PAST GATEWAYS

4TH INTERNATIONAL CONFERENCE

TRONDHEIM, NORWAY
23-27 MAY 2016

IASC

GEOLOGICAL SURVEY OF NORWAY
- NGU -

KONGSBERG

Cover illustration: Bryggene (the wharves), Trondheim

PAST GATEWAYS 2016

PROGRAMME AND ABSTRACTS

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INTRODUCTION

On behalf of the local organising committee I would like to welcome you to the fourth international PAST Gateways conference, 23rd-27th of May, 2016 which is hosted by the Geological Survey of Norway (NGU) in the city of Trondheim, Norway. NGU was founded on February 6th, 1858 and has a proud tradition of geological mapping and research, in keeping with the motto: Geology for society.

PAST Gateways (Palaeo-Arctic Spatial and Temporal Gateways) is an IASC endorsed network research programme, the scientific goal of which is to understand Arctic environmental change during the period preceding instrumental records and across decadal to millennial timescales. The focus of the six year programme is on the nature and significance of Arctic gateways, both spatial and temporal, with an emphasis on the transitions between major Late Cenozoic climate events such as interglacials to full glacials and full glacial to deglacial states, as well as more recent Holocene fluctuations.

There are three major themes to the programme: (1) Growth and decay of Arctic Ice Sheets; (2) Arctic sea-ice and ocean changes, and (3) Non-glaciated Arctic environments. PAST Gateways follows on from the previous network programmes of 'PONAM' (Polar North Atlantic Margins), 'QUEEN' (Quaternary Environment of the Eurasian North) and, most recently, 'APEX' (Arctic Palaeoclimate and its Extremes). It is interdisciplinary in nature and seeks to bring together field scientists and numerical modellers to advance understanding about Arctic climate change. The network involves scientists from across Europe, Russia, Canada and the USA.

We hope you will enjoy the conference!

Lilja R. Bjarnadóttir

STEERING COMMITTEE

Helena Alexanderson, Sweden, Lund University

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Kari Strand, Finland, Thule Institute

Roger Urgeles, Spain, Institut de Ciències del Mar

ORGANISING COMMITTEE

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Lilja Rún Bjarnadóttir, Geological Survey of Norway

Kari Grøsfjeld, Geological Survey of Norway

Louise Hansen, Geological Survey of Norway

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Eiliv Larsen, Geological Survey of Norway

Astrid Lyså, Geological Survey of Norway

Dag Ottesen, Geological Survey of Norway

Colm Ó Cofaigh, Durham University

Anders Romundset, Geological Survey of Norway

LOCATION & LOGISTICS

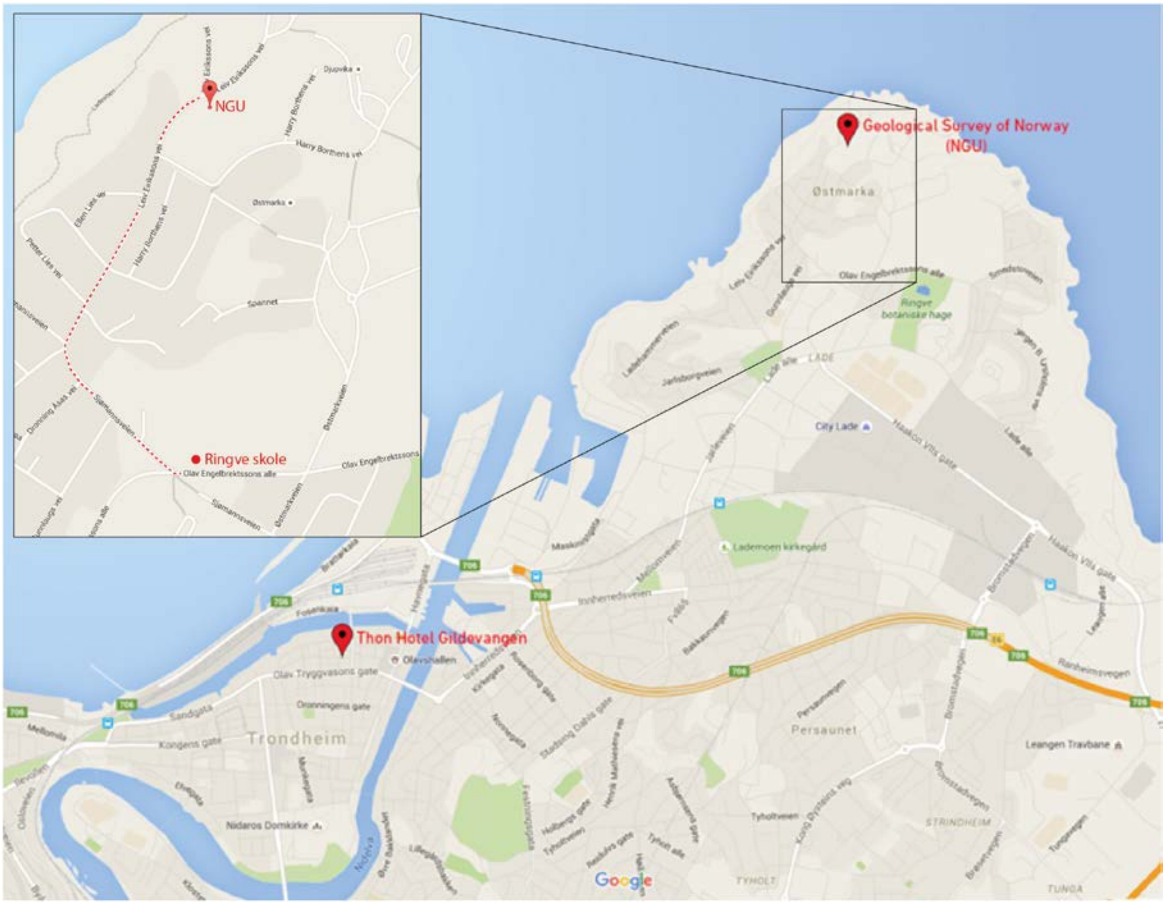
TRONDHEIM

Trondheim is located where the river Nidelva meets Trondheimsfjorden, Mid-Norway. It is the third largest city in Norway, and one of the oldest. It was founded by viking King Olav Tryggvason in 997 A.D. and served as the capital of Norway during the Viking Age until 1217 A.D. From 1152 to 1537 A.D., the city was the seat of the Catholic Archdiocese of Nidaros, and has since remained the seat of the Lutheran Diocese of Nidaros. The Nidaros Cathedral is one of the most famous sites of interest in Trondheim. The cathedral, which was built from 1070 A.D