scalar expression of climate variability more accurately than the history of alpine glaciers worldwide. They are an underused resource in solving the puzzle of the Holocene drivers of global climate. However, it is only continuous reconstructions of glacier fluctuations that can be precisely correlated to other palaeoclimatic archives and records of forcing that will enhance our understanding of decadal and multidecadal climate variability. Our approach is based on the study of lake sediments in distal glacier-fed lakes mirroring the relationship between changes in sediment transfer rates from alpine glaciers and the size of the glacier and the changing glacier mass turnover gradient, which is driven by accumulation rates in winter and ablation-season temperatures.

Karlén (1976) originally suggested that glacial erosion and its associated rock-flour production provide a record of Holocene glacial fluctuations. Based on this concept, many studies have used the organic content of lacustrine sediments (measured by loss-on-ignition), sediment grain size, bulk sediment density, and magnetic susceptibility as proxies for the amount of glacial erosion, and thus glacial activity. However, it is now clear that this simple approach outlined by Karlén needs to be supported by other methods. In order to portray the variability of glaciers at the timescale of the Holocene, it is necessary to integrate multiple methods for dating moraines (e.g. cosmogenic 10Be dating of moraine surface boulders and lichenometry) and multi-proxy analyses of sediments from distal glacial-fed lakes. The downstream lake sediments will be linked to glacier activity through a novel methodology that integrates physical properties (grain size, density, organic content, water content), geochemical properties (elements analyzed at high resolution with XRF scanner), and different magnetic properties (e.g. magnetic susceptibility, paramagnetic susceptibility, diamagnetic susceptibility, ferromagnetic susceptibility, natural remanent magnetisation) in combination with multiple dating techniques including radiocarbon dating, 210Pb dating, palaeosecular variations (PSV) and Relative PaleoIntensity (RPI), and identification of tephra layers. The SHIFTS project applies a suite of multi proxy analyses to the sedimentary records, with the aim of describing the relationship between glacier sizes and different physical properties and geochemical variability in distal glacial-fed lakes. The new glacier reconstructions provided by SHIFTS will be validated against recent instrumental climate data and glacier mass-balance measurements at a regional scale. Based on this, rigorous error estimates for the proxy records will be generated. These are essential for defining the scale of natural variability and for the data output. Information on winter climate can be extracted from reconstructed glaciers combined with an independent proxy for contemporaneous summer temperature (e.g. pollen or chironomids).

In SHIFTS we aim to establish an integrated, coherent, targeted effort to reconstruct past shifts in the major polar atmospheric circulation systems such as the Southern Annular Mode (SAM) and the Northern Annular Mode (NAM) using novel approaches involving integrated reconstructions of past glacier variability in the two hemispheres. The understanding of natural variability achieved in SHIFTS will improve attribution and prediction of recent and future warming in polar regions and will be ground breaking for constraining the potential for natural cycles to amplify or dampen anthropogenically forced changes. We hope that the development of a novel methodological approach and the application of this in polar regions where palaeoclimatic data with high resolution are scarce, will provide new insight into the puzzle of Holocene climate variability. SHIFTS will integrate specialist knowledge from different researchers and research fields. Once the methodology has been established and calibrated, the approach can be widely used in palaeoclimatic investigations, not only in distal glacial-fed lakes but also in non-glacial lakes in order to verify the sedimentary proxies used for climate reconstructions e.g. from pollen data. Hopefully the methodological approaches developed in SHIFTS will set a new standard for analyses of sediments from lakes worldwide.

So far we have done fieldwork in three out of four regions during the two first years of the project and are currently planning an expedition to Kerguelen during the fall 2013. At South Georgia, Southern Ocean we have cored seven lakes and we have sampled two moraine systems for analyses of cosmogenic samples in order to build a robust and well dated Holocene moraine chronology. Two coring campaigns have been complete, the first one was during the International Polar Year in 2008 were we surveyed a lot of lake systems and the last one was in 2012 completing the lake coring program under the SHIFTS umbrella. One of the reconstructions are finalized and presented in this poster. The Hodges glacier is now melted away for the first time during the entire Holocene as a response to the warming that has taken place over this region during the latest decades. In general the glacial history of South Georgia is a story about retreating glaciers interrupted by some large glacial advance bracketed between 8.5-8k yr BP, 6-5.5k yr BP, 2-1.5k yr BP and during the “Litte Ice Age”. In Arctic Norway we have cored seven lakes in three different areas and sampled one moraine system containing Late-Glacial and Holocene moraines. Two of these records are finalized and are presented in this poster. Two others are in progress and will be based on both lake sediments and direct dating with exposure dating. During the fall of 2012 we assembled a Norwegian – US coring team for a two weeks coring campaign at Svalbard. We set of in a 55feet long sailing yacht overloaded with equipment along the west coast of Svalbard. During this campaign we cored lakes at the Mitra Peninsula and at the Island Amsterdamøya. At Amsterdamøya we cored the northernmost lake system in the world at 79oN. This lake is assumed to be located outside the Last Glacial maximum ice sheet covering Svalbard and the Barents Sea.

The SHIFTS project aims to provide a new avenue for understanding how bi-polar climates varied during the Holocene, through the application of new methods for reconstructing primary features of atmospheric circulation and variability. Based on the wide spectrum of analyses that is planned in the proposal the project will in any case be able to refine our understanding of past climates in polar regions.

*SHIFTS project members; Jostein Bakke, Hella Wittmeier, Lea Toska Oppedal, Willem van der Bilt, Marthe Gjerde, Sædis Olafdottir, Anne E. Bjune, Kristian Vasskog, Reidar Løvlie, Øyvind Paasche, Ray Bradley, Billy D´Andrea, Gerald Haug, Torgeir Røthe, Arild Sunde Rinnan, Thea Eeg and Sunniva Vatne

SEDIMENT CORE AND GLACIAL ENVIRONMENT RECONSTRUCTION – A METHOD REVIEW

Bakke, Jostein [1]

[1] University of Bergen;

Alpine glaciers are often located in remote and high-altitude regions of the world, areas that only rarely are covered by instrumental records. Reconstructions of glaciers has therefore proven useful for understanding past climate dynamics on both shorter and longer time-scales. One major drawback with glacier reconstructions based solely on moraine chronologies – by far the most common –, is that due to selective preservation of moraine ridges such records do not exclude the possibility of multiple Holocene glacier advances. This problem is true regardless whether cosmogenic isotopes or lichenometry have been used to date the moraines, or also radiocarbon dating of mega-fossils buried in till or underneath the moraines themselves.

To overcome this problem Karlén (1976) initially suggested that glacial erosion and the associated production of rock-flour deposited in downstream lakes could provide a continuous record of glacial fluctuations, hence overcoming the problem of incomplete reconstructions.

We want to discuss the methods used to reconstruct past glacier activity based on sediments deposited in distal glacier-fed lakes. By quantifying physical properties of glacial and extra-glacial sediments deposited in catchments, and in downstream lakes and fjords, it is possible to isolate and identify past glacier activity – size and production rate – that subsequently can be used to reconstruct changing environmental shifts and trends. Changes in average sediment evacuation from alpine glaciers are mainly governed by glacier size and the mass turnover gradient, determining the deformation rate at any given time. The amount of solid precipitation (mainly winter accumulation) versus loss due to melting during the ablation-season (mainly summer temperature) determines the mass turnover gradient in either positive or negative direction. A prevailing positive net balance will lead to higher sedimentation rates and vice versa, which in turn can be recorded in downstream lakes. To retrieve these glacial sediments it is necessary to collect sediment cores from the lake bottom. Reading the glacial signal, as preserved in the lake sediments, now includes the application of various methods such as measuring the amount of minerogenic versus biologic matter (typically inferred from Loss-on-ignition (LOI)), grain size analysis (GSA), magnetic properties (MP), geochemical elements (GE), Rare-Earth Elements (REE), Bulk Sediment Density (BSD), but also other techniques such as XRF analyses. Moreover, detailed glacier reconstructions can also be used to assess denudation rates, chemical and physical weathering as well specific glaciological changes.

As an example on how small glaciers and their history can be valuable in understanding past climate dynamics we would like to discuss the termination of the last glaciation in Arctic Norway as seen from small cirque glacier variability. The time period is known as a period of rapid climate oscillations superimposed on the overall warming trend, resulting from large-scale reorganizations of the atmospheric and oceanic circulation patterns in both hemispheres. Here we present a new multi-proxy reconstruction from a sub-annually resolved lake sediment record from lake Lusvatnet in arctic Norway suggesting inter-hemispheric climate linkages during the Bølling/Allerød and Younger Dryas time period. The Bølling-Allerød time period was a warm interval in the North Atlantic with a strong Atlantic meridional overturning circulation setting the stage for the later fresh water forcing of the Younger Dryas cold reversal with reduced overturning. Two minor cold reversals, the Older Dryas and the Intra Allerød Cooling, took place during this time span. Our reconstruction of the Lusvatnet cirque glacier shows a synchronous glacier advance with the Birch-hill moraine complex in the Southern Alps, New Zealand, during the Intra Allerød Cooling. We propose these inter-hemispheric climate oscillations to be forced by the northward migration of the southern Subtropical Front during the Antarctic Cold Reversal. This hypothesis may challenge the earlier assumption that fresh water releases from the Laurentide Ice Sheet forced these century-scale cold events during the Bølling-Allerød warm period.

DEFINING THE TRANSITION TO THE LATE HOLOCENE NEOGLACIAL PERIOD USING LAKE SEDIMENT RECORDS FROM SOUTHEAST GREENLAND

Balascio, Nicholas L [1]; **D'Andrea**, William J. [2]; **Bradley**, Raymond S. [3]

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[3] Climate System Research Center, Department of Geosciences, University of Massachusetts, Amherst, MA, USA;

Holocene climate in the Arctic can generally be characterized by two multi-millennial-scale intervals primarily driven by changes in high latitude summer insolation: the mid-Holocene thermal maximum (HTM), and the late Holocene Neoglacial period, which was marked by the expansion of mountain glaciers and ice caps. However, regional climate reconstructions show that the onset and the termination of these intervals were not spatially uniform. High resolution paleoclimate records allow us to better characterize regional conditions during these intervals. In addition, we can examine the transition from the HTM to the Neoglacial period in order to investigate whether changes were gradual or rapid, which may suggest nonlinearities or threshold responses in the climate system. Here we present evidence from lake sediment records from southeast Greenland that show distinct changes from the mid- to late Holocene. We have examined biogeochemical evidence from a sediment core recovered from Flower Valley Lake, a non-glacially influenced catchment, and physical sediment properties of a sediment record from Kulusuk Lake, a proglacial environment.

Biogeochemical evidence from Flower Valley Lake defines changes in moisture balance and runoff over the last 8.8 cal ka BP. Magnetic susceptibility, bulk biogeochemical properties (TOC, C/N, δ13C), and lipid biomarkers (n-alkanes; C16 – C31) reveal changes in clastic sedimentation and the relative input of terrestrial- and aquatic-derived organic matter. Hydrogen isotope values (δD) of mid- (n-C25) and long-chain (n-C29, n-C31) n-alkanes allow reconstruction of δD of precipitation and summertime evaporation of lake water. Most notably, this record shows a decrease in the evaporative enrichment of the lake water and an abrupt transition to more variable sedimentation after 4.1 cal ka BP with the lowest inferred lake water evaporation occurring from 3.0-1.8 cal ka BP.

Kulusuk Lake is presently fed by meltwater from two small cirque glaciers and our record tracks their activity over the last c. 10 cal ka BP. A 3.5 m sediment record contains distinct lithologic changes defined by grain size, magnetic susceptibility, organic content, and scanning XRF data. In particular, the interval from 8.0-4.0 cal ka BP is clearly defined by high organic content (>20%) and extremely low magnetic susceptibility values, which we interpret to indicate a lack of glacial input showing the complete disappearance of the glaciers in the catchment during the HTM. After 4.0 ka, the organic content decreases, magnetic susceptibility abruptly increases, and the sediment is finely laminated showing sedimentation typical of a proglacial environment and indicating a re-growth of the glaciers marking the transition to Neoglacial conditions. Higher resolution changes in lithology are characterized by scanning XRF data and indicate further expansion of the cirque glaciers c. 1.5 ka and a subsequent decline in activity over the last ~150 years.

The records from Flower Valley Lake and Kulusuk Lake contribute to our understanding of Holocene paleoclimate in this region and the comparison of the nature and timing of changes between the two sites helps to better define terrestrial environmental changes across the Neoglacial transition.

PALEOMAGNETIC STUDY OF HOLOCENE SEDIMENTS FROM THE MACKENZIE RIVER TROUGH IN THE BEAUFORT SEA

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High-resolution Holocene Arctic paleomagnetic records are vital to both magnetostratigraphy and geomagnetic field studies, yet remain sparse due to the inaccessibility and low sedimentation rates of many high-latitude locations. Here, paleomagnetic records of exceptional temporal resolution are developed for two Calypso square cores (CASQ) and accompanying box cores (cores 690 and 680) which were sampled from the Mackenzie River Trough, the site of the highest rate of sediment accumulation in the region (up to ≈250 cm/ka). The CASQ core, a type of large volume gravity core (Fig. 1), is ideal for studies such as this as it maintains pristine sediment conditions and is designed to recover the sediment-water interface, preserving the most recent part of the paleomagnetic record for comparison with historical and observational data. Preservation of the sediment-water interface was confirmed by correlating measurements of magnetic and physical properties between the upper CASQ cores and their corresponding box cores.

Natural, anhysteretic, isothermal, and saturated isothermal remanent magnetizations (NRM, ARM, IRM, and SIRM) were measured at one centimeter intervals using a cryogenic u-channel magnetometer, whereas magnetic hysteresis measurements were performed at core section breaks using an alternating gradient force magnetometer. These analyses indicate a high concentration of magnetite dominated by pseudo-single domain grains, which bears a strong potential of carrying a reliable paleomagnetic signal. In both cores, measurements of magnetic susceptibility and remanences suggest a uniform concentration of remanence-carrying minerals, while maximum angular deviation (MAD) values are < 3° (< 5° are generally considered to be indicative of excellent directional data; Stoner and St-Onge, 2007), and median destructive field (MDF) values fall within the 20-40 mT range (typical for low coercivity minerals such as magnetite). For the entire length of core 690 and the middle section of core 680, inclination varies about the geocentric axial dipole (GAD) for those latitudes. Furthermore, 21 pelecypod shells were found well-distributed throughout both cores and were used to construct robust age models, which is rare for Arctic sites.

The directional paleomagnetic records for both cores are presented here and compared with other regional records as well as two geomagnetic field models. Relative paleointensity has been assessed by comparing various normalization techniques. Finally, CAT-scan images and grain size data, in conjunction with the high-resolution magnetic properties will be analyzed in order to determine the environmental and depositional history of the Trough.

Stoner, J.S., St-Onge, G., 2007. Magnetic stratigraphy in paleoceanography: reversals, excursions, paleointensity and secular variation. In: C. Hillaire-Marcel and A. de Vernal (Eds.), Proxies in Late Cenozoic Paleoceanography, Elsevier, pp. 99-137.

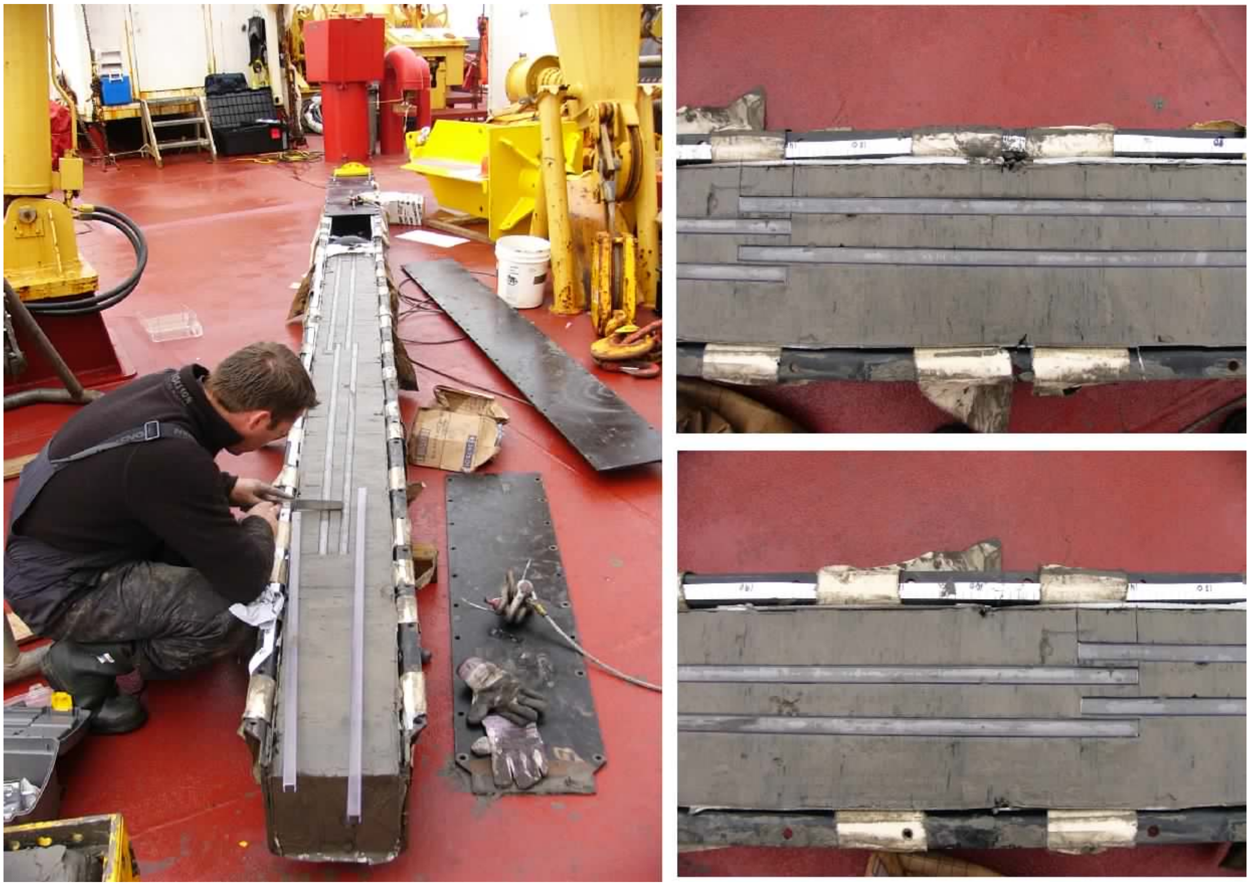

Fig 1. Sampling of u-channels from a CASQ core during the 2009 Malina expedition.

CONTROLS ON SLOPE-TO-CHANNEL FINE SEDIMENT CONNECTIVITY IN A LARGELY ICE-FREE VALLEY, HOOPHORN STREAM, SOUTHERN ALPS, NEW ZEALAND.

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There has been little work to date into the controls on slope-to-channel fine sediment connectivity in alpine environments largely ice-free for most of the Holocene. Characterization of these controls can be expected to result in better understanding of how landscapes “relax” from such perturbations as climate shock. We monitored fine sediment mobilization on a slope segment hydrologically connected to a stream in the largely ice-free 8.3 km2 Hoophorn Valley, New Zealand. Gerlach traps were installed in ephemeral slope channels to trap surficial material mobilized during rainfall events. Channel sediment flux was measured using turbidimeters above and below the connected slope, and hysteresis patterns in discharge-suspended sediment concentrations were used to determine sediment sources. Over the 96 day measurement period, sediment mobilization from the slope segment was limited to rainfall events, with increasingly larger particles trapped as event magnitude increased. Less than 1% of the mass of particles collected during these events was fine sediment. During this period, 714 t of suspended sediment was transported through the lower gauging station, 60% of it during rainfall events. Channel sediment transfer patterns during these events were dominated by clockwise hysteresis, interpreted as remobilization of nearby in-channel sources, further suggesting limited input of fine sediment from slopes in the lower valley. Strong counterclockwise hysteresis, representing input of fine sediment from slope segments, was restricted to the largest storm event (JD2 2009) when surfaces in the upper basin were activated. The results indicate that the slopes of the lower Hoophorn catchment are no longer functioning as sources of fine sediment, but rather as sources of coarse material, with flux rates controlled by the intensity and duration of rainfall events. Although speculative, these findings suggest a shift to a coarse sediment dominated slope-to-channel transfer system as the influence of pre-Holocene glacial erosion declines.

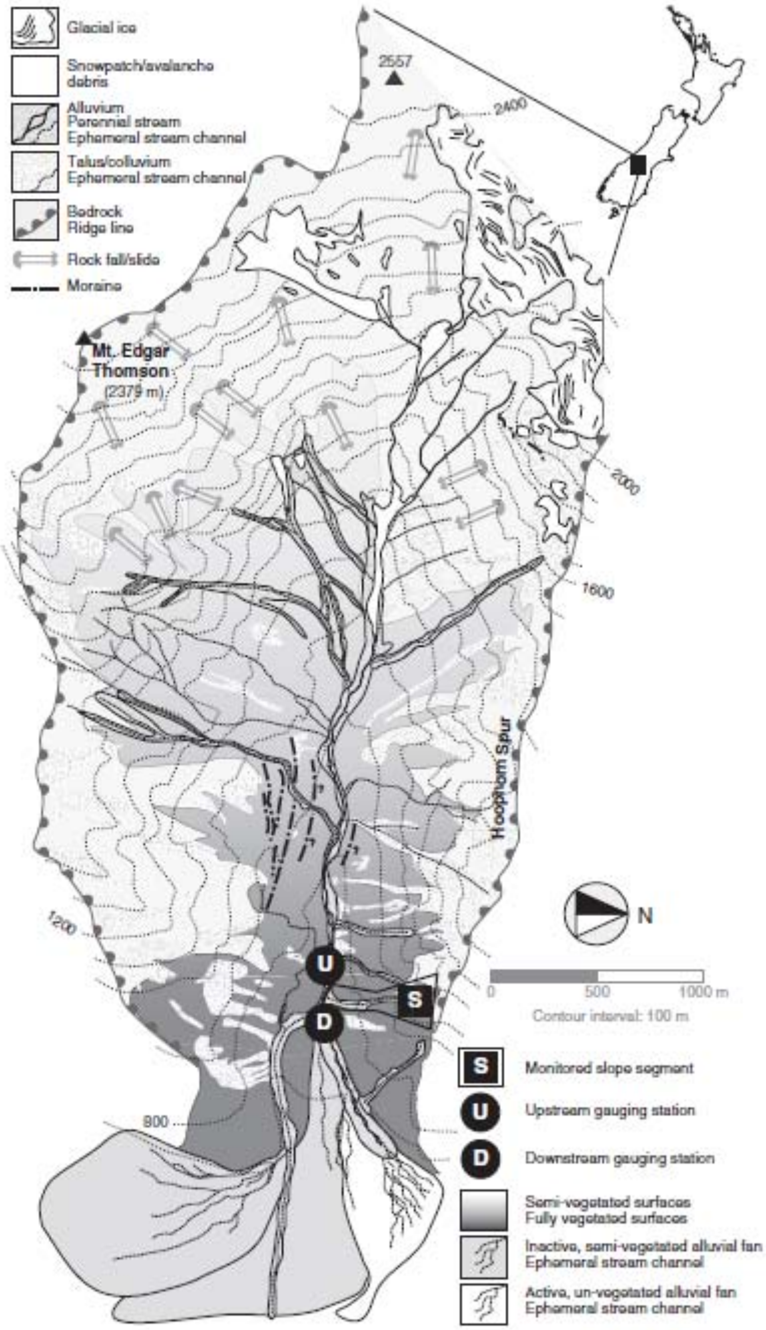

Fig 1. Location and geomorphic map of the Hoophorn Stream catchment, Aoraki-Mt Cook National Park, New Zealand.

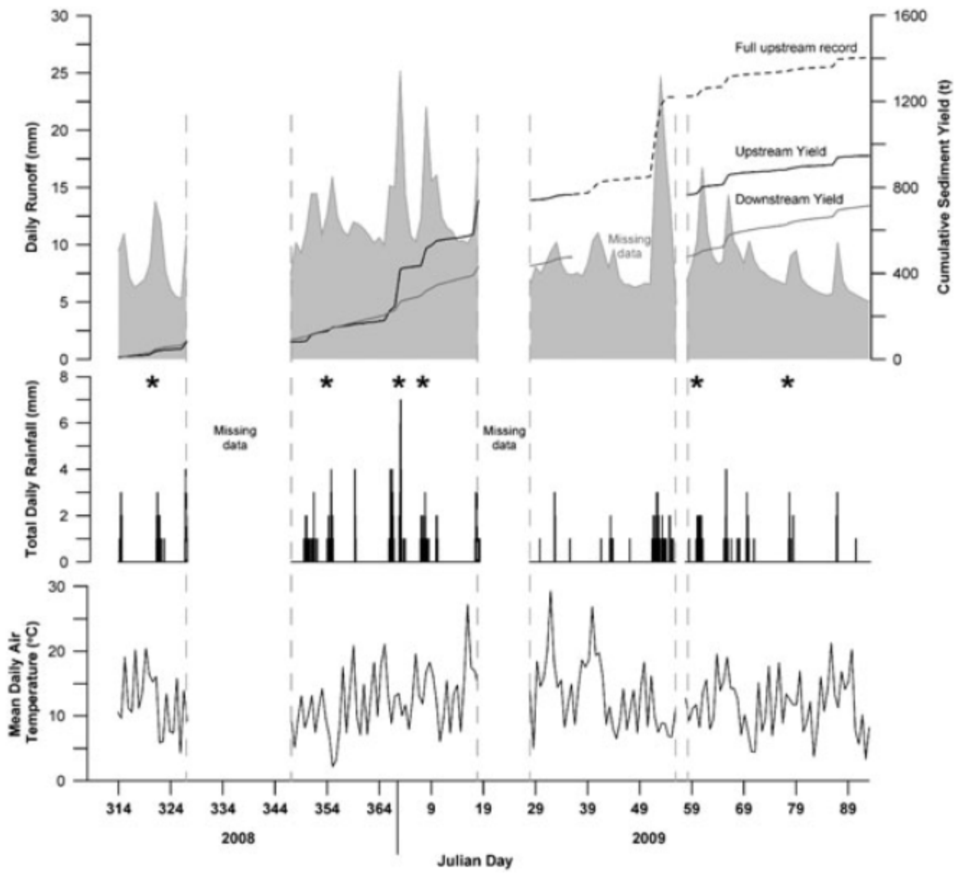

Fig 2. Data record over the 114 day measurement period. Two cumulative channel suspended sediment yield curves are shown for the upstream station: one for the full record, the other for the period in common (96 days). An asterisk indicates a rainfall event when fine sediment mobilization on the slope was monitored. Note the significant departure in channel suspended sediment yield during the JD2 event, interpreted here as showing the influence of snow melt in the upper catchment, and the resulting activation of sources of fine sediment on slopes.

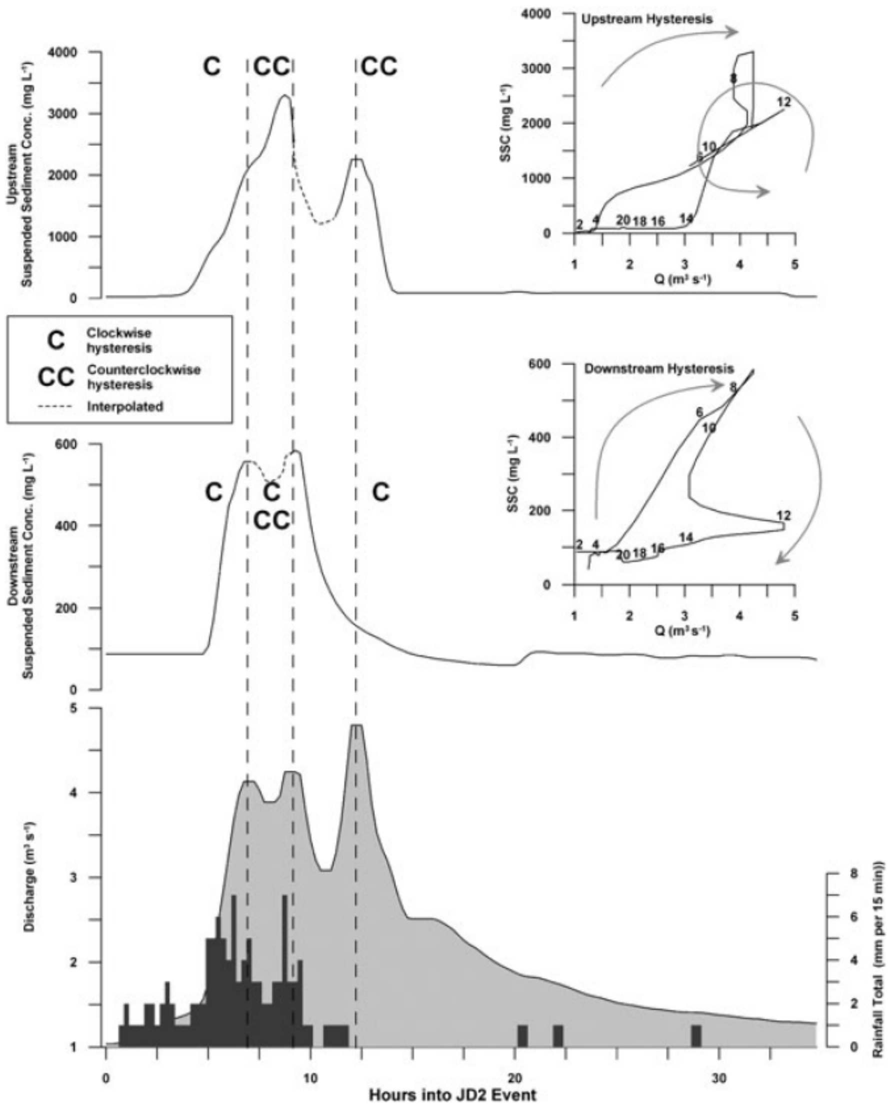

Fig 3. Information from the JD2 storm event showing (1) the shift from an initial clockwise hysteresis pattern – interpreted as mobilization of nearby in-channel fine sediment – to a strong counterclockwise hysteresis at the upper gauging station and (2) weaker counterclockwise hysteresis at the lower gauging station. The appearance of a strong counterclockwise loop at the upper station seven hours into this event, strongly suggests that fine sediment was sourced from slopes and channel sediment sources in the upper catchment during this two year return period event. The weaker counterclockwise loop during the same storm event for the lower gauging station was likely due to the modulating effect of the intervening step-pool morphology on transfer patterns. Note the elevated suspended sediment concentrations at the end of the storm event for the lower gauging station, suggesting continued remobilization and throughput of fine sediment deposited in the channel reach between the two gauging stations.

A 10,800 YEAR XRF DERIVED LAKE LEVEL RECORD SPANNING THE LATEGLACIAL TO MIDDLE-HOLOCENE FROM OTTER LAKE, SOUTHCENTRAL ALASKA

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Paleoclimatic reconstructions that cover the end of the Last Glacial Maximum (LGM) through the mid-Holocene provide important records of potential climatic variability. Here we present a new record of lake level change derived from a 4.2-m-long sediment core at Otter Lake in northern Cook Inlet region of southcentral Alaska (Fig. 1) spanning ~4,300-15,100 calendar years BP (4.3-15.1 cal. ka).

Otter Lake (61.2895° N, 149.7355° W, 28 meters above sea level) is a small (~ 0.5 km2), shallow (7.5 m maximum depth) precipitation- and groundwater-feed lake perched on a topographic high within the terminal Elmendorf Moraine adjacent to the Cook Inlet in south-central Alaska. The lake sits near the farthest LGM ice extent within a paleo-meltwater channel, likely formed during glacial retreat ~16 ka (Dyke et al. 2003). As the lake is "perched" on a topographic high within the paleo-channel it has a small watershed area (< 1 km2) with no riverine inputs likely making water level a good indicator of local precipitation-evaporation balance.

Otter Lake has a shallow (1-3 m) carbonate shelf, occupying ~60% of the northeastern lake area, and pair of deeper basins (5.5 and 7.5 m) in the southwest (Fig. 1C). Summer time measurements made down the water column show increasing anoxia (9.87 - 0.10 ppm O2); decreasing pH (7.83 – 6.99) and alkalinity (96 – 88 mg/L), suggesting the lake is moderately hard. Aquatic vegetation in the lake is dominated by Chara macroalgae, which is rooted to the lake bottom in a dense mat along all shallow (0-3 m) areas, but diminishes quickly in water depth >3 m. Chara macroalgae favors high pH oligotrophic cool environments with low turbidity and grows only in the upper photic zone of lakes due to its poor tolerance for low light conditions (Wehr and Sheath, 2003;). Charaphytes can contain up to contain 75% carbonate biominerals by dry mass and develop a calcite scale during photosynthesis which sheds off. These factors all lead to a trend of decreasing carbonate depostion with water depth.

In this study we develop a modern calibration relating benthic carbonate content to water depth by linear regression (r-squared = 0.81). We reconstruct changes in past water depth by applying this calibration to the Ca abundance in lake core OT103-A, measured by scanning x-ray fluorescence (XRF) at 1-mm resolution. We also note concomitant shifts in elemental indicators of runoff (rare earth elements La Pr Ce; REE), anoxia (S, Fe, V, Co), evaporation (Cl), as well as dating of a marl-peat transition within a proximal peatland.

This record provides additional insight into changes in atmospheric circulation over the North Pacific region at the end of the LGM and during important Holocene climatic transitions. These include two periods of high lake level at ~ 10.6-12.3 and 7.2-8.4 ka BP; separated by a shallow variable period coinciding with the regional Holocene Thermal Maximum (HTM). Termination of sediment deposition at the coring site 4.2 ka suggests that drier conditions prevailed in the late Holocene. Comparison of Otter Lake with other records in southcentral Alaska, eastern Alaska, and the Yukon suggests a coherent shift in moisture source associated with changing Aleutian Low strength.

Dyke, A.S., A. Moore, and L. Robertson, 2003, Deglaciation of North America. Geological Survey of Canada Open File, 1574.

Wehr and Sheath, (2003) Freshwater algae of North America: ecology and classification. 918 pages

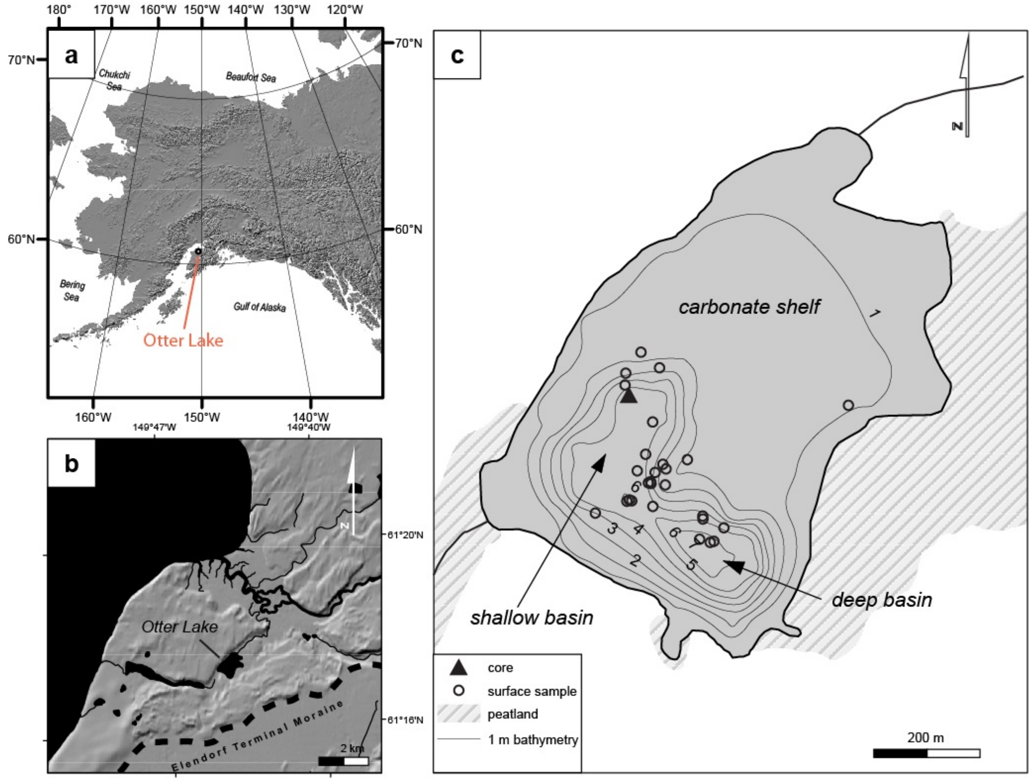

Fig 1. (A,B) Location map of study site, (C) sampling sites, local topography, and Otter Lake bathymetry.

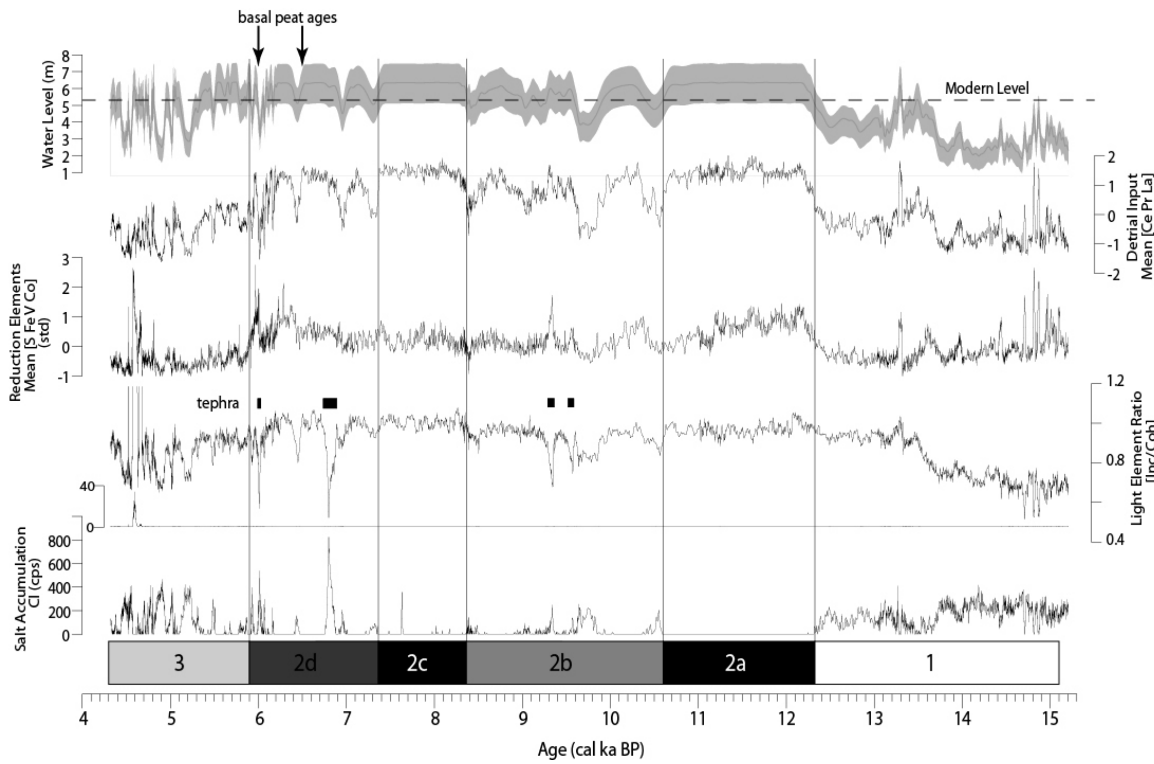

Fig 2. XPF elemental abundance for elements demonstrating correlation with water level. Normalized mean of rare earth element abundance (La, Pr, and Ce), normalized S elemental abundance, normalized Cl abundance.

MILLENNIAL SCALE CHANGE FROM LAKE EL'GYGYTGYN, NE RUSSIA: DID WE STEP OR LEAP OUT OF THE WARM PLIOCENE INTO THE PLEISTOCENE?

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The Pliocene-Pleistocene climate evolution of the Arctic must have modulated the glacial history of Greenland and the onset of Northern Hemisphere glaciation. What is known from the terrestrial stratigraphy of Arctic climate change comes from sites that are spatially and temporally fragmented. In 2009, International Continental Deep drilling at Lake El'gygytgyn (67o30' N, 172 o 05' E) recovered lacustrine sediments dating back to 3.58 Ma that provide the first time-continuous Pliocene-Pleistocene Arctic paleoclimate record of alternating glacial-interglacial change. The warmest/wettest Pliocene interval of the lake record occurs from ~3.58-3.34 Ma and is dominated by exceptional tree pollen implying July temperatures nearly 7-8o C warmer than today with nearly ~3 times the annual precipitation. Atmospheric CO2 levels are estimated to have been 360 to 400 ppm implying exceptionally high climate sensitivity and polar amplification. In fact, pollen spectra and modern analog analysis show an unbroken persistence of summers much warmer and wetter than the last interglacial, MIS 5e until nearly 2.2 Ma. Extreme warmth in the Mid Pliocene Arctic occurs at the same time ANDRILL results suggest the West Antarctic Ice Sheet was non-existent.

Using physical, chemical, and biological proxies we find pronounced glacial episodes commenced ~2.6 Ma ago, but the full range of typical Pleistocene glacial/interglacial change wasn't established until ~1.8 Ma ago. Greenland must have also responded to numerous "super interglacials" during the Quaternary record, with maximum summer temperatures and annual precipitation, especially during MIS 9,11 and 31, at Lake El'gygytgyn exceeding that documented for MIS 5e. The correspondence of many of these super-interglacials with retreat of the West Antarctic Ice Sheet (Naish et al. 2009) could coincide with intervals when the Greenland Ice was reduced in size. The climate record from Lake El'gygytgyn, especially the history of past interglacials, provides a fresh means of testing the evolving magnitude of polar amplification over time, and the sensitivity of the Greenland Ice Sheet to extreme warmth in the rest of the Arctic.

Brigham-Grette, J., Melles M., Minyuk,P., Andreev, A, Tarasov, P., DeConto, R., Koenig, S., Nowaczyk, N., Wennrich, V., Rosén P., Haltia-Hovi, E., Cook, T., Gebhardt, T., Meyer-Jacob, C., Snyder, J., Herzschuh, U.. in revision March 2013, Pliocene Warmth, extreme Polar Amplification, and Stepped Pleistocene Cooling recorded in NE Russia. Submitted to Science, 21 Nov. 2012.

Melles, M., Brigham-Grette, J., Minyuk, P., and others. 2012, 2.8 Million Years of Arctic Climate Change from Lake El'gygytgyn, NE Russia. Science v. 337, p. 315-320.

Naish T. et al., 2009, Obliquity-paced Pliocene West Antarctic ice sheet oscillations. Nature v. 458, p. 322-328.

See also Climate of the Past Special issue on Lake El'gygytgyn, >20 manuscripts.

AMINO ACID RATIOS IN REWORKED MARINE BIVALVE SHELLS CONSTRAIN GREENLAND ICE SHEET HISTORY DURING THE HOLOCENE

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Reconstructions of Greenland Ice Sheet changes can constrain the spatial expression of its response to climate variability on longer timescales. An important period over which to evaluate past Greenland ice margin response is the Holocene due to its relatively well-constrained temperature history that includes early to middle Holocene thermal maximum conditions that were warmer than 20th century temperatures. However, generating ice sheet reconstructions during warm times in the Holocene is challenging because the geologic record of past ice sheet change is mostly obscured by subsequent ice advances of larger relative magnitude during Neoglaciation. The great abundance of reworked marine material in deposits that fringe a large portion of the Greenland Ice Sheet not only attests to ice-free marine environments now occupied by the ice sheet, but also provides information on the timing of these past conditions. Here, we report a new approach for generating ages of large suites of reworked bivalve shell collections from western Greenland to constrain ice margin positions through the Holocene. The technique is based on the D/L ratio of amino acids preserved within bivalve shells, and is a cost-effective means to obtain large datasets of dated specimens.

We measured enantiomeric (D- and L-isomers) separations of amino acids in 247 mollusk (Mya truncata) fragments that were re-worked into historic moraine deposits from three different ice margin sites in western Greenland (Fig. 1). The shells were cleaned by acid leaching and pretreated with bleach to isolate the intra-crystalline fraction of amino acids. The total hydrolysable amino acid (THAA) population of amino acids was measured by reverse phase, high-performance liquid chromatography. To evaluate the relationship between aspartic acid (Asp) values and age, we selected twenty-two specimens for radiocarbon dating guided by Asp and glutamic acid (Glu) D/L ratios. The range in Asp and Glu D/L values from each site overlap and form a single data array. Thus, we combine Asp D/L values and radiocarbon ages from all sites to generate a single calibration curve that describes the radiocarbon age vs. Asp D/L relationship (Fig. 2). The r2 value of a linear fit between Asp D/L and radiocarbon age is 0.86. We use the Asp D/L vs. radiocarbon age calibration curve to transform the Asp D/L values into age for the individual Mya fragments. We generate histograms of mollusk age in 1000-yr bins to show the population of bivalve ages for each of our three ice-margin locations (Fig. 3).

The distribution of bivalve ages is consistent with what is known about the climate and ice margin history of western Greenland. Despite differing ice sheet histories at our three sampling locations, all three populations show the largest number of bivalve ages from 4 to 5 ka. This single largest bin of bivalve ages is amid an interval from 2-6 ka with the highest frequency of ages. The timing of the highest frequency of bivalve ages generally coincides with independent records of relative warmth from coastal western Greenland sites. Furthermore, the fewer number of bivalve ages prior to ~7 ka reflects that some areas had not yet become deglaciated, and the small number of ages since ~2-3 ka is consistent with advancing ice in the latest Holocene. Despite many potential complications that might influence Asp D/L values in Mya shells, or control the distribution of bivalve ages in moraine deposits, bivalve ages show a similar pattern at all sites and show similarities with independent records of climate and ice margin change in western Greenland.

To conclude, Asp racemization in Mya bivalves is fast enough to yield robust calibration curves, even for the Holocene. Asp D/L values can aid in selecting the oldest and youngest reworked specimens for radiocarbon dating, and even provide the complete population of ages for bivalves reworked into moraines. The great abundance of locations where Greenland ice advanced over marine deposits, which encompasses the majority of Greenland's perimeter, suggests that this approach could have wide applicability. Hence we add a new chronometer to our toolkit for constraining smaller-than-present ice margin histories.

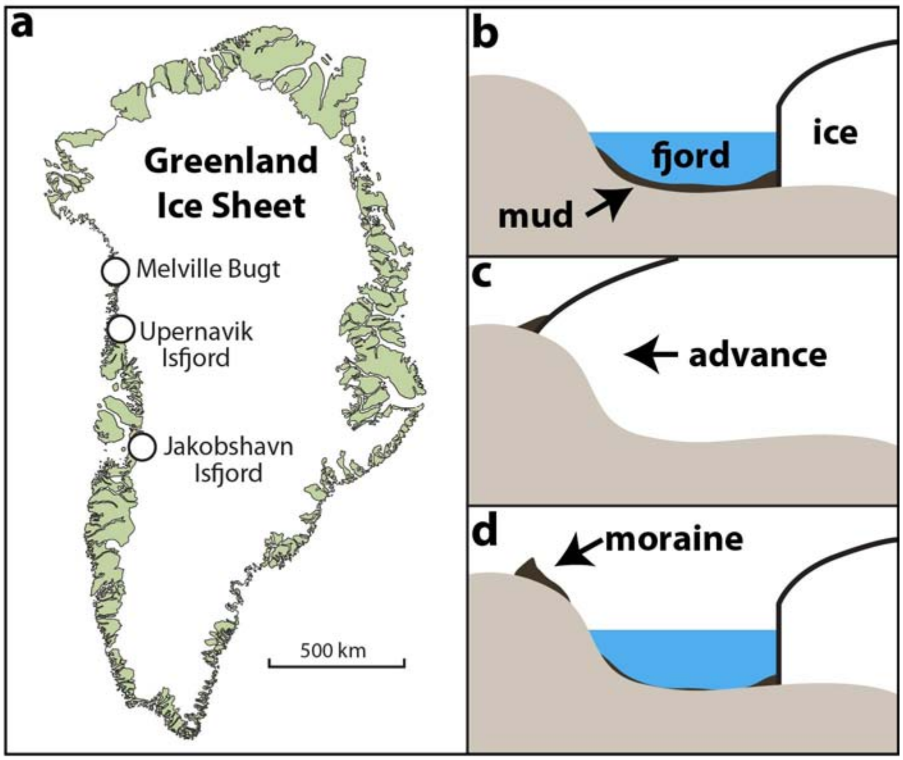

Fig 1. A. Greenland and the three ice margin locations where we collected re-worked marine bivalves from the historic (Little Ice Age) moraine. B-D. Illustrations of how advances of the Greenland Ice Sheet into marine settings re-works fossiliferous marine sediment into Neoglacial moraines.

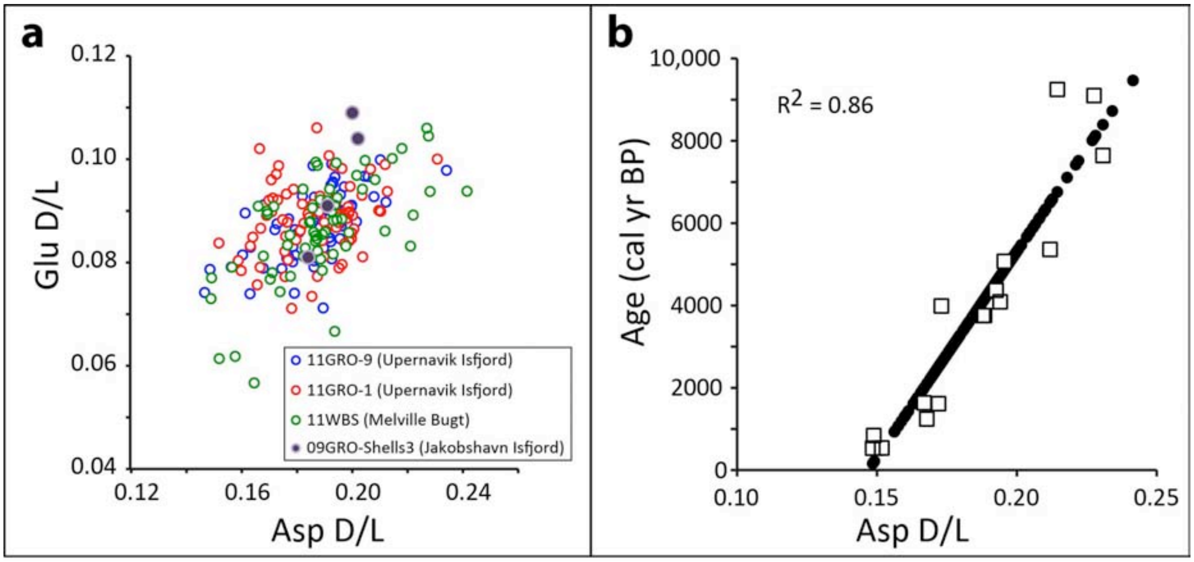

Fig 2. A. The enantiomeric composition (D- and L-isomers) of glutamic (Glu) and aspartic (Asp) acids from 204 My truncata specimens collected from three different fjords in western Greenland (Fig. 1). B. Calibration curve showing linear fit of Asp D/L versus radiocarbon age (n=20; white squares); black circles show range of all Asp D/L values from all sites with linear fit.

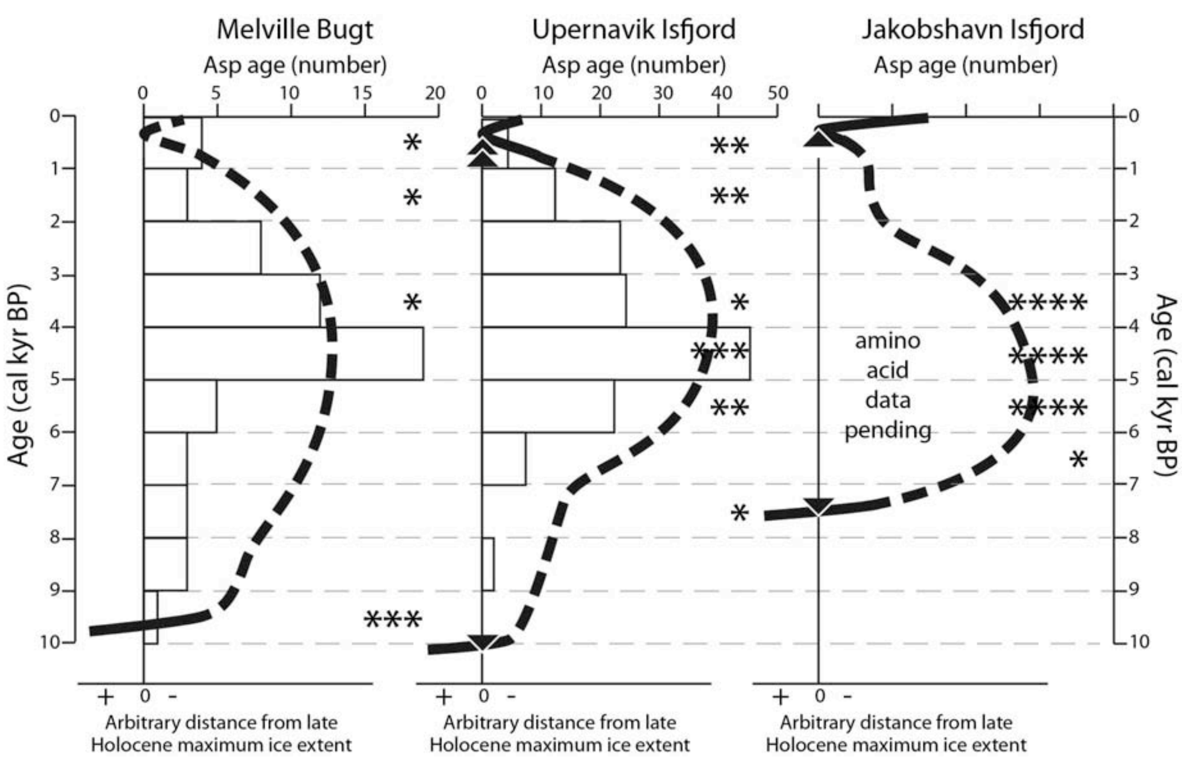

Fig 3. Histograms of Asp shell ages from three study sites. Superimposed on the histograms are ice margin time-distance curves (bold line), independent chronology (black triangles) and all the radiocarbon ages (asterisks) on reworked bivalves from this (n=23) and previous (n=9) work.

EXAMINING GLACIAL-INTERGLACIAL CONTINENTAL TEMPERATURE VARIABILITY IN THE BERINGIAN ARCTIC DURING MARINE ISOTOPE STAGES (MIS) 1-7, MIS 9-11 AND MIS 31: INSIGHTS FROM AN ORGANIC GEOCHEMICAL INVESTIGATION OF LAKE EL'GYGYTGYN

Castañeda, Isla S. [1]; **Finkelstein**, David B [2]; **Wei**, Jeremy [3]; **D'Anjou**, Robert M [4]; **Phu**, Victoria [5]; **Urann**, Ben [6]; **Wilkie**, Kenna [7]; **Brigham-Grette**, Julie [8]

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Drill coring at Lake El'gygytgyn (NE Russia) in 2009 recovered sediments spanning the past 3.6 Ma from the largest and oldest unglaciated Arctic lake basin. These sediments provide the first terrestrial Arctic paleoclimate record spanning the Plio-Pleistocene and thus offer a unique opportunity for examining high-latitude climate variability beyond the relatively short 100 Ka interval captured by Greenland ice core records. Proxy data (e.g. pollen, diatom assemblages, and Si/Ti ratios) generated thus far from Lake El'gygytgyn sediments suggest a number of "super"- interglacials (e.g. Marine Isotope Stages 11 and 31) characterized by significantly warmer temperatures than at present (e.g. Melles et al, 2012). The Arctic is presently warming at an unprecedented rate and therefore these "super" interglacials are of interest for investigating processes under conditions of increased warmth. Currently, the magnitude of warming during these interglacials, as well as the overall amplitude of glacial-interglacial temperature fluctuations, has yet to be quantified at Lake El'gygytgyn.

In this study, we investigate the potential of using an organic geochemical paleothermometer, the Methylation of Branched Tetraethers/Cyclization of Branched Tetraethers (MBT/CBT) Index (Weijers et al., 2007), to reconstruct temperature at Lake El'gygytgyn. The MBT/CBT paleothermometer is based on branched glycerol dialkyl glycerol tetraethers (GDGTs) present in soils and peats, which are thought to be produced by anaerobic soil bacteria such as acidobacteria (Weijers et al., 2007; Sinninghe Damsté et al., 2011) although the source organism remains unknown. The MBT/CBT Index was originally developed for use in soils provides a proxy for mean annual soil temperature, which is usually similar to mean annual air temperature. Subsequent research has provided strong evidence that branched GDGTs are also produced in-situ in lakes and a number of different calibrations between MBT/CBT ratios in lake surface sediments and lake surface temperature have been suggested (e.g. Sun et al., 2011; Tierney et al., 2010; Pearson et al., 2011). We find that branched GDGTs are abundant in Lake El'gygytgyn sediments and that relative changes in the MBT/CBT-derived temperature record are in agreement with the overall patterns of glacial-interglacial climate variability noted in global climate records such as the LR04 benthic $\delta^{18}O$ stack (Lisiecki and Raymo, 2005). Warming in the Lake El'gygytgyn record during MIS 5e (Figure 1), MIS 9 and11 (e.g. Chapligin et al., 2012; D'Anjou et al., in press) and MIS 31 is supported by numerous other paleoenvironmental records, both from Lake El'gygytgyn (e.g. Melles et al., 2012) and throughout the North Atlantic (e.g. Lawrence et al., 2010). Interestingly, cooling during MIS 4 (Figure 1) appears to have been more severe than during the Last Glacial Maximum (MIS 2) (e.g. Holland et al., 2013), in agreement with the observation that glacial moraines were restricted to the Chukotka Peninsula during the LGM but reached St. Lawrence Island during MIS 4 (Brigham-Grette et al., 2001).

Currently MBT/CBT cannot be used to reconstruct absolute temperature at Lake El'gygytgyn due to the lack of a site specific calibration, which is likely needed when applying the MBT/CBT paleothermometer to lakes (e.g. Castañeda and Schouten, 2011). Given the large range in mean annual air temperature at the site (-40°C to +26°C with a mean annual average temperature of -10.3°C) (Nolan and Brigham-Grette, 2007), and the fact that the main source of branched GDGTs to Lake El'gygytgyn is unknown (e.g. from the surrounding catchment or within the lake itself), any of the existing soils or lakes MBT/CBT calibrations could be applicable, especially if production of branched GDGTs is weighted towards a particular season (e.g. summer). However, this study demonstrates that relative temperature changes derived from the MBT/CBT Index at Lake El'gygytgyn are robust. Overall, application of the MBT/CBT paleothermometer to Lake El'gygytgyn sediments appears to be a promising technique for generating a Plio-Pleistocene temperature record from the western Arctic. If a site specific MBT/CBT calibration can be created, then the potential exists for creating a 3.6 Ma record of Arctic continental temperature variability.

Brigham-Grette J., Hopkins D. M., Ivanov V. F., Basilyan A. E., Benson S. L., Heiser P. A., and Pushkar V. S. 2001. Quaternary Sci. Rev. 20, 419-436.

Castañeda I. S. and Schouten S. 2011. Quaternary Sci. Rev. 30, 2851-2891.

Chapligin, B., Meyer, H., Swann, G.E.A., Meyer-Jacob,C., and Hubberten,H.-W. Climate Past, 2013, in press.

D'Anjou, R.M., Wei, J.H., Castañeda, I.S., Brigham-Grette, J., Petsch, S.T., Finkelstein, D.B. Climate of the Past, 2013, in press.

Holland, A., Wilkie, K.M., Petsch,S.T., Burns, S.J., Castañeda, I.S. Brigham-Grette,J., and El'gygytgyn Scientific Party. Clim Past, 9, 243-260, 2013.

Lawrence K., Sosdian S., White H., and Rosenthal Y. 2010. Earth. Planet. Sci. Lett. 300, 329-342.

Lisiecki L. E. and Raymo M. E. 2005. Paleoceanography 20.

Melles M. et al. 2012. Science 337, 315-320.

Pearson E. J. et al. 2011. Geochim. Cosmochim. Acta 75, 6225-6238.

Sinninghe Damsté J. S., Rijpstra W. I. C., Hopman E. C., Weijers J. W. H., Foesel B. U., Overmann J., and Dedysh S. N. 2011. Appl. Environ. Microbiol. 77, 4147-4154.

Sun, Q., et al., 2011. Journ. Geophys. Res. 116.

Tierney J. E., Russell J. M., Eggermont H., Hopmans E. C., Verschuren D., and Sinninghe Damsté J. S. 2010. Geochim. Cosmochim. Acta 74, 4902-4918.

Weijers J. W. H., Schouten S., van den Donker J. C., Hopmans E. C., and Sinninghe Damsté J. S. 2007. Geochim. Cosmochim. Acta 71, 703-713.

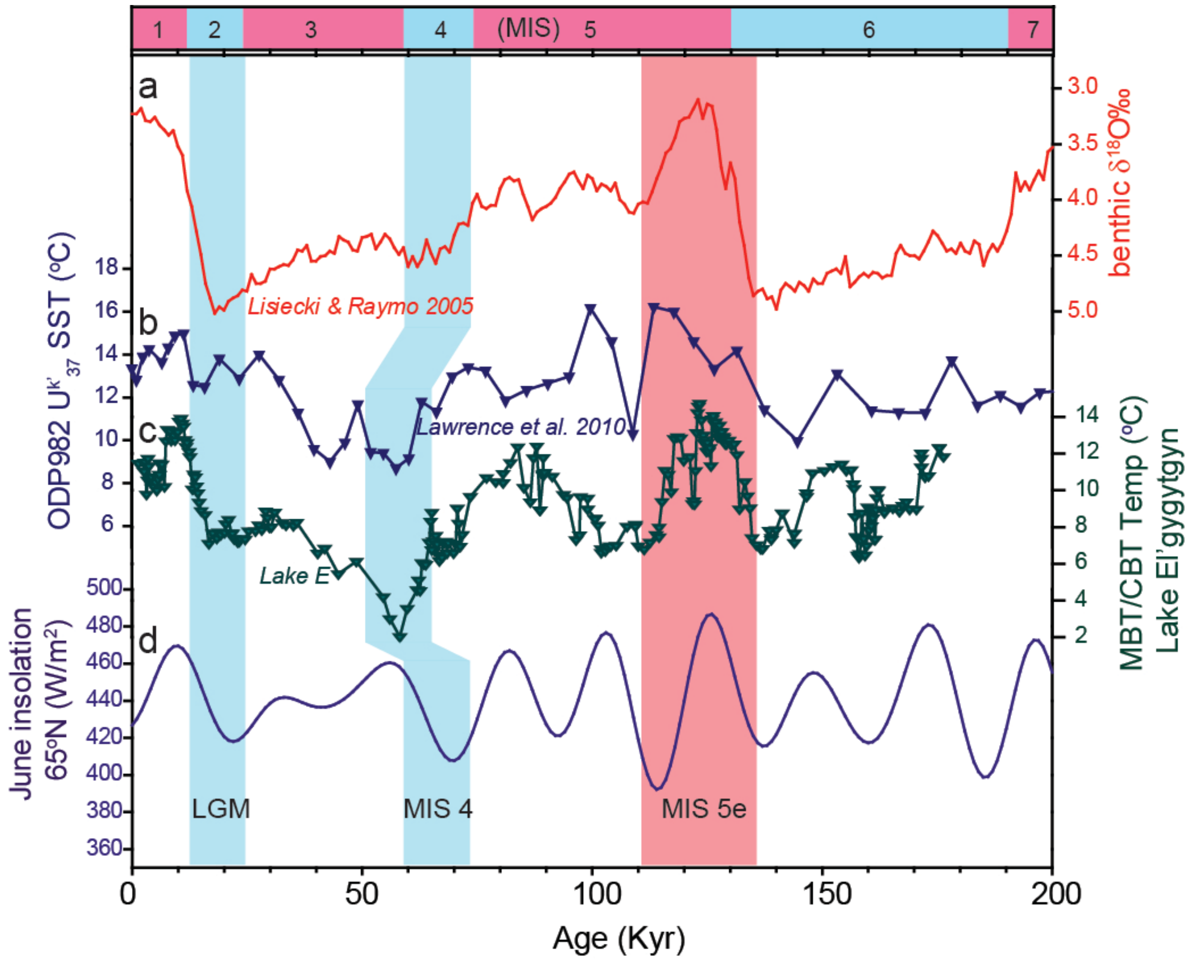

Fig 1. a) The LR04 benthic δ18O stack (Lisiecki & Raymo, 2005). b) Alkenone sea surface temperature record from ODP site 982 (Lawrence et al., 2010). c) Lake El'gygytgyn MBT/CBT record, plotted using the calibration of Sun et al. 2011. d) Summer insolation at 65°N. Marine Isotope Stages (MIS) are indicated by the shading at the top.

A GCM COMPARISON OF MARINE ISOTOPE STAGES 1, 5E, 11C AND 31 IN RELATION TO LAKE EL'GYGYTGYN NE RUSSIA

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The lack of scientific data concerning interglacials of the Pleistocene in the Arctic has been a major obstacle within the climate community. Study of the interglacials of Marine Isotope Stage(s) (MIS) 1, 5e, 11c and 31 in high latitudes is important to decoding Arctic sensitivity and providing us with a potential analogue for a future Arctic with climate change. Data from a sediment core recovered from Lake El'Gygytgyn in northeastern (NE) Russia gives a continuous, high-resolution record of the Arctic spanning the past 2.8 million years whilst recording these interglacials. The data was used to correlate simulated interglacial Arctic climate with Arctic climate derived from sediment core proxy studies. Here, we use a Global Circulation Model (GCM) with a coupled atmosphere and land-surface scheme complete with an interactive vegetation component to simulate marine isotope stages 1, 5e, 11c and 31 in the Arctic. GCM simulations of MIS 5e and 31 in the Arctic both show a warmer arctic climate that can be explained by high obliquity, high eccentricity, high CO_2 (287 ppmv ,325 ppmv , respectively) and precession that aligns perihelion with boreal summer. Consequently, MIS 5e showed the greatest summer warming compared to the other interglacials and pre-industrial control. However, the distinctly higher values of mean temperature of the warmest month (MTWM) and annual precipitation during stage 11c cannot readily be explained by summer orbital forcings and greenhouse gas (GHG) concentrations. Montane forest is seen migrating northward in stages 1, 5e and 31 as the surface insolation increases and sea ice melts, whereas in 11c, the warmest of the interglacials, evergreen forest takes over and migrates pole ward toward the coast. Feedback from low albedo forest biome was studied and conclusions suggest the increase in temperature due to forest cover is insignificant in creating a significantly warm regional climate. The warming associated with a lack of a Greenland Ice Sheet (GIS) in stage 11c and 31 was not enough to warm temperatures to the observed temperatures seen in 11c during proxy analysis of the Lake El'Gygytgyn sediment core. The surprising warmth during MIS 11c might be explained by linkages with Antarctic ice retreat and decreased Antarctic Bottom Water (AABW) formation. The Lake El'Gygytgyn core provides a high-resolution terrestrial record that is unprecedented. The difficulty for the GCM to properly simulate stage 11c sparks questions for the Arctic climate community. Teleconnections such as the formation Antarctic Bottom Water (AABW) and the upwelling of bottom water in the Arctic could play a major role in affecting temperatures on a smaller, regional scale.

A HIGH RESOLUTION ICEBERG MODEL TO UNDERSTAND HOW MELTWATER TRIGGERS ABRUPT CLIMATE CHANGE

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Climate models continue to tell us that the Earth's climate is very sensitive to changes in freshwater runoff to the ocean, especially from the high latitudes. Indeed, many periods of abrupt climate change during the last deglaciation (~7-21 cal yrs BP), such as the Younger Dryas and 8.2-kyr-event, can be linked to catastrophic meltwater events at their onset. However, to accurately quantify the sensitivity of ocean circulation and climate to past and future changes in freshwater forcing, climate models need to simulate the cryosphere as realistically as possible.

Results will be presented from the ongoing development of a state-of-the-art, high resolution, coupled, thermodynamic iceberg model. The iceberg model incorporates the latest developments in iceberg forecast technology, including the use of a keel shape below the waterline. In addition, icebergs roll when they become unstable, collide with each other, ground, calve into smaller (bergy) fragments due to wave erosion at the waterline, and change albedo when they are snow covered. We also consider the stress exerted by sea ice on each iceberg; a factor that becomes more important during glacial climate simulations when sea ice was thicker and more extensive.

The iceberg model is coupled to a high resolution (1/6°) ocean-seaice numerical model (MITgcm) to accurately simulate the trajectories of individual icebergs by resolving narrow coastal fjords and boundary currents. We find that a large fraction (up to 80%) of freshwater is delivered more than 200 km offshore of the Greenland coast, suggesting 'dumping' freshwater into the ocean along the edge of an ice sheet is not an effective way to understand the sensitivity of the climate system to changes in freshwater forcing.

PAIRED RESPONSE OF TWO HIGH-ARCTIC LAKES TO 5000 YEARS OF CLIMATE AND ENVIRONMENTAL CHANGE

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Sedimentary records from two adjacent, high-Arctic lakes provide a means for comparing the responses of nearby lake systems to a singular pattern of climatic forcing through the mid Holocene. Upper and Lower Murray Lakes (81&deg20'N, 69&deg30'W) occupy a glacially carved valley on northeastern Ellesmere Island, Nunavut, Canada (Figure 1). The lakes are similar in size with surface areas of ~6 km&sup2 and a combined drainage basin covering ~261 km&sup2. Approximately 70% of the watershed drains directly into Upper Murray Lake, which is connected to Lower Murray Lake by a short (~100m), shallow (<0.5m) stream. Two small (~2.5 km&sup2), stagnant ice caps are located to the east of Lower Murray Lake and a portion of their runoff drains directly into Lower Murray Lake through several small streams. A larger ice cap (~15 km&sup2), located west of the lakes, drains directly into Upper Murray Lake and has formed a large fan shaped delta composed of coarse-grained sediment. The maximum depth of Upper and Lower Murray Lakes are ~80 m and ~45 m, respectively. Both lakes are depleted in oxygen near the sediment water interface, and clastic laminations are well preserved in the sediments.

A ~5200 year varved-based chronology of annual sediment accumulation in Lower Murray Lake has been previously interpreted in terms of variations in melt season (July) temperature (Cook et al., 2009). Chronological control for the sedimentary record in Upper Murray Lake is provided by seven accelerator mass spectrometry (AMS) radiocarbon dates of terrestrial organic matter recovered from the sediment cores. The radiocarbon based chronology for Upper Murray Lake extends to 3905±30 radiocarbon years BP (median 1 sigma calendar year age of 4409 years BP). Varve thickness measurements of Lower Murray Lake sediments yield a mean sediment accumulation rate of 0.46 mm/yr. In contrast, the radiocarbon based chronology from Upper Murray Lake indicates a long-term accumulation rate of 1.4 mm/yr, which is considerably higher than the rate of sedimentation in Lower Murray Lake over the same time interval (Figure 2). Although the radiocarbon ages from Upper Murray Lake indicate a relatively consistent rate of deposition over long time scales, the three youngest ages, spanning the upper 24 cm of the record indicate a lower sedimentation rate ~0.7 mm/yr over the past 350+ years.

Recently acquired, high-resolution, X-ray fluorescence (XRF) and surface reflectance spectroscopy analysis of sediment cores from both lakes will facilitate the comparison of geochemical indicators of past climate and environmental change as recorded in the two different lakes. Additionally, geochemical and surface reflectance variations will be assessed in relation to the existing varve-based climate reconstruction from Lower Murray Lake in order to further constrain the limnological response of the lake systems to climate forcings.

Cook, T. L., Bradley, R. S., Stoner, J. S., and Francus, P., 2009, Five thousand years of sediment transfer in a high arctic watershed recorded in annually laminated sediments from Lower Murray Lake, Ellesmere Island, Nunavut, Canada: Journal of Paleolimnology, v. 41, p. 77-94.

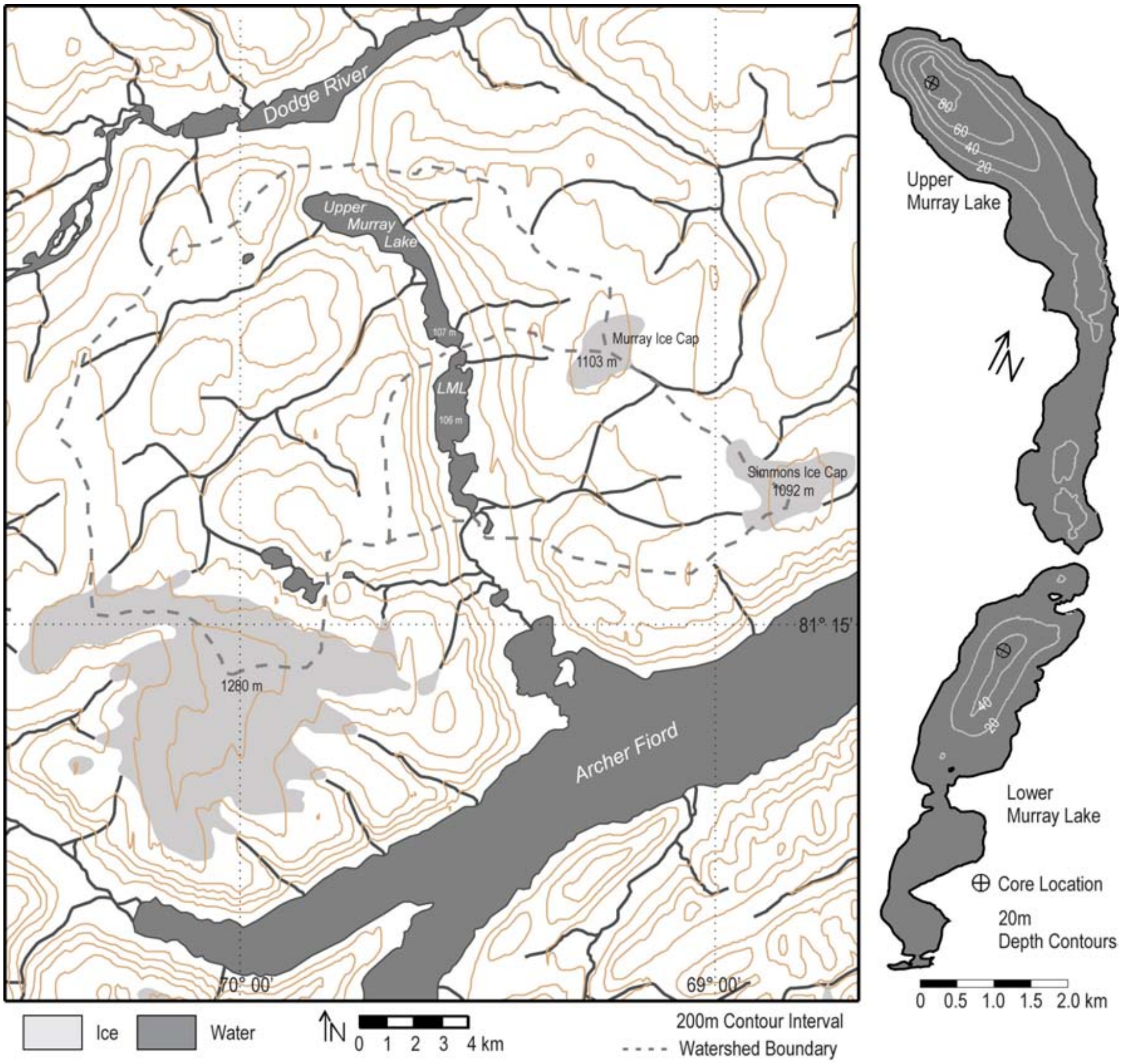

Fig 1. Map of the Murray Lakes watershed indicating the position of local ice caps and the boundary of the watershed. Shown at right is the general bathymetry of Upper and Lower Murray Lakes and the locations where sediment cores were collected.

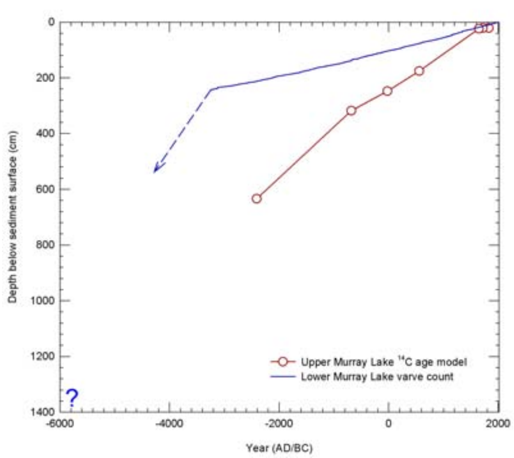

Fig 2. Age model for Upper and Lower Murray lake sediment accumulation. Lower Murray Lake age model is based on a varve chronology for the past 5200 years. The dashed line indicates a presumed increase in the rate of sediment accumulation prior to the varved portion of the record. Upper Murray Lake age model is based on calibrated radiocarbon ages.

PRELIMINARY ^{10}BE AND ^{26}AL TERRESTRIAL COSMOGENIC NUCLIDE EXPOSURE DATES ON FAR-TRAVELLED (>1000KM) ERRATIC BOULDERS FROM PRINCE PATRICK ISLAND, NWT

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Enigmatic erratic boulders from the Precambrian shield (≤4 m long; Fig. 1) have long been recognized above the marine limit in Prince Patrick Island (PPI), along the Arctic Ocean coast of the Canadian Arctic Archipelago (Tozer, 1956; Tozer & Thorsteinson 1964; Hodgson 1990). These previous investigations have suggested emplacement during ancient glaciations or ice-rafting and deposition during periods of much higher sea levels as possible methods of emplacement.

Fieldwork since 2004 has confirmed that shield erratics occur across all of PPI up to the 280m summit. U-Pb zircon crystallization ages indicate that the erratics orginate from the Precambrian shield in the region south of Queen Maud Gulf on the northern Canadian mainland. This origin requires that the boulders were transported to PPI by the Laurentide Ice Sheet (LIS; Fig. 2). However, the record of ice retreat and sea level regression in PPI during the late Wisconsinan and Holocene is consistent with only a local, island-based ice cap.

To investigate the history of erratic boulder emplacement in PPI, a N-S transect of boulders was sampled for paired ^{10}Be and ^{26}Al terrestrial cosmogenic nuclide exposure dating. All sampled boulders were ≥1 m in longest dimension, came from stable bedrock surfaces with negligible shielding and minimal evidence of erosion, past burial or exhumation. A glacially polished surface was preserved on one boulder. The preliminary results indicate apparent ages between ca. 20 ka and 90 ka BP.

From the preliminary data, three possible models are suggested to explain the distribution of apparent erratic boulder dates:

1) Regional glaciation of PPI by the LIS occurred only prior to the late Wisconsin. The “old” (>25 ka BP) apparent dates indicate cumulative exposure to cosmic rays since initial emplacement, and some boulders have experienced variable amounts of previous exposure and/or differential (local ice) burial histories after deposition in PPI. “Young” (<25 ka BP) apparent dates are due to re-working of previously deposited boulders by local ice during the late Wisconsin, and only reach their current positions after deglaciation ca. 12 – 14 cal ka BP.

2) Regional glaciation of PPI by the LIS occurred only during the late Wisconsin. The “old” apparent dates indicate significant previous (inherited) exposure of most boulders prior to deposition in addition to post-late Wisconsin exposure (ca. 12-14 cal ka). Only the “young” dates accurately date deglaciation. This model requires that the local PPI ice cap during deglaciation is a remnant of the late Wisconsinan LIS.

3) Regional glaciation of PPI by the LIS occurred both prior to and during the late Wisconsin. The “old” dates indicate initial boulder delivery by the LIS prior to the late Wisconsin, followed by a lengthy period of exposure, and subsequent burial by local ice during the late Wisconsin. In this example, the “young” boulder dates indicate renewed glaciation by the LIS and the delivery of “fresh” erratic boulders during the late Wisconsin.

Hodgson, D. A., 1990. Were erratics moved by glaciers or icebergs to Prince Patrick Island, western Arctic Islands, Northwest Territories? p. 67-70. In: Current Research, Part D. Geological Survey of Canada, Paper 90-1D. 218 p.

Tozer, E. T., 1956. Geological reconnaissance, Prince Patrick, Eglinton, and western Melville islands, Arctic Archipelago, Northwest Territories. Geological Survey of Canada, Paper 55-5, 32 p.

Tozer, E. T. & Thorsteinsson, R., 1964. Western Queen Elizabeth Islands, Arctic Archipelago. Geological Survey of Canada, Memoir 332, 242 p.

Fig 1. Granite erratic boulder on a peneplainated bedrock surface, south central PPI.

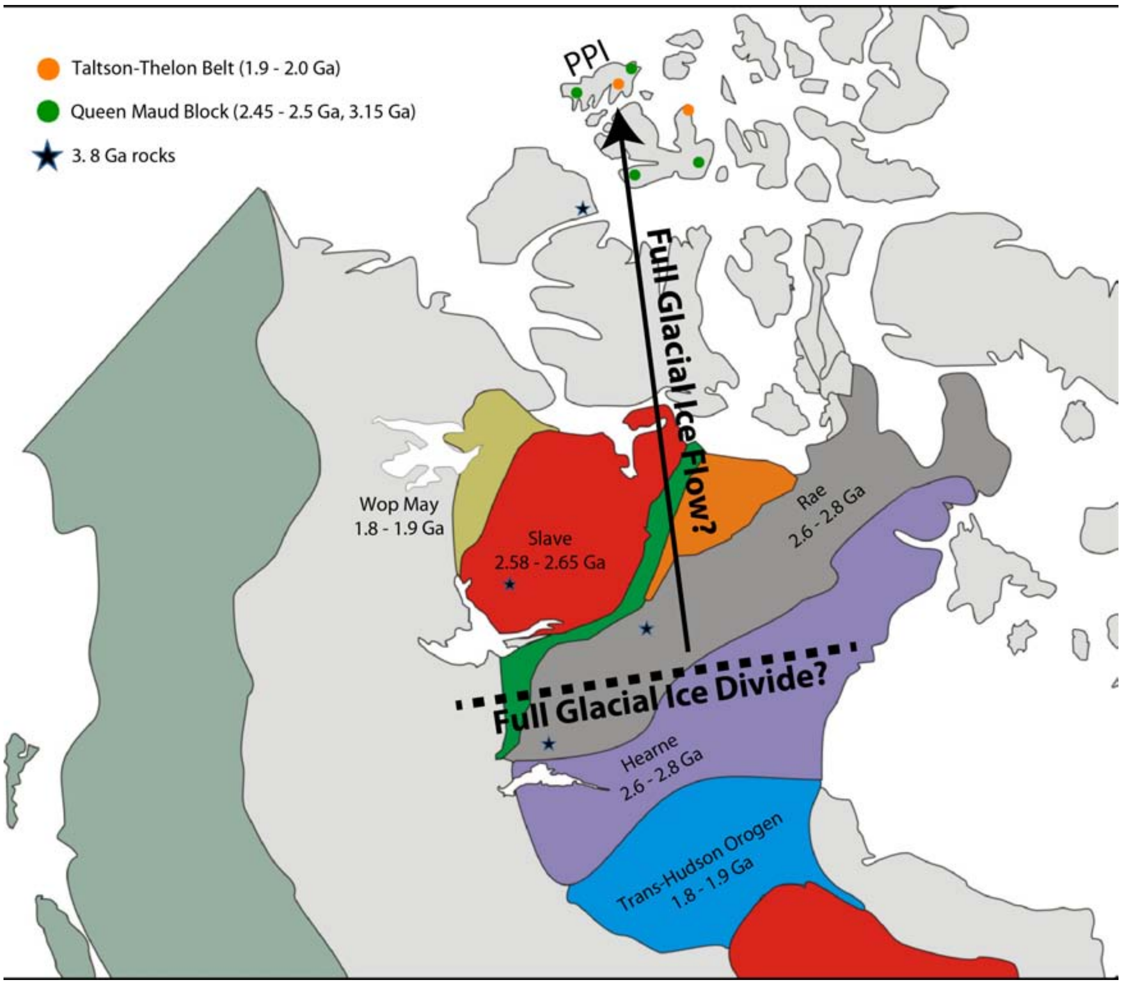

Fig 2. Schematic map of the Precambrian shield and Arctic Canada, with locations of selected erratic boulders having diagnostic U-Pb zircon crystallization ages. A possible full glacial ice divide and one possible flow line are shown.

RECONSTRUCTING HOLOCENE ICE SHEET MARGINS IN CENTRAL WESTERN GREENLAND: WHAT IS THE AGE OF THE DRYGALSKI MORAINES?

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Analyses of radiocarbon-dated lake sediments and in-situ fossil vegetation were used to constrain Greenland Ice Sheet (GrIS) advance and retreat during the Holocene on the Nûgssuaq Peninsula in central western Greenland. This is one of the few areas where moraines are thought to date to the middle Holocene (~5 ka). This estimation comes from the cross-cutting relationship between the Drygalski Moraines and present sea level suggesting that deposition could have only occurred after sea level receded to this position at ~5 ka (Weidick, 1968). The goal of this study is to determine the age of the Drygalski Moraines using absolute dating techniques. GrIS margin reconstructions inform Holocene ice sheet models and ultimately influence the predictive climate and relative sea level rise models used by climate change policymakers.

Macrofossils from sediment cores were radiocarbon dated to provide age constraints for deglaciation as well as deposition of the nearby Drygalski Moraines. Moraine boulders were also sampled for cosmogenic 10Be exposure dating but we are still processing the samples. The lacustrine sediment cores were analyzed for organic vs. minerogenic material by measuring loss-on-ignition and magnetic susceptibility in order to determine glacial and non-glacial sequences. In-situ fossil vegetation was collected near the present ice margin and radiocarbon dated to document the last time ice advanced far enough to induce fatality.

Newspaper Lake (70°11’49.62” N, 50°27’57.87” W)

Newspaper Lake (informal name) is a proglacial threshold lake currently fed from a nearby ice lobe (<1 km distance) by two inflow channels that cut through the Drygalski Moraines. The eastern portion of the lake borders the outermost moraines. We cored this lake during the summer of 2012 in order to collect a sequence that would allow us to constrain moraine age. The uppermost sediments (~0-10 cm depth) in the Newspaper Lake core are minerogenic rich and terminate at a sharp contact with organic-rich sediments beneath them. The organic-rich sediments (~10-48 cm depth) end in another sharp contact with underlying minerogenic-rich sediments (~48-114 cm depth). Radiocarbon dating of macrofossils placed the upper and lower contacts at 600±60 calibrated 14C years before 1950 (cal yr BP) and 5,390±80 cal yr BP, respectively. The ages support three possible interpretations: (1) deglaciation at this site was not achieved until ~5.4 ka, (2) the area deglaciated prior to ~5.4 ka, but sediment continued to wash in from the moraines and other surrounding hillslopes until ~5.4 ka, (3) the ice margin did not retreat entirely out of Newspaper Lake’s drainage basin until ~5.4 ka. After a period of retreat whose length is dependent upon the above mentioned scenarios, the ice margin advanced back into the lake catchment at ~0.6 ka.

Hvide Falk Pond (70°11’36.99” N, 50°25’04.53” W)

Hvide Falk Pond (informal name) is a small lake, not presently fed by the ice margin, and is situated outboard of the Drygalski Moraines. Dry outwash channels associated with the Drygalski Moraines suggest Hvide Falk Pond would receive significant amounts of minerogenic material during the deposition of the Drygalski Moraines. We analyzed a sediment core from Hvide Falk Pond that is ~104 cm long and mainly composed of gyttja with some evidence of mass wasting. A basal 14C age is 7,400±80 cal yr BP and we interpret this as a minimum age constraint for the outer Drygalski Moraines. This constraint suggests that out of the interpretations suggested by the Newspaper Lake core, the most likely is for the ice margin to have retreated out of the drainage basin at 5,390±80 cal yr BP.

Fossil Vegetation at Ice Margin

During our visit to the field area in 2012, we discovered in-situ dead surface vegetation at varying distances from the 2012 ice margin position. A sample of moss from within a meter of the ice margin, and another sample of moss ~5 m from the present margin, yield radiocarbon ages of 130±130 cal yr BP and 480±150 cal yr BP, respectively. These young ages suggest that, even though advance into the Newspaper Lake catchment began around 600±60 cal yr BP, the maximum late Holocene extent was reached more recently.

Conclusions

We conclude that the outermost Drygalski Moraines are older than 7,400±80 cal yr BP, and suggest that they may be equivalent to the Fjord Stade Moraines to the south (Young et al., 2011). The maximum extent of Neoglacial advance is constrained to be at least younger than 600±60 cal yr BP. Further constraint using radiocarbon dating of vegetation suggests the ice margin reached its maximum position during this advance phase between ~480 and 130 cal yr BP. We now have constraints on moraine age and 10Be dating results of moraine boulders may help us to more fully answer the question: “How old are the Drygalski Moraines?”

Weidick, A., 1968, Observations on some Holocene glacier fluctuations in West Greenland: Meddelelser om Gronland, v. 165, p. 79-92.

Young, N.E., Briner, J.P., Axford, Y., Csatho, B., Babonis, G.S., Rood, D.H., & Finkel, R.C., 2011, Response of a marine-terminating Greenland outlet glacier to abrupt cooling 8200 and 9300 years ago: Geophysical Research Letters, 38(24), p. L24701.

CLIMATE IMPACTS ON HUMAN SETTLEMENT AND AGRICULTURAL ACTIVITIES IN NORTHERN NORWAY REVEALED THROUGH SEDIMENT BIOGEOCHEMISTRY

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Disentangling the effects of climate change and anthropogenic activities on the environment is a major challenge in paleoenvironmental research. Here, we used fecal sterols and other biogeochemical compounds in lake sediments from northern Norway to identify both natural and anthropogenic signals of environmental change during the late Holocene. The area was first occupied by humans and their grazing animals at ~2,250 ± 75 calendar years before 1950 AD (calendar years before present). The arrival of humans is indicated by an abrupt increase in coprostanol (and its epimer epicoprostanol) in the sediments and an associated increase in 5β-stigmastanol (and 5β-epistigmastanol), which resulted from human and animal feces washing into the lake. Human settlement was accompanied by an abrupt increase in landscape fires (indicated by the rise in pyrolytic polycyclic aromatic hydrocarbons) and a decline in woodland (registered by a change in n-alkane chain lengths from leaf waxes), accelerating a process that began earlier in the Holocene. Human activity and associated landscape changes in the region over the last two millennia were mainly driven by summer temperatures, as indicated by independent tree-ring reconstructions, although there were periods when socioeconomic factors played an equally important role. In this study, fecal sterols in lake sediments have been used to provide a record of human occupancy through time. This approach may be useful in many archeological studies, both to confirm the presence of humans and grazing animals, and to distinguish between anthropogenic and natural factors that have influenced the environment in the past.

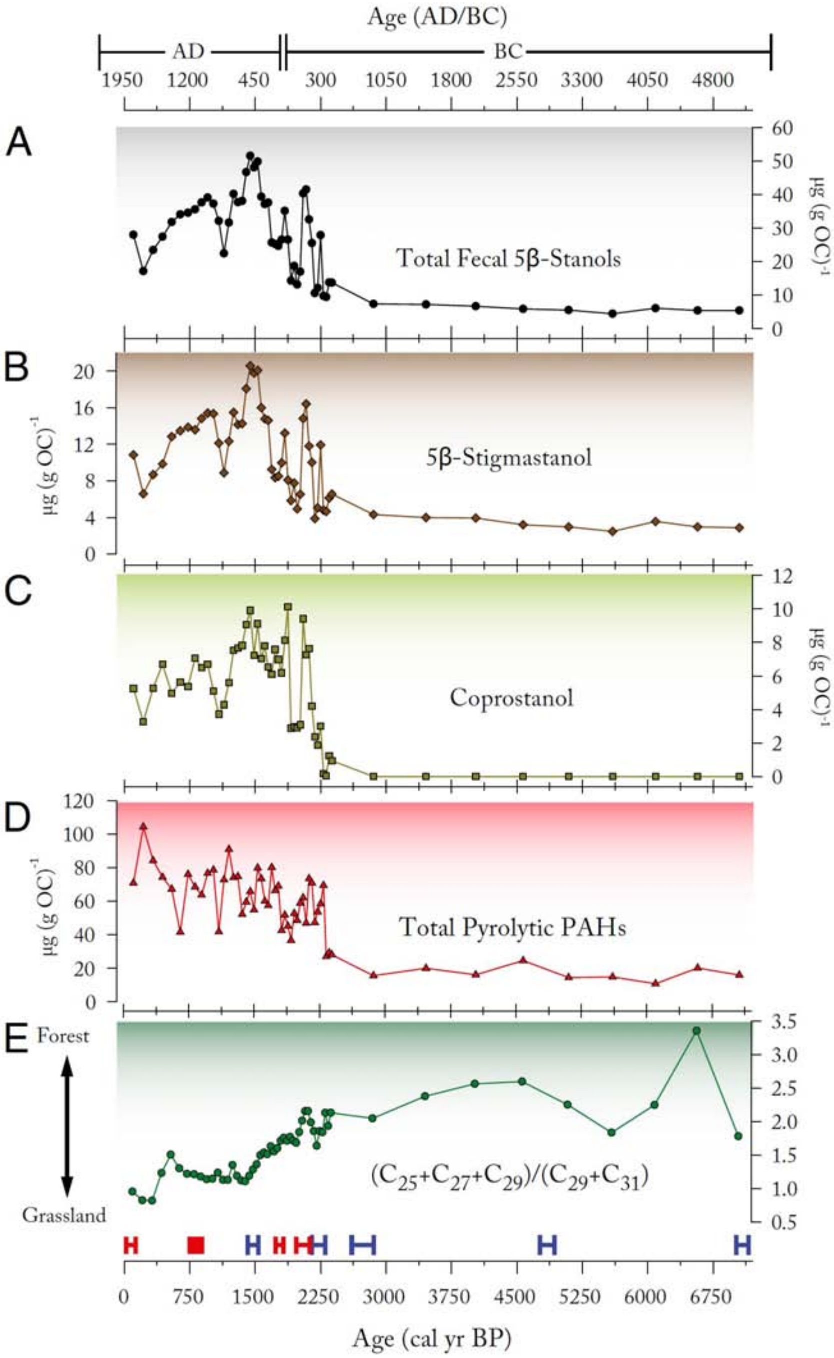

Fig 1. (A) Total fecal 5β-stanol concentrations (μg g−1 organic carbon), (B) from grazing livestock and (C) human sources over the last 7,000 calendar years together with the concentration of pyrolytic PAHs (Total PAHs = [pyrene] + [benzo(e)pyrene] + [benzo(ghi)perylene] + [fluoranthene] + [benzofluoranthenes]) (D) and an index of n-alkanes from leaf waxes: [([C25] + [C27] + [C29])/([C29] + [C31])] indicating the relative contributions from forest vegetation versus grassland vegetation (E). Dating control is indicated at bottom with radiocarbon dates measured from macrofossils (blue) and tephra (red).

HIGH-LATITUDE NORTH ATLANTIC HOLOCENE CLIMATE RECONSTRUCTION FROM SVALBARD LAKE SYSTEMS: INSIGHTS ON THE ATLANTIC MULTIDECADAL OSCILLATION (AMO) IN THE ARCTIC NORTH ATLANTIC

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The North Atlantic has been identified as a key source of internal variability, regulating global climate through interactions between pole-ward heat/salinity fluxes, and deep convective activity associated with the Atlantic Meridional Overturning Circulation (AMOC). The Atlantic Multidecadal Oscillation (AMO) is a climate index based on a multidecadal oscillation in North Atlantic sea surface temperature (SST), and is thought to be closely tied to global ocean circulation and the AMOC. However, despite the recognized importance of the AMO and its influence on global climate processes, relatively little is known about this mode of variability. Several factors contribute to this major gap in our knowledge: There are a limited number of suitable paleo-archives available which offer continuous Holocene length records with the chronological control and resolution required to capture the frequency bands characteristic of AMO variability throughout the Holocene.

During the summer field season of 2012 a joint coring team (made up of Norwegian and US scientists) completed a two-week long lake coring campaign along the Western coast of Svalbard. Several sediment cores were retrieved from four lakes situated within the Mitra Peninsula, in addition to several cores extracted from a lake on the island of Amsterdamøya, which (at 79 degrees N) constituts the northernmost lake system in the world. The location of these glacially fed lake systems are ideal for reconstructing Holocene Climate dynamics. The Svalbard Archipelago is at the northern limit of North Atlantic oceanic and atmospheric circulation systems, such that small changes in their behavior will likely cause a significant climate response. Furthermore, this location has a strong potential for teleconnections to northern hemisphere and global climate systems, making it a key location for environmental and climatic reconstructions.

In this study, we use biomarkers in lake sediment cores from Svalbard, along with high- resolution scanning techniques to advance our understanding of the behavior of the AMO over past millennia. Sediments deposited in the glacier-fed lake systems (Hajeren, Kløsa, “un-named Moraine lake”, Erlingvatnet, and Amsterdamøya lake) were retrieved using a piston corer outfitted with a 6m core tube. To recover the upper most sediments making sure the water-sediment interface remained intact, a gravity corer equipped with a 2m core tube. Lake bottom profiles and sediment depths were initially mapped using ground penetrating radar (GPR) in order to identify the optimal coring locations. The sediments have been analysed using a multi-proxy approach using Geotek and XRF core providing magnetic susceptibility profiles, whole core wet bulk density, scanning reflectance spectroscopy, and elemental geochemical analysis. The results from preliminary biomarker and organic geochemical analyses will also be presented here, including rough calculations of the alkenone unsaturation (UK37) and brGDGT based MBT/CBT indicies from the Svalbard lake sediment cores. Age-depth relationship will be achieved through Pb-210 dating of the upper sediments and 14c dating of terrestrial macrofossils. This approach will enable a high-resolution reconstruction of environmental and climatic changes related to the Atlantic Multidecadal Oscillation (AMO) and associated modes of Holocene climate variability, as well as clarify the role of ocean and atmospheric circulation in the climatic changes recorded in the Svalbard region.

A 7000 YEAR RECORD OF CLIMATE CHANGE FROM AMMASSALIK, SE GREENLAND

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Lake sediments provide unique records environmental variability, including climate signals. Climate signals recorded in the subaqueous sediments of lakes add an important dimension to our understanding of natural climatic variability, and provide a means of reconstructing climates of the past as well as assessing the impacts of climate change on lake systems. Of particular interest are lakes situated at high latitudes, whose susceptibility to climate change is great due to polar amplification, the resultant of positive feedbacks systems (e.g. Moritz et al., 2002).

This research presents an 7000 year record of climate change in the Ammassalik region of Southeast Greenland, derived from Lower Sermilik Lake. The Lower Sermilik sediment core is a composite formed from two separate sediment cores composed of three drives each. The two cores were taken at adjacent locations to ensure the strongest possible relationship. To establish an effective chronology, rapid sedimentation events representing possible turbidites were removed prior to establishing a final age-depth model. The age-depth model for the Lower Sermilik core has been established using 8 radiocarbon dates, the oldest of which was taken at 4 meters down core and dates to approximately 6.2 kyr BP. The bottom meter of the core below the final radiocarbon date contains a transition from cobbles and coarse sand to organic-poor laminations, indicating the termination of direct glacial influence.

A multiple proxy approach including magnetic susceptibility, bulk organic geochemistry, percent opal acquired via diffuse reflectance infrared Fourier transform spectroscopy (DRIFTS), elemental profiles acquired by XRF scanning, and spectral data will be used to characterize the sediment and to reconstruct seven thousand years of climate change and environmental variability. The use of the emerging DRIFTS technology to obtain inferred biogenic silica concentrations has not been widely applied to high latitude lake sediments and will help to contribute to the presently limited pool of literature on the topic. Preliminary results of the data reveal distinct changes corresponding to both local and regional variation. The data provided by this study will contribute to the understanding of Holocene Arctic climate change at a centennial scale.

HOLOCENE CLIMATE VARIABILITY RECONSTRUCTED FROM A LAKE SEDIMENT RECORD IN SE GREENLAND

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Arctic climate variability over the Holocene has been both extensive and, at times, abrupt. Current understanding of these changes is still quite limited with few high-resolution paleoclimate records available for this period. In order to place observed and predicted 21st century climate change in perspective, reliable and highly resolved paleo-reconstructions of Arctic climate are essential. Using an 8.5 m sediment core from Nanerersarpik Lake, this project will characterize climate changes during the Holocene, including the deglacial transition, the transition from Holocene thermal maximum (HTM) to the colder Neoglacial period, and intervals of abrupt climate change during the late Holocene such as the Medieval Warm Period and Little Ice Age. The 8.5 m sediment core from Nanerersarpik contains a dense gray clay in the lower 0.5m. The upper 8.0m of sediment is light brown and organic-rich with centimeter to half-centimeter laminations, interrupted by mass-movement events. Paleoenvironmental conditions have been interpreted using magnetic susceptibility, grain size, biogenic silica, TOC, C/N, and δ13Corg, as well as with high-resolution spectral reflectance and scanning XRF profiles. These parameters allow us to interpret changes in autochthonous productivity and clastic input throughout the Holocene. A chronology for the record has been established using 210Pb and 7 radiocarbon dates. The age-model indicates Nanerersarpik Lake contains an ~10,000-yr sediment record with a linear age/depth relationship and a sedimentation rate of 0.1cm/yr, allowing for potentially decadal scale resolution of environmental changes. Preliminary results show an abrupt transition from dense glacial clay to laminated organic rich sediment near the base of the core. High frequency variations dominate the spectral, scanning XRF, and magnetic susceptibility data and indicate some correlation with Holocene climate intervals. Biogenic silica and TOC analysis indicate broad scale changes in primary productivity generally consistent with known Holocene climatic intervals: the deglacial period, the Holocene Thermal Maximum, and the Neoglacial, with high variability during the late Holocene. We will present higher resolution primary productivity proxy results from the most recent section of the core to better understand late Holocene conditions on a decadal time scale at Nanerersarpik Lake. In addition, further biogeochemical temperature proxy results for the entire record will also be presented to contribute to a regional understanding of deglaciation and Holocene climate variability in the region.

MORPHOSTRATIGRAPHIC STUDY OF THE PINGUALUIT CRATER LAKE, NUNAVIK: INITIAL LIDAR RESULTS

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High-latitude lakes are excellent archives of past climatic and environmental variations owing to the sediments they can preserve (Pienitz et al., 2004). In the Northern Hemisphere, most of the lakes have undergone erosion and/or remobilization of their sediments during the last glacial period, allowing the accumulation of only Holocene sediments (Pienitz et al., 2008). The existence of a subglacial lake in the Pingualuit Crater (Nunavik, Québec) (Fig. 1), which was covered by the Laurentide Ice Sheet during the Last Glacial Maximum, precluded glacial erosion of the bottom sediments (Guyard et al., 2011). This characteristic makes the Pingualuit Crater Lake and its sedimentary record a unique opportunity to understand Arctic climate and glacial dynamics during the Quaternary.

In order to maximize the paleoclimatic archives recovered in the Pingualuit Crater, a better understanding of its geologic history, especially the morpho-stratigraphic context, is required. To this end, two expeditions were conducted in May 2010 and September 2012 under strict environmental regulations due the clearness and pristine state of the lake waters. During these surveys a total of 50 km of seismic profiles (using a 3.5 kHz sub-bottom profiler), and 35 high-resolution LiDAR (Light Detection And Ranging) topographic soundings were recorded along the subaqueous and subaerial slopes of the crater (Fig. 2). Topographic and seismic data will be used to document lake level variations and identify the main sedimentation processes in the lake. Based on the dense grid of seismic lines, we were able to determine the bathymetry of the lake. This bathymetry will be coupled for the first time with the seismic and LiDAR data in order to document lake level fluctuations and mass movements in the Pingualuit Crater Lake. The work presented here will mostly focus on the LiDAR data acquisition, processing, and interpretation which suggest that several paleo-shorelines can be identified on the internal slopes of the Pingualuit Crater.

Guyard, H., St-Onge, G., Pienitz, R., Francus, P., Zolitschka, B., Clarke, G. K. C., Hausmann, S., Salonen, V-P., Lajeunesse, P., Ledoux, G. & Lamothe, M., 2011, New insights into Late Pleistocene glacial and postglacial history of northernmost Ungava (Canada) from Pingualuit Crater Lake sediments: Quaternary Science Reviews, v. 30, p. 3892-3907.

Pienitz, R., Douglas, M. S. V., Smol, J. P., 2004, Long-term Environmental Change in Arctic and Antarctic Lakes: Developments in Paleoenvironmental Research (DPER), v. 8, Springer Publishers, Dordrecht, p. 562.

Pienitz, R., Doran, P., Lamoureux, S., 2008, Origin and geomorphology of lakes in the polar regions: In: Vincent, W. F., Laybourn-Parry, J., Polar Lakes and Riverse Limnology of Arctic and Antarctic Aquatic Ecosystems, Oxford University Press, Oxford, UK, p. 25-41.

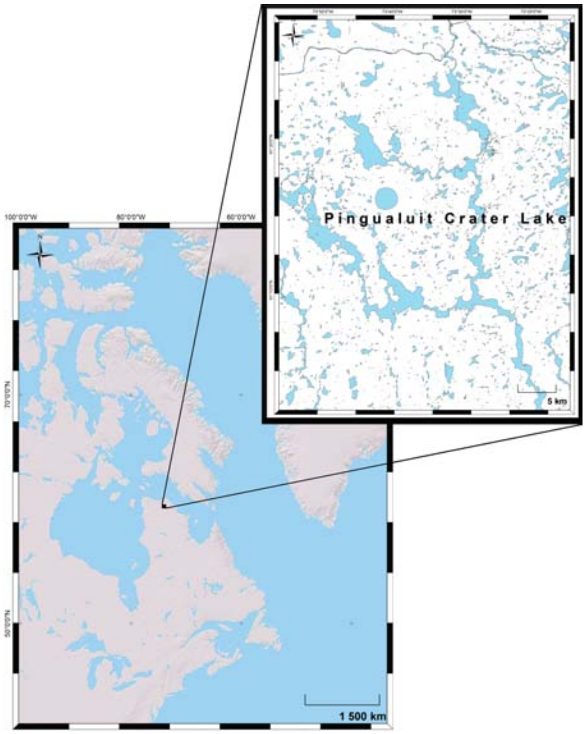

Fig 1. Location of Pingualuit Crater Lake in Nunavik, Québec.

Fig 2. Alexandre Normandeau and Guillaume St-Onge making a LiDAR measurement during the September 2012 expedition.

LATE HOLOCENE PALEOCLIMATE RECONSTRUCTION FROM VARVED SEDIMENT RECORD, LINNÉVATNET, SVALBARD, NORWAY

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Global climate systems have experienced unprecedented change over the last century caused primarily by a severe increase in greenhouse gas concentrations (IPCC, 2007). The Arctic is particularly responsive to current climate change due to its location and the presence of amplifying feedback loops. This sensitivity is indicated by increases in average Arctic temperatures of almost twice the global average over the past 100 years (IPCC, 2007). In order to place the current transformation of the Arctic into context and anticipate the effects of future climate change, Arctic climate change in the past must be quantified and understood (D'Andrea et al., 2012).

The purpose of this study is to reconstruct late Holocene climate conditions in Western Spitsbergen, Svalbard, Norway on a yearly to decadal scale, from the varved sediment record preserved in proglacial lake Linnévatnet. Linnévatnet is located at 12m a.s.l. on Kapp Linné, Spitsbergen and is 4.7 km in length with a maximum depth of 40 m. Linnévatnet's primary inflow is meltwater from a polythermal cirque glacier, Linnébreen, located 6 km to the south. Previous studies by Svendsen et al. (1997) and the Svalbard REU program suggest that the varved lacustrine sediments in Linnévatnet are closely tied to the mass balance of Linnébreen. This study aims to build upon previous research at Linnévatnet and studies on other proglacial lake systems to relate the physical characteristics of the sediment record to past climatological and watershed conditions. The annual nature of Linnévatnet's varved sediment record allows these environmental conditions to be projected into the past with yearly resolution. Furthermore, research by Leonard (1997) suggests that over longer timescales (centuries to millennia) the varved sediment record will likely reflect longer scale changes in glacier position.

The two sediment cores analyzed in this study (LH-4 and LH-Long) were collected in the spring of 2012 from the distal basin of Linnévatnet at site H, shown in Figure 1. Core LH-4 is a 49 cm long universal core and core LH-Long is a 1.4 m long modified Nesje piston-percussion core. Both cores exhibit millimeter to sub-millimeter lamination couplets comprised of a coarse-grained tan summer layer and a fine-grained winter layer as shown in Figure 2. Some intra-couplet beds are present but are limited due to the distal location of the coring site. The two cores can be easily correlated through the matching of thick lamination sequences with very distinct coarse-grained summer layers. Core LH-4 was analyzed for bulk density, % LOI, and grain size at 1 cm intervals and LH-Long was analyzed for grain size at 2 cm intervals. In addition, the top 10 cm of core LH-4 was subsampled at 0.5cm intervals for plutonium age determination to confirm the annual periodicity of the lamination couplets. Through the application of dating methods from Ketterer et al. (2004), the peak in $^{239+240}$Pu, which occurred in the interval 3.0-3.5cm, can be related to peak atmospheric bomb testing in 1963 and the separation from baseline $^{239+240}$Pu values that occurred in the 4.0-4.5cm interval can be related to the beginning of bomb testing in 1953. Thin sections were created from both cores and at present varve thicknesses have been measured from core LH-4. The core contained 639 varves with an average varve thickness of 0.75mm. Individual measurements along the core are shown related to age in Figure 3. This same analysis is ongoing for core LH-Long.

The measurements of grain size and varve thickness will be compared to instrumental weather data from the past century and climate proxy data through the late Holocene. The instrumental records that will be used for comparison include weather data from Kapp Linné collected since 2003, the Longyearbyen airport temperature and precipitation records since 1911 and data from other coastal Norwegian High Arctic locations that perhaps experience conditions similar to Kapp Linné. In addition, the physical characteristics of the sediment record will be compared to other climate proxies through time, including previous studies from Linnévatnet (Snyder et al., 2000) and Svalbard ice core climate reconstructions from Lomonosovfonna and Austfonna (Isaksson et al. 2003). The resulting paleoclimate reconstruction is expected to provide a valuable climate record that further characterizes late Holocene climate variability in Western Spitsbergen.

D'Andrea, W. J., Vaillencourt, D., Balascio, N. L., Werner, A., Roof, S. R., Retelle, M., & Bradley, R. S., 2012, Mild Little Ice Age and unprecedented recent warmth in an 1800 year lake sediment record from Svalbard. Geology, v. 40, p. 1007-1010.

IPCC, International Panel on Climate Change., 2007, Climate Change 2007: Synthesis Report. Geneva, Switzerland.

Isaksson, E., Hermanson, M., Hicks, S., Igarashi, M., Kamiyama, K., Moore, J., Motoyama, H., Muir, D., Pohjola, V., Vaikmae, R., van de Wal, R. S. W., Watanade, O., 2003, Ice core from Svalbard – useful archives of past climate and pollution history. Physics and Chemistry of the Earth, v. 28, p. 1217-1228.

Ketterer, M. E., Hafer, K. M., Jones, V. J., Appleby, P. G., 2004, Rapid dating of recent sediments in Loch Ness: inductively coupled plasma mass spectrometric measurements of global fallout plutonium. Science of the Total Environment, v. 332, p. 221-229.

Leonard, E. M., 1997, The relationship between glacial activity and sediment production: evidence from a 4450-year varve record of neoglacial sedimentation in Hector Lake, Alberta, Canada. Journal of Paleolimnology, v. 17, p. 319-330.

Snyder, J.A., Werner, A., and Miller, G.H., 2000, Holocene cirque glacier activity in western Spitsbergen, Svalbard: sediment records from proglacial Linnevatnet, Holocene, v.10, p. 555-563.

Svendsen, J.I., Mangerud, J., 1997, Holocene glacial and climatic variations on Spitsbergen, Svalbard: Holocene, v. 7, p. 45-57.

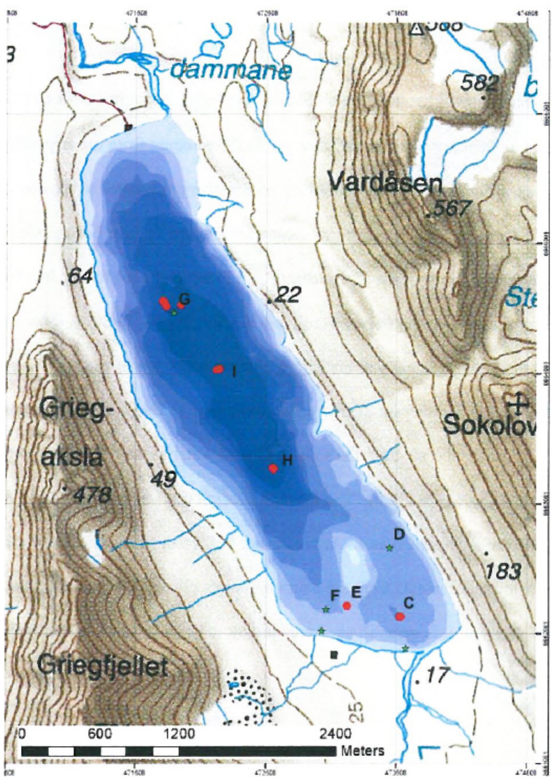

Fig 1. A map of Linnévatnet showing the different core and sediment trap locations used by the Svalbard REU program. Cores LH-4 and LH-Long were collected from site H.

Fig 2. A scanned thin section from the LH-4 core. This section shows the interval from approximately 7 to 14cm. Lamination couplets are well defined.

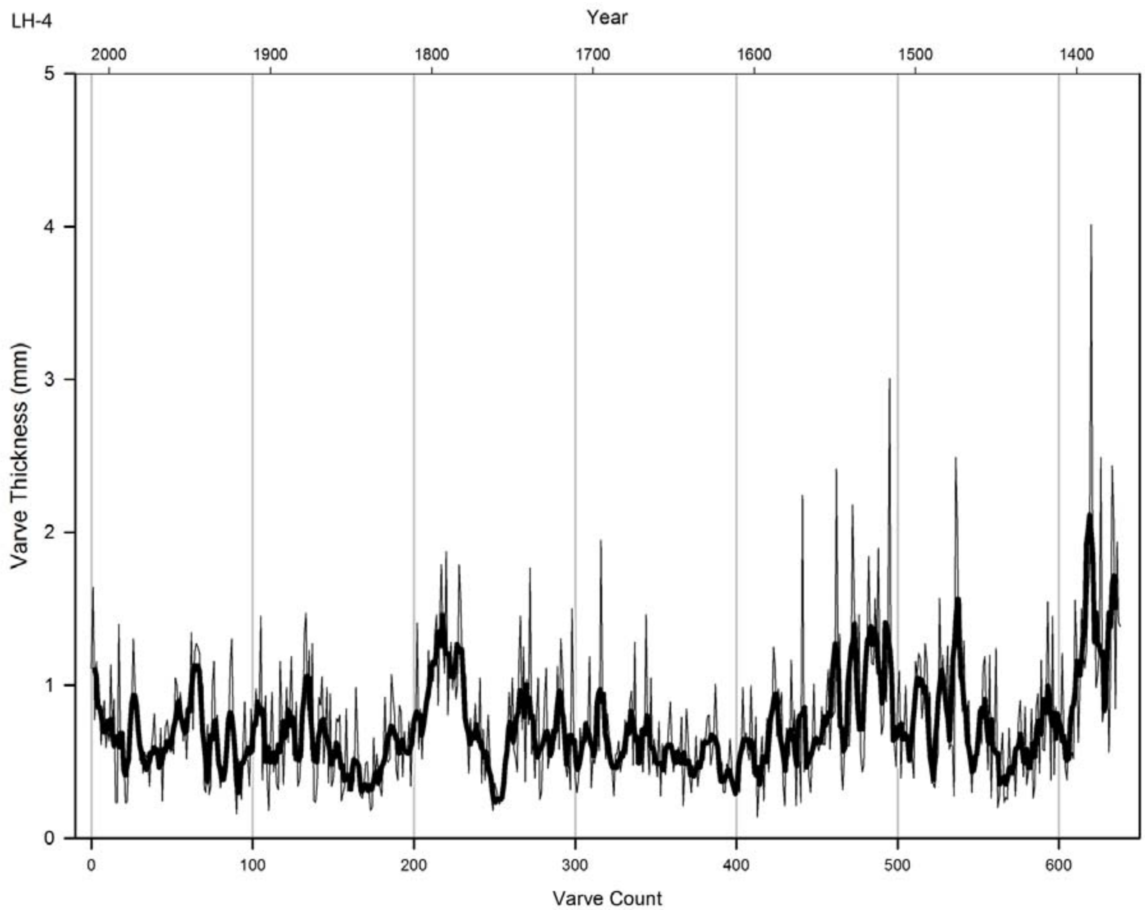

Fig 3. A plot showing varve thickness measured along core LH-4. The thin line represents the thickness of each varve. The thick line is a 5-year centered average.

PALEOMAGNETISM AND ENVIRONMENTAL CHANGES FROM SOUTHWESTERN HUDSON BAY HOLOCENE SEDIMENTS: PRELIMINARY RESULTS

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The magnetic field is not a simple magnetic dipole like a bar magnet. Its behaviour is more complicated, and it varies at several time scales, sometimes even reversing its polarity. Recent observations demonstrate that the geomagnetic field has dramatically changed. For example, its intensity is decreasing and the North Magnetic Pole, which has been located in the Canadian Arctic for the last 400 years, has been migrating rapidly towards the Arctic Ocean over the last few decades. Moreover, the geomagnetic field seems to have a different behaviour at high latitudes, and an important magnetic flux lobe is located in North America, but the spatio-temporal variability of these high latitude features is currently poorly constrained.

To understand these rapid changes and the geomagnetic field dynamics at high latitudes, paleomagnetic records derived from Arctic and sub-Arctic sediments are used to study geomagnetic field variations during the Holocene. Located at high latitudes and within the current North American magnetic flux lobe, Hudson Bay is thus a key area to learn more about the past behavior of this phenomenon. Here we present the preliminary paleomagnetic and sedimentological data from four gravity and their companion box cores sampled on board CCGS Pierre Radisson (Figs. 1 and 2) in southwestern Hudson Bay (including the mouth of the Churchill and Nelson Rivers), in order to 1) study Late Holocene geomagnetic changes, and 2) reconstruct the Nelson and Churchill river dynamics through the Late Holocene based on their magnetic, physical and sedimentological properties. Initial results indicate that the cores collected near the river mouths show clear laminations and high frequency variations of all the physical properties (Fig. 3). These high frequency changes are most likely associated with changes in river dynamics through time. Finally, initial results also indicate that the cores sampled farther from the coast are much more homogeneous, which is promising for the reconstruction of geomagnetic field variability.

Fig 1. The CCGS Pierre Radisson in Hudson Bay in September 2012.

Fig 2. A box corer on board the CCGS Pierre Radisson in September 2012.

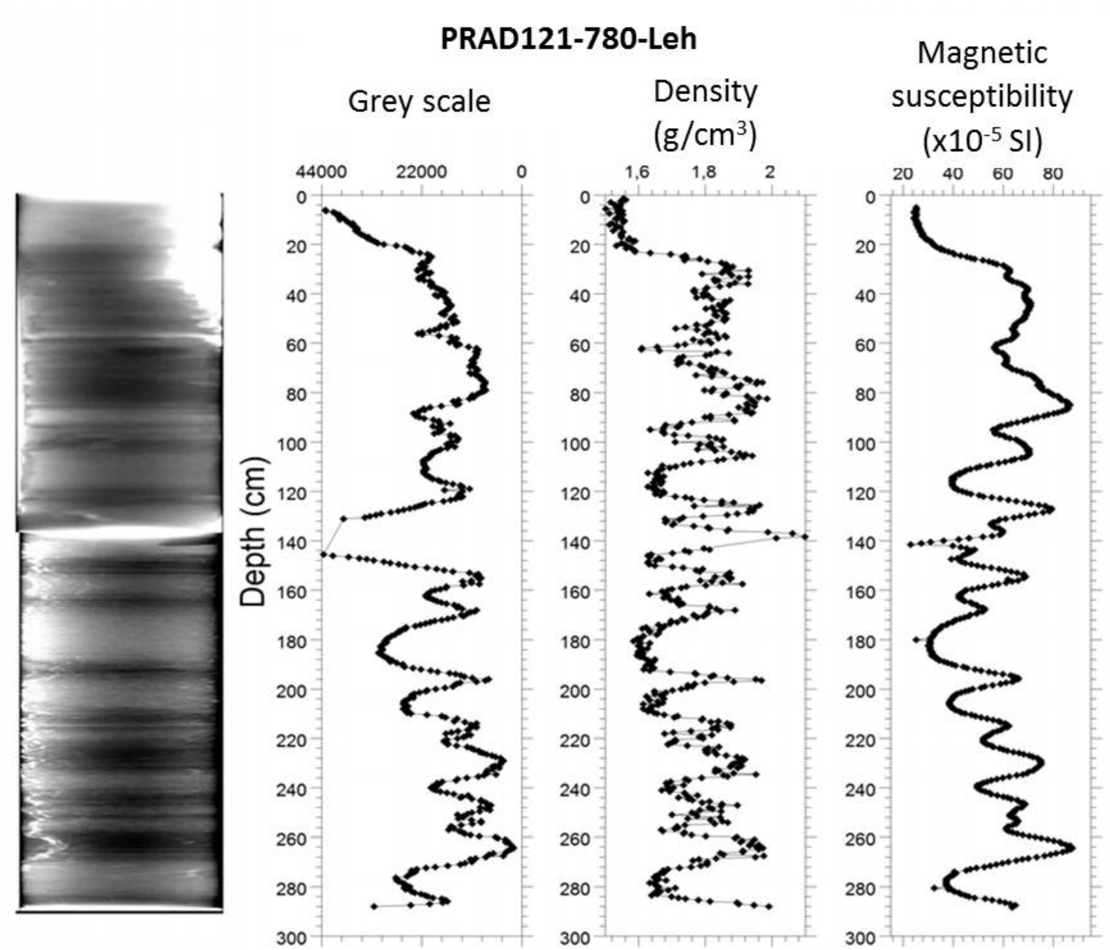

Fig 3. Physical properties of core PRAD121-780-Leh sampled near the Nelson River mouth. The image to the left was obtained with a GEOTEK XCT CT-Scanner. The grey scale profile was derived from that image, whereas the other properties were measured with a GEOTEK Multi Sensor Core Logger (MSCL). Note the high frequency variability in all the parameters.

STRUCTURE OF RELICT ARCTIC PLANT COMMUNITIES ALONG THE NORTH SHORE OF LAKE SUPERIOR

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The rocky shoreline of Lake Superior is home to disjunct arctic plant populations that are relicts from the Wisconsinan glaciation. The majority of arctic plants found along Lake Superior are restricted to growing in cracks in the outcropping bedrock within 20 m of the lake. There, they survive in a cold lake-supported microclimate (Soper and Maycock, 1963; Larsen, 1980; Given and Soper, 1981) with reduced continentality (Kopec, 1965), warmer mean minimum temperatures in winter, and cooler mean maximum temperatures in summer (Scott and Huff, 1996). While these plants have survived thus far in a unique environment, this community is threatened by climate change. As Lake Superior's water temperature increases and ice coverage decreases (Austin and Colman, 2007 and 2008), disjunct arctic plant communities reliant on lake cooling may experience structural changes and habitat loss, and may disappear altogether from the Superior basin. However, beyond a list of species and the locations of these communities (Soper and Maycock, 1963; Given and Soper, 1981), little is known about their structure and diversity and relation to abiotic factors. I characterized the plant communities and abiotic environment of one of the largest expanses of disjunct arctic communities growing in cracks in the bedrock along a rocky shoreline of Lake Superior in northern Minnesota. Common species included: Sibbaldiopsis tridentata, Deschampsia cespitosa, Solidago ptarmicoides, Senecio congestus, Primula mistassinica, Trichophorum cespitosum, Campanula rotundifolia, Pinguicula vulgaris, Lobelia kalmii, Euphrasia hudsoniana, and Trisetum spicatum, most of which are arctic plants. Diversity (H') increased with crack volume and the standard deviation of volume along the crack, but not with crack depth. Additionally, diversity increased with soil moisture. The distribution of cover amongst plant species in some cracks suggests high degrees of competition while the distribution of cover amongst species in other cracks suggests little or no competition. Two-way cluster analysis of species cover identified 4 communities, 3 with distinct species assemblages and 1 with an assemblage that is a combination of species in Communities 2 and 3. A Bray-Curtis ordination also suggested four communities segregated according to crack volume, width, and length, as well as soil moisture and diversity. Soil moisture was also correlated with crack volume. These correlations suggest that with a warmer and potentially drier climate, the plants will experience increased moisture stress, especially in smaller cracks. This increased stress could lead to the dissembling of these communities, species by species.

Austin, J. A., and Colman, S. M., 2007: Lake Superior summer water temperatures are increasing more rapidly than regional air temperatures: A positive ice-albedo feedback. Geophysical Research Letters, 34: L06604, doi: 10.1029/2006GL029021.

Austin, J. A., and Colman, S. M., 2008: A century of temperature variability in Lake Superior. Limnology and Oceanography, 53: 2724-2730.

Given, D. R., and Soper, J. H., 1981: The arctic-alpine element of the vascular flora at Lake Superior. Publications in Botany, v. 10. Ottawa, Canada: National Museum of Natural Sciences.

Kopec, R. J., 1965: Continentality around the Great Lakes. Bulletin American Meteorological Society, 46: 54-57.

Larsen, J. A., 1980:The Boreal Ecosystem. New York: Academic Press Inc., 500 pp.

Scott, R. W., and Huff, F. A., 1996: Impacts of the Great Lakes on regional climate conditions. Journal of Great Lakes Research, 22: 845-863.

Soper, J. H., and Maycock, P. F., 1963: A community of arctic-alpine plants on the east shore of Lake Superior. Canadian Journal of Botany, 41: 183-198.

Fig 1. Field site at Temperance River, MN, USA.

Fig 2. *Senecio congestus* growing at Temperance River, MN, USA.

DUCK HAWK BLUFFS, SW BANKS ISLAND: REVISITING THE LYNCHPIN TO A LONG-ESTABLISHED NEOGENE-QUATERNARY MODEL OF THE WESTERN CANADIAN ARCTIC

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Previous reconstructions of the Neogene and Quaternary history of Banks Island, NWT, contain the most elaborate and continuous record in Arctic Canada. This purportedly included late Neogene fluvial sand and gravel (Beaufort Fm), the subsequent, preglacial Worth Point Fm, followed by at least three glacial and interglacial intervals (Vincent 1982; 1983; 1990; Vincent et al. 1983; 1984; Barendregt et al. 1998). This model was initially proposed for the surficial record of the entire island (70,000 km2) where multiple till sheets, glacioisostatic seas, expansive proglacial lakes and moraine systems were assigned to three discrete glaciations, spanning at least the last 780 ka. Subsequently, subsurface units from expansive coastal sections were assumed to replicate the same surficial sequence. Fieldwork conducted during the past decade; however, has fundamentally revised all aspects of the surficial geology throughout Banks Island (e.g. most purported till sheets are weathered bedrock; England et al. 2009; Lakeman & England, 2012; Lakeman & England, in press). In contrast to Vincent's model, the most recent glacial landform assemblage across the island is now demonstrated to be late Wisconsinan.

Fieldwork during 2012 focussed on Duck Hawk Bluffs (DHB), a continuous section, eight km in length and up to 50 m thick forming the SW tip of Banks Is (Fig. 1). Here we summarize our observations at DHB and highlight some of the primary disparities with the original Vincent model.

Unit 1: The basal unit (at high tide) is composed of coarse gravel, previously assigned to the Beaufort Fm. The gravel increases in thickness eastward reaching 38 m asl. The gravel includes glacial clasts, striated boulders and dips uniformly northwestward from a glacial source, presumably in Amundsen Gulf. Ice wedge casts suggest aggradation under subaerial conditions, likely a sandur, and the previous correlation with the Beaufort Fm is untenable.

Unit 2: The second unit is composed of medium to fine sand, previously assigned to the Worth Point Fm. It is exposed discontinuously (up to 11 m thick) and contains abundant bryophyte vegetation between well-preserved sand wedges, some up to 3-4 m deep (Fig. 2). The sand is heavily deformed and intruded by post-depositional clastic dykes. This unit is not preglacial, but rather represents either an interstadial or an interglacial. The species composition of the bryophytes and pending OSL dates will help to clarify the age and paleoenvironment.

Unit 3: This unit comprises a matrix-supported diamict up to 14 m thick, separated from the underlying sand by a heavily deformed zone of folded, faulted and sheared sediment, in part derived from Unit 2. The sense of shearing in the lower part of Unit 3 is highly variable but is predominantly towards the southwest or between NNW and NNE. In the upper part of Unit 3 the sense of shearing is towards WSW, although some evidence of a northerly shear direction is apparent. We interpret this to record the convergence of Laurentide ice lobes advancing westward across both the interior of Banks Island and adjacent Amundsen Gulf, with the contact close to the DHB section.

Unit 4: comprises less than 5 m of waterlain sand, silt and clay locally containing abundant organic detritus, and has been heavily deformed post-depositionally. The sense of shearing is towards the SSW. We interpret Unit 4 as a glaciolacustrine deposit with paleocurrents from the south, heavily deformed by the emplacement of overlying glaciofluvial outwash (Unit 5).

Unit 5: comprises up to 10 m of deformed, matrix-supported gravel. The thickest outcrops display a general coarsening-upward sequence that we interpret to record outwash from an approaching ice margin.

Unit 6: varies from 1 to 11 m in thickness and displays the most complex deformation structures at DHB. It is primarily a heterogeneous matrix-supported diamicton or a mélange of material, probably derived from matrix-supported gravels, laminated sands, silts and clays, common in units 4 and 5. In places the whole of unit 6 has been complexly deformed to produce stacked overfolds (Fig. 3) and thrust faults indicative of shearing towards the southwest, consistent with the advance of Laurentide ice from the interior towards Amundsen Gulf.

Summary: Our observations at DHB indicate a fundamental mismatch with previous interpretations of the site. For example, Unit 1 gravel is not the Beaufort Fm, but is glacial outwash recording a nearby glacier in Amundsen Gulf. This is replaced up-section by Unit 2 which is unequivocally a vegetated tundra surface with sand wedges that is of either interglacial or interstadial rank but is not pre-glacial as proposed by Vincent (his Worth Point Fm). Overlying Unit 2 is the first evidence that Laurentide ice overrode the site (Unit 3), depositing what Vincent called the Bernard till (assigned to his Banks Glaciation, >780 ka BP). Following the Banks glaciation, Vincent et al. (1983) proposed that the site was inundated by the sea (post-Banks Sea) followed by the Morgan Bluffs interglacial. DHB was then presumably transgressed by the Big Sea (Thompson Glaciation) and after its regression, presumably contains the Cape Collinson interglacial (Sangamonian). We emphasize that we observed no evidence for these depositional environments above Unit 3 (which both models recognize as the first diamict in the section). Rather, above Unit 3, we note ice proximal deposition in Units 4 (glaciolacustrine) and 5 (outwash) that are in turn overlain by Unit 6 (glaciotectonite) recording the return of pervasive Laurentide ice. We see no need to separate Units 3 and 6 into two separate glaciations, but rather interpret them to represent ice marginal oscillation, with intervening Units 4 and 5, during a single glaciation. In Vincent's model, Unit 3 is >780ka. However, if Units 3 and 6 are amalgamated as we propose, they could have been deposited by the late Wisconsinan Laurentide ice that we have documented across the island.

England, J. H., Furze, M. F. A. & Doupé, J. P., 2009. Revision of the NW Laurentide Ice Sheet: implications for the paleoclimate, the northeast extremity of Beringia, and Arctic Ocean sedimentation. Quaternary Science Reviews, v. 28, p. 1573-1596. doi:10.1016/j.quascirev.2009.04.006.

Lakeman, T. R. & England, J. H., 2012. Paleoglaciological insights from the age and morphology of the Jesse moraine belt, western Canadian Arctic. Quaternary Science Reviews, v. 47, p. 82-100.

Lakeman, T. R., England, J. H. in press. Late Wisconsinan glaciation and postglacial sea level change on western Banks Island, Canadian Arctic Archipelago. Quaternary Research.

Vincent, J. -S., 1982. The Quaternary history of Banks Island, NWT, Canada. Géographie physique et Quaternaire, v. 36, p. 209-232.

Vincent, J. -S., 1983. La géologie du Quaternaire et la géomorphologie de l'Île Banks, Arctique Canadien. Geological Survey of Canada, Memoir 405.

Vincent, J. -S. 1990. Late Tertiary and Early Pleistocene deposits and history of Banks Island, southwestern Canadian Arctic Archipelago. Arctic, v. 43, p. 339-363.

Vincent, J. -S., Occhietti, S., Rutter, N., Lortie, G., Guilbault, J. -P. & De Boutray, B. 1983. The late Tertiary - Quaternary stratigraphic record of the Duck Hawk Bluffs, Banks Island, Canadian Arctic Archipelago. Canadian Journal of Earth Sciences, v. 20, p. 1694-1712.

Fig 1. Duck Hawk Bluffs cliff section, looking west. July 2012.

Fig 3. Stacked overfolds within glaciotectonite (Unit 6) at Duck Hawk Bluffs.

< **Fig 2.** Well-preserved sand wedge (Unit 2), underlying till (Unit 3) at Duck Hawk Bluffs

A GEOMORPHIC AND SEDIMENTOLOGICAL STUDY OF THE PERIGLACIAL PROCESSES AND ENVIRONMENTS, VARDEBORGSLETTA, WESTERN SPITSBERGEN, SVALBARD

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Periglacial environments in today's polar regions are highly susceptible to current and future climate change. In arctic regions, climate has warmed significantly as compared to mid-latitude regions. This study investigates geomorphological and sedimentological evidence of late Holocene changes in Vardeborgsletta, a unique high arctic periglacial landscape situated in karst terrain in western Spitsbergen, Svalbard. Fieldwork was conducted in the summer of 2012 and included geomorphological mapping and investigations of the current status of the active layer of the permafrost and karst hydrologic processes. In addition, two sediment cores were recovered from two lakes, informally named Lake 4 and Lake 7, within this periglacial terrain (Figure 1). Laboratory analyses of the cores shed light on recent changes in climate and in the karst hydrologic system. In Lake 4, field season measurements and geomorphic evidence (raised shorelines, outlet channels and exposed lake floor interbedded with fan-delta deposits) illustrate the dynamic nature of karst and periglacial processes. In Lake 7, the lack of similar geomorphic evidence indicates that lake level has remained stable in recent times. Laboratory analysis conducted on the two surface cores (up to 35cm) from Lake 4 and 7 include loss-on-ignition, bulk density, grain size analysis, and plutonium (239+240Pu) and radiocarbon age determination (Figure 2 and 3). Both cores contained complex lithostratigraphic sedimentation patterns likely reflecting distinct changes in hydrological and limnological regimes and changing lake level. In Lake 7, the basal 15 cm of the core is massive organic-rich silt, containing finely disseminated organic matter. This unit is most likely deposited in stable quiet water with autochthonous biogenic sedimentation. The upper 20 cm contains alternating terrigenous sediment from reworking fine-grained Holocene-age marine sediments in the watershed and biogenic sediment similar to the basal unit. Lake 4 is dominated by terrigenous sediments, similar in composition to the upper sediment in Lake 7, with alternating coarse fine layers of inorganic fine sandy silt and clayey silt. This unit reflects a series of lake level fluctuations. A 2 meter-deep soil pit excavated at the margin of the delta fan on a section of former lake floor exposes alternating clay-rich and silty sand layers, similar to the core stratigraphy. The sediment core and pit stratigraphy likely reflect periodic (seasonal) input from snowmelt and slope processes as well as episodic fluctuations in lake level. The development of a clear understanding of the modern and recent processes shaping the periglacial landscape in the Vardeborgsletta terrain will provide insight to the response of the high arctic periglacial environments to future climate change.

Ackerman, H. J., 2005, Relations between slow slope processes and active-layer thickness 1972-2002, Kapp Linné, Svalbard: Norsk Geografisk Tidsskrift - Norwegian Journal of Geography, v. 59, p. 116-128.

Christiansen, Hanne H., Etzelmuller B., Isaksen K., Juliussen H., Farbrot F., Humlum O., and Johansson M., 2010, The Thermal State of Permafrost in the Nordic Area during the International Polar Year 2007-2009: Permafrost and Periglacial Processes, Wiley InterScience, v. 21 p. 156-181.

Christiansen, H., Humlum, O., 2012, Pers. Comm French, Hugh M., 2007, The Periglacial Environment. 3rd ed. West Sussex: John Wiley & Sons, p. 3-5.

Humlum, Ole, Instanes A., and Ludvig Sollid J., 2003, Permafrost in Svalbard: A Review of Research History, Climatic Background and Engineering Challenges: Polar Research, v. 22.2 p. 191-215.

Ingólfsson, Ó, Outline of the geography and geology of Svalbard (unpublished report).

Fig 1. Both study lakes are located in the Vardeborgsletta region of Western Spitsbergen. Lake 4 is found towards the northern end of the valley and Lake 7 is on the southern end closer to Linnevatnet (photo: UNIS: NorskPolarInstittut).

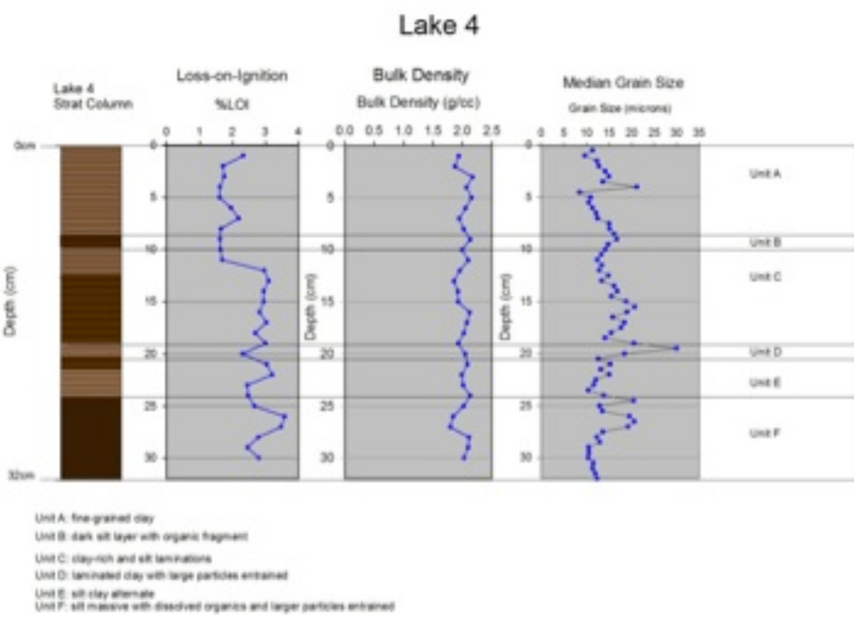

Fig 2. The stratigraphic column for Lake 4 is shown with down core values of percent loss-on-ignition, bulk density, and median grain size.

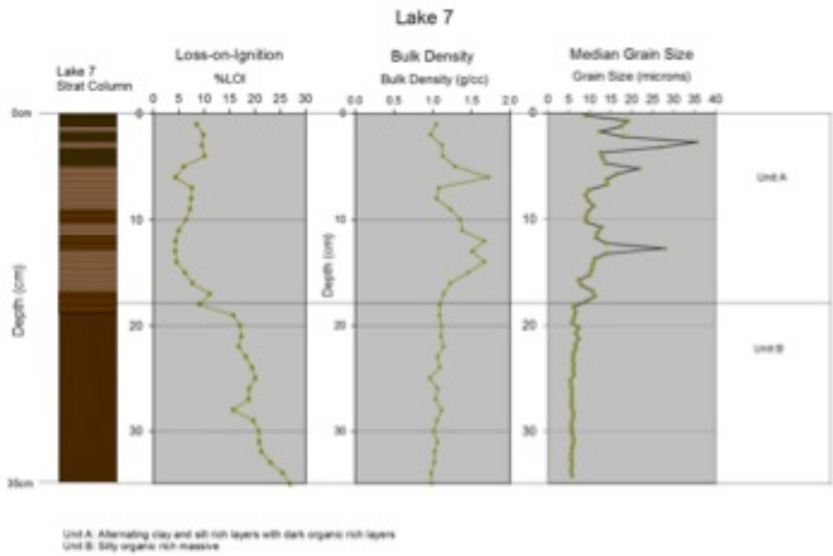

Fig 3. The stratigraphic column for Lake 7 is shown next to the values determined for percent loss-on-ignition, bulk density, and median grain size.

CONNECTING THE ATLANTIC-SECTOR AND THE NORTH PACIFIC (MT LOGAN) ICE CORE STABLE ISOTOPE RECORDS DURING THE HOLOCENE: THE ROLE OF EL NIÑO AND THE GREAT 4.2 KA BP EVENT

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The δ(18O) Holocene of the Mt Logan ice core is very different from those of eastern Arctic Canada and Greenland. The large changes seen in Logan dwarf even the largest change (the cooling event 8200 years ago) in the Atlantic-sector cores. Large changes in Logan's δ(18O) and d are related to the state of El Niño as reflected by the Quelccaya δ(18O) series. It is found that the lagged auto-difference series of the ice core records from the Agassiz ice cap, Greenland and the 23-site stack of paleo-temperature records of Kaufman et al. (2009) produce highly significant matches to the Mt Logan δ(18O) series. These correspondences suggest a lag of 1200 years. This lag time is what some models of the Diffusive-Great Ocean Conveyor (D-GOC) predict for the average travel time from the North Atlantic to the tropical eastern Pacific. Monte Carlo testing of the correlations show that they are very significant. The implications of ENSO being affected by the difference between temperatures today and those of 1200 years ago are touched on. The great drought event of 4.2 ka BP is the largest feature in the Logan Holocene and its cause is hypothesized to be a couple of centuries of extreme El Nino's that heralded the beginning of the "modern ENSO" era. This event had dire consequences in many of the world's early agricultural civilizations.

A HOLOCENE MIDGE (CHIRONOMIDAE) RECORD FROM FLOWER VALLEY LAKE, SOUTHEAST GREENLAND

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Understanding Greenland's climate is important because of the potential contribution of ice sheet melting to future sea level rise. Greenland has been experiencing unprecedented melting in recent years, so understanding regional climate dynamics is even more important. Temperature is one of the main determinants of midge species distributions, and thus midges have been shown to be sensitive paleoindicators of climate change. Response of biota to temperature change and other environmental variables is also important in determining how species will respond to future climate warming.

The midge assemblages at Flower Valley Lake show a distinct shift at about the same time that diatoms shift from benthic to planktonic species, at about 7 ka BP. Before 7 ka, the midge assemblage was dominated by *Corynocera oliveri* type, a taxon associated with cold ponds and lakes. After 7 ka, *C. oliveri* was replaced by *Micropsectra*, a cold stenotherm which became highly dominant. This shift may reflect decreasing solar insolation and cooling from the Mid-Holocene onward, and/or changes in sediment characteristics as the landscape developed. A similar shift between *C. oliveri* and *Micropsectra* was observed in lakes from southern Greenland (Francis, unpublished data).

Interestingly, the chironomid assemblages are quite different from those reported from lakes in western Greenland by Axford et al. 2013. This may reflect the influence of the cold East Greenland Current on temperatures at Flower Valley Lake. Warm-indicator taxa were mostly absent from the Flower Valley core, including *Chironomus*, *Procladius*, and the subfamily Tanypodinae, which were present throughout the cores studied by Axford et al.

The midge fauna of Greenland may present a unique opportunity for biogeographical studies of midge dispersal and colonization. The differences between the east and west Greenland midge assemblages are reflected in potential source regions for colonization. For example, *Abiskomyia* is common in sediments from Baffin Island, and is found in the west Greenland cores, but not found in cores from east Greenland or Iceland. *Parochlus* occurs in east Greenland and Iceland cores, but not in Baffin Island or west Greenland sediments

Axford, Y., S. Losee, J.P. Briner, D.R. Francis, P.G. Langdon, and I.R. Walker. 2013. Holocene temperature history at the western Greenland Ice Sheet margin reconstructed from lake sediments. Quaternary Science Reviews. v. 59, p. 87-100.

INTEGRATING CONTEMPORARY ARCTIC RESEARCH INTO SECONDARY EDUCATION CURRICULUM: EXPERIENCE, OUTREACH, AND CURRICULUM BUILDING THROUGH A FIELD SEASON IN SVALBARD

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Students in grades 9-12 are rarely exposed to contemporary scientific research in the arctic regions and often only hear of polar issues through anecdotal media contributions. Moreover, science and mathematics education at the secondary level consistently navigates a course where topics are relegated to the world of academia, answers can be checked with a key, experiments should always ‘work,’ and the real world relevance of it all can be kept at an arm’s length. Through programs such as PolarTREC and the collaboration of high school teachers with active researchers in the arctic regions, students can connect with current scientific missions and greatly enhance their global perspective while enriching their studies of enumerable topics at their home institutions. Such objectives are met by:

-Teachers, researchers, and professors establishing working relationships that share ideas, data, and insights into current arctic and local field research. Such collaboration is not only useful in spurring intellectually productive scientific dialogue but also can often serve as a valuable link/contact for students into the world of higher education and beyond. Possibilities for student involvement in meetings, camps, and field courses emerge when secondary educators have an ear to the happenings of research groups such as ARCUS or collaborative universities.

-Teachers participating in actual arctic research acts as a means to lend credibility to the information they pass on, a link for students to relate to the science, and to stay professionally active in the fields they teach. If students can hear first-hand accounts of science in the field and laboratory it becomes real to them, not just writing in a text book.

-The creation of curriculum that integrates actual data along with the background story of how it was ascertained. While the scientific education applications of arctic field work and data collection are direct there a number of ways for the science to serve as the basis for education in mathematics. Examples include geometrical analysis of frost polygons and patterned ground, the use of advance rates of surging glaciers and retreat rates of receding glaciers in algebraic modeling, calculating algebraic best-fit lines using temperature profile data with depth in the active layer above permafrost, and countless other ways.

-The involvement of students in completing original research in both the field and lab to explore interconnections with local and arctic science. In a time of rapid global climate change, students can readily examine how climate change is manifesting itself in their own environment and compare that to those in the arctic, where change is occurring at an unprecedented rate. Students living in landscapes formerly glaciated in the Pleistocene can examine current glacial processes to see how their own landscape was formed. In areas where lakes are in close proximity, teachers and students can undertake lake monitoring and even recover paleoclimate/paleoenvironmental records and note the changes in the sediment character of their waterbodies as opposed to those of the arctic (organic matter content, laminated sediments, glacial versus non glacial lakes, etc.). Examples of all of the above are readily available as web content but more importantly packaged with the pure intent of education and outreach in journals such as those of educators participating in the PolarTREC program.

Additionally, in the same vein that educators encourage students to attend and present at academic meetings and workshops, research scientists and teachers must themselves actively conduct outreach beyond their classroom to the community and in return to the working relationships they’ve fostered. This poster explores ideas on how to integrate arctic scientific research into science and mathematics education and the benefits of teacher involvement in such projects as the Svalbard Research Experience for Undergraduates and the greater PolarTREC program as a whole.

ABRUPT CLIMATE TRANSITIONS RECORDED IN SYNCHRONIZED HOLOCENE GLACIAL AND NON-GLACIAL LACUSTRINE RECORDS IN ICELAND

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Accurate dating of high-resolution records is essential when assessing rates of climate and environmental change. Two Icelandic lakes, the glacial lake HVT and the non-glacial lake HAK, both with high sedimentation rates through the Holocene, numerous tephra layers of known age together with high-resolution paleomagnetic secular variations (PSV) allow synchronization with a well-dated marine core from the shelf north of Iceland. A standardized multi-proxy climate record from the two lakes result in a single time series that most completely describes what the multi-proxy records are reflecting collectively about past environmental change. The first-order trends in the lacustrine climate proxies (BSi, d13C, C:N) are similar. They rise relatively abruptly following deglaciation, reaching maximum values shortly after 8 ka following a brief minimum between 8.7 and 8.0 ka. The HTM in Iceland was warm enough to melt most glaciers completely, with summer temperatures estimated 3.5 °C higher relative to 1960-1990 averages. Decreasing summer insolation after the HTM is reflected by incremental cooling, initially ~5.5 ka and reflected in the sediment accumulation rate, TOC, density and MS. TOC and BSi track each other during warm times, but diverge, and sedimentation rates, TOCflux and C:N ratios increase, during perturbations and cold times at 8.7 to 8 ka, 5.5 ka, 4.3 to 4 ka, and 3.1 to 2.8 ka. Following each of these departures, BSi re-equilibrates at a lower value. Some of the departures may be related to Icelandic volcanism influencing catchment stability, but the lack of a full recovery to pre-existing values after the eruptions suggests increased periglacial activity, decreased vegetation cover, and glacier growth in the highlands of Iceland. The strongest disturbance occurred after 2 ka with initial summer cooling occurring ca. 1250 AD, followed by a more severe drop in summer temperatures around 1450 AD, and the final and most severe step around 1800 AD. The LIA began earlier and apparently peaked later than reflected by many mainland European records. The similarity in timing, direction and magnitude of the sedimentation rate changes and the various proxies in lakes with and without an ice cap influence as well as correlation with marine data, suggest that changes in sedimentation rates and climatic proxies reflect North Atlantic climate change.

QUATERNARY ARCTIC OCEAN: SEA ICE AND OCEAN CIRCULATION VARIABILITY OVER ORBITAL TIMESCALES

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In order to understand the impacts of past climatic changes on the Arctic Ocean, we analyzed microfaunal assemblages (ostracodes, foraminifera) from six piston cores from the Northwind, Mendeleev Ridges and the Lomonosov Ridge in the western and central Arctic to reconstruct paleoceanographic history during Quaternary glacial-interglacial cycles. Cores come from water depths between 700 and 2000 meters and the sediments recovered represent glacial-interglacial cycles of the past ~500 ka (kiloannum) including a record of the mid-Brunhes climatic transition (~ 400-300 ka). Age models for the cores are based on bio-, litho- and cyclostratigraphy. The most important ostracode taxa (and their paleoceanographic significance) are Acetabulastoma arcticum and Pseudocythere caudata (perennial sea ice), Polycope spp. (productivity and sea ice), Krithe glacialis and Henryhowella asperrima (sea-ice free conditions, deep water formation), Pterygocythereis vannieuwenhuisei (warm interglacial conditions). Preliminary results indicate the western Arctic was seasonally sea-ice free during the warm interglacial period Marine Isotope Stage (MIS) 11. A faunal turnover at approximately 300 ka when P. vannieuenhuisei became extinct and ostracode assemblages characteristic of interglacial and interstadial periods (MIS 9, 7, 5, 3, 1) became dominant in the western Arctic. We interpret these changes as indicating that interglacials included periods of perennial sea ice, like those that characterized the late Holocene interglacial. Ostracode assemblages also vary over millennial timescales, suggesting short-term changes in ocean circulation during glacial and interglacial periods.

Cronin, T. M., L. Polyak, D. Reed, E. S. Kandiano, R. E. Marzen, E.A. Council. In press. A 600-kyr Arctic Sea-Ice Record from Mendeleev Ridge based on Ostracodes. Quaternary Science Reviews.

Cronin, T. M., G. S. Dwyer, J. Farmer, H. A. Bauch, R. F. Spielhagen, M. Jakobsson, J. Nilsson, W. M. Briggs, Jr., A. Stepanova. 2012. Deep Arctic Ocean Warming during the last Glacial Cycle. Nature Geosciences 5, 631-634.

Farmer, J., T. M. Cronin, G. S. Dwyer. 2012. Ostracode Mg/Ca Paleothermometry in the North Atlantic and Arctic Oceans: Evaluation of the Carbonate Ion Effect. Paleoceanography 27, 1-14, PA2212, doi:10.1029/2012PA002305.

Yasuhara, M., G. Hunt, G. van Dijken, K. R. Arrigo, T. M. Cronin, J. E. Wollenburg. 2012. Patterns and controlling factors of species diversity in the Arctic Ocean. Journal of Biogeography. 39, 2081-2088.

Farmer, J. R., T. M. Cronin, A. de Vernal, G. S. Dwyer, L. D. Keigwin, R. C. Thunell. 2011. Ocean temperature variability in the Western Arctic Ocean during the last 8000 years. Geophysical Research Letters 38, L24602, doi:10.1029/2011GL049714.

Cronin, T. M., L. Gemery, W. M. Briggs, Jr., M. Jakobsson, L. Polyak, E. M. Brouwers. 2010. Quaternary sea-ice history in the Arctic Ocean based on a new sea-ice proxy. Quaternary Science Reviews 29, 3415-3429.

OCEANOGRAPHIC REGIMES IN THE WESTERN LABRADOR SEA SINCE MARINE ISOTOPE STAGE 3 BASED ON DINOCYST AND STABLE ISOTOPE PROXY RECORDS

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Sea surface temperature (SST) and salinity and density gradients in the upper water column of the western Labrador Sea have been reconstructed based on a high resolution analysis of a core (HU2008-029-004PC) spanning the last ~ 30 ka, raised off Hudson Strait. The modern analogue technique was applied to dinocyst assemblages, in combination with stable isotope data from Neogloboquadrina pachyderma sinistral (Npl), for this purpose. Three oceanographic regimes were identified, broadly corresponding to the "glacial", "late deglacial" and "post-glacial" intervals. The site remained under the direct influence of the Laurentide Ice Sheet (LIS) margin until ~12.2 cal ka BP. It did not record the Bølling-Allerød warming and weakly recorded the Younger Dryas event. The "glacial" regime thus lasted until ~12.2 cal ka BP and is characterized by sparse dinocysts in the sedimentary record indicating nearly perennial sea ice, followed by consistently low abundances within assemblages characteristic of quasi-perennial sea ice. Under the "deglacial" regime (ca. 12.2-8.3 cal ka BP), increased productivity and more diversified dinocyst assemblages are interpreted as a response to an increased North Atlantic inflow. Warm summer (~11°C) but low winter SSTs (~0°C), sea-ice cover during about 3.5 months per year, and low summer salinity (~28) then suggest the persistence of a strongly stratified surface water layer relating to steady meltwater supplies from the Laurentide Ice Sheet (LIS). Following the final drainage of glacial Lake Agassiz through Hudson Strait (dated here at ~8.3 cal ka BP), and the subsequent LIS collapse, increased summer salinity (up to ~35) was accompanied by a reduced seasonality with increased winter (~3.8°C) and decreased summer (~8.6°C) SSTs. This weakened stratification of the surface water layer allowed for winter convection and Labrador Sea Water formation, as shown by increased Npl-$\delta^{13}C$ values in response to higher ventilation rates of the intermediate water layer.

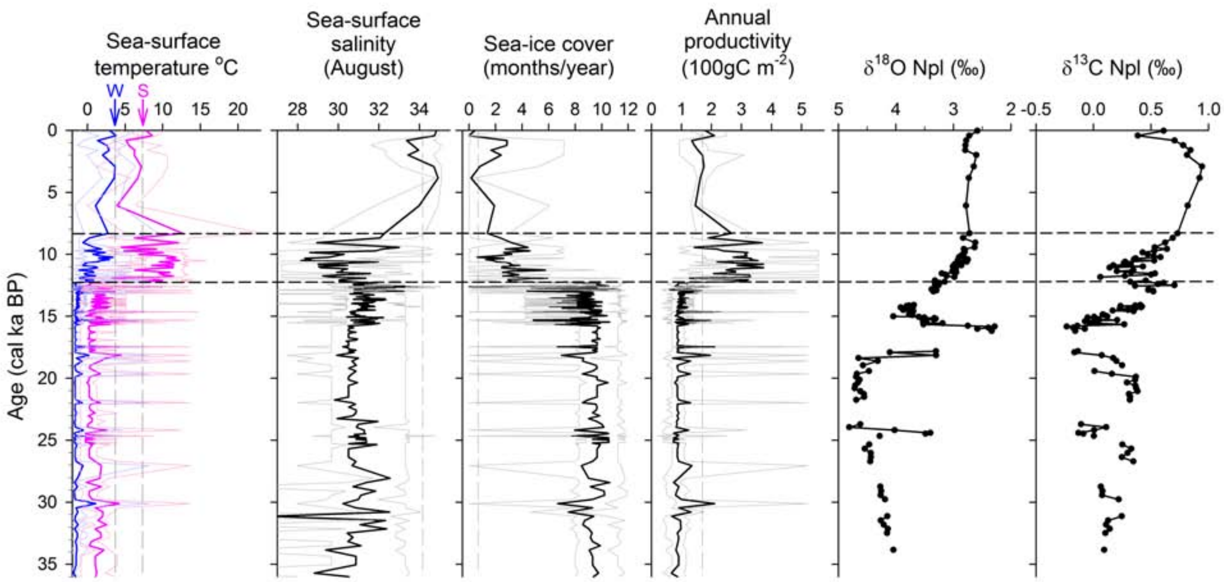

Fig 1. Reconstruction of sea-surface conditions from dinocyst assemblages and the oxygen and carbon stable isotopes of Neogloboquadrina pachyderma (Npl) of core PC04 covering the past ~36,000 years. Sea-surface temperatures (SST) in winter and summer are represented by blue and pink curves respectively. The lighter blue and pink curves correspond to maximum and minimum SSTs possible as calculated from a set of 5 modern analogues. Sea-surface salinity, sea-ice cover and annual productivity are represented by black (most probable values) and grey lines (minimum and maximum possible). Modern values of winter and summer sea-surface temperature, sea-surface salinity and sea-ice cover, as provided by the NODC and NSIDC, are indicated by the vertical dashed lines. Ecostratigraphic stages are separated by a horizontal dashed line.

REVERSING THE IMPACT OF THE HAUGHTON CRATER, DEVON ISLAND, CANADA

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The Miocene cooling age of the Haughton Crater, Devon Island, based on 40Ar/39Ar dating of a single impact-ejected gneiss clast with multiple K-bearing phases [23.4±1.0, Jessberger, 1988] and apatite fission track thermochronology [22.4±1.4, Omar et al. 1987] in similarly impact-melted gneiss clasts among the impact breccia was recently revised to 39±2Ma using a spot-dating 40Ar/39Ar approach on glass within the gneiss [Sherlock et al. 2005]. The former age is consistent with Miocene faunal and floral fossil evidence in lake sediments within the crater. The latter more popularly cited age supports an Eocene multiple impact cluster including the Canadian Wanapitei and Mistastin Craters. The possibility that the crater was much older than the fossil-bearing sediments previously could not be precluded, although no earlier fossil assemblages have been found. Using thermochronometers with a lower closure temperature (apatite-He (75°C, and zircon-He 150°C), here we report new ages for the timing of the Haughton Crater impact. (U-Th-Sm)/He ages on apatite and zircon from different partially-melted granitic gneiss clasts found on the surface of the impact breccia yield mean ages of 21.4±0.9 Ma and 21.2±0.8 Ma. New paleomagnetic stratigraphy of the lake sediments above the breccia-sediment contact to near the top of the sequence suggest that the entire sequence has reversed polarity. This, along with XRD analysis of clays that show no evidence of an early marine incursion into the crater (which was initially at or below sea level) supports the interpretation that the fossil-bearing lake sediments were formed soon after impact and refutes the hypothesis that there was a long delay between impact and fossil record. We conclude that the impact age of the crater is 21.3±0.6 Ma (1SE, n=16), there was no long hiatus between impact and lake, and this is the maximum-limiting age on the rich fossil record, including the recently discovered land-sea missing-link mammal Puijulla darwinii.

Jessberger, E. K., 2012, 40Ar-39Ar Dating of the Haughton Impact Structure. Meteoritics, 23(3), 233-234.
Omar, G., Johnson, K., Hickey, L., Robertson, P., Dawson, M., & Barnosky, C. W.,1987, Fission-track dating of Haughton Astrobleme and included biota, Devon Island, Canada. Science, 237, 1603-1605.
Sherlock, S. C., Kelley, S. P., Parnell, J., Green, P., Lee, P., Osinski, G. R., & Cockell, C. S., 2010, Re-evaluating the age of the Haughton impact event. Meteoritics & Planetary Science, 40(12), 1777-1787.

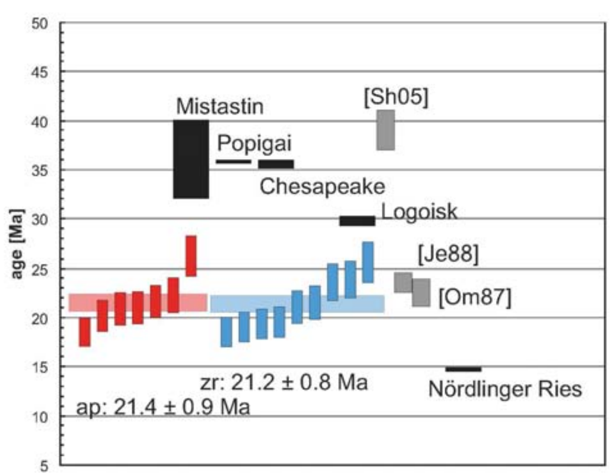

Fig 1. New apatite (red) and Zircon (blue) Helium ages for the Haughton Crater. Also shown are ages for the Haughton Crater using Ar and AFT methods (grey boxes) and the ages of other mid-Tertiary impacts (black boxes).

BIOAVAILABILITY OF METHYLMERCURY TO ARCTIC CHAR ON CORNWALLIS ISLAND, NUNAVUT

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Mercury (Hg) is anthropogenically released into the atmosphere by the burning of fossil fuels. Once in the atmosphere, Hg can remain there for up to two years. Prevailing winds can carry Hg to remote locations, and Hg can thereby be deposited great distances from where it was initially volatilized. Because of prevailing wind patterns, much of the Hg generated in low latitudes is deposited in the Arctic. Because Hg is toxic, persistent, and bioaccumulates in aquatic food webs, this phenomenon affects fish, piscivorous wildlife, and humans inhabiting the North. Cornwallis Island, Nunavut (74°N) is a polar desert, but has many lakes inhabited by arctic char (Salvenius alpinus) including Char Lake, one of the best-studied high Arctic lakes. Arctic char are the apex predators in the simple food webs of the Arctic lakes they inhabit. As such they are the organisms most prone to accumulation of methylmercury (MeHg). Methylmercury is the form of Hg which most readily bioaccumulates and is the most difficult for organisms to eliminate. Understanding the methylation process and the introduction of MeHg into Arctic lacustrine food webs is therefore crucial. Mercury methylation occurs in lake sediments after Hg is deposited on the lake or its watershed. Mercury levels in arctic char on Cornwallis Island have been monitored for the past 15 years. During that time, deposition of Hg has not changed significantly, but trends in Hg concentrations in char tissues have become apparent. Specifically, Hg concentration tends to increase during warmer summers. In addition to non-point mercury contamination, the North is experiencing climate warming, which is resulting in longer ice-free seasons and higher water temperatures in lakes. The resulting cascade of biotic and abiotic responses, including effects on contaminant partitioning, warrant further investigation. The overarching objective of my research is to determine whether there are interactions between the effects of environmental variables associated with climate change and the availability of MeHg to arctic char. The experimental approach includes year-round water and sediment temperature monitoring, testing of the effects of increased temperature on methylation and demethylation rates in sediments, and investigation into the main sites of mercury methylation in four lakes on Cornwallis Island. Also, the emergence of chironomid larvae and pupae from sediments and their levels of MeHg will be investigated. Testing of the effects of temperature on the MeHg concentration in chironomids will also be investigated. Sample collection and experiments will be carried out during the summer of 2013 and 2014.

Chételat, J., M. Amyot, et al., 2008, Metamorphosis in chironomids, more than mercury supply, controls methylmercury transfer to fish in high arctic lakes: Environmental Science & Technology v. 42 (24), p. 9110 - 9115.

Gantner, N., M. Power, et al., 2010, Mercury concentrations in landlocked arctic char (Salvenlinus alpinus) from the Canadian Arctic. Part I: Insights from trophic relationships in 18 lakes: Environmental Toxicology and Chemistry v. 29 (3), p. 621 - 632.

THE ROLE OF OCEAN WARMING IN ICE SHEET-OCEAN INTERACTIONS IN EASTERN BAFFIN BAY FROM LGM THROUGH DEGLACIATION

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Geophysical and marine geological data from offshore central West Greenland have shown that large, fast flowing ice streams of the Greenland Ice Sheet (GIS) extended to the continental shelf edge during the Last Glacial Maximum (LGM) (Ó Cofaigh et al., 2012) and that ocean warming played a significant role in ice retreat from the LGM positions (Sheldon, 2012). To gain an understanding of the timing of GIS retreat from the shelf edge and to ascertain the role and timing of ocean warming in initiating and sustaining ice retreat (via advection of Atlantic Water in the West Greenland Current) requires study of sediment archives from sites beyond the maximum ice sheet margin at the shelf edge.

Trough mouth fans on the central West Greenland continental margin provide the needed sediment records. The trough mouth fans were built by focused sediment delivery from successive advances of ice streams to the shelf edge and by hemipelagic sedimentation processes including ice-berg rafting, suspended sediment deposition and marine productivity. Using sediment cores collected from the Disko and Umanak Trough Mouth Fans in 2008 (HU2008-029-12PC) and 2009 (JR175 VC35, VC29 and VC46) we investigate the timing of GIS retreat from the LGM through the deglaciation on central West Greenland and the ice margin response to advance of the West Greenland Current along the margin (Figure 1). Proxy evidence from the cores used to determine changes in environmental conditions includes lithofacies analysis from x-radiography and visual core descriptions, IRD stratigraphy (ice rafted detritus counts from x-radiographs), quantitative x-ray diffraction mineralogy (qXRD) to document changes in sediment provenance, and foraminiferal assemblage analyses to assess the presence/absence of Atlantic Water and sea ice. Radiocarbon dates on foraminifers and molluscs constrain the timing of events interpreted in the cores.

IRD peaks in the cores result from two distinct processes and provenances. IRD-rich intervals with a proximal Greenlandic origin were derived from retreat of the GIS off the nearby shelf edge, whereas detrital carbonate-enriched IRD intervals (DC events) indicate melting of icebergs calved from Laurentide and Innuitian ice sheet margins in northern Baffin Bay (Andrews and Eberl, 2011; Simon et al., 2012). The earliest IRD event in these cores is recorded in 2008-029-12PC as a Greenland sourced event younger than 19.3 cal kyr BP (based upon a 14C date 1.9 m below the IRD peak) and as young as 15 cal kyr BP by correlation to IRD records in VC46 and VC29. This IRD event is interpreted to record initial retreat of the GIS from the shelf edge after the LGM. In VC46 foraminiferal evidence of ocean warming preceded shelf-edge ice retreat, suggesting that northward advance of the WGC likely is associated with GIS retreat from the LGM (Sheldon, 2012). The DC events begin slightly earlier than 14.1 cal kyr BP, after the GIS has retreated from the shelf edge. Several DC events occur between c. 14.1 cal kyr and 10.7 cal kyr in cores VC46, 12PC, VC29, and VC35. The first event is associated with a strong Atlantic Water signal and is dated in several cores to c. 14 cal kyr BP. More radiocarbon dates are in process to constrain the timing of the DC events.

Andrews J.T., Eberl D., 2011, Surface (sea floor) and near-surface (box cores) sediment mineralogy in Baffin Bay as a key to sediment provenance and ice sheet variations. Canadian Journal of Earth Science, v. 48, p. 1–21. doi:10.1139/E11-021

Ó Cofaigh, C., Dowdeswell, J.A. , Jennings, A.E. , Hogan, K.A. , Kilfeather, A., Hiemstra, J.F. , Noormets, R. , Evans, J. , McCarthy, D.J. , Andrews, J.T. , Lloyd J.M. , and Moros, M., 2012, An extensive and dynamic ice sheet on the West Greenland shelf during the last glacial cycle. Geology published online 30 November 2012; doi: 10.1130/G33759.1

Sheldon, C., 2012, The deglacial history and paleoceanography of the Umanak System, West Greenland. MS thesis, University of Colorado, Boulder.

Simon, Q., St-Onge, G., Hillaire-Marcel, C., 2012, Late Quaternary chronostratigraphic framework of deep Baffin Bay glaciomarine sediments from high-resolution paleomagnetic data, Geochem. Geophys. Geosyst. v.13 : Q0AO03, doi:10.1029/2012GC004272.

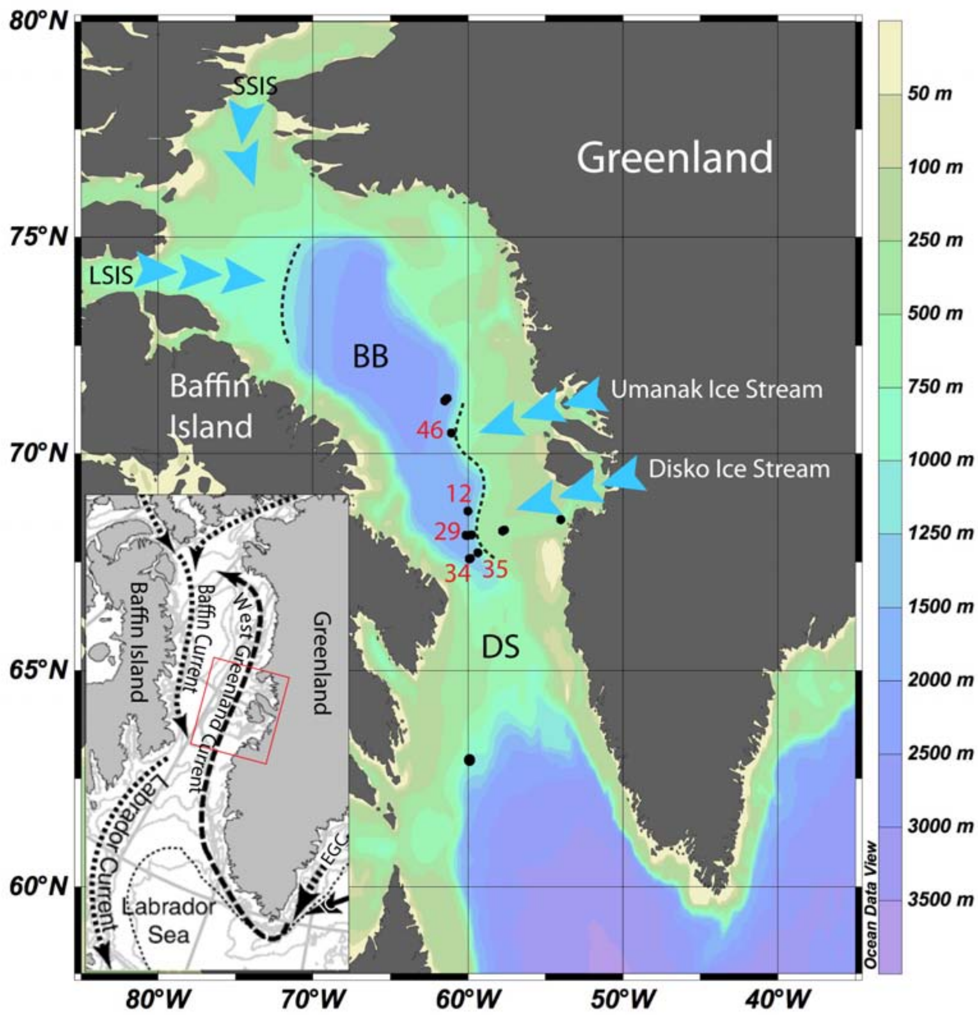

Fig 1. Figure 1. Bathymetric and location map of Baffin Bay showing locations of sediment cores mentioned in this study (red labels by black dots), locations of other important cores in the region (unlabeled black dots), ice streams (cyan arrows), grounding lines (dashed black lines). Inset map shows the main currents in Baffin Bay, including the West Greenland Current, which brings Atlantic Water northward along the West Greenland margin.

EXAMINING THE PAST DYNAMICS OF THE NORTHEAST GREENLAND ICE SHEET THROUGH RADAR INTERNAL STRATIGRAPHY

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In Greenland, ice transport from the interior to the coast is through outlet glaciers that only penetrate a few hundred kilometers inland, except in the vicinity of the Northeast Greenland Ice Stream (NEGIS), which reaches 800 km inland from the coast to nearly the summit dome (Joughin, 2001). The ice stream's large catchment, ability to discharge ice directly to the ocean through deep marine outlets, and unique inland extent highlight the need to include the ice dynamical effects of NEGIS in future mass balance predictions of the Greenland Ice Sheet. Here we use airborne radio-echo sounding (RES) surveys, ground-based geophysical surveys, and ice-core derived age depth scales (traced through radar stratigraphy from a core site to Northeast Greenland) to investigate the current and past dynamics of NEGIS.

Although basal melt produced by high geothermal flux initiates streaming flow (Fahnestock, 2001), our geophysical surveys reveal that fast-flow is propagated solely by ice dynamical effects. Furthermore, internal layers in our IPR data, which result from changes in atmospheric fallout via volcanic eruptions or other processes and thus represent constant time horizons (Whillans, 1991; Alley, 1993), persist throughout the 3-km ice column and can be dated by linking these layers to ice core sites via airborne RES data. Our analysis shows the propagation of internal layers of at least ~60 ka through the shear margin into the center of the ice stream, indicating the possibility of long-term stability. Here we use layers of known age and theoretical ice-core age depth relationships to examine past changes in vertical strain and interpret their implications for past ice dynamics in northeast Greenland.

Our results show that radar studies provide a window into past dynamics of ice sheets, especially in sensitive regions like NEGIS, that complements ice core archives. In addition, spatially variable age-depth scales can be used to identify and target large volumes of ice from specific epochs since the last glacial maximum in Northeast Greenland.

Alley, R.B., D. A. Meese, C A Shuman, A. J. Gow, K. C. Taylor, P. M. Grootes, J. W. C. White, M Ram, E D Waddington, P. A. Mayewski, and G. A. Zielinski, 1993, Abrupt increase in Greenland snow accumulation at the end of the Younger Dryas event: Nature, v. 362, p. 527-529.

Fahnestock, M., W. Abdalati, I. Joughin, J. Brozena, and P. Gogineni, 2001, High Geothermal Heat Flow, Basal Melt, and the Origin of Rapid Ice Flow in Central Greenland: Science, v. 294, p. 2338–2342.

Joughin, I., M. Fahnestock, D. MacAyeal, J. L. Bamber, and P. Gogineni, 2001, Observation and analysis of ice flow in the largest Greenland ice stream: Journal of Geophysical Research, v. 106, p. 34,021–34,034.

Whillans, I. M., 1976, Radio-echo layers and the recent stability of the West Antarctic ice sheet: Nature, v. 264, p. 152–155.

RECONSTRUCTING HOLOCENE ICE MARGIN FLUCTUATION IN DISKO BUGT, WEST GREENLAND

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Recent research has demonstrated asynchronous advance and retreat of the western margin of the Greenland Ice Sheet (GIS) during the Holocene. By examining variability in the timing and extent of ice margin fluctuations at differing ice margin types (i.e. land-based vs. marine-based), we hope to gain insight into the mechanisms that drive this discordant behavior. We employ a collection of geochronologic techniques that allow us to constrain position of the ice sheet margin both in front of and behind its present configuration throughout the Holocene. To place chronologic constraints on ice margin positions more extensive than present we use cosmogenic 10Be exposure dating, as well as adding limiting constraints on ice sheet recession from radiocarbon dating macrofossils from sediment exposures and in lake sediments. Constraints on the recession of the ice sheet behind the present configuration can be acquired through the coring of "proglacial-threshold lakes," which currently receive meltwater from the GIS and have catchments that extend beneath the present ice sheet.

By combining these techniques we have begun to reconstruct a record of Holocene ice margin fluctuation for the broader Disko Bugt region, western Greenland, with an emphasis on examining differing ice margin types. Early results from this project have demonstrated that at least one land-based sector of the ice sheet exhibited a late Holocene maximum advance culminating at the end of the 20th century (Kelley et al. 2012). This is in contrast with the record of ice margin fluctuation at Jakobshavn Isbræ, where the Little Ice Age position (AD 1850) represents the maximum late Holocene extent (Weidick and Bennike, 2007), followed by significant (40 km) retreat to the present day.

In the summer of 2012, we investigated Holocene ice margin fluctuations along Torsukáttak Fjord in northeastern Disko Bugt. This location was chosen to represent a marine-based ice margin to compare with land-based sections of the ice sheet, as well as to the very large outlet glacier Jakobshavn Isbræ. Our first 10Be ages place recession of the GIS to the head of Torsukáttak Fjord by 9.4 ±0.5 ka, from a single 10Be age located ~250 m beyond the present ice margin. This age is corroborated by a radiocarbon age of 8260 ± 100 cal yr BP derived from a shell within a raised marine deposit ~ 3 km beyond the present ice margin. A prominent moraine, located 600 m beyond the present ice margin provides geomorphic evidence of a readvance or standstill during early Holocene deglaciation. The moraine grades to a relative-sea-level ~35 m asl, and thus we estimate that it is of early Holocene age. This estimate is supported by one 10Be age of 9.4±0.5 ka, from a bedrock sample collected just inboard of the moraine.

Sedimentary evidence from a threshold lake ~ 1 km east of the ice margin indicates sedimentation changed from marine to lacustrine at 5080 ± 200 cal yr BP. This indicates that the GIS had retreated out of the lake's catchment behind the present ice margin at the time local sea level fell below the lake's outlet at 2 m asl. Following the Holocene Thermal Maximum, the GIS advanced back into the lake's catchment at 490 ± 150 cal yr BP, altering sedimentation in the lake from organic to minerogenic.

Evidence of Neoglacial ice margin fluctuations is derived from two lake basins abutting the current ice margin. A core from a small lake, dammed by an unvegetated moraine, affords a basal radiocarbon age on peat overlain by silty-clay of 140 ± 140 cal yr BP. We infer this to date the emplacement of the moraine and the initial filling of the lake. Further evidence of Neoglacial ice margin fluctuations comes from rooted, dead vegetation newly exposed in the lakebed of recently drained lake basins. Two samples (from each of two different lakes) of dead shrub returned "modern" radiocarbon ages, which translate to AD 1957-58 or 1992-93 and AD 1962 or 1976-78. We postulate that the death of these two shrubs (and many at a similar elevations) corresponds to a lake high-stand caused by a maximum ice extent damming the lake.

While this project is still in progress, our early results indicate similarities exist in the general pattern of Holocene retreat and advance between the Torsukáttak Fjord and that of Jakobshavn, though a number of differences exist in the timing and magnitude of the ice margin fluctuations. Specifically, ice had retreated to near its present margin in the Torsukáttak Fjord (~9 ka) earlier than at Jakobshavn Isbræ (~7.5 ka; Young et al., 2013). Furthermore, large contrasts exist in the temporal and spatial pattern of latest Holocene ice margin changes between Jakobshavn Isbrae and two other ice margin sites in the Disko Bugt region. We believe these differences in timing and magnitude of ice margin fluctuations are important clues for understanding how the GIS responds to climate perturbations and demonstrate the value of a multi-technique evaluation of the Holocene glacial record in western Greenland.

Kelley, S.E., Briner, J.P., Young, N.E., Babonis, G.S., and Csatho, B., 2012, Maximum late Holocene extent of the western Greenland Ice Sheet during the late 20th century: Quaternary Science Reviews, v. 56, p. 89-98.
Weidick, A., and Bennike, O., 2007, Quaternary glaciation history and glaciology of Jakobshavn Isbræ and the Disko Bugt region, West Greenland: A review: Geological Survey of Denmark and Greenland Bulletin 14, 78 p.
Young, N.E., Briner, J.P, Rood, D.H., Finkel, R.C., Corbett, L.B., and Bierman, P.R., 2013, Age of the Fjord Stade Moraines in the Disko Bugt Region, western Greenland and the 9.3 and 8.2 ka cooling events: Quaternary Science Reviews, v. 60, p. 76-90.

RECONSTRUCTING CLIMATE AND ENVIRONMENTAL CHANGE OVER THE LAST 9000 YEARS BASED ON A PEAT BOG RECORD FROM NORTHERN NORWAY

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Peatlands form by the accumulation of partially decayed vegetation in wetlands and provide archives of paleoenvironmental information. The rate of peat accumulation, the surface wetness, and the distribution of vegetation types can be related to paleoclimate and paleohydrologic conditions. In addition, characteristics of peat can be influenced by human activities and provide records of human impacts on landscapes. Here we present preliminary results from the investigations of a low-elevation (26 m a.s.l; 0.32 km2) ombrotrophic peat bog (69°44'40.50" N, 19°07'55.43" E) located 13 km northeast of Tromsø, northern Norway. The peat bog is formed on a late glacial recessional moraine along Balsfjord and is surrounded by a complex of Neolithic archaeological sites occupied from c. 10-5 cal ka BP. Here we focus primarily on results from the analysis of peat humification to reconstruct bog surface wetness (BSW) related to regional paleoclimate, but the overall purpose of the study is to reconstruct Holocene climate variability based on a multi-proxy analysis of sediment cores taken from the deposit, and to examine relationships between periods of human occupation of the site during the early Holocene and paleoenvironmental conditions.

In 2012, ground-penetrating radar profiles were collected and sediment cores were recovered from three sites across the deposit. Cores were split, described, and photographed. RGB data were extracted from core images to study colors variations, and radiocarbon dates were analyzed from all three cores to examine the rate of peat accumulation. More detailed analysis has focused on core sites Tø12-A and Tø12-B, where additional radiocarbon dates have been collected, and samples were taken for analysis of organic content by loss-on-ignition and the degree of humification using an alkali extraction and colorimetry technique.

Our results show that the bog is generally 5-6 m thick, has an organic matter content of 94-99%, and accumulated over the last 9,000 cal yr BP. The record of humification from site Tø12-B also shows distinct changes throughout the Holocene and we interpret greater humification to correspond with intervals of decreased BSW. Transmittance values range from 55-85%. During the early Holocene, reduced BSW persisted from 11.1-9.3 ka BP and was followed by an abrupt shift to increased BSW. During the late Holocene the data show two significant shifts in BSW. There is a shift to lower values at c. 4.3 ka BP and a return to higher values from 0.4 ka to present. These variation in BSW interpreted from our humification analysis also correspond to visible color variations in the cores. The relationship between BSW and regional temperature and/or precipitation changes is not always clear, so we will compare these results to quantitative pollen-derived records of paleoclimate in order to explore the factors affecting BSW at this site.

HOLOCENE SEDIMENT TRANSPORT FROM THE BERING SEA INTO THE CHUKCHI SHELF: MINERALOGICAL AND ISOTOPIC RECORDS

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Since the Holocene opening of the Bering Sea, sediment transport from the Bering Sea into the Chukchi Shelf was studied using the clay mineralogical and isotopic tracers for three sediment cores (GC12ex, JPC30, JPC35). The 5 AMS 14C dates of core GC12ex and the correlation of proxies to the age-dated cores nearby define the age of three cores. Downcore profiles of geochemical and isotopic properties of three cores are obviously consistent, which can be divided into three distinct stages corresponding to the lithologic units; Stage 1 (until about 8.0 ka), Stage 2 (about 8.0 to 3.5 ka), and Stage 3 (3.5 ka to the present). Stage 1 represents the transgressive condition to reflect the less marine productivity and dominant effect of terrestrial input. Stage 2 is characterized by mixture of terrestrial and marine contribution with increasing marine productivity, following the Holocene sea level rise, but still dominant of terrestrial condition relative to marine condition. Stage 3 indicates the stable marine condition with high biogenic opal production similar to the present-day oceanographic feature. Thus, three cores preserve evident signatures of Holocene paleoceanographic changes in the Chukchi Shelf. In particular, the sediment deposition in the Chukchi Shelf after the opening of the Bering Strait seems to be governed by particle transport from diverse sources. However, neodymium isotope value (eNd) of clastic particles and smectite/illite ratios clearly indicate that the sediments originated from the Bering Sea northward through the Bering Strait have been mainly deposited during the late Holocene since about 2-3 ka.

DISTRIBUTION OF BRANCHED AND ISOPRENOIDAL GDGTS IN RELATION TO MODERN SSTS AND ENVIRONMENTAL VARIABLES IN THE BERINGIAN GATEWAY

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Satellite records indicate sea ice cover is decreasing and adsorbed insolation is increasing in the Arctic Ocean and marginal seas [1]. However, it remains unclear whether similar rapid changes occurred during past climate warming. A number of lipid-based indices, such as TEX86, can be used to reconstruct sea surface temperatures (SSTs). TEX86 is a paleothermometer based on isoprenoidal glycerol dialkyl glycerol tetraethers (GDGTs) mainly biosynthesized by Thaumarchaeota [2]. TEX86 has been used to reconstruct SSTs in a variety of temperate and tropical settings but its application to polar ocean sediments is not straightforward. A recent study found that the crenarchaeol regio-isomer is insensitive to temperature change in the polar oceans and a TEX86 calibration was developed for low temperature settings (<15°C, TEX86-L) [3]. The TEX86-L calibration does not include data from the Bering or Chukchi Seas where annual SSTs are <4°C. The distribution of GDGTs in relation to modern conditions is also not well constrained in this region. As part of our research on paleo sea ice concentration (SIC) and SST change, we are examining shallow surface and short-sediment records from the Bering and Chukchi Seas (Figure 1). In this study, we show the distribution of branched and isoprenoidal GDGTs in relation to modern seasonal conditions and environmental variables across the Beringian Gateway. The fractional abundances of branched and isoprenoidal GDGTs are compared to solar insolation, satellite-derived SST, salinity, nutrients, dissolved oxygen, as well as total organic carbon (TOC), total nitrogen (TN), and grain-size.

Based on sedimentation rates (~0.6-0.9 cm yr-1), the top cm of our locations integrates ~10 years of deposition [4]. We find no significant relation ($p<0.01$) among the fractional abundances of GDGTs used in the TEX86-L calibration with environmental, including SIC, or sedimentary variables. Correlation matrices indicate TEX86-L temperatures exhibit low correlation (r2=0.30; $p<0.01$) with satellite SSTs. The ratio of branched to isoprenoid tetraethers (BIT index), which is an indictor of terrestrial input [5], has generally higher values near the coast. We note that calibration correlations do not vary by removing samples with BIT index values >0.4. TEX86-L temperatures are also reconstructed from a sedimentary record spanning the last ~70 years in the Western Bering Sea (DBSB) (Figure 1). While satellite SSTs indicate a slight warming toward the present, the TEX86-L temperature curve displays an overall cooling trend, with values offset ~6°C warmer than the satellite temperature record. This discrepancy may be related to increased upwelling associated with the Pacific Decadal Oscillation (PDO), which has occurred over this time interval. In several marine upwelling systems it has been noted that Thaumarchaeota likely reside at 30-150 m depth and reflect cooler temperatures in comparison to surface conditions [6-8]. Conversely, other unidentified variables may be affecting Thaumarchaeota distributions in this region of the Arctic Ocean. As part of our ongoing research, GDGT distributions are being analyzed in sedimentary records spanning 21-10 ka in the Bering Sea (JPC-03, JPC-51), and 13-0 ka in the Chukchi Sea (JPC-24) (Figure 1) to further examine such processes. This study provides for understanding modern environmental controls affecting the distribution of GDGTs in polar latitudes and context for quantifying SST change during the last deglacial and Holocene in the Beringian Gateway.

[1] Stroeve, J.C., Serreze, M.C., Holland, M.M., Kay, J.E., Malanik, J., Barrett, A.P., 2011, Climate Change, DOI 10.1007/s10584-011-0101-1.
[2] Schouten, S., Hopmans, E.C., Schefuß, E., Sinninghe Damsté, J.S., 2002, EPSL 204, 265-274.
[3] Kim, J.H., van der Meer, J., Schouten, S., Helmke, P., Willmott, V., Sangiorgi, F., Koc, N., Hopmans, E.C., Sinninghe Damsté, J.S., 2010, Geochim Cosmochim 74, 4639-4654.
[4] Pirtle-Levy, R., Grebmeier, J.M., Cooper, L.W., Larsen, I.L., 2009, DSR II 56, 17, 1326-1338.
[5] Hopmans, E.C., Weijers, J.W.H., Schefuß, E., Herfort, L., Sinninghe Damsté, J.S., Schouten, S., 2004, EPSL 224, 107-116.
[6] Lee, K.E., Kim, J.H., Wilke, I., Helmke, P., Schouten, S., 2008, Geochem. Geophy. Geosy. 9, 1-19.
[7] Huguet, C., Schimmelmann, A., Thunell, R., Lourens, L.J., Sinninghe Damsté, J.S., Schouten, S., 2007, Paleoceanography 22, PA3203-1-PA3203-9.
[8] Lopes dos Santos, R.A., Prange, M., Castañeda, I.S., Schefuß, E., Schulz, M., Niedermeyer, E.M., Sinninghe Damsté, J.S., Schouten, S., 2010, EPSL 300, 407-414.

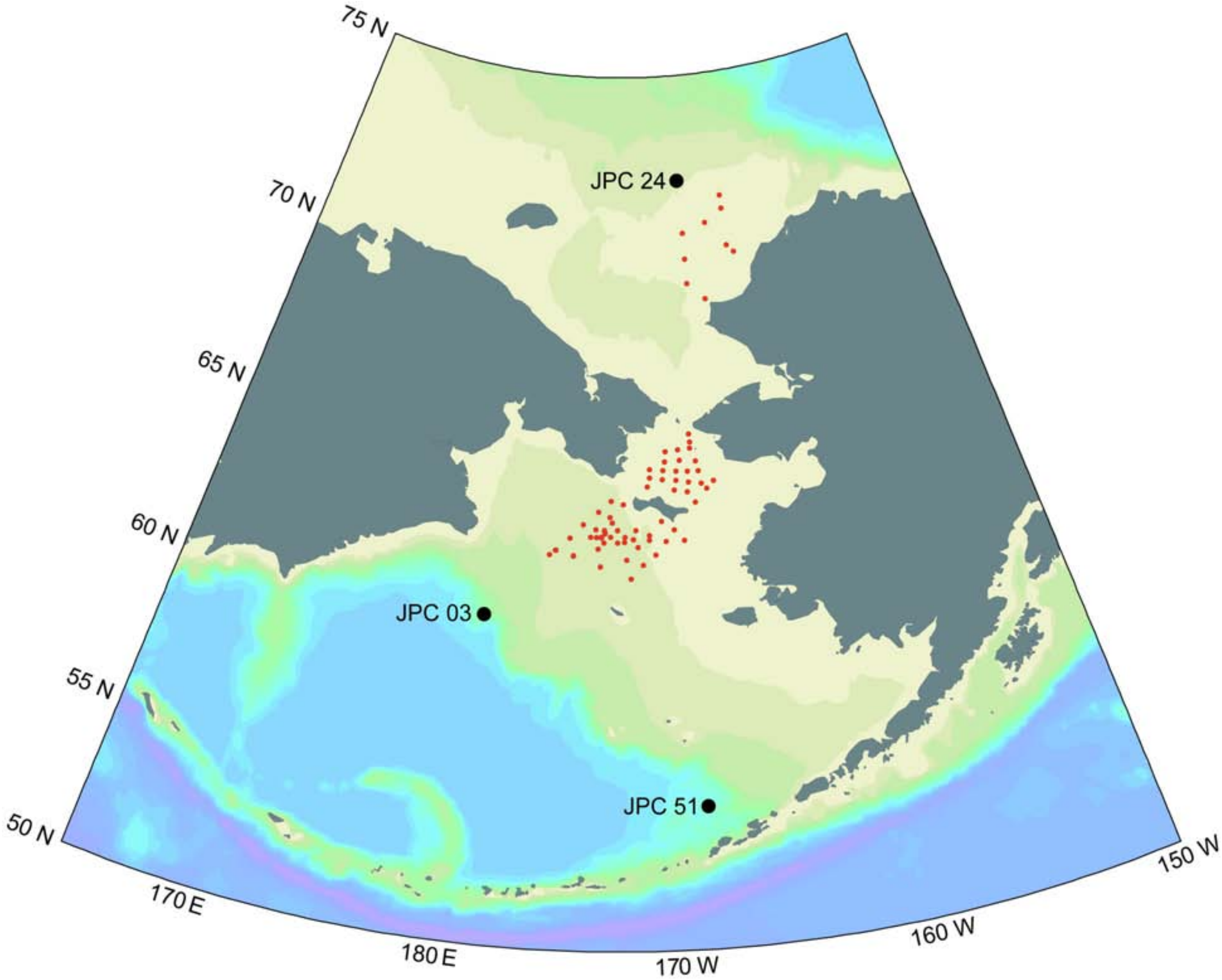

Fig 1. The Beringian Gateway with location of surface samples (red dots), the modern core (blue dot) and longer-term cores (black dots) analyzed in the Bering and Chukchi Seas.

REGROWTH OF LITTLE ICE AGE BRYOPHYTES EXHUMED FROM A POLAR GLACIER: THE RELEVANCE OF TOTIPOTENCY TO BIOLOGICAL REFUGIA

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Across the Canadian Arctic Archipelago, widespread ice retreat during the 20th century has sharply accelerated since 2004 1,2. The retreat of Teardrop Glacier, central Ellesmere Island, Nunavut (Fig. 1), is exposing intact plant communities overridden during the Little Ice Age (LIA, 1550-1850 AD). Bryophyte populations exhumed from beneath the cold-based ice margin show remarkable preservation, including unexpected signs of regrowth (in vivo). To test their viability, these populations were collected along the ice margin for growth chamber experiments (in vitro). Based on measured rates of ice retreat spanning the past several decades populations within 5 m of the ice margin have been exposed recently in the last several years. These LIA populations are distinct from modern colonizing species in both population size and species diversity. Results include the first successful regeneration of several moss species from subglacial vegetative material, including Aulacomnium turgidum. The regeneration of presumably dead, land-plant tissue significantly expands our understanding of modern glacial ecosystems as biological reservoirs. It also challenges the traditional concept of Ice Age refugia that confines land plant recolonization to populations that survived above and beyond glacier margins3,4. Most living bryophyte cells have the capacity to reprogram the developmental pathway into a meristematic state (totipotency) in response to interruption. This cellular feature has been compared recently to faunal stem cells5. Our data indicates that bryophytes can be reactivated from 400 yr old, subglacial populations. Resilience of these extremophiles aligns bryophytes with bacteria, fungi, cyanobacteria and green algae, rather than other land plants (lycopods, ferns, gymnosperms, angiosperms). Bryophytes have a critical role in the establishment, colonization, and maintenance of polar terrestrial ecosystems, otherwise inhospitable for many land plants.

1. Overpeck, J. et al. Arctic environmental change of the last four centuries. Science 278, 1251– 1256 (1997).
2. Gardner, A. S. et al. Sharply increased mass loss from glaciers and ice caps in the Canadian Arctic Archipelago. Nature 473, 357-360 (2011).
3. Brochmann, C., Gabrielsen, T. M., Nordal, I., Landvik J. Y., Elven, R. Glacial survival or tabula rasa? The history of North Atlantic biota revisited. Taxon 52, 417-450 (2003).
4. Fernald, M. L. Persistence of plants in unglaciated areas of boreal America. Mem. Am. Acad. Arts Sci. 15, 239-342 (1925).
5. Ishikawa, M. et al. Physcomitrella cyclin-dependent kinase a links cell cycle reactivation to other cellular changes during reprogramming of leaf cells. Plant Cell 23, 2924–2938 (2011).

Fig 1. Teardrop Glacier, Sverdrup Pass, central Ellesmere Island, Nunavut. Note: Little Ice Age trimline ~ 200 m beyond the ice margin. Measured ice retreat has rapidly accelerated since 2004 exposing pristine LIA plant communities composed of bryophytes and vascular plants.

REVISION OF THE QUATERNARY STRATIGRAPHY AT MORGAN BLUFFS, BANKS ISLAND, WESTERN CANADIAN ARCTIC ARCHIPELAGO

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Stratigraphic exposures of glacial and non-glacial sediments at Morgan Bluffs, a >6 km long exposure on the east coast of Banks Island, comprise a unique but discontinuous paleoenvironmental record in the Canadian Arctic Archipelago (Fig. 1). Initially surveyed by Vincent (1982, 1983), these sediments purportedly constitute one of the most complete climatostratigraphic archives for the Quaternary in Arctic Canada outside the Yukon, and include fossiliferous preglacial fluvial gravel, till, outwash, and glaciomarine rhythmites, among others. New observations of lithofacies and lithofacies associations delineate three distinct intervals of sedimentation that are incompatible with several lithostratigraphic units proposed previously (Vincent, 1982, 1983, 1990; Barendregt et al., 1998). Our revised stratigraphic framework records i) the progradation of a delta followed by fluvial aggradation of a braided river valley (Fig. 2) perhaps ~1 Ma ago, ii) a glacier advance (Fig. 3a) across a former marine delta more than 780,000 years ago, and iii) progradation of an ice-contact delta (Fig. 3b) into an ice-dammed lake during the last deglaciation, ~12,750 cal yr BP. Consequently, the previous purported climatostratigraphic interpretations and correlations, which are widespread in the literature (Vincent, 1982, 1983, 1990; Vincent et al., 1984; Clark et al., 1984; Matthews et al., 1986; Barendregt et al., 1998), are deemed untenable. Given the absence of a precise chronology for much of the stratigraphy at Morgan Bluffs, it is premature to consider potential correlations to other exposures on Banks Island (i.e. Worth Point, Duck Hawk Bluffs; Fig. 1) and elsewhere. Nevertheless, clarifying the origin and climatostratigraphic importance of Quaternary sediments on Banks Island has further elucidated the nature of the terrestrial Quaternary sedimentary archive in Arctic Canada and its utility for accurate paleoenvironmental reconstructions.

Barendregt, R.W., Vincent, J.-S., Irving, E. & Baker, J., 1998, Magnetostratigraphy of Quaternary and late Tertiary sediments on Banks Island, Canadian Arctic Archipelago: Canadian Journal of Earth Sciences, v. 35, p. 147–161.

Clark, D.L., Vincent, J.-S., Jones, G.A. & Morris, W.A., 1984, Correlation of marine and continental glacial and interglacial events, Arctic Ocean and Banks Island: Nature, v. 311, p. 147–149.

Matthews, J.V., Jr., Mott, R.J. & Vincent, J.-S., 1986, Preglacial and interglacial environments of Banks Island: pollen and macrofossils from Duck Hawk Bluffs and related sites: Géographie physique et Quaternaire, v. 40, p. 279–298.

Vincent, J.-S., 1982, The Quaternary history of Banks Island, NWT, Canada: Géographie physique et Quaternaire, v. 36, p. 209–232.

Vincent, J.-S., 1983, La géologie du Quaternaire et la géomorphologie de l'Île Banks, Arctique Canadien: Geological Survey of Canada Memoir 405.

Vincent, J.-S., 1990, Late Tertiary and Early Pleistocene deposits and history of Banks Island, southwestern Canadian Arctic Archipelago: Arctic, v. 43, p. 339–363.

Vincent, J.-S., Morris, W.A. & Occhietti, S., 1984, Glacial and nonglaical sediments of Matuyama paleomagnetic age on Banks Island, Canadian Arctic Archipelago: Geology, v. 12, p. 139–142.

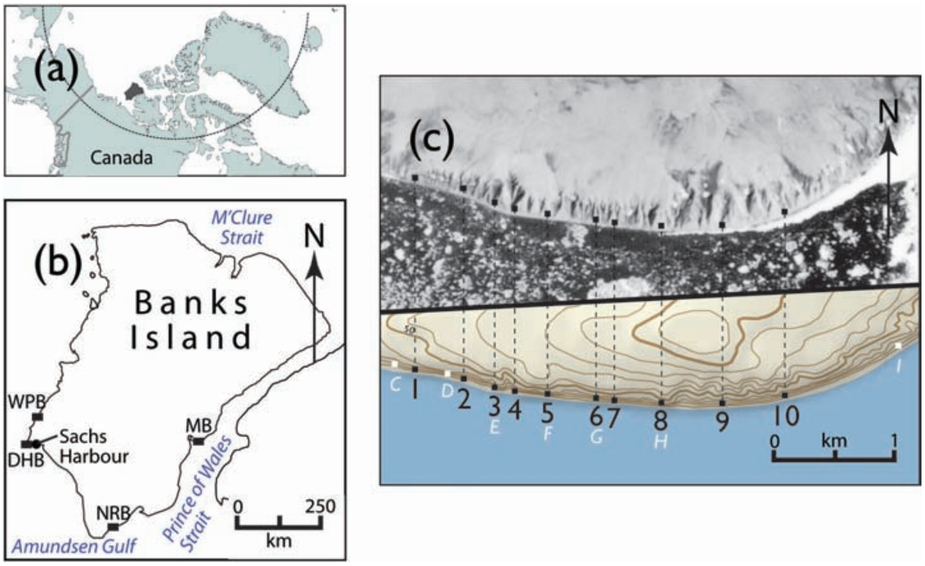

Fig 1. (a) The location of Banks Island (shaded) within the Canadian Arctic Archipelago. (b) The location of Morgan Bluffs (MB), Nelson River Bluffs (NRB), Worth Point Bluffs (WPB) and Duck Hawk Bluffs (DHB) across southern Banks Island. (c) Stratigraphic exposures at Morgan Bluffs shown on an aerial photograph (above) and a topographic map (below). Black numbers and boxes correspond to stratigraphic exposures described in this study. Those identified and characterized by Vincent (1982, 1983) and Barendregt et al. (1998) are denoted by the white letters and boxes.

Fig 2. Photograph of Section 2 showing an involuted paleosol within fluvial gravel. Also visible are two ice wedge casts (situated beside the shovel and fieldbook). The right-most ice wedge cast is vertically nested in a chevron pattern and is, thus, likely syngenetic.

Fig 3. (a) Matrix-supported, clay-rich diamict interpreted as till. (b) Inclined, stratified sand and gravel comprising ice-contact delta forsets.

1750 YEARS OF LARGE RAINFALL EVENTS INFERRED FROM SEDIMENTARY PARTICLE SIZE AT EAST LAKE, CAPE BOUNTY, MELVILLE ISLAND, CANADA

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Annually laminated sediments (varves) from lakes are especially of interest for precise chronological control and paleoenvironmental analyses in areas lacking tree-ring records, such as the Arctic. This study is based on the annual grain-size variation of the finely varved sediments from East Lake, Cape Bounty. An innovative image analysis system was used to store and analyse 86 thin sections images acquired with a flatbed scanner at 2400 dpi resolution. Varve boundaries were marked and saved digitally within the same image analysis software system. Regions of interest (ROI) were identified for each varve on the digital flatbed scan images and were imageded with a scanning electron microscope in backscattered electron (BSE) mode that optimizes contrast between clastic grains and the clay matrix. A total of 6148 BSE images were acquired for varves covering the last 2845 years (a 360 cm—long sediment interval). The gray-scale BSE images were transformed to black and white in which black elements were the mineral grains within the sedimentary facies using a series of processing steps. The size of each particle was then calculated and the following particle size distribution (PSD) indices were calculated for each varve: mD0 or the median disk apparent diameter, standard deviation (sD0), percentile 98% (P98D0), and maximum (maxD0).

Results indicate that several PSD indices show a similar trend through time, especially for the sD0 and P98D0. These two PSD are strongly associated with high-energy events (turbidites and debris flows) and they sharply increase to maxima at the beginning of the 20th century. Comparison of coarse grain size the 98th percentile with instrumental data suggests a strong correlation (r2=0.72) with large summer rainfall event at Rea Point, the nearest weather station to Cape Bounty. The long record suggests that Cape Bounty has experienced an unprecedented increase in summer rainfall since ~1920 AD. By contrast, changes in varve thickness (sediment deposition) are weakly correlated with the PSD indices. Indeed, sediment accumulation can result from different successive hydroclimatic and geomorphologic mechanisms such as snowmelt, rain events, landslides as well as by changes in lake circulation and stratification. Collectively, these results have important implications for interpreting varve sediments in polar regions and elsewhere, and highlight the need to obtain annually resolved grain size data to relate sediment properties to a single climate forcing.

Lapointe, F., Francus, P., Lamoureux F.S., Saïd, M., Cuven, S. 2012. 1750 years of large rainfall events inferred from particle size at East Lake, Cape Bounty, Melville Island, Canada. Journal of Paleolimnology. 48 (1) : 159-173.

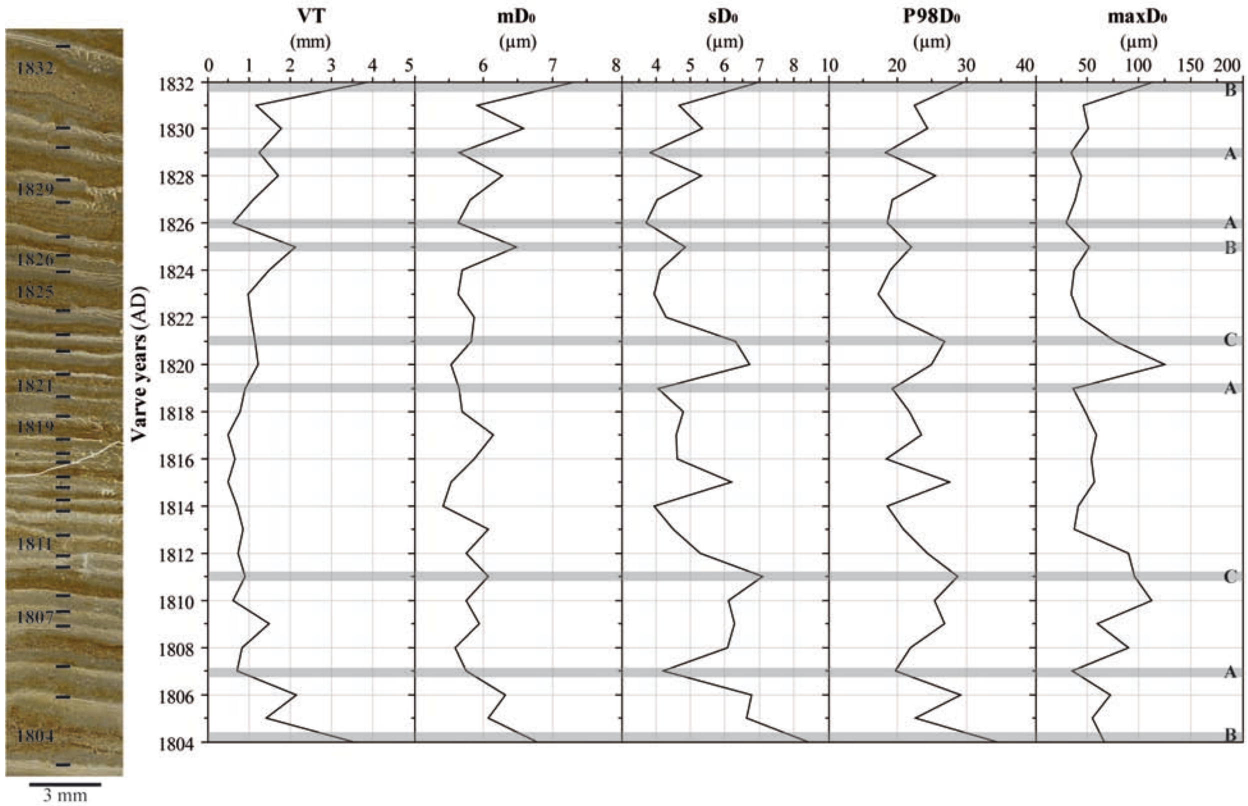

Fig 1. Varves formed during years 1832 to 1804. Shaded areas correspond to the lithozone found within the varves at East Lake : A: classic nival deposit; B: turbidites; C: debris flow.

USING GIS TO RECONSTRUCT PALEO EQUILIBRIUM-LINE ALTITUDES FROM CIRQUES IN NORTHWEST ICELAND

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The purpose of this study is to use a geographic information system (GIS) to calculate the equilibrium-line altitudes (ELA) of cirques on Vestfirðir, Iceland (Fig. 1). A 20 meter resolution digital elevation model was obtained from the National Land Survey of Iceland. Three methods are used to reconstruct the ELA of cirques: the cirque-floor method, the altitude-ratio method (THAR), and the accumulation-area ratio method (AAR) (Meier and Post 1962, Meierding 1982, Porter 2001). In ArcGIS, contour lines and surface slope are generated and used to identify cirques in the study region. The two points with the greatest derivative along each elevation profile are used to identify the locations of the headwall and the toewall. Altitude ratios are then developed using the established toewall and the headwall of each cirque (Fig. 2). The flattest location between the headwall and the toewall is interpreted as the cirque floor. Data from the cirque floor method is exported to Microsoft Excel, and ELAs are determined from calculations using the toewall-headwall altitude ratio (THAR) method. A modified accumulation-area ratio (AAR) calculation is also used to calculate the paleo ELA of cirques. The width of the cirque is determined by inflection points on contour lines. Area is calculated from a delineated polygon that connects inflection points to the toewall and the headwall in ArcGIS. Hypsometric curves were generated to identify ELAs using the accumulation-area ratio method (Fig. 3). Preliminary results indicate similar ELAs are generated using all three methods, and the less cumbersome cirque-floor and THAR methods were predominantly used for determining the ELA of each cirque. The cirque-floor method yields ELAs with a minimum of 40 m, a maximum of 669 m, and a median of 384 m (n=80). The THAR method generated greater ELAs with a minimum of 79 m, a maximum of 672 m and a median of 421 m (n=80). Finally, the AAR method produced ELA results with a minimum of 58 m, a maximum of 348 m and a median of 247 m (n=10). At least 80 cirques have been identified, and additional analyses of the relationship between ELA and aspect and ELA and latitude are in progress.

Meier, M. F. and A. S. Post, 1962, Recent variations in mass net budgets of glaciers in western North America: International Association of Scientific Hydrology Publications, v. 58, p. 63-77.

Meierding, T. C., 1982, Late Pleistocene glacial equilibrium-line altitudes in the Colorado Front Range: a comparison of methods: Quaternary Research, v. 18, p. 289-310.

Porter, S. C., 2001, Snowline depression in the tropics during the Last Glaciation: Quaternary Science Reviews, v. 20, p. 1067-1091.

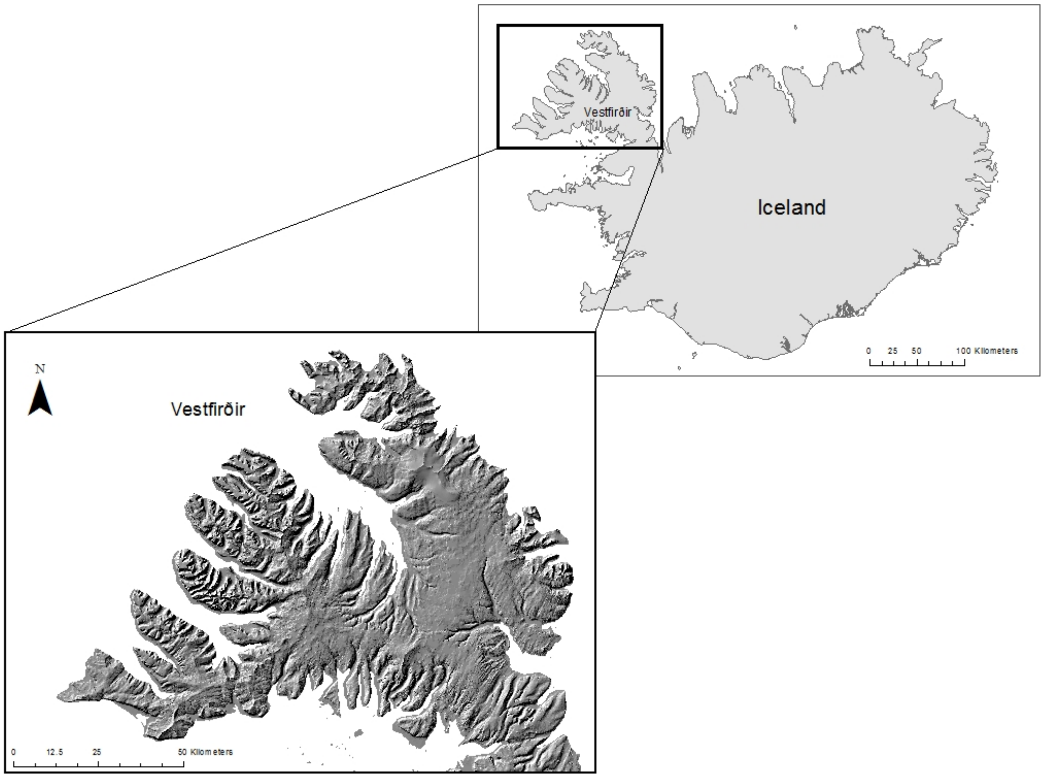

Fig 1. Study area on Vestfirðir, Iceland.

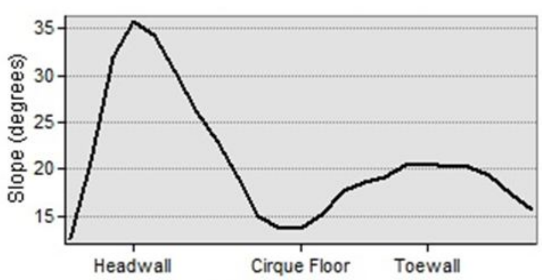

Fig 2. An example of a cirque profile graph of the surface slope that was used to determine the paleo-ELA using cirque-floor and THAR methods

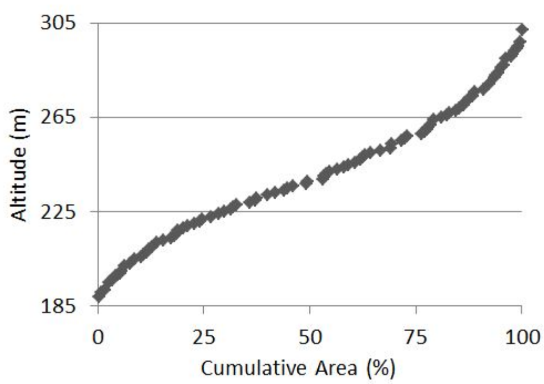

Fig 3. An example of a cirque's hypsometric curve, which was used to estimate the paleo-ELA by applying an AAR value to the plot and determining the corresponding altitude

NOVEL TRI-UNSATURATED ALKENONES IN ARCTIC LAKES: IMPLICATIONS FOR PALEOTEMPERATURE RECONSTRUCTION

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Long chain alkenones (LCAs) are a class of di-, tri-, and tetra-unsaturated ketone biomarkers that have long been employed to reconstruct paleo-sea surface temperatures via the UK37 and UK'37 indices (1). Increasingly, researchers are investigating LCAs in lacustrine settings for their potential to produce continental paleoclimate records (2-4) and recent studies have provided quantitative LCA temperature records from arctic lakes (5-6). These efforts highlight lacustrine LCA paleothermometry as an effective tool for arctic paleolimnologists and they encourage further exploration of the proxy in high latitude lakes.

In this study, we report the discovery of novel tri-unsaturated LCAs in the water column and surface sediments of lakes in Northeastern Alaska (NE AK). In June of 2012, we obtained water column samples and accompanying physical and chemical data from Toolik Lake (68.3°N, 149.36°E) and two neighboring lakes, E5 and F2. LCAs were present in all three lakes throughout the sampling period that began during isothermal spring mixing and persisted for three weeks through the onset of thermal stratification. Traditional gas chromatographic (GC) analyses yielded an unresolved mixture of tri-unsaturated LCAs, but novel GC techniques provided unprecedented separation and revealed that the 37-, 38- and 39-carbon homologs are composed of two positional isomers. Tentative structural identifications of the new compounds are proposed here. Analysis of LCAs from the sediments of Lake BrayaSø, Greenland—the site of a recent 6 kyr LCA temperature record (5)—reveal remarkably similar LCA profiles that include the tri-unsaturated isomers. LCAs extracted from a culture of the predominant marine haptophyte algae, *Emiliana huxleyii*, and from surface sediments of lower latitude lakes in North America and China, revealed no tri-unsaturated isomers using the same GC methods. Our findings suggest that these compounds are produced by a common high-latitude adapted haptophyte.

The discovery of novel LCAs in Greenland and Alaska necessitates an investigation of these compounds and their correlations with temperature and environmental parameters. Many lacustrine LCA-based temperature reconstructions employ the UK37 index, which uses the relative abundances of the 37-carbon tetra-, tri-, and di-unsaturated LCAs to quantify temperature. The discovery of tri-unsaturated LCA isomers raises the question as to whether one or both of the compounds respond to changes in temperature. Additionally, unprecedented separation of the 38-carbon LCAs provides the opportunity for further investigation into these compounds and their correlations with environmental parameters. Our results show that relative abundances both 37-carbon isomers are correlated with *in situ* temperature. Further investigation of the environmental controls on the 37- and 38-carbon LCAs will be addressed in this study.

In addition to exploration of the novel tri-unsaturated isomers, this study aims to investigate LCAs in NE AK using traditional methods in order to compare the abundance, occurrence and temperature correlations of LCAs in this region with findings from other studies. We find that the UK37 index is correlated with *in situ* lake water temperature and, furthermore, that the slopes of these correlations are comparable to previous findings. DNA sequencing studies from Toolik Lake suggest the presence of only one LCA producing haptophyte (Greenland haptophyte), which was originally discovered in Lake BrayaSø Greenland (7). Our survey of surface sediments from 10 lakes in NE AK indicate that LCAs tend to occur in systems with relatively higher conductivities, lower nutrients, and higher average depths than other lakes in the region.

Together, these findings support the application of LCA paleothermometry in NE AK and they suggest that high latitude LCAs have common or similar haptophyte producers. The discovery of tri-unsaturated isomers generates new questions about the biosynthesis and evolutionary history of these biomarkers, but the correlation of both 37-carbon isomers with in situ temperature provides evidence that the LCA-temperature relationship is resilient.

1) Brassell, S. C. et al., 1986, Molecular stratigraphy: a new tool for climate assessment. Nature 320, 129–133.
2) Liu, Z., Henderson, A. C. G. & Huang, Y., 2006, Alkenone-based reconstruction of late-Holocene surface temperature and salinity changes in Lake Qinghai, China. Geophysical Research Letters 33, L09707.
3) Toney, J. L. et al., 2010, Climatic and environmental controls on the occurrence and distributions of long chain alkenones in lakes of the interior United States. Geochimica et Cosmochimica Acta 74, 1563–1578.
4) Pearson, E. J., Juggins, S. & Farrimond, P., 2008, Distribution and significance of long-chain alkenones as salinity and temperature indicators in Spanish saline lake sediments. Geochimica et Cosmochimica Acta 72, 4035–4046.
5) D'Andrea, W. J., Huang, Y., Fritz, S. C. & Anderson, N. J., 2011, Abrupt Holocene climate change as an important factor for human migration in West Greenland. Proceedings of the National Academy of Sciences of the United States of America 108, 9765–9.
6) D'Andrea, W. J. et al., 2012. Mild Little Ice Age and unprecedented recent warmth in an 1800 year lake sediment record from Svalbard. Geology 40, 1007–1010.
7) Crump, B. C., Amaral-Zettler, L. a & Kling, G. W., 2012, Microbial diversity in arctic freshwaters is structured by inoculation of microbes from soils. The ISME journal 6, 1629–39.

ARCTIC SEA-ICE GEOCHEMICAL AND ISOTOPIC TRACERS AND ITS ENHANCED EXPORT DURING THE YOUNGER DRYAS

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The most widely supported causal mechanism of the Younger Dryas (YD) cold spell and related slowing of the Atlantic Meridional Overturning Circulation (AMOC), is a sudden freshening of the North Atlantic linked to a partial drainage of the Laurentide ice sheet. Model experiments and land-based studies in the Mackenzie River outlet area, as well as deep-sea core studies from the western Arctic provide strong clues for a northward drainage route through the Arctic Ocean. Here, based on radiogenic isotope (Sr, Nd) analysis of ice-rafted detrital (IRD) sediments from the Lomonosov Ridge and Fram Strait areas, we provide strong evidence for enhanced sea-ice drift in the Beaufort Sea area and its subsequent export through Fram Strait during this critical interval. This pattern, exclusive to the YD, followed a Last Glacial Maximum-Bølling-Allerød interval, when multiyear/reduced sea-ice mobility resulted in sedimentary hiatuses in the Central Arctic. Meanwhile, IRD from Svalbard-Barents ice-sheet margin origin were still occurring in the Fram Strait area. Following the "isotopic excursion" of the YD, pointing to enhanced sea-ice drift in the Beaufort Sea and exports through an active Beaufort Gyre, the Holocene has been characterized by a 5-fold reduction in IRD rates with a shift towards prominent sea-ice production along Russian shelves then exported by the Trans-Polar Drift towards the Nordic seas, as indicated by radiogenic isotope records. From a paleoceanographic perspective, we conclude that an Arctic freshwater/sea-ice export route should now be seen as the most likely mechanism for an AMOC reduction during the YD in accordance with more recent improved model experiment.

HOLOCENE ICE CAP DYNAMICS RECONSTRUCTED FROM RADIOCARBON-DATED MOSS AND MAMMAL BONES CURRENTLY EMERGING ALONG RECEDING ICE MARGINS ON CUMBERLAND PENINSULA, BAFFIN ISLAND

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Receding cold-based ice caps and cold-based parts of polythermal ice caps along the rim of the Eastern Canadian Archipelago steadily uncover fossil fauna and flora which died coincident with, or shortly before, previous ice expansion. Dating of relict vegetation emerging beneath withdrawing cold-based ice caps began during early reconnaissance expeditions to northern Baffin Island (Falconer, 1966) and Cumberland Peninsula (Carrara and Andrews, 1972), both yielding single radiocarbon ages of 330 years BP. The subfossil organic material thus provides a record of Holocene ice dynamics and hence climate sensitivity that can be compared to various other proxy records. Unlike moraines, which provide records of punctuated ice marginal retreat, the dated fossils provide close maximum-limiting ages on periods of ice growth from ice marginal positions that were at least as retracted as they are now. We suggest that most samples record the time of entombment in perennial snow or ice, because the dates are on delicate seasonal growth increments (moss stems, plant leaves) that have little or no preservation potential on the wind-swept, high-elevation polar desert sites where they are found. These ages can be used to test hypotheses regarding the importance of volcanism, solar irradiance, paleoceanographic circulation and sea ice variability, and regional atmospheric trends. To examine these varying propositions we collected and radiocarbon dated relict organic material along receding cold-based ice caps on Cumberland Peninsula and our results (1) support a hypothesis proposed by Miller et al. (2012) that ice advance phases were synchronous with volcanic eruptions, and (2) extend the timeline of dated fossil flora and fauna to the mid-Holocene allowing us to evaluate climate forcing mechanisms on longer time scales.

The exceptionally warm summer of 2009 on Baffin Island and consequent rapid ice marginal retreat exposed large areas to mine the well-preserved subfossil material. Different cold-based ice caps were targeted for sampling in order to test hypotheses concerning the inception and growth of ice caps. In total 64 samples were collected along nine different ice caps ranging in elevation from 800 - 1600 m and varying in size from <1 to 80 km2. All collected samples were characterised microscopically and 47 macrofossils were identified, cleaned, and submitted for AMS analysis at the Keck Carbon Cycle facility at the University of California. Forty-four dated samples consisted of moss, willow leaves, or liverwort, and three samples were of mammal bones or antlers. A few samples were observed to be partly overgrown by modern bryophytes or algae that are evidently recolonizing the subfossil surface. Although this was not evident at time of collection, these samples were not submitted for dating. Despite the careful sample selection and preparation, two of the dated samples (willow leaves) yielded modern ages; of these one sample was reanalysed using moss, which yielded a calibrated age of 1.2 ± 0.1 cal ka (2σ). The modern willow leaves were probably deposited onto the relict vegetation mat from the overlying ice surface or blew into the site. Calibration of seven samples, using the Calib 6.1.0 program (Stuiver et al., 2005) with the IntCal09 calibration data set (Reimer et al., 2009), yielded non-unique calendar years ranging from modern to 0.4 cal ka BP, though there is no reason to suspect that they are truly modern (e.g., they lack bomb 14C).

The dated fossil moss and mammal bones reveal distinct phases of ice cap expansion following deglaciation from the last glacial maximum during the early Holocene thermal maximum (8 – 6 ka BP). A first pulse of ice advance occurred between 4.7 - 3.2 cal ka BP followed by a millennium-long hiatus prior to renewed ice expansion between 1.9 – 1.1 cal ka BP. The last ice cap growth interval started just after 0.8 cal ka BP following a shorter hiatus of 300 years. A general decrease in elevation of the dated subfossil material over this time is consistent with a decrease in equilibrium line altitude (ELA) due to declining temperature or increasing precipitation. This relationship is more apparent for individual ice caps constraining the local topographic variations of the ELA, and supporting Ives' (1957) 'instantaneous glacierization' hypothesis.

Gradual decrease of summer insolation in the Northern Hemisphere induced steady lowering of air temperatures during the Holocene and facilitated ice cap expansion at around 4.7 cal ka. The onset of Neoglaciation is documented by only a few samples (n = 7), however their distribution from five different ice caps shows the regional character of this early ice cap expansion phase. The following hiatus in the moss age distribution (3.2 – 1.9 cal ka BP) is interpreted to indicate either halt of ice cap growth or ice recession preventing further entombment of organic material. A renewed ice expansion starting at about 1.9 cal ka BP and continuing until 1.1 cal ka BP was recorded by the majority of the samples (n = 22) from six different ice caps. The second hiatus in radiocarbon dates (1.1 – 0.8 cal ka) corresponds to the Medieval Warm Period (1150 - 850 years BP) known to be a period of ameliorated climate and indicating once more a halt of ice extension or recession. The last episode of ice cap growth is documented at six different ice caps (n = 17 samples) and coincides with the Little Ice Age (700 – 100 years BP), which likely was the largest extension phase during the Neoglacial, accounting for the conspicuous vegetation trimline around ice caps.

Declining summer insolation cannot explain the multiple occurrences of synchronous ice cap growth documented by the dated fossil flora and fauna. Other forcing mechanisms, such as oceanic and atmospheric circulation patterns related to North Atlantic Oscillation phase, solar activity, and volcanism must be considered and their possible link to climate feedback systems involving changes, for instance, in albedo through sea ice expansion. In a similar study dating relict organic material along receding ice caps on Baffin Island, Miller et al. (2012) recently hypothesized that individual pulses of ice cap expansion during the Little Ice Age were triggered by large volcanic eruptions injecting large amounts of sulfur gases into the stratosphere, where they are transformed into sulfur aerosols. Initial cooling caused by scattering of solar radiation by the sulfur aerosols was further sustained by positive sea-ice/ocean feedbacks. Our data support Miller's et al.(2012) hypothesis indicating correlation between ice cap expansion phases on a centennial-timescale; however, additional climate forcing is required to explain the observed ice advance episodes on a millennial-timescale.

Carrara, P., Andrews, J., 1972, The Quaternary history of northern Cumberland Peninsula, Baffin Island, N.W.T. Part I: The late-and neoglacial deposits of the Akudlermuit and Boas glaciers: Can. J. Earth Sc., v. 9, p. 403-414.

Falconer, G., 1966, Preservation of vegetation and patterned ground under a thin ice body in northern Baffin Island, N.W.T: Geographical Bulletin, v. 8, p. 194-200.

Ives, J., 1957, Glaciation of the Torngat mountains, northern Labrador: Arctic, v. 10, p. 66-87.

Miller, G.H., Geirsdóttir, Á., Zhong, Y., Larsen, D.J., Otto-Bliesner, B.L., Holland, M.M., Bailey, D.A., Refsnider, K.A., Lehman, S.J., Southon, J.R., Anderson, C., Björnsson, H., Thordarson, T., 2012, Abrupt onset of the Little Ice Age triggered by volcanism and sustained by sea-ice/ocean feedbacks: Geophys. Res. Lett., v. 39, L02708.

Reimer, P.J., Baillie, M.G.L., Bard, E., Bayliss, A., Beck, J.W., Blackwell, P.G., Ramsey, C.B., Buck, C.E., Burr, G.S., Edwards, R.L., Friedrich, M., Grootes, P.M., Guilderson, T.P., Hajdas, I., Heaton, T.J., Hogg, A.G., Hughen, K.A., Kaiser, K.F., Kromer, B., McCormac, F.G., Manning, S.W., Reimer, R.W., Richards, D.A., Southon, J.R., Talamo, S., Turney, C.S.M., van der Plicht, J., Weyhenmeyer, C.E., 2009, IntCal09 and Marine09 Radiocarbon Age Calibration Curves, 0-50,000 Years cal BP: Radiocarbon, v. 51, p. 1111-1150.

Stuiver, M., Reimer, P. J., and Reimer, R. W. 2005, CALIB 5.0. [WWW program and documentation].

SERMILIK FJORD OUTLET GLACIERS, SOUTHEAST GREENLAND: COHERENT BEHAVIOR OR A DRUNKARDS WALK?

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Marine-terminating Greenland Ice Sheet outlet glaciers have recently been found to vary more rapidly than previously believed. Amongst the most dynamic are the outlet glaciers in southeast Greenland, including Helheim glacier. Three major outlet glaciers – Helheim, Fenris and Midgård – terminate in the upper part of Sermilik fjord, the largest fjord system in southeast Greenland (Fig. 1). Their close proximity, only 7–15 km apart from each other, suggests that the glaciers are under the same atmosphere and oceanic regime, and thereby may have a common response to variability in external forcing. The range of variability and the degree of co-variability between them is poorly known, and there are few studies of the long-term variability of glacier calving at high temporal resolution.

Here we present results from the most temporally well-sampled satellite record produced to date for these glaciers, spanning 30+ years at monthly to seasonal resolution through the period, 1980–2012. These efforts are part of the SEALEV project at the Centre for Climate Dynamics at the Bjerknes Centre for Climate Research, Bergen, Norway. We identify approximately decadal sub-periods (1980–1991, 1992–2001 and 2002–present) when the three glaciers exhibit different advance–retreat (co)variability than in the other sub-periods, which are marked by rapid shifts. The early period from 1980–1991, which has been little studied previously, was highly dynamic despite no significant overall trend for Helheim and Fenris. This period was characterized by: (1) the largest seasonal cycle in advance–retreat, (2) advance–retreat patterns that were generally consistent between the three glaciers, and (3) individual years that were extremely dynamic, e.g., 1985/86, when Helheim advanced 6 km and then retreated 4.6 km in just two weeks, suggestive of possible surge-type behavior. The second period was more quiescent, with a lower amplitude seasonal cycle and no multiyear advances or retreats. The third period since 2001 is characterized by changes in behavior, including: (1) renewed seasonal variability , albeit half that observed in 1980–1991, (2) enhanced interannual/multiyear variability, including the well-known retreat of Helheim 2001–05, and (3) overall retreat for each of the three glaciers, though Midgård exhibits divergent behavior with an unabated retreat through the entire period. We compare our results for the past 30 years with recently published results for the Sermilik fjord glaciers from the earlier parts of the 20th century, based on historical observations and a sediment-based proxy for calving in Sermilik fjord. The possible reasons for the sometimes coherent and sometimes incoherent behavior of the three glaciers are discussed.

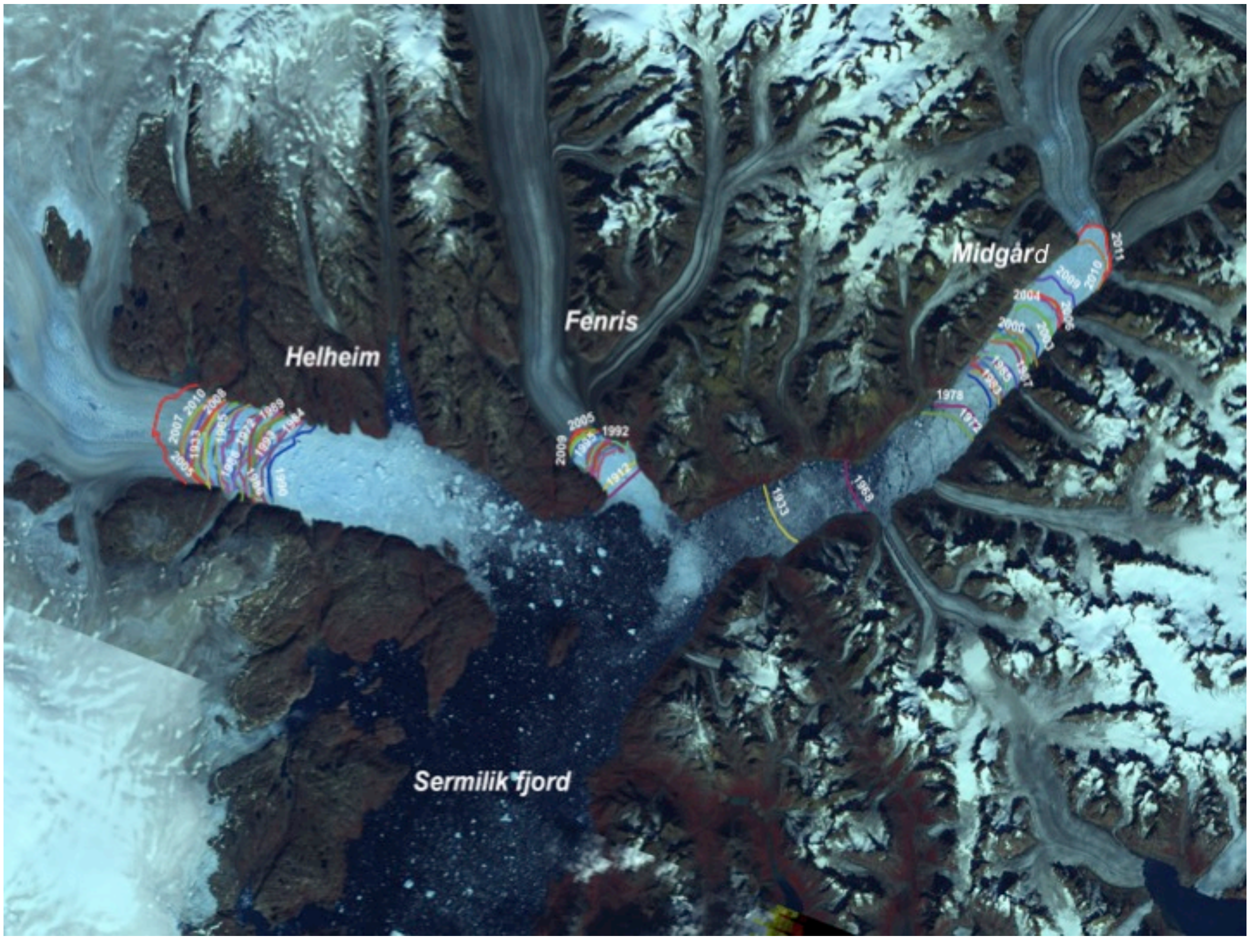

Fig 1. Landsat image of Sermilik fjord, southeast Greenland, including Helheim, Fenris and Midgård glaciers, with previous calving-front position denoted for different years.

USING GIS AND STREAMLINED LANDFORMS TO INTERPRET PALEO-ICE FLOW IN NORTHERN ICELAND

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Climate oscillations since the Last Glacial Maximum (LGM) led to massive glacial retreat in northern Iceland, exposing streamlined landforms that are used to study past subglacial conditions. Drumlins, mega-scale glacial lineations (MSGL), grooves, and striations provide direction of paleo-ice flow. Additionally, drumlins and MSGL may indicate fast subglacial ice flow (i.e. Clark 1994, Colgan and Mickelson 1997, Stokes and Clark 2001, Dowdeswell et al. 2010). In this study, Google Earth and ArcGIS are used to quantify characteristics of landforms located south of Húnaflói, northern Iceland (Figure 1). Landforms in two valleys, Viðidalur and Vatnsdalur, are analyzed by quantifying length of the long axis, maximum width perpendicular to long axis, elongation ratio, orientation of the long axis, parallel conformity, density, and packing. Landforms were classified as Rogen moraines, drumlins, or drumlinoid features based on degree of symmetry and completeness of landform perimeter. Initial results include an average elongation ratio of approximately 4.65 for drumlins and 6.30 for drumlinoid features. Mode orientations of drumlins and drumlinoid features in Viðidalur are NW-SE and features in Vatnsdalur are NW-SE. Parallel conformities of drumlins and drumlinoid features are approximately 35.66 and 8.10 decimal degrees for Viðidalur and Vatnsdalur, respectively. The higher parallel conformity for Viðidalur is due to the movement of paleo-ice flow around a mountain peak, which suggests a strong topographical influence on ice flow. Landforms in Vatnsdalur have a higher density than those in Viðidalur, indicating a higher velocity paleo-ice flow in Vatnsdalur. This high paleo-ice flow velocity could be due to the smaller valley width of Vatnsdalur (approximately 7.8km) compared to Viðidalur (approximately 12.2km), or it could be related to shear and lateral stresses and basal thermal regime. Packing of landforms is evenly distributed in both valleys. The presence of Rogen moraines superimposed on streamlined landforms may indicate the presence of a paleo-ice stream, with moraines forming during ice stream shut down and bed freezing (Stokes et al. 2006). These initial results suggest the presence of two regions of fast paleo-ice flow feeding out into Húnaflói, supplying ice to the LGM margin of the Iceland Ice Sheet. Additional analyses are currently in progress.

Clark, Chris D. 1994. Large-scale ice-moulding: a discussion of genesis and glaciological significance. Sedimentary Geology 91: 253-268.

Colgan, Patrick M. and David M. Mickelson. 1997. Genesis of streamlined landforms and flow history of the Green Bay Lobe, Wisconsin, USA. Sedimentary Geology 111: 7-25.

Dowdeswell, J.A. et al. 2010. Past ice-sheet flow east of Svalbard inferred from streamlined subglacial landforms. Geological Society of American Publications 38(2): 166-168).

Stokes, Chris R. and Chris D. Clark. 2001. Palaeo-ice streams. Quaternary Science Reviews 20: 1437-1457.

Stokes, Chris R. et al. 2006. Geomorphological map of ribbed moraines on the Dubwant Lake paleo-ice stream bed: a signature of ice stream shut-down? Journal of Maps 2006: 1-9.

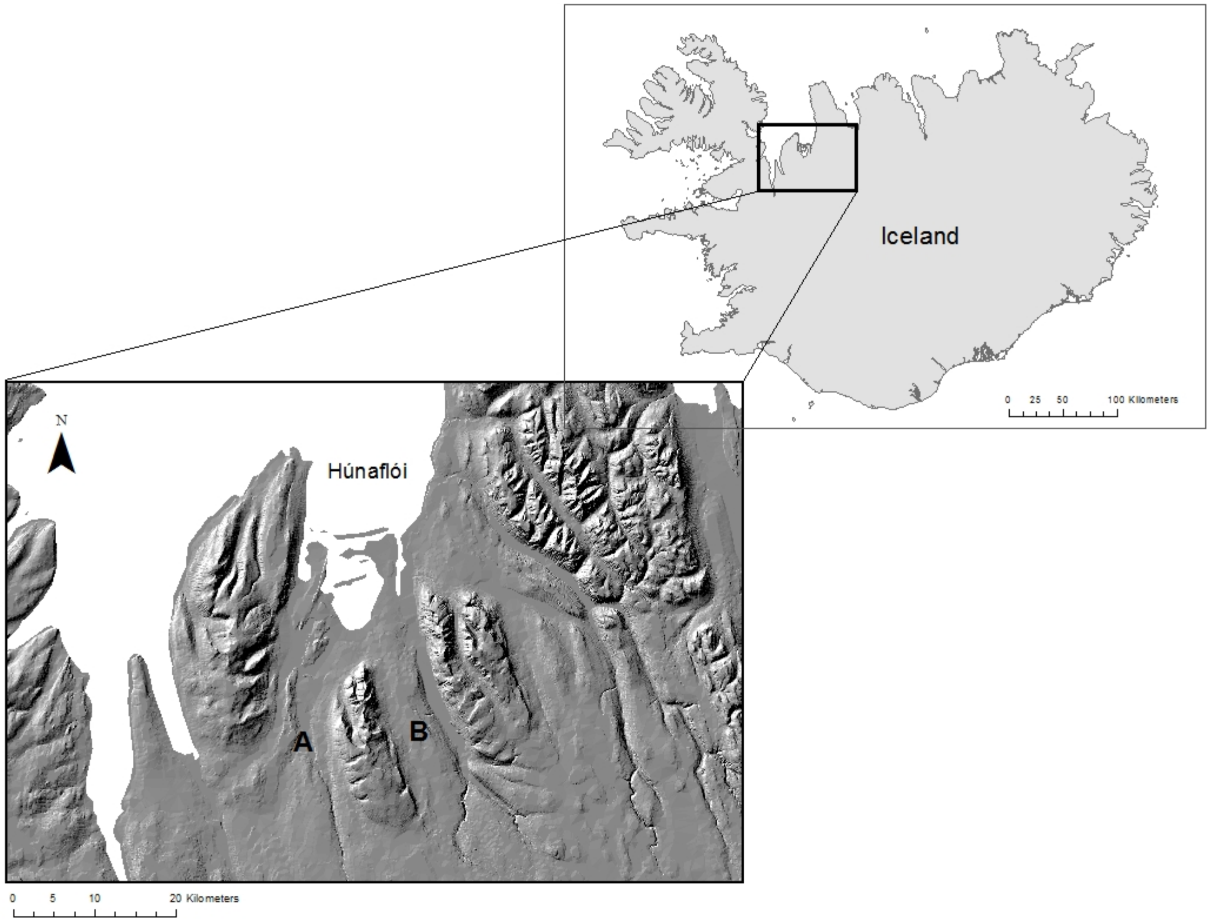

Fig 1. Location of Viðidalur (A) and Vatnsdalur (B) in northern Iceland.

CAN GREENHOUSE GAS EMISSIONS FROM ARCTIC THAW POND BE DRIVEN BY THEIR GEOMORPHOLOGY?

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Thawing of permafrost is associated with the formation of thermokarst or thaw ponds. The greenhouse gas (GHG) emissions from these ponds are substantial, with high variability making them areas of concern under a warming Arctic climate. On Bylot Island, there are two geomorphological formations: polygonal and runnel ponds. Polygonal ponds are circular, stable environments naturally associated with the active layer and thawing permafrost. Runnel ponds are long and narrow, feature more erosion, and are associated with the accelerated permafrost thawing under a changing climate. The possibility of these different geomorphological thaw pond formations influencing GHG emissions was explored. This was performed by measuring dissolved GHG concentrations, dissolved δ13C -CO2 & CH4, ebullition Δ14C -CO2 & CH4, water physicochemical properties (temperature, O2, nutrients), and microbial (archaeal & bacterial) identification in surface waters and sediments with 16S rRNA pyro-sequencing of community DNA. The dissolved GHG concentrations from these thaw ponds were highly variable just during the summer months of June and July (91 ponds sampled over 3 yrs from 2009 to 2011; 1.8-609 μM CO2, and 0.1-25 μM CH4). In this data set, runnel ponds had consistently higher emissions of CO2 (in average 17.0 compared to -1.7 mmol m-2 d-1 in polygonal ponds) and of CH4 (0.7 compared to 0.2 mmol m-2 d-1, respectively). While the water physicochemical properties differed among pond formations, the water bacterial community and water hydrology were more similar. Therefore, while microbes in the water column could influence GHG concentrations (especially by the methanotrophic communities since the water is oxic), this does not seem to be the case, as most microbial influences on GHG seem to be explained by differences in the sediment bacterial community. For instance, in polygonal ponds there was a higher amount of methanotrophs (oxidizing CH4 to CO2; 11 – 20%) with the associated δ13C -CO2 signatures indicating CH4 oxidation (-20.7 to -19.1‰), and ultimately reduced amounts of CH4 released into the water. Comparatively, runnel ponds have fewer methanotrophs (1 – 5%), with less reduced δ13C -CO2 (-17.4 to -14.9‰), and also Δ14C -CH4 signatures indicating a slightly older (yet still < 200 yrs old) C source from within the sediment. Both thaw pond geomorphologies overall have characteristics for GHG production including a diverse and high percentage of methanogens in the sediment, numerous carbon degraders in their water bacterial community, and evidence of sufficient C supplies for GHG production (acetoclastic methanotrophy). However, runnel ponds seem more predisposed to higher GHG production through physical and geomorphological factors: more erosion, leading to a higher C supplies, and the slightly older C in ebullition CH4, potentially indicating recent release of C-rich peat deposits; and their microbial community: no cyanobacterial mats to withdraw CO2, and fewer methanotrophs to oxidize CH4. Although the question remains, how these two pond geomorphologies have similar water bacterial communities, and water hydrological influences, while their physiochemical characteristics and surface sediment bacterial communities vary.

COMPLEX AND HIGHLY VARIABLE CARBON ACCUMULATION AT IMNAVAIT CREEK PEATLAND

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Northern peatlands of the Arctic and Boreal regions are an important part of the global carbon cycle. While they only cover about 3% of the land surface, they account for about 550 Gt of carbon (Yu et al., 2010). It is currently unclear how this large stock of carbon will be affected by future warming, especially in the Arctic. To constrain the effects of changing climate and vegetation on carbon accumulation, we reconstruct all three of these parameters using the the same samples in a core from an Arctic site, the Imnavait Creek permafrost peatland near the Toolik Lake LTER Station, North Slope, AK

The Imnavait Creek Peatland was chosen for its potential to contain Late Pleistocene age sediments: it remained unglaciated during the late Pleistocene Itkillik advance, and it is underlain by glacial sediments of middle Pleistocene Sagavanirktok age (Eisner, 1991; Walker and Walker, 1996). To construct our age-depth model, we dated samples of identified terrestrial macrofossils by accelerator mass spectrometry from 30 different levels within our nearly two-meter sediment record. The oldest sediments were determined be 12.7 ka. We tested several different methods of age-depth model determination, including piecewise linear, polynomial, and autoregressive techniques (BACON, Blaauw and Christen, 2011), to determine the most statistically robust and physically reasonable estimates of carbon accumulation at the site. We found that sedimentation at the site was not continuous over the history of the record, and rates of carbon accumulation during the times when sediment was preserved varied over at least two orders of magnitude. Three erosional surfaces were identified, overlain by rapidly accumulated peat. Some dated samples indicate the re-deposition of eroded organic material during times of high carbon accumulation.

To place these large changes in carbon accumulation in context, we also produced reconstructions of past changes in vegetation assemblage and hydroclimate. We reconstructed vegetation using macrofossil counts and concentrations of leaf wax biomarkers and produced an independent record of hydroclimate change using the hydrogen isotope ratios of leaf wax biomarkers. We also measured C and N stable isotope ratios of bulk sediment and C isotope ratios of specific organic compounds to attempt to disentangle carbon deposited by primary production and reworking of eroded peat. Data from this site underscore the complex relationships among climate, vegetation, and carbon accumulation in permafrost regions and emphasize the necessity of detailed chronologies from individual sites.

Blaauw, M. and A. Christen, 2011, Flexible Paleoclimate Age-Depth Models Using an Autoregressive Gamma Process: Bayesian Analysis, v. 6(3), p. 457-474.

Eisner, W., 1991, Palynological Analysis of a Peat Core from Imnavait Creek, the North Slope, Alaska: Arctic, v. 44(4), p. 279–282.

Walker, D. A., and Walker, M. D., 1996, Terrain and Vegetation of the Imnavait Creek Watershed, in: Landscape Function: Implications for Ecosystem Disturbance, a Case Study in Arctic Tundra (J.F. Reynolds and J.D. Tenhunen, Eds.), p. 73-108.

Yu, Z., Loisel, J., Brosseau, D. P., Beilman, D. W., & Hunt, S. J., 2010, Global peatland dynamics since the Last Glacial Maximum: Geophysical Research Letters, v. 37(13), L13402. doi:10.1029/2010GL043584.

TEMPORAL ANALYSIS OF SUSPENDED SEDIMENT CONCENTRATION CHANGES IN A PROGLACIAL MELTWATER STREAM, LINNÉBREEN, SVALBARD.

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Data suggest that climate change has significantly affected and will continue to affect global environments. It is therefore important to study current environmental systems in order to understand the complicated dynamics of warming and response (Parry et al. 2007). The Arctic shows particular sensitivity to global climate change because of several positive feedbacks that work in tandem, magnifying changes. Ice and snow melt caused by initial warming decreases surface albedo, which can affect atmospheric temperature stability by absorbing larger amounts of incident solar radiation. This positive feedback process results in increased air temperatures, which further encourages melting, and can exacerbate other feedback mechanisms that alter the rate of Arctic climate change and cryosphere dynamics, including thawing permafrost (permanently frozen ground that underlies most Arctic land), melting sea and lake ice, and increasingly dramatic winter precipitation and summer droughts (AMAP 2011; Mangerud and Svendsen 1997; Overpeck et al. 1997). Since 1980, the rise in Arctic annual average temperature has been twice as high as the rise in global annual average temperature (Overpeck et al. 1997; AMAP 2011).

Studying glacier retreat contributes to scientific understanding of changing Arctic climate conditions and the interwoven mechanics of Arctic glacio-fluvial systems. This study investigates water discharge patterns in a proglacial meltwater stream flowing from Linné Glacier in Spitsbergen, Svalbard. Using statistical methods to provide a framework with which to qualitatively describe subseasonal forcings behind glacier melt, this study will contribute to continuing research on the Arctic's responses to climate change.

This project was funded by the National Science Foundation and run through the Svalbard Research Experience for Undergraduates (REU) program. The program, which has lead undergraduates into the field for eight years, focuses on the Linné Valley situated on western Spitsbergen, Svalbard. Faculty, REU participants, and students attending the University in Svalbard (UNIS) have been continually studying the glacier-river-lake system contained in the valley. Research has been conducted on Lake Linné using cores to examine varve layers and deploying sediment traps to investigate sedimentation patterns. Because of Lake Linné's clear varve record, the entire system has been a site of continued scientific inquiry in order to more thoroughly understand both the distal and proximal processes by which sediment is transported and deposited. Lying at the head of this system, Linné Glacier contributes to the overall sediment flux in the proglacial stream and ultimately affects the sedimentation events recorded in the lake.

Lying well north of the Arctic Circle boundary, the Linné Glacier lies at 77.97°N, 13.92°E on Spitsbergen, the largest island in the Svalbard archipelago located nearly 1000 km north of mainland Norway. The Linné Glacier sits at the head of the Linné Valley, 6 km upstream (south) from Lake Linné, a monomictic and isothermal lake formed during the Late Weichselian (Mangerud and Svendsen 1997). The glacier is a 4 km long polythermal valley glacier, which reached its maximum extent in the Holocene at the end of the Little Ice Age as evidenced by prominent ice-cored end moraines as well as air photos taken in 1936-1938 (Mangerud and Svendsen 1989) (Figure 1). The river that drains the meltwater from the glacier into Lake Linné follows a typically braided system but occupies primarily one channel partially cut into bedrock (Mangerud and Svendsen 1989). The river drainage area is approximately 27 km^2, which includes the Linné Glacier as well as other smaller glaciers (Snyder et al. 1999).

This study uses suspended sediment concentrations (SSC) in the proglacial melt water stream flowing from the terminus of Linné Glacier measured from mid-July to mid-August 2012. Two ISCO 6712 water samplers were set up in the upper reaches of Linné River, one at a proximal location to the glacier terminus and one about 500 meters downstream, with intake sieves installed to be suspended in the water column so as to minimize bedload interference. Programmed to sample 500 mL of water every three hours, the samplers ran continuously for the 5-week field season. These water samples were processed through a vacuum-pump filtration system, passing through .45 μ Whatman filters, then dried and massed in order to determine SSC in the stream at the time of sampling. Other field methods included salt-water discharge experiments in order to create a stage-discharge rating curve. Additionally, stage, turbidity, luminous flux, and air and water temperature were measured continuously for the duration of the field season using TROLL and Levellogger instrumentation installed in weather stations situated at the terminal moraine, distal ISCO sampling site, and on the glacier. These data were used in tandem with measured SSC to determine subseasonal and erosional forcing in the glacio-fluvial environment.

Previous research conducted by Hodgkins et al. measured SSC within other glacier-valley systems on Spitsbergen to study the relationship between denudation rates, catchment dynamics, and meteorological fluctuations. Extensive SSC monitoring in 2003 contributed to research that concluded that discrete high discharge events drastically affected sediment yield (Hodgkins et al. 2003). Previous students in the REU program have also conducted research on Linné Glacier, particularly examining sediment flux in the glaciofluvial system (Pendelton 2010). This project builds off of Pendelton's previous work by including more advanced statistical modeling techniques as described by Irvinne-Fynn in "Geocryological processes linked to High Arctic proglacial stream suspended sediment dynamics: examples from Bylot Island, Nunavut, and Spitsbergen, Svalbard", published in 2005. Statistical analyses of SSC data collected during the summer field season included multivariate regression techniques and principle component analysis, which determined subseasonal breaks within the field season as a result of different parameter forcings and modulated by discharge events. SSC shows a distinct diurnal variability that can be correlated with luminous flux as a result of solar angle (Figure 2). SSC and discharge rise coincidently, but SSC depletes before discharge declines, indicating a flushing relationship between sediment flux and meltwater or precipitation-driven discharge events. Continued measurements and analyses of this nature will contribute to the ongoing effort to monitor responses to arctic climate changes in the coming years and decades.

AMAP 2011, Arctic Climate Issues 2011: Changes in Arctic Snow, Water, Ice and Permafrost, Arctic Monitoring and Assessment Programme (AMAP).

Hodgkins, R. et al., Suspended sediment fluxes in a high-Arctic glacierised catchment: implications for fluvial sediment storage: Sedimentary Geology, v. 162, p. 105-117.

Overpeck, J., et al. 1997, Arctic environmental change of the last four centuries: Science, v. 278, p. 1251-1256.

Parry, M.L. et al. 2007, IPCC, 2007: climate change 2007: impacts, adaptation and vulnerability. Contribution of working group II to the fourth assessment report of the intergovernmental panel on climate change.

Pendelton, S., 2010, The Glaciofluvial Environment of Linnébreen, Spitsbergen, Svalbard: Department of Geology, Whitman College.

Snyder, J. et al., 1999, Holocene cirque glacier activity in western Spitsbergen, Svalbard: sediment records from proglacial Linnévatnet: The Holocene, v. 10, p. 555-563.

Svendsen, J.I. & Mangerud, J. 1997, Holocene glacial and climatic variations on Spitsbergen, Svalbard: The Holocene, v. 7, p. 45-57.

Svendsen, J.I., Mangerud, J. & Miller, G.H. 1989, Denudation rates in the Arctic estimated from lake sediments on Spitsbergen, Svalbard: Palaeogeography, Palaeoclimatology, Palaeoecology, v. 76, p. 153-168.

Fig 1. A 1936 oblique aerial photograph showing the extent of Linnédalen. At this time, the glacier nose lies flush against the LIA moraine, which now lies approximately 1.5 km from the current glacier terminus. Norsk Polarinstitutt.

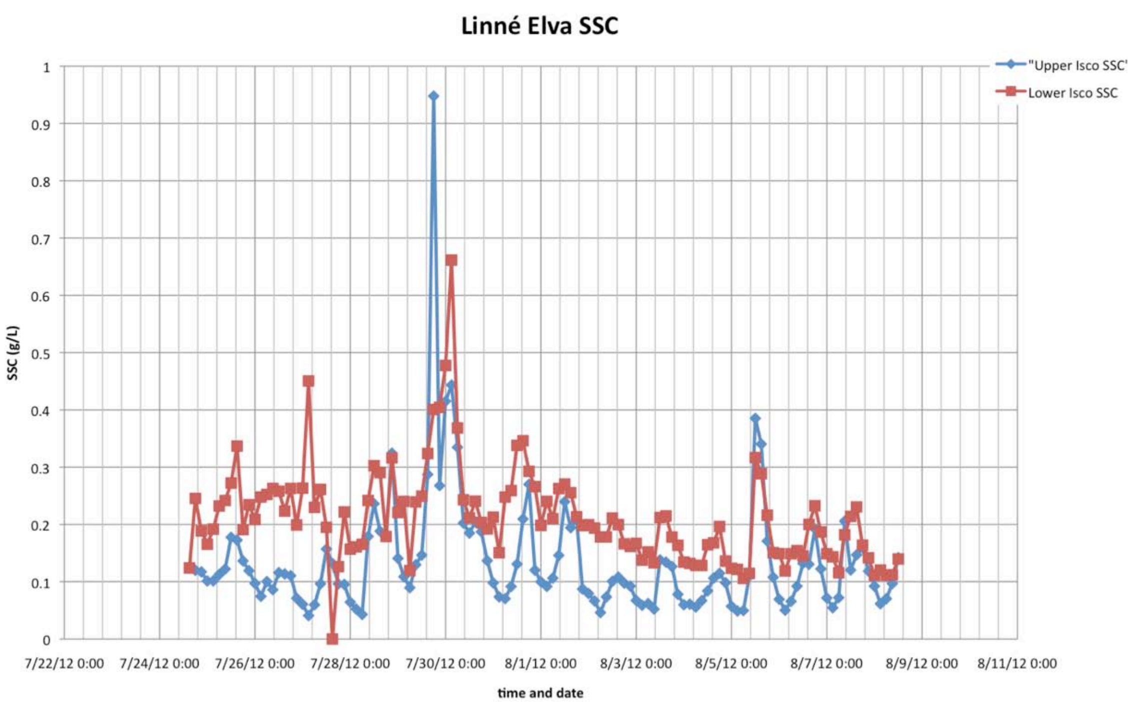

Fig 2. Suspended sediment concentrations sampled in three hour increments continuously throughout the field season. Note the strong diurnal variability despite the 24-hour daylight.

URANIUM-SERIES IN DEEP BAFFIN BAY SEDIMENTS AS TRACERS OF DETRITAL SOURCES AND SEDIMENTARY PROCESSES

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Uranium- (U) and thorium- (Th) series in deep sea sediments have been used to provide information on sediment accumulation processes, notably in subarctic and Arctic environments. Here they are used to document the sedimentary history of deep Baffin Bay during the last glacial cycle. U- and Th-series have been performed at 16 to 8 cm intervals on PC016 (70°27'N, 64°39'W; 2063 m water depth) retrieved from central Baffin Bay. The lack of correlation between concentrations in U, $^{234}U/^{238}U$ activity ratios, organic carbon and redox sensitive elements leads us to infer reduced early diagenetic U-uptake, which could be related to low organic matter fluxes. U and Th concentrations, U/Th and $^{234}U/^{238}U$ activity ratios are thus interpreted in relation with sediment sources. Surprisingly, they do not show any unequivocal linkage with detrital dolomitic carbonates fluxes versus detrital silicates material. Results thus suggest point source glacial events with singular U-Th signatures. Initial excesses in ^{230}Th ($^{230}Th_{xs}$) above the fraction supported by parent ^{234}U, was calculated based on initial ^{234}U activities and the age model of Simon et al. (2012), mostly based on magnetic paleointensity stratigraphy. Values point towards some focusing or advection of ^{230}Th versus the vertical production from the dissolved U in the overlying water column. This excess varies downcore suggesting some high frequency variability in sedimentation rate that are not captured in the above age model. The lack of $\delta^{13}C$ carbon or $\delta^{18}O$ oxygen isotopes stratigraphy due to the paucity of foraminifers and their particular isotopic behaviour when they are present due to the production of isotopically light brines in sea-ice environments, make impossible to interpret further the observed $^{230}Th_{xs}$. On-going analysis of radiogenic isotopes in the study core are expected to help identifying the U- and Th-series signatures of the circum Baffin Bay glacial and sea-ice sediment sources.

Simon, Q., G. St-Onge, and C. Hillaire-Marcel, 2012, Late Quaternary chronostratigraphic framework of deep Baffin Bay glaciomarine sediments from high-resolution paleomagnetic data: Geochemistry, Geophysics, Geosystems, v. 13, p. 1-24.

HYDROCLIMATIC VARIABILITY INFERRED FROM SUBANNUAL SEDIMENT PULSES IN LAKE LINNÉVATNET, SVALBARD

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Hydroclimate variability is readily recorded in glacial-fed Arctic lakes containing annually laminated (varved) sediment. Although most previous studies associate varve thickness with summer temperatures, precipitation is also an important variable (Chutko and Lamoureux 2008; Cuven et al. 2011). High hydraulic energy driven by snow ablation and rainfall produces runoff that mobilizes sediment throughout the catchment. Additional research is necessary to better understand the influence of precipitation on subannual stratigraphy and varve thickness in Arctic lake sediment. Arnold (2009) and DeWet (2011) focused on temperature increases during the early summer freshet as the dominant hydrological process causing sedimentation in Lake Linnévatnet. In contrast, this study highlights the importance of late-season rainfall for generating sediment input to the lake.

Lake Linnévatnet is on the main island of the Arctic archipelago, Svalbard, located at 78ºN and 13ºE. The lake receives melt water from the Linné Glacier located 6 km south of the lake via the Linné River. Additional discharge is derived from snow melt and precipitation. The lake is 4.7 km long and 1.3 km wide, with a maximum depth 35 m. Previous studies by Snyder et al. (2000), McKay (2005) have shown that the sediments are varved in proximal and distal sites within the lake.

Sediment traps and an intervalometer, an instrument using LED lights and voltage sensors to record the time of sedimentation events, were deployed in Lake Linné in July 2011 and were recovered one year later. Additional sediment traps deployed during the spring 2012 were also recovered in July 2012. Temperature loggers and a weather station provided climate data within the watershed. Rainfall was only recorded during fall 2011, due to instrument malfunction. A Snow melt indicator provides snow ablation data using a temperature logger placed 20cm above ground level. Stream discharge was not recorded; however, lake level was recorded by a level logger and was used as a discharge proxy. Sediment collected in the traps was analyzed for grain size and percent biogenic silica (BSi) at 0.25 cm resolution (= 0.32 mm lake-floor equivalence) with a LS 230 Coulter Particle Size Analyzer and wet geochemistry process adapted from Mortlock and Froelich (1989). The sediment traps deployed in spring 2012 were used as time markers for the beginning of the 2012 sedimentation season. Relative percent of total voltage recorded by the intervalometer was used to correlate recorded pulses with collected sediment, assuming that the two traps accumulated the same amount of sediment simultaneously.

Site C is 15 m deep and the most proximal site (0.4 km) to the major inflow. Sediment trap C4, located 0.9 m from the lake bottom, was the primary focus due to the location and the availability of previous years' data for comparison. The trap contained 2.02 cm of equivalent lake-bottom thickness, which accumulated between July 2011 and July 2012. The sediment is composed inorganic mineral matter with thin beds and sharp contacts. The lowest 0 to 1.5 mm of trapped sediment is clayey silt. The sharp contact separating the clayey silt from sandy silt appears to be the distinction between winter and summer. Three major sediment pulses were recorded in the intervalometer and sediment trap between September 2011 and July 2012 (Figure 1). The 9/2/11 pulse accounts for ~50% of the total accumulated sediment thickness and was generated by a storm that delivered 47.6 mm of rain with peak intensity of 1.6 mm in 0.5 hr. As a result of the rainfall, lake level rose 25 cm. Mean grain size is 7.96 μm as analyzed in 31 samples from the pulse layer (Figure 2). Following a long period of quiescence during the winter of 2011-12, two summer pulses occurring on 6/29/12 and 7/9/12 account for ~24% and ~10% of the total sediment accumulation, respectively. During the first pulse, mean grain size increased from 9.85 to 27.35 µm over 3 days to form a bed 4 mm thick. Stream temperature increased by 1.7°C and air temperature rose by 2.1°C over the duration of the 3 day event. There was no significant change in lake level. During the second summer pulse, sediment size deceased from 22.3 to 12.18 μm in the 12 hr. Concurrently, stream temperature increased by 2.2°C the day before the sediment pulse and lake level rose by 1.7 cm.

BSi content of the collected sediment is low but measurable, ranging from 0.26% to 0.89% and averaging 0.47% through the year (Figure 2). BSi is inversely correlated with mean grain size (r^2 = 0.38, n = 42). Assuming that grain size is related to accumulation rate, then this suggests that dilatation of BSi by mineral matter is a primary control on BSi content measured on a percent-wise basis. Nutrient availability might also play a role, as indicated by the peak in BSi content associated with the fall 2011 sediment pulse. The September sediment pulse has a distinct signature compared to the summer pulses. The sediment contains a high proportion of fine particle sizes, was associated with a significant rise in lake level, and was rainfall-generated. The June and July events produced small quantities of coarse sediment sizes, had little effect on lake level, and were products of snow ablation from warming air temperatures. The differences in the pulses are related to the differences in hydrology of snowmelt and rainfall. Rainfall mobilizes sediment over the entire catchment and transports sediment for the duration of the event through overland flow and the Linné River. In contrast, snowmelt is distributed unevenly in the catchment and melts quicker in certain areas. The results of this study show that late-season rainfall can produce a significant proportion of annual sediment deposition; snowmelt generated during warming early season temperatures also delivers sediment to the lake, but to a lesser extent.

Arnold, M., 2009, Sedimentation in High-Arctic Lake, Linnévatnet, Svalbard: A Modern Process Study Using Sediment Traps [B.S. thesis]: Bates College.

Chutko, K. J., Lamoureux, S. F., 2008, Identification of coherent links between interannual sedimentary structures and daily meteorological observations Arctic proglacial lacustrine varves: potentials and limintations., Canadian Journal of Earth Science, v.45, p. 1-13.

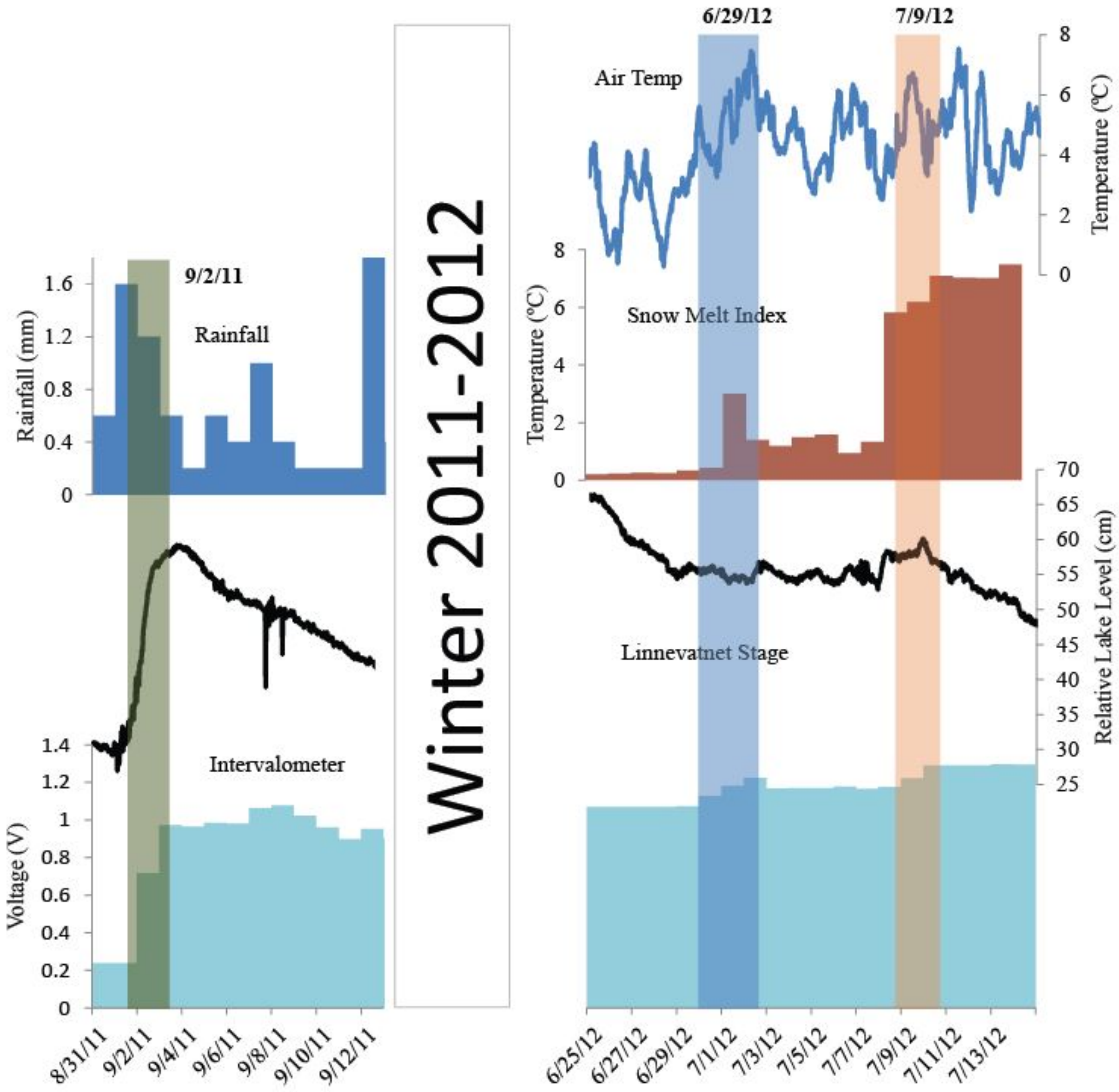
Cuven S., Francus, P., and Lamoureux, S., 2011, Mid to Late Holocene hydroclimatic and geochemical records from the varved sediments of East Lake, Cape Bounty, Canadian High Arctic, Quaternary Science Reviews, v. 30, p. 2651-2665.

DeWet, G., 2011, Analysis of Sediment Trap Yields in glacial fed Linnevatnet, Svalbard: calibrating watershed and lacustrine processes for paleoclimate analysis [B.S. thesis]: Bates College.

McKay N.P., 2005, Characterization of Climatic Influences on Modern Sedimentation in an Arctic Lake, Svalbard, Norway [B.S. thesis]: Northern Arizona University.

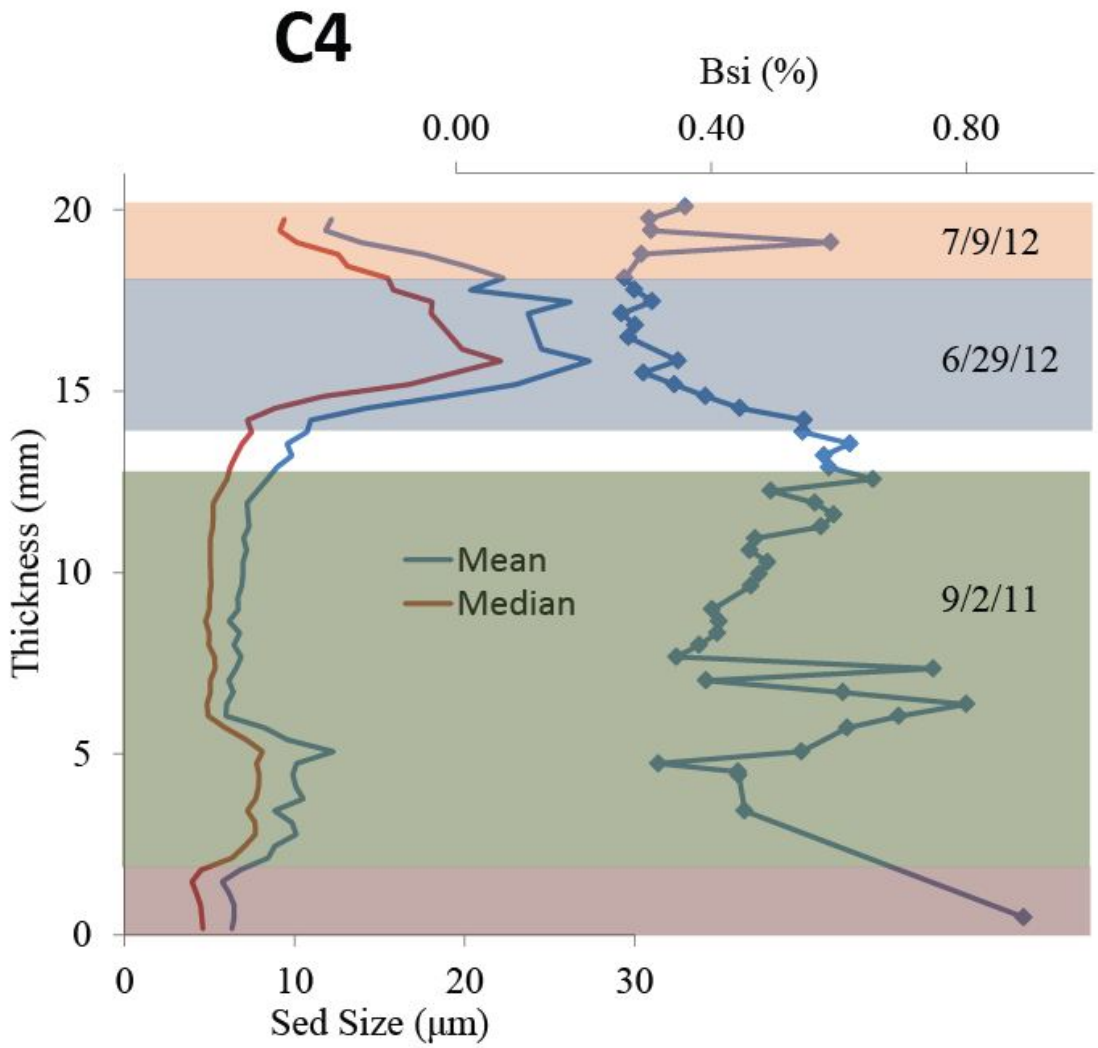
Mortlock, R. A., and Froelich, P.N., A simple method for the rapid determination of biogenic opal in pelagic marine sediments, Deep-Sea Res., v. 36, p. 1415-1426.

Snyder. J. A., Werner, A., and Miller, G. H., 2000, Holocene cirque glacier activity in western Spitsbergen, Svalbard: sediment records from proglacial Linnévatnet, The Holocene, v. 10, p. 555-563.



Instrumental climate data compared with sediment accumulation from the intervalometer at site C, Lake Linnévatnet. Data during the inactive winter season (9/13/11 to 6/24/12) are not shown so as to focus on the hydrologically active season.

Fig 1.



Biogenic silica (BSi) and grain-size analysis of sediment trap C4. Sediment accumulation in the trap was converted to equivalent lake bottom thickness. The three major sediment pulses inferred by correlating thicknesses with the intervalmeter data are represented by same colors as in Figure 1, except for the red unit at the bottom. The white bar between the green and blue represents winter sedimentation.
The black bar between the white and green represents the time marker of winter deployed sediment trap.

Fig 2.

RECONCILIATION OF PHYSICAL OCEANOGRAPHIC THEORY AND PALEOCEANOGRAPHIC DATA: THE ROLE OF THE BERING STRAIT, SOUTHERN OCEAN WINDS AND THE ATLANTIC MERIDIONAL CIRCULATION

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Because North and South America are surrounded by ocean, they constitute a gigantic island whose peripheral sea level is related to the interplay of the counter-clockwise integration of the global winds around the island, the global fresh water flux, and the AMOC. Recent work demonstrates that much of the flow through Bering Strait is controlled by the Southern Ocean winds (Ortiz et al, 2009, Ortiz et al., 2012). Because the AMOC is known to be sensitive to both the Southern Ocean Winds (Toggweiler and Samuels, 1995) and freshwater fluxes (LeGrande et al, 2006), how it responds to the opening of closing of the Bering Strait through time is a question of paleoceanographic interest (Keigwin L., and M. Cook, 2007). To evaluate these interactions, we employ a slowly varying, time-dependent version of the coupled Sandal-Nof (SN) analytical model. This allows us to explore the impact of the global winds and fresh water fluxes on Holocene variations in the flow through Bering Strait (BS) and the Atlantic meridional overturning cell (AMOC). We compare the output of the analytical model with Holocene paleoceanographic proxies for variations in the BS and the AMOC and quantify the relative importance of the winds and fresh water fluxes.

The model is an application of the modified island rule. It consists of six equations that represent the conservation equations for heat and salt, transport from the Southern Ocean to the North Atlantic, transport from the Arctic to the North Atlantic, the sinking flux due to convection in the North Atlantic, and constraints on North Atlantic convections and air-sea heat exchange in the North Atlantic. We invoke the slowly varying approach, where a steady model solution is taken to be valid when the forcing varies on a time scale much longer (~1000 yr) than the advective timescale (~10 yr). The simplicity of the model, which incorporates only the fundamental physics needed to model the interaction of the wind-driven and the thermohaline circulation enables us to run the model with 100-year time steps for a period of 12,000 years. The model is forced with paleoceanographic proxies for the Southern Ocean winds (which dominate the global wind field) and the flux of water into the global ocean due to the melting of the Northern Hemisphere terrestrial ice sheets and the resulting change in sea level.

We observe a very strong correlation (r=0.69) between the Southern Ocean winds and the BS flow. A mid-Holocene weakening of the Southern Winds followed by the cession of freshwater fluxes from the melting Northern Hemisphere ice sheets strengthened the BS flow for several thousand years. Increasing the Southern Winds enhanced the near surface, cross-equatorial flow from the Southern Ocean to the Northern Hemisphere. This cross-equatorial flow decreases the Arctic outflow into the Atlantic, demonstrating a dynamic linkage between the Southern Ocean Winds and the mean flow through the BS. To test the relative importance of the southern ocean winds, fresh water fluxes, and the flow through Bering Strait, we compare output from the model with published 231Pa-230Th measurements (Gherardi et al. 2009, Negre et al, 2010). Comparison of model output with published 231Pa-230Th records from the South and North Atlantic indicates that the modeled record of sinking flux, W, is positively correlated with 231Pa-230Th in the North Atlantic at depths influenced by the NADW (r = 0.77) and inversely correlated with 231Pa-230Th records from depths associated with the AABW (r = -0.45). The correlation with the NADW is found in records from the core of the NADW at sites sampled in both the Northern and Southern Atlantic, indicating that the correlation is dynamically linked to NADA production, rather than geographic position. 231Pa-230Th records at transitional depths between these water masses produced minimal correlation with W. Additional model runs in which we varied only the wind or the fresh water fluxes (using the best estimate of the Holocene paleo-record) while holding the other variable constant were also conducted. They indicate that while a realistic reconstruction of the paleo-flow through BS required forcing the model with varying Southern Ocean winds, a realistic reconstruction of the AMOC required variable fresh water fluxes.

These results document the importance of monitoring multiple variables when reconstructing paleoceanographic changes and demonstrate that paleoceanographic data can be reconciled in a quantitative fashion with our current understand of large-scale physical oceanographic theory.

Gherardi, J. et al. Glacial-interglacial circulation changes inferred from 231Pa/230Th sedimentary record in the North Atlantic region. Paleoceanography 24, PA2204 (2009).

Keigwin L., and M. Cook, A role for North Pacific salinity in stabilizing North Atlantic climate, DOI:Paleoceanography 22 (2007): PA3102

LeGrande, A.N., G.A. Schmidt, D.T. Shindell, C.V. Field, R.L. Miller, D.M. Koch, G. Faluvegi, and G. Hoffmann, 2006: Consistent simulations of multiple proxy responses to an abrupt climate change event. Proc. Natl. Acad. Sci., 103, 837-842, doi:10.1073pnas.0510095103.

Negre C., et al., Reversed flow of Atlantic deep water during the Last Glacial Maximim, Nature, 468, 84-89, 2010.

Ortiz, J.D., Nof, D., Polyak, L., St. Onge, G., Lise-Pronovost, A., Naidu, S., Darby, D., and Brachfeld, S. 2012: The Late Quaternary flow through the Bering Strait has been forced by the Southern Ocean Winds. JPO, 42(11), 2014-2029, Early online release: 7/19/2012, (doi: 10.1175/JPO-D-11-0167.1).

Ortiz, J.D., Polyak, L., Grebmeier, J.M., Darby, D.A., Eberl, D.D., Naidu, S., Nof, D., Provenance of Holocene sediment on the Chukchi-Alaskan margin based on combined diffuse spectral reflectance and quantitative X-Ray Diffraction analysis. Global and Planetary Change, (68), 73-84, 2009.

Toggweiler, J R., and Bonita L Samuels, 1995: Effect of Drake Passage on the global thermohaline circulation. Deep-Sea Research, Part I, 42(4), 477-500.

OCEAN CHANGES AND THEIR RELATIONSHIP WITH GLACIER DYNAMICS IN DISKO BUGT AREA, WEST-GREENLAND, DURING THE HOLOCENE

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Disko Bugt is an area of interest with regard to ocean-ice dynamics as it is bathed by Atlantic waters flowing northward through the Western Greenland Current (WGC), which recorded recent warming accompanied by significant acceleration of glacier retreat (Holland et al., 2008). In order to complement the recent observational record, marine sediment archives may document long term changes of the WGC characteristics in the subsurface layer in addition to sea-surface temperature and salinity as a means to evaluate the relationships between ocean conditions and the Jakobshavn Isbrae meltwater discharges in the Disko Bugt area.

The chronology of the study core (MSM343300) was established from 25 ^{14}C measurements (Quillmann, Andrews and Jennings, 2009). The core covers the Holocene period with sedimentation rate of 60 cm/1000 years on the average. Sub-sampling was done at 8-cm and 4-cm intervals in order to provide a centennial time resolution. Palynological analyses were performed with special attention paid to dinocysts, which provide indications on the surface water conditions, including summer sea-surface temperature (SST) and salinity (SSS) thus meltwater discharge. Isotopic analyses ($\delta^{13}C$ and $\delta^{18}O$) in benthic foraminifer shells (*Islandiella norcrossi* and *Nonionellina labradorica*) were used as tracers of properties in bottom water (water depth at the core site is 519 m), i.e. in the deeper part of the WGC.

Preliminary results encompassing the last 8000 years indicate tenuous variation of the isotopic composition ($\delta^{18}O$ ranging from 3.2 to 3.4 ‰), which suggest little change in the deeper part of WGC. The palynological data show high pelagic productivity with dinocyst fluxes ranging up to 150 000 cysts/cm^2.yr. Assemblages are dominated by *Islandinium minutum* (cold water taxon associated with sea ice), which is accompanied of the cyst of *Pentapharsodinium dalei*, *Brigantedinium* spp., *Operculodinium centrocarpum*, *Spiniferites elongatus*, *Selenopemphix quanta* and *Islandinium*? *cezare*. The maximum abundance of the subpolar taxon *Pentapharsodinium dalei* is recorded between 3000 and 5500 cal. years BP. The application of the modern analogue technique (MAT) led to reconstruct cool SSTs of about ~6-8°C at the base of the sequence, before 6500 cal. year BP. A thermal optimum with SSTs ranging up to ~10-12°C is reconstructed from 6500 to 2000 cal. year BP. The record is also marked by short-lived cooling pulses at about 4500 and 1500 cal. years BP (respectively ~9 and ~6°C). They correspond to high SSS (~31 psu) whereas warm phases are characterized by low SSS (29-30 psu). Warmer summer surface water associated with low salinity may reflect strong stratification and low thermal inertia in the surface layer. They may also indicate warmer conditions that resulted in enhanced melting of the ice margin, thus suggesting that ocean thermal forcing played a determinant on the ice margin fluctuation of the Jakoshavn Isbrae during the Holocene as it is presently the case.

Quillmann, U., Andrews, J.T. and Jennings, A.E., 2009, Radiocarbon Dates from Marine Sediment Cores of the Iceland, Greenland, and Northeast Canadian Arctic Shelves and Nares Strait : Institute of Arctic and Alpine Research, Occasional Paper 59.

Holland, D.M. et al., 2008, Acceleration of Jakobshavn Isbrae triggered by warm subsurface ocean waters : Nature Geoscience, v.1, p.659–664.

SEDIMENTARY RECORD IN THE CHUKCHI PLATEAU (WESTERN ARCTIC OCEAN) AND ITS PALEOCEANOGRAPHIC IMPLICATIONS

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Two piston cores PC01 (75°28.1' N, 165°40.4' W, 558 m water depth, 587 cm) and PC04 (74°26.3' N, 165°44.3' W, 370 m water depth, 928 cm) along with multiple cores PL01 and PL04 were collected from the southern part of the Chukchi Plateau in the western Arctic Ocean during the R/V Mirai Cruise MR09-03 for the purpose of establishing the stratigraphy and unraveling the paleoceanographic history. Multiple cores were compensated for the top-loss of piston cores, based on the comparison of sediment color profiles, from which two complete composite cores were obtained successfully. Age of PC01 was estimated by nine AMS 14C dates as well as by correlation of geochemical properties and ice-rafted debris (IRD) pattern with the well-dated cores nearby our core site. Age of PC04 was decided by correlation of lithologic units with PC01. Both composite cores are composed of three lithologic units: Unit I - Last glacial gray mud with intervened IRD layer, Unit II - deglacial thick IRD layer, Unit III - Holocene brownish sandy mud. Glacial massive or laminated mud sediments in Unit I may be deposited by suspension settling from meltwater plume. Absence of coarse-grained sediments in Unit I results from limited iceberg drift due to relatively thick sea-ice cover during the last glacial period. The glacial muds in Unit I are characterized by low $CaCO_3$ content (< 2%), low TOC content (0.1~0.6%), low C/N ratio (2.3~7.6), fairly high $\delta^{13}C$ value (-25.3~-24.0‰), and low kaolinite/chlorite (K/C) ratio (0.5~0.8). The distinct deglacial IRD interval (Unit II) of both cores shows high $CaCO_3$ (2~6%) and TOC content (0.9~1.8%), high C/N ratio (7.5~16.6), and low $\delta^{13}C$ value (-26.5~-25.4‰), which clearly indicates an increased terrestrial contribution. Holocene brownish silty mud sediments (Unit III) show high opal content (up to 18%) in PC04, and high TOC content (0.4~1.4%), very low C/N ratio (0.3~1.3), and high $\delta^{13}C$ value (up to -22.0‰) in both cores which indicates an increase in diatom production and marine influence. Based on the microscope and SEM observation, IRD constituents of intervened layer of Unit I and deglacial layer of Unit II are mineralogically diverse, but mainly composed of carbonate minerals. It implies that IRD were transported from the Canadian Arctic Archipelago. Further, high K/C ratios (up to 1.2) were measured in IRD abundant layers due to increase of kaolinite, confirming the origin of IRD particles.

MODELING THE EFFECTS OF HOLOCENE PRIMARY PRODUCTIVITY CHANGES ON ORGANIC CARBON ACCUMULATION AND STORAGE IN THE BARENTS SEA

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We investigate organic carbon sedimentation patterns linked to surface water primary productivity (PP) changes throughout the Holocene in northern high latitudes through a multi-proxy geochemical and organic sedimentological approach coupled with organic facies modeling. We studied 197 surface sediment samples, 10 short (ca. 10-30 cm long) and 2 long (3-4 m) cores representing the last 10000 years on the western Barents shelf between Svalbard and the Norwegian mainland.

The Barents Sea is a shallow (mean depth ca. 200 m) Arctic Ocean shelf sea which is partially covered by sea ice in the northeast in the winter. Warm, saline Atlantic water (AW) enters the Barents Sea in the southwest and flows east- and northward until it is subducted under cold, fresh Arctic water (ArW) which enters the Barents Sea from the northeast and flows southwestward. The region where the AW is subducted under the ArW is called the Polar Front (PF). Its position is mainly topographically controlled but also depends on the relative strengths of the two water masses. This is also the region of the winter ice margin. In spring and summer, ice melting leads to a stratified water column and a phytoplankton bloom that moves northward in the marginal ice zone (MIZ) (Sakshaug and Skjoldal, 1989). This high productivity regime in the MIZ is reflected in the surface sediments which are enriched in organic carbon (Knies and Martinez, 2009).

We use OF-Mod 3D, an organic facies modeling software developed by SINTEF Petroleum Research, to determine the organic carbon fractions and to reconstruct PP changes throughout the study region. OF-Mod 3D is a predictive, process-based, forward-modeling tool used to calculate organic matter preservation in a 3D grid throughout the modeled domain. The surface sample data set is used to calibrate the model to the present-day situation. Primary productivity is an input parameter in the model. We apply a low background PP and additional PP input in the MIZ region to represent the MIZ processes.

The model is calibrated and able to reproduce the present-day regional distribution of the organic carbon fractions, including the high organic carbon content in the MIZ and on the flanks of Spitsbergenbanken. These calibrated results show the applicability of OF-Mod 3D to modeling organic carbon distribution, and show the reliability of the methodology. We are also able to model the effects an ice-free Barents Sea region could have on organic carbon accumulation in this region, and thus test the reliability of the Barents Sea (and other Arctic shelf areas) as potential CO2 sink. We further provide evidence that the reconstructed PP from sedimentary data is much lower than estimates of PP in the surface waters from ocean models to explain the accumulation of organic carbon at the seabed in the Barents Sea. This questions the general assumptions of an extreme productive environment in the Barents Sea.

Knies, J., and Martinez, P., 2009, Organic matter sedimentation in the western Barents Sea region: Terrestrial and marine contribution based on isotopic composition and organic nitrogen content: Norwegian Journal of Geology, v. 89, p. 79-89.

Sakshaug, E., and Skjoldal, H.R., 1989, Life at the ice edge: Ambio, v. 18, p. 60 - 67.

UTILITY OF SATELLITE DERIVED TRANSIENT SNOWLINE MIGRATION RATES IN MASS BALANCE ASSESSMENT ON ARCTIC GLACIERS

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Here, we explore the utility of satellite imagery derived transient snowline (TSL) migration rates throughout the ablation season for mass balance assessment on four individual glaciers in Alaska and Greenland using Landsat imagery. Three of the glaciers have ongoing mass balance field data that is submitted to the WGMS to utilize in conjunction with the TSL observations; Taku Glacier (TG) and Lemon Creek Glacier (LCG), Southeast Alaska, are monitored by the Juneau Icefield Research Program (JIRP). Mittivakkat Gletscher (MG), Southeast Greenland is monitored by the Department of Geography and Geology, University of Copenhagen, Denmark. Here we test the use of MODIS imagery for TSL observation on Taku Glacier and Narssap Sermia in Southwest Greenland.

For LCG and MG the snow ablation rates were calculated based on both the TSL-mass-balance-gradient method and the snow-pit-satellite method. For the TSL-mass-balance-gradient method ablation at the TSL is the product of the field observed balance gradient and the TSL rate of rise (Pelto, 2011). For the snow-pit-satellite method, the snow ablation rates were calculated based on observed snow loss in snow pits, from the date of excavation to the date when the TSL reaches the snowpit. For example, if the snowpack depth on July 1 in a snow pit was 1.4 m w.e., and on August 12 the TSL reached the snow pit, then it took 42 days to ablate 1.4 m w.e. of snow, yielding the snow ablation rate. At TG and LCG snow pit excavations were conducted for the years 1998 and 2003–2012 and at MG for the years 1999, 2000–2002, 2006, 2008, and 2012.

The TSL for TG and LCG has been observed for 19 time periods where satellite observations are at least 15 days apart. For MG there are 11 time periods of at least 15 days. On LCG positive TSL migration rates varied from 2.9 ± 0.9 m d-1 to 5.2 ± 0.0 m d-1 (Figure 1) with a mean for all ablation periods of 3.8 ± 0.6 m d-1. On TG the TSL migration rate ranges from 3.1 m d-1 to 4.8 m d-1 with a mean of 4.2 ± 0.5 m d-1. On MG the observed positive TSL migration rates varied from 4.0 ± 0.1 m d-1 to 10.6 m d-1 with a mean for all ablation periods of 6.9 ± 5.2 m d-1.

For LCG, based on the TSL-mass-balance gradient method the ablation rates varied from 0.023 to 0.039 m d-1, averaging 0.028 ± 0.004 m d-1, whereas ablation rates based on the for snow-pit-satellite method varied from 0.025 to 0.038 m d-1, averaging 0.031 ± 0.004 m d-1 (Figure 2). JIRP ablation measurements for LCG during the ablation seasons from 2004–2010, over a total period of 162 days, yield a mean ablation rate of 0.031 m d-1, which is in accordance with calculations: The similarity of the TSL and field ablation rates supports the concept that remote sensing TSL observations, which can be extended over longer time periods and are not simple point measurements, offering a useful approach of estimating annual ablation rates, which are important in assessing changes in glacier mass balance in the Juneau Icefield region.

On Taku Glacier the balance gradient from probing between 900 and 1070 meters is 4.5 mm m-1. The mean daily TSL rise is ranges from with a mean of 4.2 m d-1, the TSL-mass-balance gradient method derived mean daily ablation is 0.019 m d-1 water equivalent for the July-September period in the vicinity of the TSL during July-early September.

For MG the snow ablation rates showed more variability, with rates in the range from 0.037 to 0.072 m w.e. d-1, averaging 0.051 ± 0.018 m w.e. d-1 based on the TSL-mass-balance-gradient method, and 0.028 to 0.073 m w.e. d-1, averaging 0.047 ± 0.019 m w.e. d-1 based on the snow-pit-satellite method (Figure 3). At MG no direct field snow ablation measurements have been conducted for validation of the estimated snow ablation values, but in future mass balance model simulations the calculated snow ablation rates has the potential for being compared against simulated ablation rates. However, Mernild and others (2006) simulated daily snow and ice melt rates using the modeling software package SnowModel for the period 1999–2004, and these simulated rates (0.03–0.04 m w.e. d-1) were in average slightly lower than the estimated snow ablation rates presented in this study.

MODIS imagery has a lower resolution but higher availability than Landsat. A comparison of overlain MODIS and Landsat, from the same day, indicates that TSL identification using MODIS indicates a mean difference of 110 m + 80 m in horizontal TSL position versus Landsat, which corresponds to a vertical difference of 3-5 m on Taku Glacier and Narssap Sermia. For Narssap Sermia TSL was evident in 2011 on 11 days with MODIS imgagery and 4 Landsat image dates. In 2012 there were 13 MODIS dates and 4 Landsat dates where TSL was identifiable. More details will be ready on this last part of the study by the conference date.

Mernild, S.H., G.E. Liston, B. Hasholt and N.T. Knudsen. 2006, Snow distribution and melt modeling for Mittivakkat Glacier, Ammassalik Island, SE Greenland: Journal of Hydrometeorology, v. 7, p. 808–824.

Pelto, M. 2011, The utility of late summer transient snowline migration rate on Taku Glacier, Alaska: The Cryosphere, v. 5, p. 1127–1133.

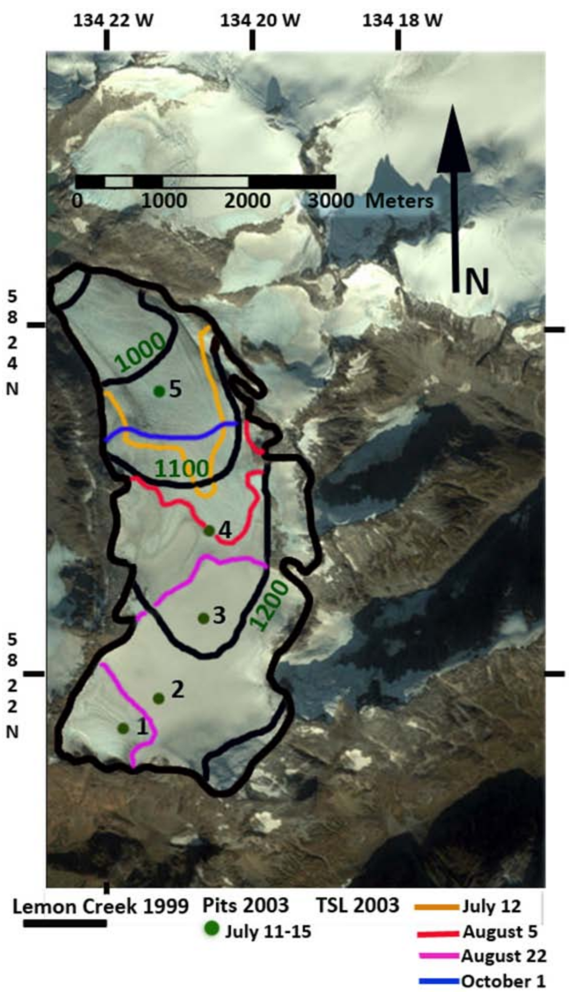

Fig 1. Satellite image of the Lemon Creek Glacier (11.6 km2) (the inset figure in the upper right corner indicates the general location of the glacier in Southeastern Alaska), with 100-m contour intervals. The green dots (one to five) indicate standard snow pit locations from 2003, and the colored bold lines the seasonal locations of snowlines during the 2003 ablation season. The glacier boundary is for 1999 and estimated from Global Land Ice Measurements from Space (GLIMS; www.glims.org).

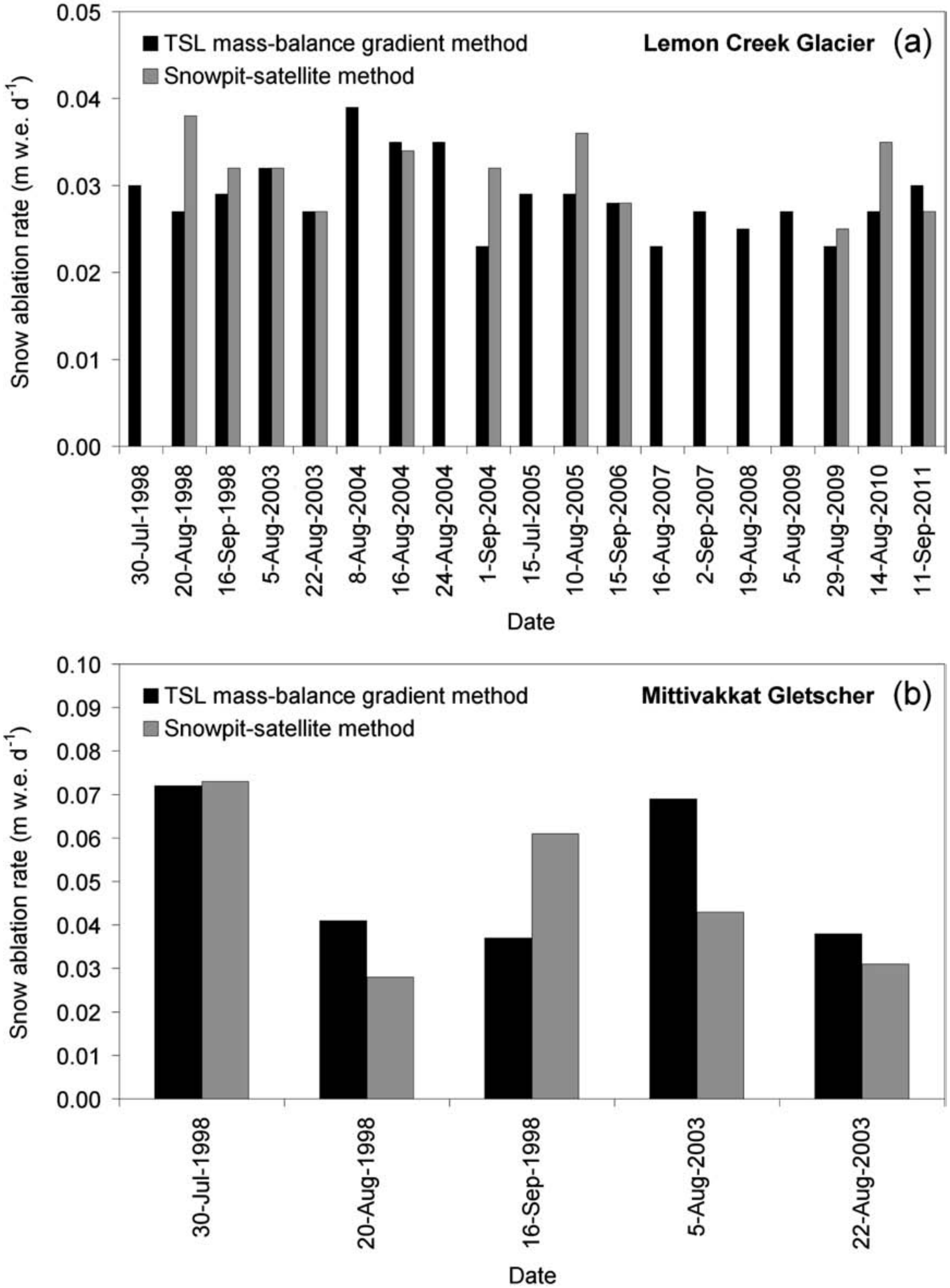

Fig 2. (a) Estimated snow ablation rates for Lemon Creek Glacier; and (b) for Mittivakkat Gletscher based on the TSL-mass-balance-gradient method and the snow-pit-satellite method.

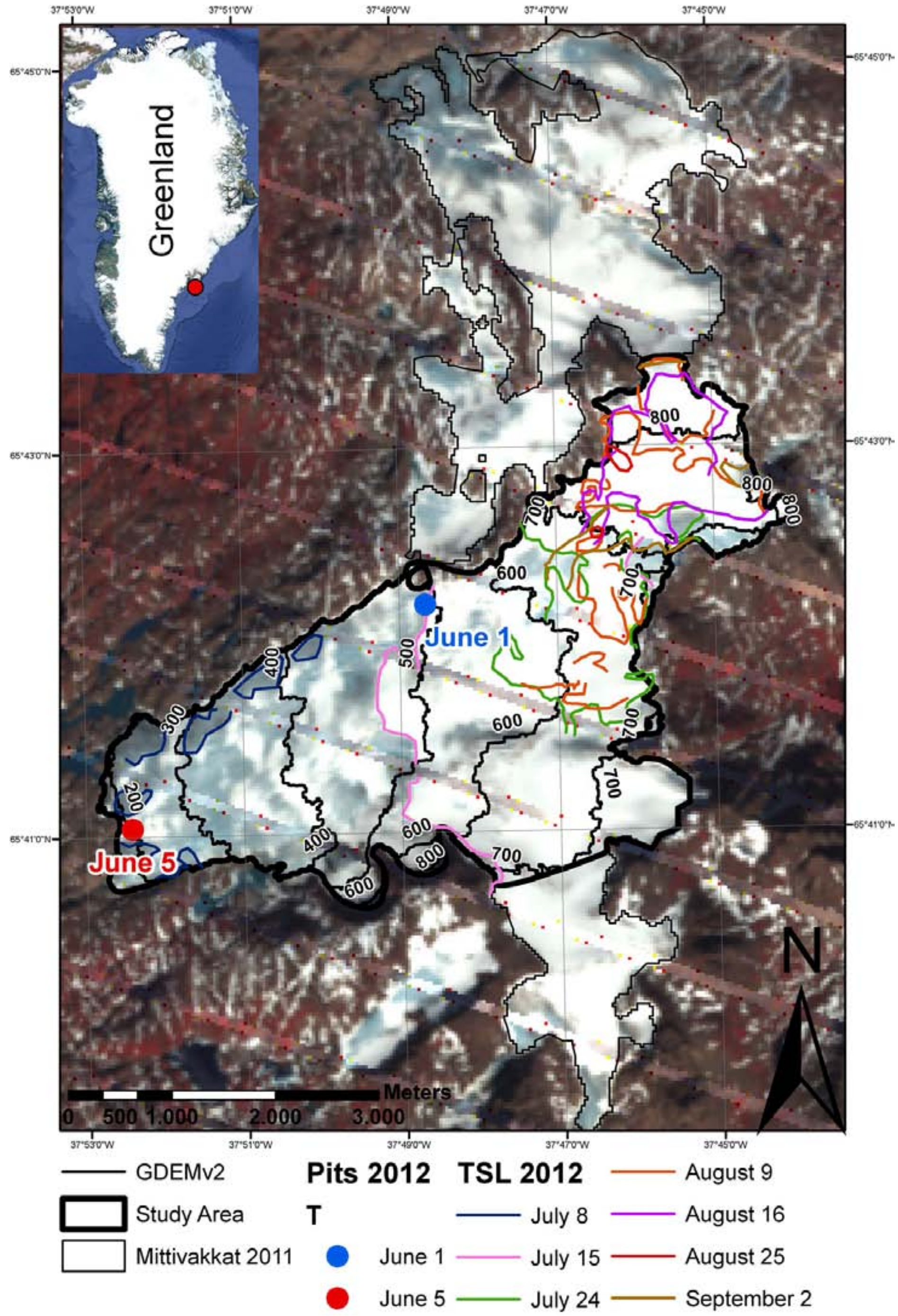

Fig 3. Satellite image of the Mittivakkat Gletscher (26.2 km2 in total in 2011, and 15.9 km2 for the observed Ba study area) (the inset figure in the upper left corner indicates the general location of the glacier in Southeast Greenland), with 100-m contour intervals. The red and the blue dots indicate an example of snow pit locations from 2012 and the colored bold lines the seasonal locations of snowlines during the 2012 ablation season. The glacier boundary is based on Landsat 7 ETM+ Mosaic imagery (1 August 2009 and 14 August 2011).

BERING/CHUKCHI SEA LATE QUATERNARY PROVENANCE AND FLOW REGIME RECONSTRUCTION THROUGH SEDIMENTOLOGIC EVIDENCE

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The Bering Strait is a narrow connection (about 85 km wide) between the Arctic and Pacific Oceans (Figure 1) averaging less than 50 m in depth. The flow through the Bering Strait is of vital importance to global ocean circulation through its role in North Atlantic deep-water formation (NADW). Thus understanding the paleoceanographic history of the Bering and Chukchi seas over the past 30,000 years is important to further knowledge of ocean circulation and its connection to climate change.

Much research has been aimed at determining the sea ice extent over the past 30,000 years in the Bering and Chukchi Seas and the direction of flow through the Bering Strait. Bering Strait throughflow delivers one-third of the freshwater entering the Arctic Ocean, and is also an important oceanic nutrient source to Arctic ecosystems. Bering Strait throughflow today is dominantly northward into the Arctic Ocean (Figure 1) with an average flow of 0.8 Sv. However, possible changes in Bering Strait throughflow intensity and direction during deglaciation and submergence of the Bering Land Bridge are poorly constrained in both sedimentary archives and modeling simulations. In addition, sedimentary records from Beringia hold promise to help resolve how flow across the Bering Strait may influence water masses in the Arctic and their impact on NADW formation in the Holocene. To help address these questions, examination is underway of physical and geochemical properties of marine sediment cores collected from across this region.

Five sediment cores collected during USCG Healy cruises in 2002 are investigated here; two from the Bering Sea, and three from the Chukchi Sea (Figure 1). Major and trace element geochemistry spanning the past ~30 kyr was determined for these cores using an ITRAX XRF core scanner (Figure 2). Other sedimentologic descriptors include line scanning, GRAPE bulk density, x-radiographs, magnetic susceptibility, visual core descriptions, and spectrocolorimetric data applied using the CIELAB (l*a*b*) system. Bulk biogeochemical properties include %TOC, % carbonate, Corg/N ratios, δ13Corg and δ15N. Principal component analysis is being applied to determine covariance of sedimentologic and geochemical properties of these sediments. Rare earth element ratios and other geochemical properties are being used to provide indicators of sediment provenance, that can be coupled to throughflow strength and direction.

This work complements parallel efforts (see Kocis et al. this meeting) using lipid biomarkers including IP25, UK'37, TEX86 and other GDGT data to better constrain temperature and sea-ice reconstructions. The biomarker work aims to obtain a modern calibration relating IP25 to current sea ice conditions. Using this knowledge, down core IP25 and other SST proxies are being examined to inspect possible changes in past environmental conditions such as seen during sea level transgression. A key goal is the identification of how variations in geochemical properties correspond to bulk biogeochemical or biomarker variability, in comparison to sea ice proxies.

Once analyzed, these data will be used collectively to test existing data and models (Ortiz et al. 2009, 2012 Bradley et al 2008; Farmer et al. 2011) through comparison of chemical and physical properties preserved in the record of our cores to previous work concerning the post glacial and Holocene evolution of changes that took place across the marine portion of the Bering Land Bridge. The data being collected will potentially answer the questions of what sea ice extent has been over the Bering Sea, and when the currents that flow through the Bering Strait began to operate as they do today.

Bradley, R.S., England, J.H., 2008, The Younger Dryas and the Sea of Ancient Ice: Quaternary Research, v. 70, p. 1-10.
Farmer, J.R., Cronin, T.M., Vernal, A., Dwyer, G.S., Keigwin, L.D., Thunell, R.C., 2011, Western Arctic Ocean temperature variability during the last 8000 years: Geophysical Research Letters, v. 38, L24602.
Ortiz, J.D., Polyak, L., Grebmeier, J.M., Darby, D., Eberl, D.D., Naidu, S., Nof, D., 2009, Provenance of Holocene sediment on the Chukchi-Alaskan margin based on combined diffuse spectral reflectance and quantitative X-Ray Diffraction analysis: Global and Planetary Change, v. 68, p. 73-84.

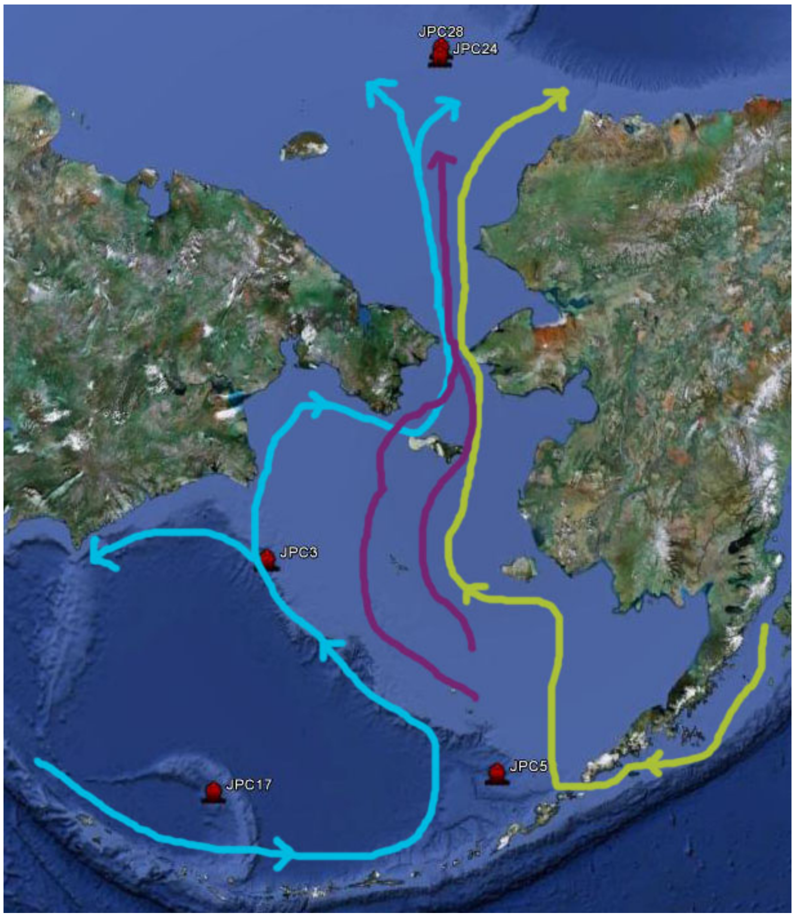

Fig 1. Core locations with present currents. Yellow- Alaskan Coastal Water, Purple- Bering Shelf Water, Blue-Aleutian North Slope-Bering Slope, Anadyr Waters.

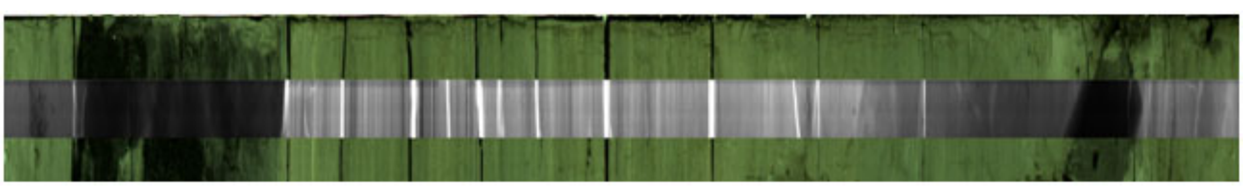

Fig 2. JPC 51 Section 12 114-269 cm, image of core with overlain radiograph image. Black sections are tephra blocks. The core was taken from the Bering Sea about 150 km north of Umnak Island of the Aleutians.

MODELING HABITAT USE BY BOWHEAD WHALES IN RESPONSE TO PAST AND FUTURE ARCTIC CLIMATE CHANGE

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The effects of climate change are projected to be disproportionately pronounced in polar regions, where changes in the concentration and extent of sea ice will affect the spatio-temporal dynamics of the marine planktonic ecosystem. The endangered bowhead whale (Balaena mysticetus) is one of the largest animals in the Arctic, yet they feed on some of the smallest arctic animals, zooplankton. Changes in the abundance and distribution of zooplankton due to changes in sea ice would have direct effects on bowhead whales.

The objective of our research is to improve understanding of how the arctic planktonic ecosystem and sea ice affects the regional distribution of bowhead whales in the Beaufort and Chukchi seas, and to develop hindcasts and long-term forecasts of bowhead whale distribution under different arctic climate change scenarios. Our approach combines a multi-decadal bowhead whale survey dataset with modeled environmental data from the pan-Arctic Biology/Ice/Ocean Modeling and Assimilation System (BIOMAS) – a fully coupled 3D model with an 11-component lower-trophic model that includes three zooplankton groups (microzooplankton, mesozooplankton/copepods, and predatory zooplankton).

We used 23 years of aerial survey data and BIOMAS model output to train bowhead whale species distribution models for the Beaufort and Chukchi seas. We hindcasted monthly habitat suitability and achieved a reasonable model accuracy (mean AUC across all years = 0.80). In the next phase of our research we will force BIOMAS with IPCC GCMs and use the results to drive bowhead whale habitat models. This type of scenario study will help us understand the potential changes in bowhead whale habitat and help evaluate strategies for minimizing human-whale interactions as sea ice extent and whale populations change in the coming decades.

A 10BE CHRONOLOGY OF LATE PLEISTOCENE AND HOLOCENE GLACIATION IN THE ALAPAH MOUNTAIN REGION, NORTH-CENTRAL BROOKS RANGE

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The geomorphic record of Alpine glaciers in the Brooks Range, Alaska has long been recognized as an important archive of late Pleistocene and Holocene glaciation in the Arctic. However, despite the general chronology of Pleistocene glaciation being fairly well documented (Hamilton, 1994), precise ages of prominent late Wisconsin moraines, deglaciation, and Neoglacial moraines are lacking (Ellis and Calkin, 1984). Here, we investigate deglaciation following the last glacial maximum (LGM) in several valleys in the north-central Brooks Range. We also target the moraines of the Alapah Mountain Drift (hereafter termed Alapah Mountain moraines), one of the few late Pleistocene moraine sequences located in the headwaters of the range. Finally, we build upon of the work of Badding et al. (2013) in obtaining 10Be ages of Neoglacial moraines. We report these new cosmogenic 10Be exposure ages as part of an emerging late Pleistocene and Holocene glacial chronology of the north-central Brooks Range.

The Alapah Mountain moraines are prominent features located in several small valleys in the Ernie Pass region in the headwaters of the Anaktuvuk River. The moraines are located ~10% of the distance downvalley between modern glaciers and Itkillik II terminal moraines near the northern Brooks Range front. We sampled five moraine boulders from the Limestack Creek valley. After excluding one young outlier, four boulders from a latero-frontal moraine system yield an average 10Be age of 18.7 ± 1.0 ka. 10Be ages of two erratic boulders just inboard of the Alapah Mountain moraines indicate ice recession from the moraines by 17.2 ± 0.2 ka. We also sampled two erratic boulders perched on bedrock in the middle reaches of an adjacent valley (Alapah River valley), whose 10Be ages show ice free conditions by 17.1 ± 0.9 ka. In a third valley (Erratic Creek valley) to the northeast of the Alapah River valley, two erratic boulders in the upper reaches of the catchment yield an average 10Be age of 17.0 ± 0.2 ka.

The two outermost Neoglacial moraines of East Erratic Glacier (informal name) were surveyed using lichenometry to guide sampling for 10Be dating. Two moraine boulders from the outermost moraine, with largest-lichen diameters of 88 mm, yield an average 10Be age of 3.1 ± 0.5 ka. Two moraine boulders from the next moraine in, with largest-lichen diameters of 76 mm, yield an average 10Be age of 2.7 ± 0.9 ka. The 88 and 76 mm moraines yield lichenometric ages of 3.1 ± 0.6 ka and 2.6 ± 0.5 ka, respectively. Comparison of the 10Be ages and licheometric ages demonstrates a high degree of similarity.

Two additional boulders from the outermost Neoglacial moraine of East Erratic Glacier yield 10Be ages of 8.0 ± 0.4 and 7.1 ± 0.4 ka, far older than the other moraine boulder 10Be ages and lichenometry indicate. In addition, one boulder perched on a small bedrock knoll downvalley from the Neoglacial moraines yielded a 10Be age of 8.4 ± 0.4 ka. We speculate that these older ages are the result of a landslide that we mapped on the cirque floor adjacent to the Neoglacial moraines. If so, the older age of 8.4 ± 0.4 ka from the perched boulder beyond the Neoglacial limit may provide an age for the landslide. If this is true, it is possible that the two boulders on the outermost Neoglacial moraine with 10Be ages of 8.0 ± 0.4 and 7.1 ± 0.4 ka represent reworked landslide debris deposited in the Neoglacial moraines. Therefore, the landslide event occurred when East Erratic Glacier was smaller than its Neoglacial extent.

We have three conclusions: (1) The morphostratigraphic position of the Alapah Mountain moraines is similar to a moraine in the northeastern Brooks Range dated to about the same time (Balascio et al., 2005). Together, the two sites, separated by 320 km, support the presence of a Itkillik II advance across the north central Brooks Range well upvalley of Itkillik II terminal moraines. This would require significant glacier recession during peak global LGM conditions. (2) Our ages of glacier retreat at ~17 ka from multiple valleys suggest rapid deglaciation of the majority of the valleys following the advance at ~18-19 ka. (3) In terms of Neoglaciation, our chronology suggests that the Erratic Creek Glacier reached its maximum Neoglacial extent between 3-2 ka. These data build on and refine a newly emerging chronology of latest Pleistocene and Holocene glaciation from the Brooks Range.

Badding, M. E., Briner, J. P., and Kaufman, D. S., 2013, 10Be ages of late Pleistocene deglaciation and Neoglaciation in the north-central Brooks Range, Arctic Alaska: Journal of Quaternary Science, v. 28, no. 1, p. 95-102.

Balascio, N. L., Kaufman, D. S., Briner, J. P., and Manley, W. F., 2005, Late Pleistocene glacial geology of the Okpilak-Kongakut rivers region, Northeastern Brooks Range, Alaska: Arctic, Antarctic, and Alpine Research, v. 37, no. 4, p. 416-424.

Ellis, J. M., and Calkin, P. E., 1984, Chronology of Holocene glaciation, central Brooks Range, Alaska: Geological Society of America Bulletin, v. 95, p. 897-912.

Hamilton, T. D., Late Cenozoic glaciation of Alaska, in Proceedings The geology of Alaska1994, Volume G-1, Geological Society of America, Boulder, CO, United States, p. 813-844.

ESTIMATES OF TIDEWATER GLACIER MELTING FROM WARMING FJORD WATERS IN SVALBARD

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Melting of marine terminating glaciers is of high scientific and societal interest due to its importance as a boundary condition of ice dynamics, grounding-line stability, and understanding future sea level rise. Water flowing past tidewater ice cliffs produces consistent morphologies on the submarine ice surface that are analogous to geological sedimentary bedforms. By considering boundary-layer dynamics that characterize the sedimentary bedforms and the derived algorithms to describe the currents, it is possible to obtain estimates of flow velocity of the water over the ice face. These velocities are important constraining data for modeled rates of ice face melting that feeds into predictions of ice dynamics and contributions to sea level rise. Submarine discharges from subglacial streams exit the glacier on the sea floor and rise as turbulent jets through the fjord water column up to the sea surface. As they rise, they flow against the ice face at velocities calculated to be 3-4 times higher than general fjord circulation water velocities against the rest of the ice face. Consequences of the higher melt rates are embayments that commonly demarcate such upwelling waters at marine tidewater termini. Melt rates estimated from these velocities derived by using empirical relationships determined from structures exposed on icebergs recently calved form the ice cliff, are less than estimated calving rates, although those at the upwelling streams almost equal calving rate estimates.

LEAD CONCENTRATIONS AND ISOTOPIC COMPOSITIONS OF EASTERN AND NORTHERN BAFFIN BAY SURFACE SEDIMENTS.

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Untill now, the documenting of glacial/interglacial erosional processes over Greenland, Baffin Island and the Canadian Arctic Archipelago has been essentially based on mineralogical and major/trace element measurements (Andrews and Eberl, 2011; Simon et al., 2012). Radiogenic isotope signatures in such sediments might add precision on the identification of detrital sources. However, the incidence of distinct erosion mechanisms (physical/chemical or rates), of variable ice stream and river inputs, and of sediment dispersal processes (sea-ice, icebergs, turbidity currents...), invalidate every linkage of sedimentary radiogenic isotope signatures with the surrounding bedrock geology.

In this study, we use surface sediments from 24 sites on Baffin Bay margins, as a proxy for labelling regional detrital sources. The analytical program will include grain size, mineralogical, major and trace element analysis, as well as Sr, Nd and Pb isotope measurements. We report here Pb isotope measurements in box-cores, top-vibrocores or grabs from the selected sites. In most cases, we were able to analyze surface vs sub-surface (25-30 cm) sediments, in order to define Pb-anthropogenic contamination.

Data define four clusters with notably 208Pb/204Pb-206Pb/207Pb ranges : Greenland [1.16-1.25]-[37.0-40.0], Baffin Island [1.12-1.16]-[39.0-40.5], Disko Bugt [1.20-1.22]-[39.5-40.0] and North Polynya [1.21-1.25]-[39.2-39.7]. Baffin Island and Atlantic inputs Pb isotopic compositions are distincts. In most cases, specially with Disko Bugt, Greenland and North Polynya, isotopic datas are relatively similars but geographically distants. It can be explained by the importance of water mass circulation in the bay (Tang et al, 2004). In response to this glacial activity, Baffin Bay outflow waters towards the North Atlantic (via Labrador Sea) might thus carry a terrigenous Pb-sources signatures through time.

Tang, C.C.L., 2004, The Circulation, water masses and sea-ice of Baffin Bay: Progress in Oceanography, v.63, p183-228.

Andrews, J.T., 2011, Surface (sea floor) and near-surface (box cores)sediment mineralogy in Baffin Bay as a key to sediment provenance and ice sheet variations: Can. J. Earth Sci, v.48, 1307-1328.

Simon, Q., 2012, Late Quaternary chronostratigraphic framework of deep Baffin Bay glaciomarine sediments from high-resolution paleomagnetic data: Geochem. Geophys. Geosyst, v.13.

LINKS BETWEEN PERMAFROST, WATER AND CARBON CYCLING ACROSS THE TERRESTRIAL ARCTIC UNDER A WARMING CLIMATE

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Arctic amplification is manifested as enhanced warming over the terrestrial Arctic of approximately double the global average. Warming has the potential to mobilize large stores of organic carbon from the terrestrial landscape in the form of both carbon dioxide and methane. Water in the solid, liquid, and gas phases connects virtually all aspects of the Arctic climate system. Permafrost represents a confining layer between surface and subsurface water and is important for storing carbon matter and energy. Mobilization from the land to the atmosphere of long frozen carbon from permafrost regions represents a potential large positive feedback to warming. Northern Eurasia is characterized by large carbon stocks such as Yedoma – Pleistocene-age loess permafrost with a relatively high ice content. Given the lack of long-term observations, the carbon cycle of the Eurasian pan-Arctic is poorly understood. Carbon fluxes between the land and ocean (eg. dissolved organic carbon in rivers) and the land and atmosphere (eg. due to fire) are highly variable in both space and time, and are also poorly understood.

In this talk I describe recent efforts to better understand the cycling of carbon across the northern high latitudes. Given the challenges in extrapolating field measurements across multiple spatial and temporal scales, large collaborative programs have begun to develop field campaigns and scoping studies which bring together remote sensing estimates, in-situ observations, and numerical modeling. Two such efforts are underway in Alaska. For northern Eurasia I describe how remote sensing data characterizing the extent of fire are used to quantify land-to-atmosphere carbon fluxes. Remote-sensing estimates of inundated area assimilated in a numerical permafrost-hydrology model can provide spatial estimates of methane flux from areas of Eurasia where carbon stocks are particularly vulnerable to warming.

LAMINATED SEDIMENTS FROM A PROGLACIAL LAKE IN BODALEN, NORDENSKIOLDLAND, SVALBARD: IMPLICATIONS FOR LATE LITTLE ICE AGE AND 20TH CENTURY GLACIER DYNAMICS AND GLACIAL-LACUSTRINE SEDIMENT PRODUCTION

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Varved proglacial lake sediments have been increasingly utilized in the arctic region to ideally provide annually resolved paleoclimate records that infer connections to summer melt season processes and conditions (Kaufman, 2009. A pilot study was begun in April 2012 to investigate late Holocene climate records archived in varved sediments in proglacial lakes in Nordenskiöldland, Svalbard. Sediment cores were recovered from two adjacent core sites in a reconnaissance of small proglacial lakes in Bodalen, approximately 15 km south of Longyearbyen. The lakes are dammed between the Bodalesbreen Little Ice Age terminal moraine and the facing valley wall to the south. Two short surface cores (~40cm in length) and a 1.4 meter-long piston-percussion core were recovered from two sites at 15 and 16 meters depth.

Cores were split and visually logged. Half cores were scanned on a Geotek multisensor core logging system which provided magnetic susceptibility and color spectral data at 0.5 cm intervals downcore and high resolution core imagery. Bulk density and grain size were also measured at 0.25 cm increments. Preliminary varve counts were made directly on the core surface using a traditional "varve tape" method. The varve boundaries were marked and annotated on the narrow paper tape which was later scanned and measured using a digital analysis system. Thin sections will be utilized in more detailed measurements of the laminated sediments and are currently in production. A composite varve chronology was constructed by overlapping the surface core and long core from the same core site. Visual overlap of the cores was made using distinct series of marker beds. Varve counts were compared with radiometric ages using 239+240 Pu (Ketterer et al.,2004) with care in distinguishing annual varve couplets from thicker intra-annual deposits.

The Bodalen lake sediments are finely laminated, dominated by distinct silt-clay couplets 2 to 10mm thick. The basal "summer" layer of the couplet is brown and generally thicker than the tan-colored overlying "winter" layer. The basal layer lies in sharp contact with the previous year's winter layer. Series of silt-clay couplets are interrupted by fining upward layers up to 5 cm thick that have basal mm-thick sand layers that overlie erosional basal contacts.

The composite lamination series extends back to approximately 1840 A.D. From 1840 to 1920, the record is dominated by a near-continuous sequence of varve couplets averaging 0.9 cm thick. The thick fining upward layers occur mainly in the period from 1920 to 1990 within a series of generally thinner varve couplets (average ~0.35 cm). Couplet thickness increases from 1990 to 2011 in the range of 0.5 to 0.8 cm.

An examination of a series of air photographs from Svalbard (Norsk Polarinstitutt) show that cirque and valley glaciers on Nordenskiöldland were at, or close to, their Little Ice Age maximum extents in 1936, and most glaciers have been in retreat since that time. The interpretation of the varve sediment record must reflect a consideration of long-term changes in sediment availability and glacier dynamics in additional to climatological controls that control varve thickness over shorter frequencies. (Leonard, 1997). The varve record prior to 1920 likely reflects late Little Ice age conditions when Bodalsbreen was stabilized at its terminal moraine. Between 1920 and 1990 thinner varves are deposited but interrupted by thick fining upward layers, interpreted as turbidites. The turbidites may be surge deposits related to increased melting, increase in intense summer rainfall events (Lamoureux, 2000) or episodic slumps or avalanches related to warming of the active layer of the permafrost in this steep narrow valley.

Kaufman, D.S., 2009, An overview of late Holocene climate and environmental change inferred from Arctic lake sediment, p. 1-6 in D.S. Kaufman (ed.) Late Holocene climate and environmental change inferred from arctic lake sediment, Journal of Paleolimnology, volume 41, 242 p.

Ketterer, M.E., Hafer, K.M., Jones, V.J., and Appleby, P.G., 2004, Rapid dating of recent sediments in Loch Ness: inductively coupled plasma mass spectrometric measurements of global fallout plutonium: Science of the Total Environment, volume 322, p. 221–229.

Lamoureux, S.,2000, Five centuries of interannual sediment yield and rainfall-induced erosion in the Canadian High Arctic recorded in lacustrine varves, Water Resources Research, Volume 36, p. 309-318. Leonard, E.M., 1997, The relationship between glacial activity and sediment production: evidence from a 4450-year varve record of neoglacial sedimentation in Hector Lake, Alberta, Canada. Journal of Paleolimnology, volume 17, 319-330

HOLOCENE FLUCTUATIONS OF LINNÉ GLACIER: CONSTRAINING ITS PRE-LITTLE ICE AGE HISTORY USING COSMOGENIC RADIONUCLIDE EXPOSURE DATING

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As is observable today, Arctic glaciers are especially sensitive to climate change. By studying the past fluctuations in glacier extent, we can determine the cause of these fluctuations due to climatic shifts in temperature, albedo, and green house gas accumulation.

Here, we investigate the timing of the Late Weichselian and Neoglacial retreat of Linné Glacier, a high Arctic glacier located in southwestern Spitsbergen, Svalbard. Linné Valley contains Lake Linné, a glacial lake formed during the Younger Dryas-Holocene transition; 6 km upstream from the lake lies Linné glacier. The valley terminates at Isfjorden, with a series of three marine terraces. Up-valley, about 1.5 km from the present terminating edge of Linné glacier is the Little Ice Age maximum (LIAM) moraine. To the east along the outside edge of the LIAM moraine, there is a section of older moraine remnants approximately 0.3 km long that is presumed to be Neoglacial in age (see Fig. 2; Werner, 1993).

Studies of the marine sediments in Linné Valley indicate that Linné Glacier filled the lake basin during the late Weichselian maximum, before retreating further up-valley (south) around 12.3 ka. There is no evidence of growing glaciers on Spitsbergen during the Younger Dryas, and some glaciers may have been smaller than their LIAM (Mengerud and Svendsen, 1990). Lake cores taken from Lake Linné demonstrate that this valley was ice free from ~10.0 to 4.4 ka. The varve record then shows regular fluctuations in sedimentation indicating the presence of Linné Glacier. It has been suggested that, during this time of regular fluctuations, a Neoglacial readvance may have occurred as evidenced by till underlying Little Ice Age moraines. Evidence of these advances is relatively rare on Spitsbergen, due to the LIAM moraines that reworked past deposits, and there is little data regarding this possible late Holocene advance (Svendsen and Mangerud, 1997). A Neoglacial advance is also supported by lichenometry, which indicates two stages of moraine deposition and stabilization in Linné Valley (~1.5 and 1.0 ka) prior to the Little Ice Age advances (Werner, 1993).

In order to better constrain the Neoglacial history of Linné Glacier, we use cosmogenic 10Be surface exposure ages of moraine boulders deposited on the moraine remnants found just outside of the LIAM moraine. These surface exposure ages will be compared with yet-unpublished Neoglacial ages sampled from the same Neoglacial moraine in 2010, as well as lichenometry data from Linné Valley. We use this same technique on boulders found in Linné Valley beyond the extent of the LIAM moraine and upstream of Lake Linné to investigate when Linné Glacier retreated to the LIAM extent in the early Holocene/late Weichselian period to determine if there was a response to Younger Dryas cooling. We plan to examine current mass balance data for Spitsbergen glaciers, and to create equilibrium line altitude reconstructions for Linné Glacier in order to estimate the past climate conditions associated with each moraine-depositing event. The exposure ages from Linné Glacier will also be put in the context of the rigorous lacustrine records available for Lake Linné.

Werner, A. 1993, Holocene moraine chronology, Spitsbergen, Svalbard: lichenometric evidence for multiple Neoglacial advances in the Arctic: The Holocene, v. 3, p. 128-37.
Svendsen, J.I. & Mangerud, J. 1997, Holocene glacial and climatic variations on Spitsbergen, Svalbard: The Holocene, v. 7, p. 45-57.
Mangerud, J. & Svendsen J.I. 1990, Deglaciation chronology inferred from marine sediments in a proglacial lake basin, western Spitsbergen, Svalbard: Boreas, v. 19, p. 249-72.

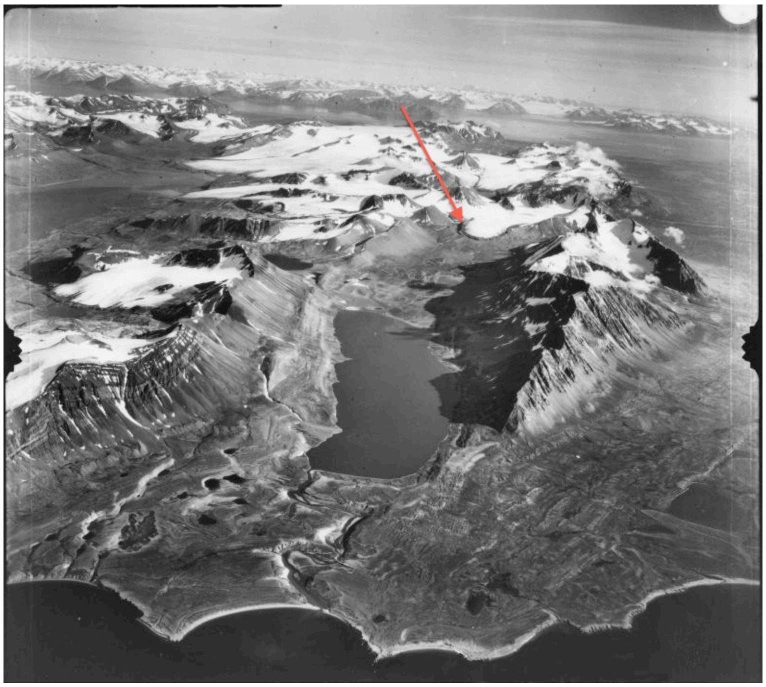

Fig 1. 1936 air photo facing south, down Linné Valley. Note the prominent Little Ice Age moraine. Arrow: approximate location of Fig 2. Norsk Polarinstitutt.

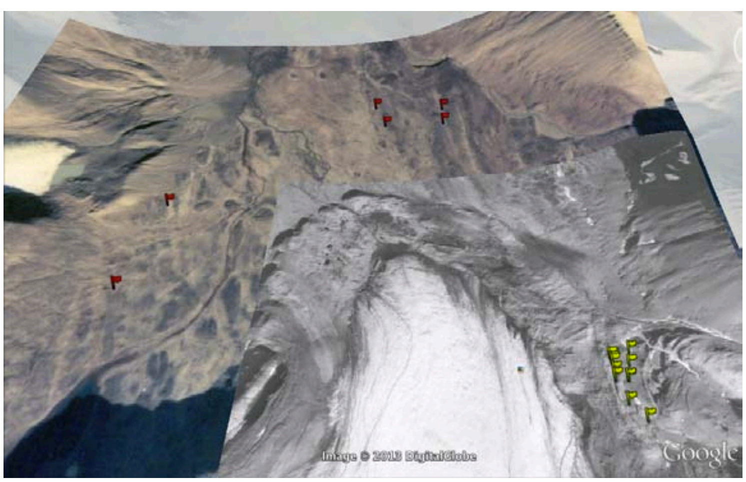

Fig 2. Showing sample sites in Linné Valley. Red flags: early Holocene samples. Yellow flags: Neoglacial samples. Air photos overlaid in Google Earth (Norsk Polarinstitutt, 1969, 1995).

THE EFFECT OF ORBITAL FORCING ON POLAR CLIMATE

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An important aspect of the long term variability of the earth's climate has been the alternating glacial and interglacial conditions which has been present for at least the past 3 million years. Several theories have been proposed associating these cycles with the variation in the Earth's orbital configuration. An improved understanding of the how the Earth's insolation varied in the past with respect to the different orbital forcing factors has provided an opportunity to identify the mechanisms that control these glacial cycles. However, to accurately constrain these proposed mechanisms, climate models need to accurately simulate the effects of orbital forcing leading to glaciation.

The variability of Northern hemispheric versus Antarctic ice sheets have been a mystery for a long time. The most favored hypothesis given by Milankovic says that Northern Hemisphere ice sheets form when obliquity is low and aphelion coincides with Northern Hemisphere summer. Globally integrated proxies such as δ18O record the history of growth and collapse of ice sheets across the world. δ18O records from marine sediments have periods of 41,000 and 21,000 years and an unexplained strong component of 100,000 years. In this study we consider the period from late Pliocene to early Pleistocene (41k world), when the glacial cycles typically lasted 41,000 years and hence is related to the obliquity period. The precession period (21,000 years) is missing from the marine records.

Peter Huybers (2006) proposed Antarctic glacial cycles are linked with the duration of summer rather than the intensity of summer insolation, which controls Northern Hemisphere climate. According to Huybers, the amount of melting an ice sheet undergoes can be explained by integrating the total insolation over summer. This summer metric varies mainly at the obliquity period and is therefore consistent with the δ18O records observed in marine sample from 1-3 million years ago.

In this study, we use a top down approach and physically based models to gain insight into the role of the individual orbital forcing factors, viz. precession, obliquity and eccentricity on glacial termination in both hemispheres. Precession and Obliquity effects on Northern Hemisphere and Antarctic glaciations are studied in isolation in a GCM and nested, high resolution RCM. A preindustrial control simulation is used to provide the boundary conditions for a number of branched runs with a range of modified orbital forcing parameters. The aim is to identify the physical effects of summer duration (defined as sum of positive degree days) versus summer insolation intensity due to precession and obliquity forcing factors. If the summer-duration hypothesis can be verified with physically based models, then the potential exists to reveal useful insights into the origins of the stronger 100,000 kyr variability in the glacial cycles over the last 800,000 years.

Huybers, P. J., 2006, Early Pleistocene glacial cycles and the integrated summer insolation forcing: Science 313, p. 508–511.
Huybers, P.J., Denton, G, 2008, Antarctic temperature at orbital timescales controlled by local summer duration: Nature Geoscience, doi: 10.1038/ngeo311
Raymo, M.E; Huybers, P.J., 2008, Unlocking the mysteries of the ice ages: Nature, v.451, p. 284-285.

HOLOCENE GLACIER FLUCTUATIONS RECONSTRUCTED FROM THE DISTAL GLACIER-FED LAKE KLØSA AT MITRAHALVØYA, SPITSBERGEN

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Earlier work on reconstructing past variations in glacier extent, reconstructed from distal glacier-fed lakes in Scandinavia and the Alps, has been proven successful and has given enhanced understanding of past climate variability on both short and long time-scales. However, few records exist from the Polar Regions and here we present work in progress from a new high-resolution record of a small glacier situated at the Mitrahalvøya (Mitra Peninsula), Spitsbergen. High-resolution reconstructions from these regions are urgently needed in order to get a better understanding of past climate variability, hence relating the present warming of the Arctic to a long-term perspective.

Sediments deposited in the glacier-fed lake Kløsa, were retrieved using a piston corer equipped with a six meter long tube, the upper most sediments and the water-sediment interface were retrieved using a small gravity corer. Prior to coring, the lake was surveyed using Ground Penetrating Radar (GPR), in order to map out the sediment distribution within the lake. The sediments have been analysed using a multi-proxy approach and the analyses included magnetic properties, loss-on-ignition (LOI), dry bulk density (DBD) and geochemical analysis (XRF scanning). During the field campaign we collected sediment samples from the catchment area with the purpose of back tracking the different sediment sources within the catchment area to the stratigraphy in the lake sediments. Age-depth relationship will be achieved through ^{210}Pb dating of the top-most sediments and ^{14}C dating of terrestrial macrofossils.

The stratigraphy in the upper part of core KLP-312 is dominated by a yellowish-brown colour with laminations, followed by a transition into olive-brown colour and later olive-grey colour. Well-known patterns for Holocene intervals can here be seen in the results from LOI and DBD analysis. Supporting this is results from the XRF-scanning, where geochemical elements like Ca and Al are compatible with Holocene intervals. In the lower part of KLP-312 two distinct homogenous units are found, with a coarsening upwards sequence, and are both seen in the magnetic properties of the sediments. An undulating boundary is found between the lowest homogenous unit and the base of KLP-312, where a sharp transition from coarse to finer material with laminations occurs.

We aim to resolve the glacier build up history during the Neoglacial time period and the timing and magnitude of the Little Ice Age. The findings will contribute to the project Shifting Climate States of the Polar Regions (SHIFTS), with the goal to collect data on glacier variability from both the Polar Regions and use the results to examine possible bi-polar climate linkages in a Holocene time perspective.

ICE-MARGIN DYNAMICS OF CIRCUM BAFFIN BAY GLACIERS DURING THE LAST GLACIAL CYCLE

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Precise relationships between high-frequency ice sheet dynamics and late Quaternary climate variability are still poorly understood, notably with regard to their relative timing, rate and causal mechanisms. In this view, the synchronicity of North Atlantic ice sheet instabilities during the last glacial cycle remains uncertain. A question arises if whether or not ice stream instabilities in circum Baffin Bay (e.g., Lancaster Sound, Uummannaq) were in phase with the Hudson Strait surges recorded by the carbonate-rich Heinrich-layers (H-events)? To attempt an answer to this question, Baffin Bay offers a special interest due to the influence of ice streaming activities from the northeastern Laurentide, southern Innuitian and western Greenland ice margins on its sedimentary regimes during glacial times. An exhaustive sedimentological analysis of a piston core from the central Baffin Bay (HU2008-029-016PC – 70°46,14N/-64°65,77W – 2063 mbsl) is used to document the timing and amplitude of such ice margin dynamics during the last 115 ka. Lithofacies analysis and mineralogical assemblages are studied to reconstruct sediment sources (using the SedUnMix program to unravel sediment provenance) and depositional mechanisms (Simon et al., submitted; Andrews and Eberl, 2011).

The core yields a high-resolution record of coarse detrital carbonate (dolomite-rich) layers (Baffin Bay Detrital Carbonate, BBDC) that have been attributed to interstadial episodes in earlier studies (Andrews et al., 1998). These BBDC layers are linked to ice-surging in the northern Baffin Bay (mainly those of the Lancaster Sound ice steam). Based on our new paleomagnetic chronological framework (Simon et al., 2012), we conclude that these episodes are asynchronous with the North Atlantic H-events (Simon et al., submitted; Andrews et al., submitted). We suggest that they are mostly a record of northeastern Laurentide and Innuitian ice streaming pulses in phase with Dansgaard-Oeschger events, or of pervasive ice rafted debris (IRD) delivery processes due to fast-flowing ice streams during periods of larger extent of the northeastern Laurentide ice margin (e.g., end of MIS4). Within these BBDC layers, peaks of coarse sediments with a mineralogical signature from eastern Baffin Island are found episodically indicating a synchronicity of Baffin Island glacier instabilities with northern Baffin Bay ice streaming episodes. Out-of-phase fine-grained glaciomarine sediments with a mineralogical signature from western Greenland, linked to Uummannaq ice streaming activity, are interbedded. This sediment signature illustrates periods of large extension of the Uummannaq ice stream onto the outer-shelf during cold intervals (i.e., MIS5d-b and MIS4, MIS2) and most likely to the shelf edge during the Last Glacial Maximum (LGM).

These results suggest that during the last glacial cycle, the northeastern Laurentide and southern Innuitian ice streams were sensitive to high frequency climate fluctuations such as the Dansgaard-Oeschger events, while the western Greenland margin was more sensitive to large-scale climatic/oceanic reorganizations such as relative sea level changes and/or advection of warmer Atlantic waters into the bay.

Andrews J.T., Kirby M., Aksu A.E., Barber, D.G., Meese, D., 1998, Late Quaternary Detrital Carbonate (DC-) layers in Baffin Bay marine sediments (67°-74° N): correlation with Heinrich events in the North Atlantic? Quaternary Science Reviews, 17, 1125-1137.
Andrews, J.T., Eberl, D.D., 2011. Surface (sea floor) and near-surface (box core) sediment mineralogy in Baffin Bay as a key to sediment provenance and ice sheet variations: Canadian Journal of Earth Science, 48, 1307-1328.
Andrews, J.T., Gibb, O., Jennings, A.E., Simon, Q. (submitted). Variation in the provenance of sediment export from ice sheets surrounding Baffin Bay during MIS 2 and 3 and export to the Labrador Sea: Site HU2008029-0008, Davis Strait.
Simon, Q., St-Onge, G., Hillaire-Marcel, C., (2012). Late Quaternary chronostratigraphic framework of deep Baffin Bay glaciomarine sediments from high-resolution paleomagnetic data: Geochemistry Geophysics Geosystems, 13, Q0AO03, doi:10.1029/2012GC004272.
Simon, Q., Hillaire-Marcel, C., St-Onge, G., Andrews, J.T. (submitted). Laurentide, Greenland and Innuitian ice margin dynamics during the last glacial cycle as reconstructed from changes of mineralogical assemblages and physical properties in a deep Baffin Bay sediment core.
Simon, Q., Hillaire-Marcel, C., St-Onge, G. (submitted). Detrital carbonate events in Baffin Bay during the last climatic cycle: Their timing vs. the Greenland Dansgaard-Oeschger cycles and North Atlantic Heinrich events.

SUSTAINABLE BUT EXTINCT MEDIEVAL EUROPEAN SOCIETY IN GREENLAND. CLIMATE INFLUENCED CHANGING ECONOMIC STRATEGIES OF THE NORSE SETTLEMENTS.

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Recent archaeological excavations of Norse sites in Greenland concentrated on midden deposits in the Eastern Settlement, to better understand the subsistence and economic strategies of this part of the colony. Multiple excavations resulted in zooarchaeological collections that are still under analysis, but preliminary results indicate complex patterns of sustainable, long term natural resource management in this part of Norse Greenland.

The large ratios of seal bones in the archaeological contexts (both coastal and far inland) suggest a large-scale, communally organized hunt. In the natural environment, the numbers of available seals (migratory and local species) tend to change periodically on a local scale, usually caused by various climatic shifts. Results of such variations have been observed in the zooarchaeological record, creating an excellent proxy data for reconstruction of the human-environment interactions through time. This archaeofauna reflects on past Norse economic organization and communal management of natural resources over time, with a major change caused by the 13th Century climatic fluctuation and changing geopolitics of mainland Europe.

Dugmore, A.J., Keller, C. and McGovern, T.H. 2007a 'The Norse Greenland settlement: Reflections on climate change, trade and the contrasting fates of human settlements in the Atlantic islands' Arctic Anthropology 44 (1), 12-37

Astrid E.J. Ogilvie, James M. Woollett, Konrad Smiarowski, Jette Arneborg, Simon Troelstra, Anton Kuijpers, Albina Pálsdóttir, and Thomas H. McGovern. 2009. Seals and Sea Ice in Medieval Greenland. Journal of the North Atlantic 2(1): 60–80.

DECIPHERING CLIMATE SIGNALS FROM THE INHERENT COMPLEXITIES OF LAKE SEDIMENTS: IT IS AS CLEAR AS MUD!

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Due to the lack of direct, long-term monitoring data, paleoenvironmental approaches are increasingly used to track the long-term effects of both natural and anthropogenically induced environmental changes in polar regions and elsewhere. As lakes and ponds archive an important library of physical, chemical, and biological information in their sediments, paleolimnology has progressively played a critical role in deciphering the natural modes of long-term and more recent environmental change.

We must, however, acknowledge that we live in a multiple-stressor world, and so disentangling the effects of climate from other stressors can be difficult. In this keynote address, I argue that this is challenging, but not insurmountable – provided that we maintain a strong foundation in physics, chemistry and biology, and appreciate that various filters can complicate our paleoenvironmental interpretations. To put it more plainly, we cannot forget the limnology in paleolimnology, and we must further appreciate that limnology itself requires a fundamental understanding of physics, chemistry and biology. Similarly, when using biological proxy data, at least a rudimentary knowledge is required of the physiology and ecology of the indicators used. Common sense and a strong scientific foundation, rather than just statistical inferences, should help guide our interpretations.

Oddly, despite considerable progress in our understanding of the physiology and ecology of key indicator proxies, it appears to be increasingly "fashionable" to state that fundamental processes are very poorly understood or have not been studied (a frequent phrase it seems on grant proposals). My thesis is that considerable progress has been made in these areas due to efforts of limnologists, physiologists, chemists, ecologists, and so forth, but that this information has not been fully absorbed (or possibly not understood) by segments of the paleoenvironmental community.

Paleoenvironmental assessments are also challenged by the fact that, as we are a historical and inferential science, true experimental hypothesis testing is rarely possible. Nonetheless, a reasonable alternative is to conduct carefully designed comparative paleoenvironmental studies, where a priori questions can be answered using the paleolimnological record. In this talk, I will show how we have used such approaches to demonstrate that striking biological changes recorded in recent lake sediments are consistent with recent climate warming (e.g. Smol and Douglas, 2007a). Beginning with our first study that demonstrated this comparative approach in the Arctic (Douglas et al., 1994) to our most recent work, I will argue that recent ecological shifts are unprecedented, at least over the Holocene and likely longer, and that climate warming is the primary driver of these changes. I shall then dovetail these paleolimnological observations with approximately 3 decades of direct limnological monitoring, showing how predications made from the paleolimnological record have now been realized, most notably the desiccation of some of our Cape Herschel (and other) study sites due to increased evaporation rates (Smol and Douglas, 2007b). Moreover, hemispheric-scale comparisons, including both Arctic and temperate ecosystems, using similar paleolimnological approaches, can be instructive (e.g., Rűhland et al., 2008). Comparative approaches can also be used to show that, for example, a recent storm surge in the western Arctic that flooded over 20 km inland of the Mackenzie Delta region was also unprecedented in the ecology of the affected lakes (e.g., Pisaric et al., 2011; Vermaire et al., 2013).

These are exciting times for the paleoenvironmental sciences such as paleolimnology. We should not squander our opportunities by not taking advantage of the considerable progress made in other fundamental areas of science. Additionally, we should strive to always use the most appropriate and novel approaches for our investigations.

Douglas, M.S.V., Smol, J.P., and Blake, W., Jr. 1994. Marked post-18th century environmental change in high Arctic ecosystems. Science v. 266, p. 416-419.

Pisaric, M.F.J., Thienpont, J.R., Kokelj, S.V., Nesbitt, H., Lantz, T.C., Solomon, S., and Smol, J.P. 2011. Impacts of a recent storm surge on an Arctic delta ecosystem examined in the context of the last millennium. Proceedings of the National Academy of Sciences v. 108, p. 8960-8965.

Rühland, K., Paterson, A.M. and Smol, J.P. 2008. Hemispheric-scale patterns of climate-related shifts in planktonic diatoms from North American and European lakes. Global Change Biology v. 14, p. 2740-2745.

Smol, J.P. and Douglas, M.S.V. 2007a. From controversy to consensus: making the case for recent climatic change in the Arctic using lake sediments. Frontiers in Ecology and the Environment v. 5, p. 466-474.

Smol, J.P. and Douglas, M.S.V. 2007b. Crossing the final ecological threshold in high Arctic ponds. Proceedings of the National Academy of Sciences v. 104, p. 12395-12397.

Vermaire, J.C., Pisaric, M.F.J., Thienpont, J.R., Mustaphi, C.C., Kokelj, S.V., and Smol, J.P. 2013. Arctic climate warming and sea ice declines lead to increased storm surge activity. Geophysical Research Letters DOI: 10.1002/grl.50191.

ENVIRONMENTAL AND PALEOMAGNETIC SECULAR VARIATION CHANGES DURING THE HOLOCENE IN BAFFIN BAY: A HIGH-RESOLUTION STUDY BASED ON THE PHYSICAL AND MAGNETIC PROPERTIES OF FOUR PISTON CORES

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The physical and magnetic properties of four piston cores (HU2008-029-034PC, -038PC, -042PC and -070PC) sampled on board the CCGS Hudson (Fig. 1) in Northern (Smith Sound and Jones Sound) and Eastern (Disko Bugt) Baffin Bay (Fig. 2) were analyzed in order to reconstruct the environmental and paleomagnetic secular variation changes during the Holocene. The radiocarbon dating revealed sedimentation rates of up to 136 cm/ka. The results highlight four sedimentary facies that correspond to major Holocene climatic changes: the Younger Dryas, the last deglaciation, the climatic optimum and the Neoglacial period. In addition, two cores (HU2008-029-038PC and -070PC), present the signal of two local climatic events during the Neoglacial period. Finally, three of the four cores (HU2008-029-034PC, -042PC and -070PC) have magnetic properties that meet the quality criteria for recording directional variations of the geomagnetic field. Moreover, comparisons with other cores fromthe Chukchi Sea indicate that some millennial to secular variations are similar on both sides of the Canadian Arctic, suggesting that the geomagnetic field behavior is similar up to at least 76°N in the low Canadian Arctic.

Fig 1. Piston coring on board the CCGS Hudson in Baffin Bay. Credit: Quentin Simon

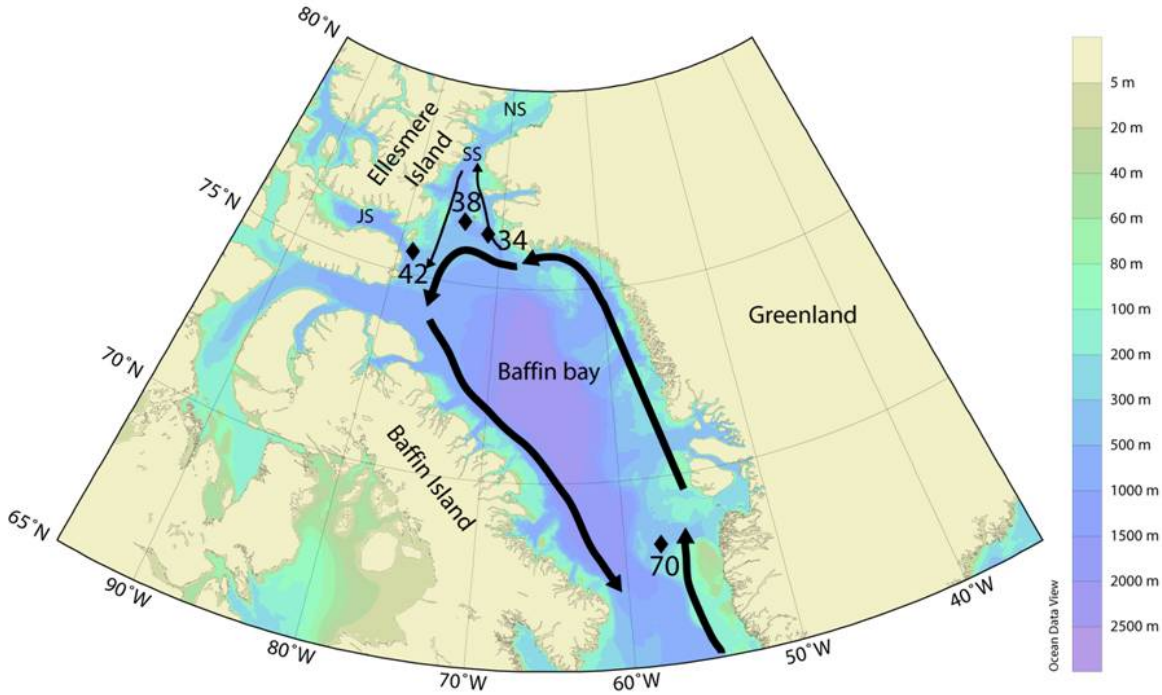

Fig 2. Sampling location of the studied piston cores and the major surface currents in the area.

USING CLAY MINERALOGY TO ANALYZE SEDIMENT CONTRIBUTIONS TO LINNÉVATNET, SPITSBERGEN, SVALBARD

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As global change becomes more pronounced, arctic regions are increasingly significant in climate studies due to their sensitivity and rapid response to environmental changes. Svalbard, an arctic archipelago located at 78° N, provides ideal subjects for studying climate history and the impacts of climate change given the abundance of glaciers and continuous permafrost. This study was conducted in Western Spitsbergen, Svalbard, as part of a larger project examining climate and sedimentation in the Linnédalen glacio-fluvial-lacustrine system. Sedimentation records in such environments can serve as important proxies of past climate as well as indicators of current climate change, particularly in the preservation of varves. However, in order to interpret such sedimentation patterns, both primary and secondary sources of sediment must be accounted for.

Soliflucting lobes of relict marine terraces around Linnévatnet were examined and compared to lake cores to identify their potential sediment contribution. Mapping and classification of the shoreline was conducted to identify areas most likely to be heavily impacted by the solifluction source (FIg. 1). Short-term sediment traps were deployed near suspected sediment sources for the summer 2012 field season to attempt to gauge the amount of sediment entering the lake during the prescribed time period. Additionally, 13 grab samples were collected from suspected source areas and 5 cores taken from the lake. Sieve and laser grain-size analyses were performed on the source samples to further characterize the potential sources. Sieve analysis in the -3 to 3ϕ range yielded an anomalous lack of medium sand (1-2ϕ) in the solifluction source samples, possibly to be due to the ease of entrainment of this fraction. Laser analysis of solifluction samples in the -1 to 14ϕ range generally revealed unimodal distributions with medium grain sizes of 5-6ϕ. Solifluction grain size distributions generated through both methods reflect the evidence of multiple depositional environments. Mineral composition of the lake cores and the clay fraction of the source samples was analyzed using X-ray diffraction. Preliminary analysis of the clay mineralogy does not indicate individual source signatures, potentially due to the focus on the solifluction clay fraction. Overall results reveal the amount of lakeshore undergoing solifluction, characterize the source and point to areas of interest to consider for future studies.

Asikainen, C.A., Francus, P. and Brigham-Grette, J., 2007, Sedimentology, clay mineralogy and grain-size as indicators of 65 ka of climate change from El'gygytgyn Crater Lake, northeastern Siberia: Journal of Paleolimnology v. 37, p. 105-122.

Boyle, J.F., Rose, N.L., Appleby, P.G., and Birks, H.J.B., 2004, Recent environmental change and human impact on Svalbard: the lake-sediment geochemical record: Journal of Paleolimnology v. 31, p. 515-531.

Ingólfsson, Ó, 2011, Fingerprints of Quaternary glaciations on Svalbard: Geological Society of London Special Publication v. 354, p. 15-31.

Harris, C., Kern-Luetschg, M., Christiansen, H.H. and Smith, F., 2011, The role of interannual climate variability in controlling solifluction processes, Endalen, Svalbard: Permafrost and periglacial processes, published online in Wiley Online Library, available at wileyonlinelibrary.com.

Matsuoka, N., 2001, Solifluction rates, processes and landforms: a global review: Earth-Science Reviews v. 55, p. 107–134.

Svendsen, J.I., and Mangerud, J., 1997, Holocene glacial and climatic variations on Spitsbergen, Svalbard: The Holocene v. 7, p. 45-57.

Svendsen, J.I., Mangerud, J., and Miller, G.H., 1989, Denudation rates in the arctic estimated from lake sediments on Spitsbergen, Svalbard: Palaeogeography, Palaeoclimatology, Palaeoecology, v. 76, p. 153-168.

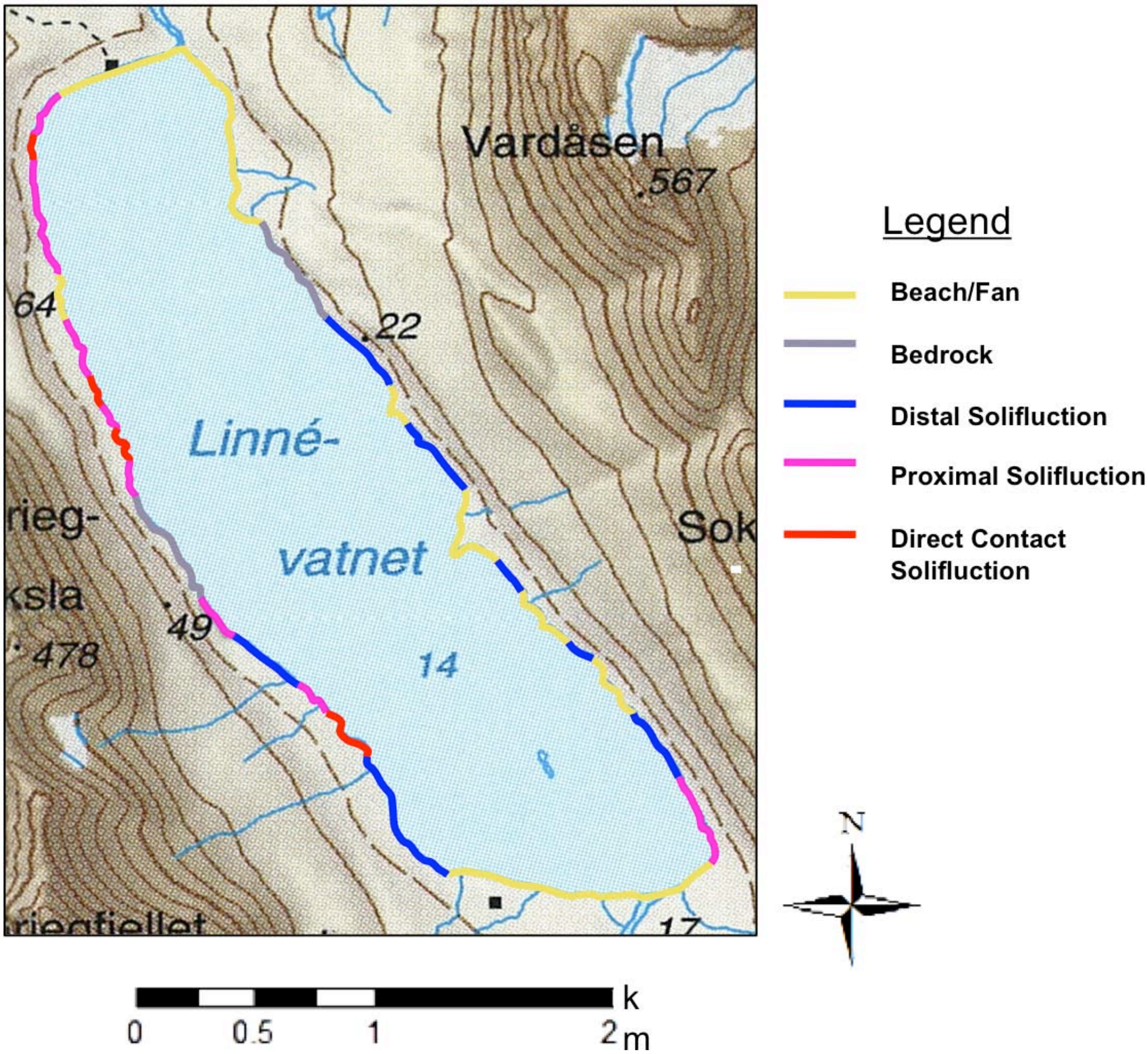

Fig 1. Shoreline Classification of Linnévatnet.

NORTH-ATLANTIC HOLOCENE CLIMATE VARIABILITY REFLECTED IN THE DYNAMICAL RESPONSE OF NORWEGIAN MARITIME GLACIERS

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[8];

Numerous glacier reconstructions have been produced in Norway during the past decade based on multi-proxy analyses of sediments deposited in distal glacier-fed lakes in combination with direct dating of terminal moraines and modern mass-balance measurements. These records have provided insight into Equilibrium Line Altitude (ELA) fluctuations and winter-precipitation changes throughout the Holocene (the last ~11,700 years) from different locations along a north-south transect spanning from 60 to 70 degrees north. The methodology used for reconstructing glacier records has evolved over time, however, which may complicate comparative studies between regions and single sites.

Therefore, as part of a synthesis project under the Bjerknes Centre for Climate Research focused on Holocene climate variability in the North-Atlantic region, all available multi-proxy glacier records from Norwegian maritime glaciers have been re-analyzed using a standardized approach. This includes updated age-depth models, numerical analyses (principal component analysis, PCA), and in some cases sediment provenance studies in the lake catchments (Vasskog et al., 2012). The methodology is presented here with examples from recent studies in the Nordfjord region (62 degrees north). Glaciers of different sizes, morphologies, and orientations are included in the analysis, and on timescales ranging from decades to centuries they are seen to react differently to climate forcing throughout the Holocene. By including such a diverse range of glaciers in an integrated study we hope to gain additional knowledge of Holocene climate dynamics in the North-Atlantic region, e.g. connected to large scale atmospheric circulation changes.

The resulting analyses pinpoint the impact of orbital forcing and long-term northern hemisphere cooling, the effect of large-scale atmospheric circulation changes at 4 ka BP and 2.7 ka BP, and the effect of changes in the ocean heat transport during the “Little Ice Age” at high northern latitudes. Preliminary results from the maritime ice cap Folgefonna (60 degrees north) highlight how the asynchronous response of different outlet glaciers may potentially be used to elucidate past changes in prevailing wind direction and atmospheric circulation patterns over the past 1500 years.

Vasskog, K., Paasche, Ø., Nesje, A., Boyle, J. F., and Birks, H. J. B., 2012, A new approach for reconstructing glacier variability based on lake sediments recording input from more than one glacier: Quaternary Research v. 77, p. 192-204.

THE GLACIOTECTONIC HISTORY OF THE WORTH POINT STRATIGRAPHIC SEQUENCE, BANKS ISLAND, NT, CANADA.

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Hill-hole pairs, comprising an ice-scooped basin and an ice-pushed hill, cluster in a belt along the west coast of Banks Island, NT. Ongoing coastal erosion at Worth Point, southwest Banks Island, has exposed a section (6 km long and ~30 m high) through an ice-pushed hill that was transported ~2 km from a corresponding ice-scooped basin to the southeast. The exposed stratigraphic sequence is polydeformed and comprises folded and faulted rafts of Early Cretaceous and Late Tertiary bedrock, preglacial organic rafts, Quaternary glacial sediments, and buried glacial ice. Three distinct structural domains can be identified within the stratigraphic sequence that represent proximal to distal deformation in an ice-marginal setting. Complex thrust sequences, interfering fold-sets, brecciated bedrock and widespread shear structures superimposed on this ice-marginally deformed sequence record subsequent deformation in a pervasive subglacial shear zone.

Analysis of cross-cutting relationships within the stratigraphic sequence combined with OSL dating indicates that the Worth Point hill-hole pair was deformed during three separate glaciotectonic events. 1) Initial ice sheet advance constructed the hill-hole pair and glaciotectonised the strata ice-marginally, producing a proximal to distal deformation sequence. A concurrent marine transgression resulted in extensive reworking of the lowermost strata and the deposition of a glaciomarine diamict. 2) A readvance overrode the ice-marginally glaciotectonised strata (including the glaciomarine diamict) and redeformed the strata in a subglacial shear zone; overprinting complex deformation structures and depositing a ~20 m thick glaciotectonite. Outwash channels that incise into the subglacially deformed strata record a deglacial marine regression, while the aggradation of glaciofluvial sand and gravel in the channels records a subsequent marine transgression. 3) A largely non-erosive ice margin overrode the strata for a final time when relative sea level was at or below modern, deforming only the most surficial units and depositing till.

The detailed analysis and interpretation of the polydeformed stratigraphic sequence at Worth Point provides an exceptional insight into the dynamics of ice-marginal and subglacial glaciotectonics in permafrost terrain, as well as recording regional glacial and sea level histories. The reinterpreted stratigraphy fundamentally rejects the widely acknowledged paleoenvironmental history of Worth Point based on fieldwork conducted several decades earlier.

HOLOCENE SEDIMENTARY ENVIRONMENTS IN SMEERENBURGFJORDEN, SPITSBERGEN

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Multi-proxy analyses of six sediment cores and analyses of swath bathymetry and chirp data were integrated to elucidate the Holocene sedimentary processes and palaeoenvironments in Smeerenburgfjorden, northwest Spitsbergen. Three basins separated by two sills define the present-day large-scale bathymetry. A transverse ridge in the innermost part of the fjord represents the Little Ice Age (LIA) maximum position of Smeerenburgbreen. Slide scars along the fjord sides and mass transport deposits in the basins indicate repeated mass wasting. Recessional moraines deposited during the last deglaciation suggest a mean annual retreat rate of 140 m/year. Another set of recessional moraines deposited between the maximum LIA position of Smeerenburgbreen and its present day terminus indicate a mean retreat rate of the ice front of ~87 m/year. Strong out-fjord decreasing trends in magnetic susceptibility and Fe-content indicate that these properties are related to material originating from the Hornemantoppen granite in the catchment of Smeerenburgbreen and are, thus, useful proxies for the reconstruction of the activity of the glacier. Relatively little ice rafting, most likely related to warmer surface water conditions, occurred between 8650 and 7350 cal. years BP. Ice rafting from both sea-ice and icebergs increased around 6200 cal. years BP and peaked at ~5200 cal. years BP, associated with a regional cooling. Smeerenburgbreen became more active around 2000 cal. years BP. It probably retreated during the Roman Warm Period (50 BC – AD 400) and advanced during the Dark Ages Cold Period (AD 400 – 800). From AD 1300 – 1500 (late Medieval Warm Period), ice rafting, sedimentation rates and productivity increased in the inner fjord. The Little Ice Age was characterised by reduced ice rafting, possibly linked to an increased sea-ice cover suppressing iceberg drift. An increase in Ice Rafted Debris (IRD) commencing around AD 1880 is suggested to represent the beginning of Smeerenburgbreen's retreat from its LIA maximum towards its present position.

DID NORTHERN HEMISPHERE GLACIATION BEGIN WITH THE NORTH PACIFIC OCEAN?

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Prior to the Pliocene-Pleistocene climate transition, warm climate extended globally, especially toward the arctic. Throughout most of the Pliocene, ice sheets were largely restricted to Antarctica, but toward the end of this Epoch, periodic Northern Hemisphere glaciations (NHG) began, extending toward the mid-latitudes by 2.7 Ma. On orbital timescales, obliquity began to pace high latitude climate by ~3 Ma. Because obliquity affects the equator-to-pole insolation gradient, changes in poleward heat transport should have been instrumental in shaping an obliquity-paced climate. Atmospheric carbon dioxide (CO2) reconstructions and numerical modeling results point to decreasing atmospheric CO2 concentrations to explain the transition toward increasingly severe NHG beginning at 2.7 Ma.

Recent evidence points to the under-studied northwest Pacific Ocean to explain changes in both atmospheric CO2 concentrations and poleward heat transport across the Plio-Pleistocene climate transition. Here we present a suite of recently generated sea surface temperature and productivity reconstructions from Ocean Drilling Program Site 1208 (36.1°N, 158.5°E; Figure 1) in the Kuroshio Current Extension (KCE), the first to cover this critical ocean region and interval at high resolution. Alkenone mass accumulation rate (MAR; Venti, 2012) provides a primary productivity proxy (not shown). Alkenone unsaturation ratio (UK'37; Venti, 2012) provides a mean annual sea surface temperature (SST) estimate (Figure 2b). Planktic foraminifer (Globigerinoides (Gs.) ruber) δ18O measurements (Venti and Billups, in press; not shown) reflect summer/fall sea surface hydrography (temperature and salinity). To isolate a surface hydrographic signal in the planktic foraminifer δ18O record, (Gs. ruber Dδ18O; Venti and Billups, in press; Figure 2a) we subtract an approximation of ice-volume-related δ18O change using the section's benthic foraminifer δ18O record (Venti and Billups, 2012) and the deep ocean δ18O reconstruction of Sosdian and Rosenthal (2009). Benthic foraminifer δ18O values provide excellent age control via tuning to the global δ18O stack of Lisiecki and Raymo (2005), and a high-latitude climate index by recording global ice volume and deep-ocean temperature change (Figure 2d; Venti and Billups, 2012).

Together alkenone MAR and sediment reflectance results illustrate increased primary productivity and nutrient availability ahead of obliquity-paced glaciations beginning at 2.7 Ma. Mean alkenone MAR increased 2-3-fold at 2.7 Ma, reflecting increased primary productivity (Venti, 2012; not shown). Leading the 41-kyr glacial cycles by 2 kyr +/- 1 kyr, primary productivity proxy values increased by an order of magnitude (Venti, 2012), suggesting that the North Pacific Ocean acted as a carbon sink, decreasing atmospheric CO2 concentrations to cool climate and promote glaciations. Similarly, sediment reflectance (Shipboard Scientific Party, 2002; Figure 2c) decreased at 2.7 Ma (from mean values of 63.7% to 57.5%), and on orbital timescales, ahead of the obliquity-paced glacial cycles by 1 kyr +/-1 kyr, indicating increased opal versus carbonate sedimentation. Venti and Billups (2012) investigated carbonate dissolution through foraminifer preservation and attributed these sediment reflectance patterns to changes in primary productivity, concluding that macronutrient (dissolved silica) concentrations increased with NHG onset at 2.7 Ma and preceding subsequent glaciations. The KCE marks the southern margin of the North Pacific high-nutrient low-chlorophyll region. Thus, the observed changes in productivity there may have been associated with significant reductions in atmospheric CO2 concentrations, which would have promoted NHG.

Sea surface temperature reconstructions from the KCE suggest increased seasonality throughout the NW Pacific at 2.7 Ma, consistent with previous sea surface reconstructions in the subarctic (Venti, 2012; Figure 2a, b). Decreased Gs. ruber Dδ18O values after NHG onset at 2.7 Ma suggests increased summer

KCE temperatures, and thus increased heat availability in the warm ocean current (Figure 2a; Venti and Billups, in press). On orbital timescales, the summer hydrography reconstruction varies at precession and eccentricity frequencies, but not with obliquity (Venti and Billups, in press). In contrast, alkenone-based estimates show a long-term decrease in mean annual KCE SST (21°C to 19°C) with NHG onset at 2.7 Ma (Figure 2b; Venti, 2012). On orbital timescales, UK'37 values correspond closely to obliquity-paced high-latitude climate change (Venti, 2012). Cooling of the KCE during glacial intervals also corresponds to cooling of the tropical sea surface (Venti, 2012). KCE and tropical SST cycles were synchronized, leading ice-volume changes by 1 kyr +/- 1 kyr (Venti, 2012). This inferred parallel long-term relationship between these reciprocal regions of ocean-atmosphere heat exchange suggests that heat transfer from the northwest Pacific sea surface to the atmosphere was integral to the obliquity pacing of NHG (Venti, 2012). In the modern ocean, the KCE is a major locus of ocean-atmosphere heat transfer, specifically in winter, when strengthened westerly atmospheric flow of the cold, dry air mass over East Asia intersects with the warm water in the western boundary current (Figure 1). Intensification of this process preceding glaciations would have contributed to ice sheet formation directly by contributing heat and moisture to the atmosphere for snowfall in North America.

Intensification of the East Asian winter monsoon, both over the long term (with NHG onset at 2.7 Ma) and at the obliquity scale during individual glaciations likely played a key role in the observed increases in primary productivity and sea surface cooling. In the modern ocean, westerly winds enhanced by the cold, dry air mass over East Asia (the Siberian High) remove >100 W/m2 from the KCE during Northern Hemisphere winter (Da Silva et al., 1994), decreasing sea surface temperatures by 10°C with respect to the summer maximum (Figure 1). These westerly winds and the dust carried therein represent the North Pacific's primary micronutrient source, thereby providing a mechanism to explain the observed increases in primary productivity. With respect to productivity increases, invoking a micronutrient delivery mechanism like the East Asian winter monsoon explains the orbital-scale lead of primary productivity increases ahead of lithology (sediment reflectance; Shipboard Scientific Party, 2002) and SST cycles that suggest sufficient macronutrient availability. In the case of cyclical SST cooling, invoking a seasonal process like the winter monsoon is necessary to explain why only certain NW Pacific SST proxies—KCE alkenones (Venti, 2012) and subarctic Globigerina bulloides δ18O values—indicate cooling at 2.7 Ma, ahead of ice-volume increases at the orbital scale (Venti, 2012). In contrast, NW Pacific summer hydrography—KCE Gs. ruber Dδ18O (Venti and Billups, in press) and subarctic alkenone-based estimates— indicate increased SSTs at 2.7 Ma and show limited sensitivity to obliquity (Venti and Billups, in press), illustrating weaker ties to arctic climate change.

Da Silva, A., Young-Molling, A.C., and Levitus S., 1994, Atlas of Surface Marine Data 1994, vol. 6, NOAA Atlas NESDIS, v. 15, Natl. Oceanic and Atmos. Admin., Silver Spring, MD.

Lisiecki, L. E. and M. E. Raymo, 2005, A Pliocene-Pleistocene stack of 57 globally distributed benthic δ18O records: Paleoceanography, v. 20, PA1003, doi:10.1029/2004PA001071.

Shipboard Scientific Party, 2002, Leg 198 summary, In Bralower T. J., I. Premoli Silva, and M. J. Malone: Proc. Ocean Drill. Program, Init. Rep., v. 198: College Station, TX (Ocean Drilling Program), p. 1-84.

Sosdian, S. and Y. Rosenthal, 2009, Deep-sea temperature and ice volume changes across the Pliocene-Pleistocene climate transtitions: Science, v. 325, p. 306-310.

Venti, N. L., 2012, The role of the Kuroshio Extension in the Pliocene-Pleistocene climate transition: ProQuest Dissertations and Theses, (Doctoral Dissertation), University of Delaware, pp. 181.

Venti, N. L., and Billups, K., 2012, Stable-isotope stratigraphy of the northwest Pacific during the Pliocene-Pleistocene climate transition: Palaeogeog., Palaeoclimatol., Palaeoecol., v. 326-328, p. 54-65, doi:10.1016/j.palaeo.2012.02.001.

Venti, N. L., and Billups, K., in press, Surface water hydrography of the Kuroshio Extension during the Pliocene-Pleistocene climate transition: Mar. Micropaleontol., doi: 10.1016/j.micro2013.02.004.

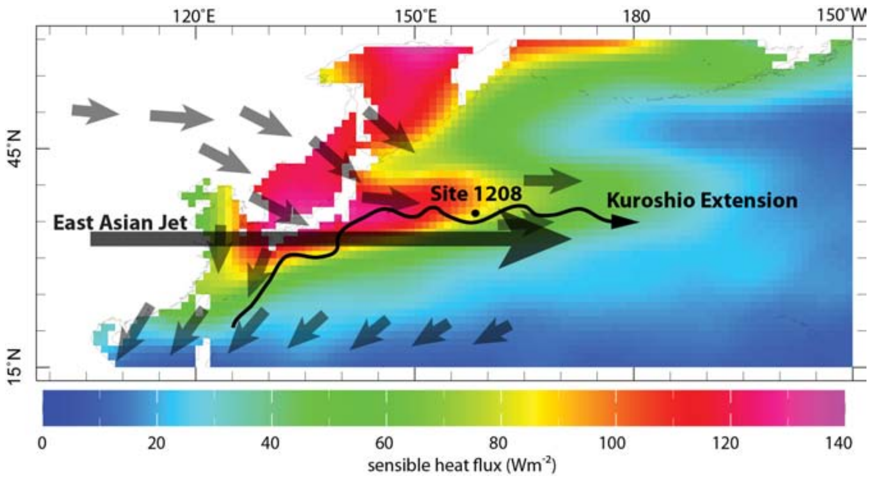

Fig 1. Site 1208 in the North Pacific. The basemap shows sensible ocean-atmosphere heat flux for January (Da Silva et al., 1994). The sinuous thin black arrow illustrates the position of the Kuroshio Current Extension. Transparent light gray arrows are scaled to approximate magnitude and direction of January surface air flow; the heavier gray arrow illustrates the position of the high-altitude (200 mb) East Asian westerly jet in NH winter.

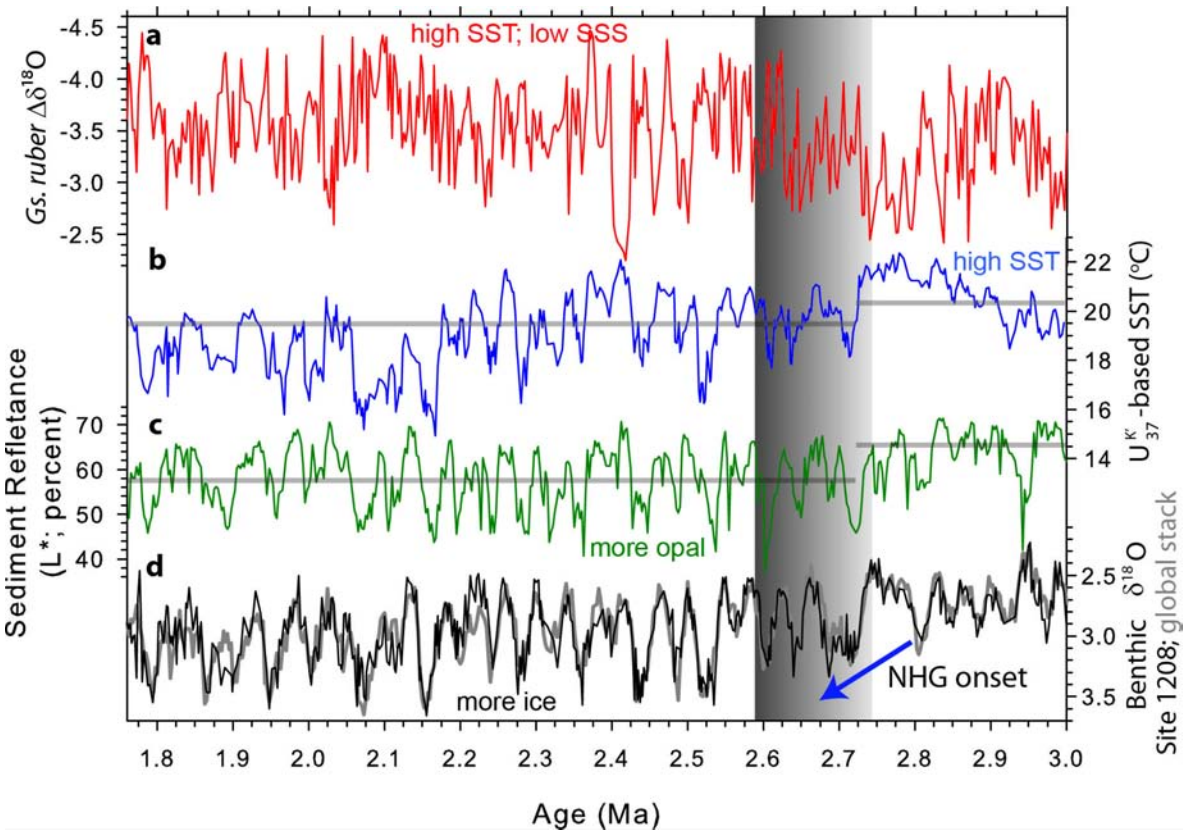

Fig 2. North Pacific Plio-Pleistocene records from KCE Site 1208. Reconstructed summer/fall sea surface hydrography (a; salinity and temperature; Gs. ruber Dδ18O; Venti and Billups, in press), mean annual SST (b; alkenone UK'37; Venti, 2012), opal content (c; sediment reflectance; Shipboard Scientific Party, 2002), and high-latitude climate (d; benthic foraminifer δ18O; black; Venti and Billups, 2012 tuned to the global δ18O stack; gray; Lisiecki and Raymo, 2005). Gs. ruber Dδ18O (a) is calculated by subtracting a 5-point running mean of benthic foraminifer δ18O values from Gs. ruber δ18O values to correct for changes in ice volume (Venti and Billups, in press). The blue arrow and shaded interval (c) indicates onset of Northern Hemisphere glaciations. Gray transparent horizontal lines (a and b) indicate reconstructed alkenone SST and sediment reflectance mean before and after this event.

COLOR REFLECTANCE SPECTROSCOPY AND MINERALOGICAL ANALYSIS FROM LAKE EL'GYGYTGYN, NE SIBERIA, DURING MARINE ISOTOPE STAGES 8 – 12

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Sediment cores ICDP 5011-1collected from Lake El'gygytgyn (67°29.98'N, 172° 6.23E), located in north east Russia, represent a 3.58 Ma terrestrial climate record representative of the western Arctic. The focus of this study is to determine the relationship between traditional sediment core analysis methods with emerging techniques used for core analysis, and to validate these new approaches. Particle size analysis and bulk clay mineralogy are being conducted to determine how temporal variability and physical properties as compared to core color analysis and biomarker investigations. Core color analysis, or reflectance spectroscopy, is a relatively new technique which is both rapid and non-destructive. Reflectance core scanning provides a dataset of the color spectrum ranging from the near infrared to near ultraviolet, captured in 10 nm reflectance bands at high resolution (1mm) intervals. Using published algorithms and ratios, proxy records can be constructed from the color data which correlate well with proxies such as total organic carbon (TOC), pollen, and global δ18O records as well as facies changes. Samples for this study were taken from a 315m long core, recovered in 2009. Eighteen sample intervals for proxy development were taken at 1cm resolution and spanning approx. 200 kyrs from Marine Isotope Stages 8 through 12 (275-475 Ka). At this spacing, all four sedimentological facies identified in the core were characterized including: massive, wavy laminated/clast rich, fine clay laminations, and red laminations. Particle size and color analysis distinguish these different facies, and validate the physical facies interpretations. Sedimentological analysis indicates finer grain sizes during glacial periods, with the largest grain size ranges in the red laminated interglacial facies. Furthermore, calculated hue values, derived from core scanning L,*a* and b* values, show remarkable correspondence to global δ18O records. Initial principle component analysis of these color datasets (hue) and XRF data sets indicates elemental iron explains a large portion of the color variability, but further mineralogical analysis is required and currently being investigated. Overall, the rapidity of color reflectance spectroscopy and the validation of color scanning could easily produce paleo-climate proxy records from long sediment records such as Lake El'gygytgyn. Using GDGTs we are investigating the possible calibration of color reflectance for estimating paleotemperatures.

USING WESTERN GREENLAND ISOLATION BASINS TO CONSTRAIN MIDDLE HOLOCENE ICE SHEET AND RELATIVE SEA LEVEL CHANGES

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Of interest among Quaternary geologists is the Holocene Thermal Maximum (HTM), which occurred roughly 9,000–5,000 years before present (Kaufman et al. 2004). Here we use two isolation basins informally named Igdlûnguaq lake and west Igdlûnguaq lake ("Iggy" and "west Iggy" lakes for short) along the southern shore of Torssukátak Fjord, western Greenland, to record relative sea level (RSL) change in response to the retreat of the Greenland Ice Sheet during the Holocene. Isolation basins are natural topographic depressions, which at various times in their history may become inundated or isolated from the sea due to changes in RSL. Due to their dynamic histories, isolation basins provide a valuable sedimentary record that can be used for tracking RSL changes (Long et al., 2011).

West Iggy Lake (Figure 1; Figure 2c) is located at 69° 58' 20.50" N; 50° 22' 57.79" W, ~90 km north of Jakobshavn Isbræ along the coast of western Greenland. The lake has no significant inflow, receiving precipitation runoff from the surrounding environment, with a bedrock-controlled outflow in its northwestern corner at 12 m asl. Iggy Lake (Figure 1; Figure 2b) is located at 69° 58' 28.00" N; 50° 21' 08.24" W, ~1 km to the east of West Iggy Lake. The inflow to Iggy Lake is from a stream carrying meltwater directly from the Greenland Ice Sheet (2.05 km to the east). The stream forms a delta on the eastern side of the lake, with a bedrock-constrained outflow at the western margin at 2 m asl. Two sediment cores were collected from the West Iggy Lake basin, 12WIG-2 and 12WIG-4; the cores are 85 cm and 148 cm in length, respectively. A single 235-cm-long core, 12IGY-4, was collected from Iggy Lake. In addition to the sediment cores, a macrofossil sample (marine shell) was collected from a raised marine deposit (12GRO-Shell-3) located along the western shore of West Iggy Lake (69° 58' 28.10" N; 50°23' 40.79" W) at an elevation of 15 m asl (Figure 1). The sedimentology of each core was catalogued with the purpose of identifying changes in the basins' sediment record.

During a fall in RSL it is expected for a basin to pass through three main phases of sedimentation (Figure 2a). The first is a fully-marine phase characterized by sand, silt and clay. The second is a brackish phase characterized by laminated clay gyttja that is commonly olive gray to black in color, which may contain minerogenic glacial lacustrine sediments. The third is a freshwater phase characterized by deposition of freshwater lake sediments comprised of various mixtures of freshwater gyttja, plant macrofossils and mineral matter from the local catchment (Long et al., 2011). The marine and brackish sedimentation phases are marked in their cessation through a sedimentological contact depicting a change in depositional environment. The contact marking the end of the marine phase is recognized by a change in sediment from minerogenic marine sediments to a finely laminated clay gyttja. The sedimentological isolation contact marking the end of the brackish phase depicts the end of any marine influx into the basin. This contact can be recognized typically by a change in sediment from an olive grey to black finely laminated clay gyttja to a brown to green finely laminated freshwater gyttja that contains an abundance of organic matter. Fully freshwater sedimentation will progress from this point onward or until the basin is once again inundated due to a change in RSL (Long et al., 2011)

Magnetic susceptibility measurements were carried out on all cores to constrain the location of the sedimentological contacts. The magnetic susceptibility values reflect the sediments' degree of sensitivity to a magnetic field. We expect that the marine and brackish deposition phases will be characterized by high magnetic susceptibility values, while the freshwater isolation phase will be characterized by lower magnetic susceptibility values. Loss on ignition (LOI) was performed to constrain further the location of the contacts within the sediment cores. The LOI procedure was performed by sub-sampling the cores every 5 mm, followed by freeze-drying. A sample weighing ~0.1 grams of the freeze-dried sediment was heated at 150 °C over 24 hours to ensure all moisture has been removed from the sample. After the 24 hour heating the sediment is weighed and heated again at 550 °C for two and a half hours in order to burn off all organic content. The organic content of the sample was calculated by comparing the mass of the sample before and after the 550 °C burn. In each sedimentation phase as the basin becomes isolated it is expected to display a successively higher organic sediment composition, i.e. the marine phase should display the lowest LOI values while the freshwater isolation phase should display the highest. Through comparison of LOI values with sediment sample depth we are then able to determine the location of the changes in sedimentation. After the location of the contacts was determined, we subsampled the sediment from the freshwater sedimentological isolation contact for radiocarbon dating to determine the timing of isolation. Samples were extracted for radiocarbon dating at depths of 62 cm in 12WIG-2, and at 60 cm in 12WIG-4. Three samples for radiocarbon dating were collected from the 12-IGY-4 core. The upper sample consisted of algal colonies at a depth of 45 cm, the second was a bulk sediment sample at 141.5 cm, while the lowest sample was a shell fragment at 235 cm.

The results of the magnetic susceptibility measurements are as predicted, with the marine and brackish phases of sedimentation displaying a higher magnetic susceptibility values than the freshwater phase. Likewise the results of LOI produced a similar expected dataset by displaying lower organic content in the marine and brackish phases of sedimentation with higher organic content for the freshwater phase. Average LOI values for the marine, brackish, and freshwater phases are 1.92±0.79%, 4.36±2.75%, and 5.35±2.24%, respectively. The radiocarbon ages were calibrated using the Calib program version 6.0 and the MARINE09 data set with a delta R of 140±25 years for marine samples, and the INTCAL09 data set for non-marine samples (Stuiver et al., 2009). The calibrated radiocarbon ages gave the timing of isolation as 6260±50 cal yr BP for West Iggy Lake. The Iggy Lake core provides an isolation age of 5080±200 cal yr BP from the bulk sediment sample from 141.5 cm. The basal shell fragment returned a radiocarbon age of 6710±130 cal yr BP and the algal sample yielded an age of 490±150 cal yr BP, providing limiting ages on sea level position. The 12GRO-Shell-3 shell sample yielded a calibrated radiocarbon age of 8260±100 cal yr BP, indicating marine inundation at this time at or above 15 m asl.

We believe that between the two West Iggy sediment cores, the date yielded by 12WIG-4 is the accurate date for basin isolation from the sea due to it correlating with radiocarbon ages from Iggy Lake, the GRO shell sample, and previously published RSL curves from the region. We suspect that the radiocarbon age from 12WIG-2 does not relate to isolation because the core was retrieved from a shallow portion of the West Iggy basin that may have undergone periods of regression during its history. We instead suggest that the age of 1940 ± 60 cal yr BP represents a contact, not of isolation, but one in which this portion of the lake may have been dry.

Our research demonstrates that isolation of two lake basins in northeast Disko Bugt occurred at 6260±50 cal yr BP and 5080±200 cal yr BP, with outflow elevations of 12 m asl and 2 m asl, respectively. In addition to these ages, limiting radiocarbon evidence from a raised marine deposit dated at 8260±100 cal yr BP with an elevation of 15 m asl is presented. In addition, maximum limiting constraints on RSL from radiocarbon ages on bulk sediments and plant macrofossils collected in 12WIG-2 and 12IGY-4 lake cores are also presented. The ages of these constraints are 1940±60 cal yr BP and 490±150 cal yr BP with elevations of 12 m asl and 2 m asl, respectively. The sediment core isolation ages coupled with upper and lower limits on RSL suggest a similar pattern of post-glacial emergence to that of other sites in the Disko Bugt region at Akulliit/Nuuk, Upernivik and Pâkitsoq (Long et al., 2006; Figure3)

By comparing our data points to the RSL curves published by Long et al. (2011) we can see that the two lakes, West Iggy and Iggy, match more closely to the emergence curve of Akulliit/Nuuk, Upernivik and Pâkitsoq (Long et al., 2006), during the mid Holocene, than that of Arveprinsen Eijland (Long et al., 1999). This similarity suggests the pattern of RSL change was more similar along the Torsukattak Fjord to sites nearer the Greenland Ice Sheet than those around Disko Bugt. In comparison to RSL curves from southern Disko Bugt, we note a difference in isostatic rebound across Disko Bugt relating to variability in the thickness of ice cover as well as the rate of retreat. Our data constrain ice recession in northeastern Disko Bugt, as well as add further density to the growing amount RSL data and the movement of the Greenland Ice Sheet in western Greenland.

Kaufman, D. S., Ager, T. A., Anderson, N. J., Anderson, P. M., Andrews, J.T., Bartlein, P. J., Brubaker, L. B., Coats, L. L., Cywnar, L. C., Duvalli, M. L., Dyke, A. S., Edwards, M. E., Eisner, W. R., Gajewski, K., Geirsdottir, A., Hup, F. S., Jennings, A. E., Kaplan, M. R., Kerwin, M. W., Lozhkin, A. V., Macdonald, G. M., Miller, G. H., Mock, C. J., Oswald, W. W., Otto-Bliesner, B. L., Porinchu, D. F., Ruhland, K., Smol, J. P., Steig, E. J., Wolfe, B. B., 2004, Holocene Thermal Maximum in the Western Arctic (0-180°W), Quaternary Science Reviews, 23, 529-560.

Long A. J., Woodroffe, S. A., Roberts, D. H., Dawson, S., 2011, Isolation Basins, sea level changes, and the Holocene history of the Greenland Ice Sheet. Quaternary Science Reviews 30, 3748-3768

Long, A. J., Roberts, D. H., Wright, M. R., 1999, Isolation basin stratigraphy and Holocene relative sea-level change on Arveprinsen Ejland, Disko Bugt, west Greenland. Journal of Quaternary Science 14, 323-345.

Long, A. J., Roberts, D. H., Dawson, S., 2006, Early Holocene history of the west Greenland Ice Sheet and the GH-8.2 event. Quaternary Science Reviews 25, 904-922.

Stuiver, M., Reimer, P. J., Reimer, R. W., 2010, CALIB 6.0. WWW program and documentationavailable at: http://calib.qub.ac.uk/calib/.

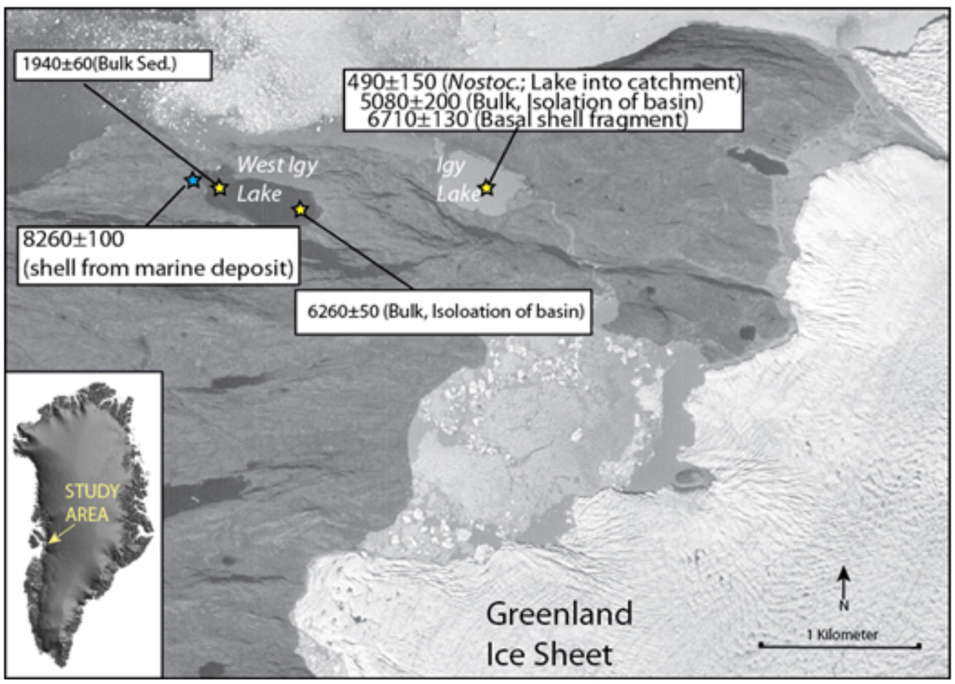

Fig 1. Figure 1: The location of West Iggy, Iggy Lake, and shell sample shown on 1985 aerial photograph. Inset map shows location of study area in Greenland. Ages are calibrated radiocarbon ages from core samples (yellow stars) and the shell (blue star) found in the raised marine deposit.

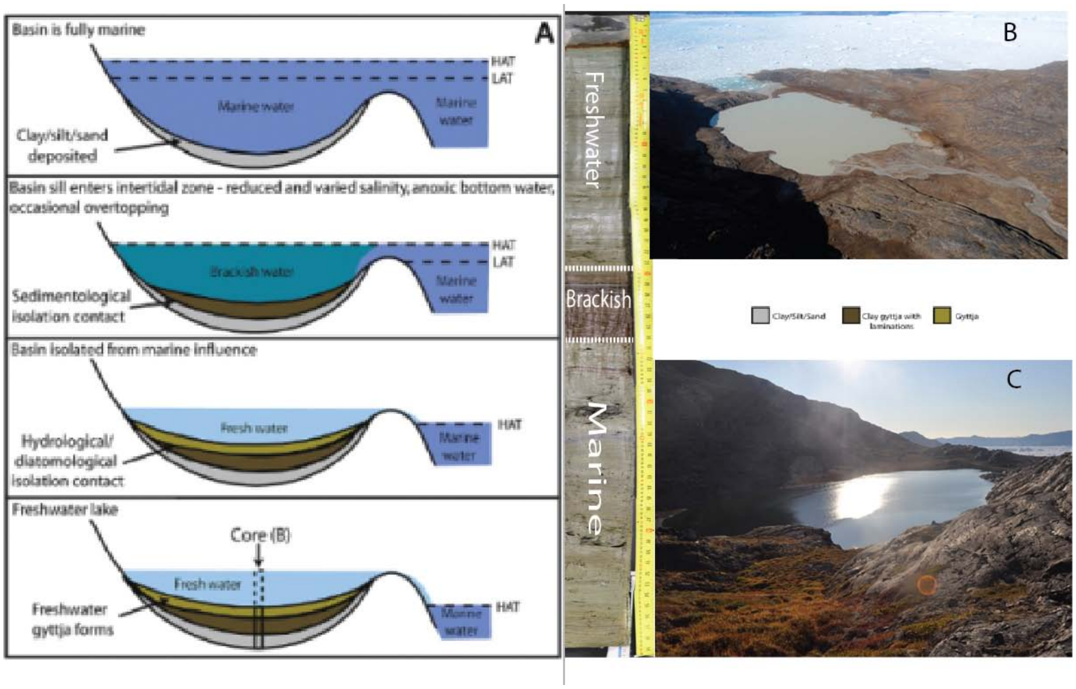

Fig 2. Figure 2: (Panel A) Diagram illustrating the isolation process with accompanying core contacts (Long et al., 2011), sediment core shown is 12WIG-4. (B) Photograph of Iggy Lake, view from the south. (C) Photo of West Iggy Lake, view from the east.

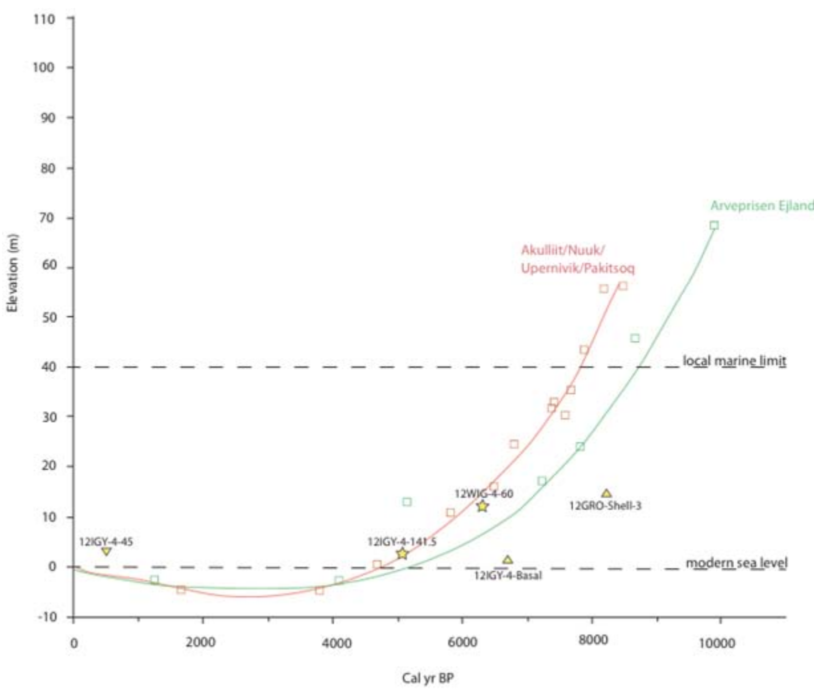

Fig 3. Figure 3: Plot of radiocarbon ages versus elevation, overlain on the published RSL curves from Long et al. (1999; 2006). Stars represent isolation contacts, triangles represent limiting ages on RSL.

ICE-MARGINAL AND PROGLACIAL FLUVIAL CHARACTERISTICS OF A HIGH-ARCTIC GLACIER, LINNÉBREEN, SVALBARD

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Linnébreen, a 2 km^2 high-arctic polythermal glacier in a valley of Proterozoic phyllite and mica schist and Paleozoic sedimentary rocks in southwest Spitsbergen, has retreated approximately 208 m since 2004, and 1.5 km from its Little Ice Age maximum (LIAM) at around 1936. Drift is continuously being reworked by meltwater as the area between the glacier and the LIAM moraine is both a sediment sink and source. Suspended sediment concentration (SSC) and particle size distribution analyses (PSD) help us to understand the current state of the ice-marginal and proglacial area. Samples were collected during the late 2012 melt season from 18 locations along supraglacial and two ice-marginal meltwater channels. These ice-marginal channels converge 150 m downvalley of the glacial terminus forming the proglacial meltwater-dominated stream, Linnéelva. SSC and discharge of Linnéelva were measured from July 24 to August 8 at two proglacial locations, 0.23 and 1.22 km downvalley of the glacial terminus. Data from the ice-marginal and proglacial study locations provide clues about where meltwater is transporting sediment from the glacier or reworking ice-marginal deposits, and a broad idea of how Linnéelva is reworking sediments in the proglacial area upvalley of the LIAM moraine.

Linnébreen, like many other small polythermal and cold-based glaciers in Spitsbergen, does not have moulins or many crevasses that permit meltwater flow to the glacier base; therefore, supraglacial, ice-marginal, and sub-marginal channels play a significant role in the fluvial transport of drift. Sampling of these channels took place in the late melt season when diurnal solar radiation cycles dictated discharge. On August 4 discharge of the east and west ice-marginal channels totaled 0.3 m^3/s, SSC of 16 supraglacial and ice-marginal sample sites ranged from 0.01 to 0.23 g/L and averaged 0.12 g/L, and particle size at the same sample sites ranged from 1.01 to 22.09 μm and averaged 8.73 μm (silt). The relationships between SSC, PSD, and channel characteristics reveal ice-marginal channels to be complicated sources and sinks for glaciofluvial sediment. In many places there is a direct correlation between change in slope, SSC, and PSD. Also, samples from a supraglacial channel suggested meltwater dilution based on a decrease in SSC but no significant change in PSD. SSC and PSD suggest that due in large part to a decrease in slope the eastern ice-marginal channel was acting as a sediment sink during the late melt season.

At the two proglacial sampling locations on Linnéelva discharge from July 24 to August 8 averaged 0.77 m^3/s with the upper site SSC averaging 0.135 g/L, and the lower site SSC averaging 0.212 g/L. From late July to early August approximately 6.6 x 104 kg more sediment in suspension passed through the lower site than the upper site, suggesting Linnéelva is significantly eroding its banks in-between the two sample sites. However, data from the 2010 field season indicates net deposition in this same area. This shift from deposition to erosion can most likely be explained by Linnéelva downcutting through the LIAM moraine-dammed lake deposits before flowing past the lower sampling site.

As Linnébreen retreats ice-marginal channels develop in areas of newly exposed basal drift, however the bulk of those sediments are most likely eroded during the high discharge events earlier in the melt season, such as the spring freshet. Data from the late melt season suggest that the bulk of material transported in suspension via the ice-marginal channels originates from supraglacial and englacial debris higher on the glacial surface. These larger particles sizes are then deposited in meltwater channels downvalley as the slope and water velocity decrease. Further downvalley the SSC data from July 24 to

August 8 reveal a significant amount of erosion, possibly from downcutting into lacustrine deposits. The spatial and temporal inconsistencies of stream behavior between the ice-marginal and proglacial regions within the LIAM moraine, and between the 2012 and 2010 field seasons represent difficulties in correlating environmental variation with the proglacial sediment record along Linnéelva and the glaciolacustrine record downvalley in Linnévatnet.

HIGH-RESOLUTION HOLOCENE GLACIER RECONSTRUCTIONS FROM HIGH NORTHERN LATITUDES: EVALUATING MODES OF CLIMATE VARIABILITY AND POSSIBLE INTER-HEMISPHERIC CLIMATE LINKAGES

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We examine Holocene and Late Glacial climate variability at two coastal sites in Troms and Finnmark, Arctic Norway, combining sediment records from distal glacier-fed lakes and moraine sequences deposited by the cirque glaciers Langfjordjøkulen and Rødhetta (FIGURE 1). The lake sediments are analysed at high temporal resolution by the means of multiple sediment parameters and dating techniques, and related to the moraine chronologies based on high-sensitivity 10Be surface exposure dating.

The dynamics of climate change in the Arctic are particularly dramatic. Hence, records of past natural climate variability in the Polar Regions and their relation to the sub-Arctic climate are critical for the understanding and prediction of climate change. Nevertheless, palaeoclimate data from the Arctic in general, and temperature reconstructions in particular, are scarce. Hence, new proxy data reflecting past natural climate variability contribute to fill a prominent data gap and, in turn, improve our knowledge about the impact of and the system's response to different forcing mechanisms. Alpine glaciers are particularly sensitive to climate change and to evaluate regional to inter-hemispheric signatures in the climate system (Bakke et al., 2008; Schaefer et al., 2009).

Variations in glacier mass balance (volume) and length are closely related to small- and large-scale changes in climate (Oerlemans 2005). This connection makes reconstructed glacier fluctuations important indicators for past climate variations, in particular winter precipitation and summer temperature.

The Holocene time period covers many episodes of cooling with corresponding glacial expansion and warming with contemporary glacier retreat. Erosion, transport and sedimentation rate vary with the size and activity of the attendant glacier in the catchment and the meltwater discharge (Karlén, 1981). The minerogenic content of distal glacier-fed lake sediments hence significantly varies according to fluctuations in glacial activity, highlighting the major importance of distal glacier-fed lake sediments as proxies for glacier fluctuations and climate variations during the Holocene and earlier (Karlén, 1981; Bakke et al., 2005).

Our data from the distal glacier-fed lake sediments cover a broad range of multi-proxy properties, including loss-on-ignition, dry bulk density, water content, magnetic susceptibility, and grain size distribution. In addition, geochemical element analyses (micro-x-ray fluorescence) is performed. We date the distal glacier-fed lake sediments by tephra, lead (210Pb) and radiocarbon dating (AMS). (FIGURE 2)

To produce a record of Equilibrium-Line Altitude (ELA) fluctuations at a sub-centennial time resolution for each glacier site, the multi-proxy core data will be combined with quaternary geomorphological mapping and terminal moraines independently dated by cosmogenic-nuclide exposure dating (10Be).

In this study, a well preserved moraine sequence, containing up to nine different ridges presumably ranging from the Late Glacial to the Little Ice Age, are mapped in detail and dated by high-sensitivity 10Be surface exposure dating. (FIGURE 3) This dating technique now allows to precisely and accurately date moraines through the entire Holocene, including the LIA period (Schaefer et al., 2006; Schaefer et al., 2009).

The samples collected during the 2012 field season are currently processed for 10Be dating at the Lamont-Doherty Earth Observatory Cosmogenic Nuclide Laboratory.

The new and improved reconstructions of past glacial variability in Arctic Norway will provide significantly enhanced and robust documentation of multi-decadal Holocene climate changes at high temporal resolution. In combination with analogical data from the southern hemisphere as a part of the SHIFTS project, the data obtained in this PhD will provide a robust documentation of multi-decadal climate changes In the northern Polar Region during the Late Glacial and Holocene time span, and a firmer basis for modelling and understanding key dynamic interactions between important components such as polar ice, atmospheric circulation patterns, sea-surface temperatures, sea-ice, as well as verifying phenomena and testing hypotheses such as polar amplification of natural climate change and the bi-polar seesaw.

In order to gain a better process understanding of polar climate variability, it is imperative that we recognize the underlying, long-term trends that characterize natural climate variability, such as for instance the Atlantic Multi-decadal Oscillation (AMO). It seems likely, although not yet proven, that both the Northern Annular Mode (NAM) and the southern hemisphere counterpart, the Southern Annular Mode (SAM), also alternate on multi-decadal or even centennial time scales. The NAM and the SAM heavily influence present atmospheric climate variability over the Polar Regions. Because these major atmospheric circulation patterns are important for the distribution of precipitation and temperature in the Polar Regions, they have high impact on the mass balance budget of glaciers. This, is why alpine glaciers are considered exceptionally well suited for addressing questions relating to the temporal structure of such patterns (Bakke et al., 2008; Schaefer et al., 2009).

Bakke, J., Lie, Ø., Dahl, S. O., Nesje, A., and Bjune, A. E., 2008, Strength and spacial patterns of the Holocene wintertime westerlies in the NE Atlantic region: Global and Planetary Change, v. 60, p. 28-41.

Bakke, J., Lie, Ø., Nesje, A., Dahl, S. O., and Paasche, Ø., 2005, Utilizing physical sediment variability in glacier-fed lakes for continuous glacier reconstructions during the Holocene, northern Folgefonna, western Norway: The Holocene, v. 15, p. 161-176.

Karlén, W., 1981, Lacustrine Sediment Studies. A Technique to Obtain a Continous Record of Holocene Glacier Variations: Geografiska Annaler Series A Physical Geography, v. 63, p. 237-281.

Oerlemans, J., 2005, Extracting a Climate Signal from 169 Glacier Records: Science, v. 308, p. 675-677.

Schaefer, J. M., Denton, G. H., Barrell, D. J. A., Ivy-Ochs, S., Kubik, P. W., Andersen, B. G., Phillips, F. M., Lowell, T. V., and Schlüchter, C., 2006, Near-Synchronous Interhemispheric Termination of the Last Glacial Maximum in Mid-Latitudes: Science, v. 312, p. 1510-1513.

Schaefer, J. M., Denton, G. H., Kaplan, M., Putnam, A., Finkel, R. C., Barrell, D. J. A., Andersen, B. G., Schwartz, R., Mackintosh, A., Chinn, T., and Schlüchter, C., 2009, High-Frequency Holocene Glacier Fluctuations in New Zealand Differ from the Northern Signature. Science, v. 324, p. 622-625.

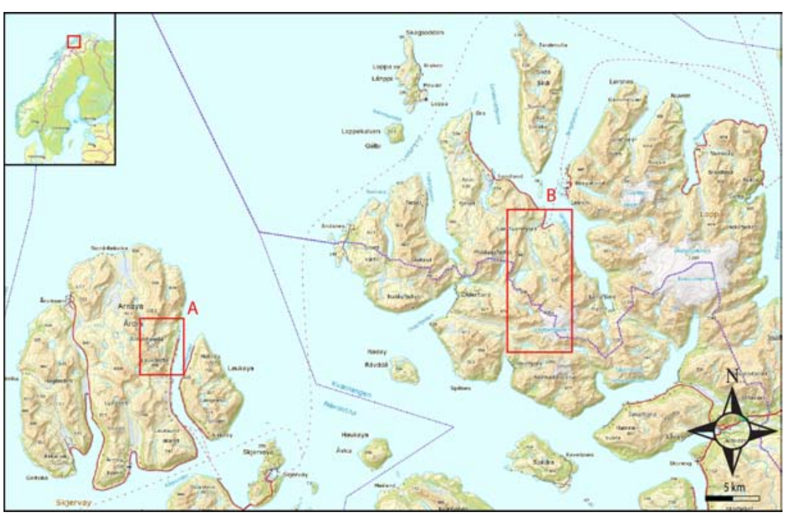

Fig 1. Overview of the study areas in Arctic Norway, marked with red squares. The northern glacier outlet of Langfjordjøkulen (B) and the cirque glacier Rødhetta on eastern Arnøya (A) are subjects to palaeoclimatic studies using glacier-fed lake sediments and cosmogenic-nuclide exposure chronologies, respectively. The combination of these approaches will give new high-resolution insight into the glacier and climate variability of the northern Polar Region during the time span of the Late Glacial and Holocene.

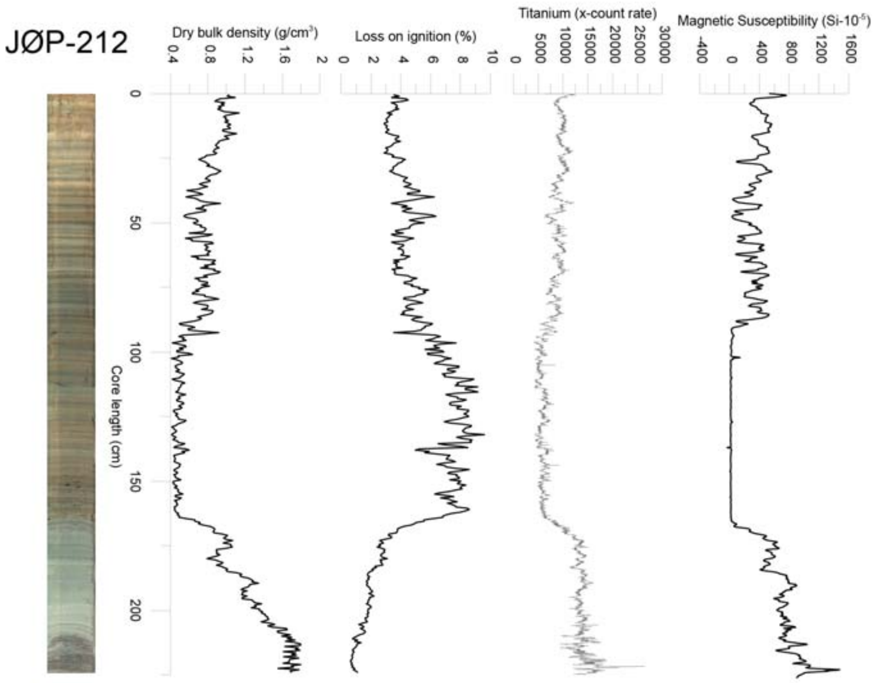

Fig 2. Selected physical sediment properties reflecting glacial activity of core JØP-212 from Jøkelvatnet.

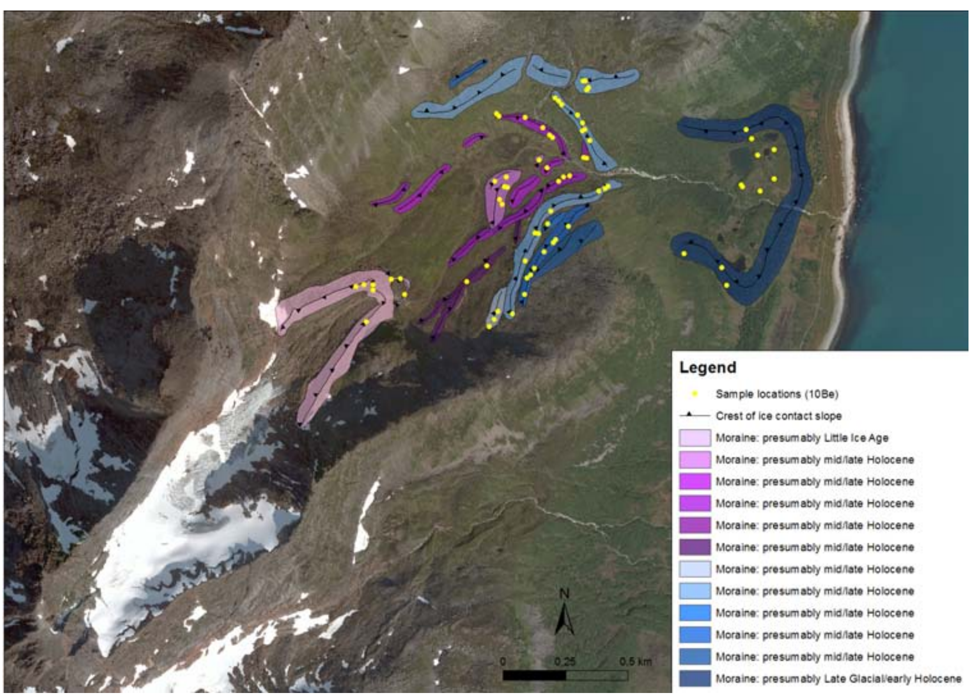

Fig 3. Terminal moraines fronting the cirque glacier in the study site on the island of Arnøya, Northern Norway. Rock samples taken from these moraines are currently processed for cosmogenic-nuclide exposure dating.

HOLOCENE EVOLUTION OF THE WESTERN GREENLAND ICE SHEET: ASSESSING GEOPHYSICAL ICE-SHEET MODELS WITH GEOLOGICAL RECONSTRUCTIONS OF ICE-MARGIN CHANGE

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Geophysical ice-sheet models routinely depict the western margin of the Greenland Ice Sheet (GrIS) as displaying enhanced sensitivity to climate change compared to other ice-sheet sectors (e.g. Simpson et al., 2009). As a test of their validity, however, ice-sheet models must be able to reconstruct past GrIS change by duplicating the geologic record. Of particular interest, is reconstructing and modeling western GrIS behavior through the early and middle Holocene because this time period encompasses the most recent interval of regional warmer-than-present temperatures. Thus, accurate geological and model-based reconstructions of western GrIS behavior during the middle Holocene have clear relevance for predicting future GrIS change and its contribution to eustatic sea-level rise in a warming world. Here, we review published model simulations of GrIS behavior that span the Holocene and compare these simulations to geological reconstructions of GrIS change spanning the Holocene at two locations in western Greenland (Disko Bugt and Søndre Strømfjord).

In the Disko Bugt and Søndre Strømfjord regions, ice-sheet models reveal an overall pattern of early Holocene retreat, a less extensive ice sheet during the middle Holocene, and late Holocene GrIS expansion. Yet one noteworthy difference between the two localities is the magnitude of middle Holocene ice-margin retreat. In Disko Bugt, the middle Holocene ice margin is within ~10-20 km of its present terminus, but near Søndre Strømfjord, the ice margin is as much as ~100 km inland of its current position. The modeled pattern and magnitude of GrIS change in Disko Bugt, appears to be consistent with available geological reconstructions of ice-margin change (Briner et al., 2010, 2011; Young et al., 2011a, 2011b, 2013). At Søndre Strømfjord, however, we present new radiocarbon ages from proglacial Lake Lucy (informal name) that, combined with the lake's sediment stratigraphy, suggest that this sector of the GrIS may have remained relatively close to its present position throughout the middle Holocene. Results from Lake Lucy suggest that current ice-sheet models could be overpredicting the magnitude of western GrIS retreat in response to warming, or in contrast, underpredicting the effects of increased precipitation on ice-sheet mass balance. Combined, geological records from Disko Bugt and Søndre Strømfjord (e.g. Levy et al., 2012) highlight the ability of the paleo-data to identify strengths and weaknesses in numerical models of GrIS evolution.

Briner, J.P. et al., 2010, Using proglacial-threshold lakes to constrain fluctuations of the Jakobshavn Isbræ ice margin, western Greenland, during the Holocene: Quaternary Science Reviews, v. 29, p. 3861-3874.

Briner, J.P. et al., 2011, Varve and radiocarbon dating support the rapid advance of Jakobshavn Isbræ during the Little Ice Age: Quaternary Science Reviews, v. 30, p. 2476-2486.

Levy, L.B. et al., 2012, Age of the Ørkadalen moraines, Kangerlussuaq, Greenaland: constraints on the extent of the southwestern margin of the Greenland Ice Sheet during the Holocene: Quaternary Science Reviews, v. 52, p. 1-5.

Simpson, M.J.R. et al., 2009, Calibrating a glaciological model of the Greenland Ice Sheet from the Last Glacial Maximum to present-day using field observations of relative sea level and ice extent: Quaternary Science Reviews: v. 28, p. 1631-1657.

Young, N.E. et al., 2011a, Response of Jakobshavn Isbræ, Greenland, to Holocene climate change: Geology, v. 39, p. 131-134.

Young, N.E. et al., 2011b, Response of a marine-terminating Greenland outlet glacier to abrupt cooling 8200 and 9300 years ago: Geophysical Research Letters, vol. 38, L24701, doi: 10.1029/2011GL049639.

Young, N.E., et al., 2013, Age of the Fjord Stade moraines in the Disko Bugt region, western Greenland, and 9.3 and 8.2 ka cooling events: Quaternary Science Reviews, v. 60, p. 76-90.

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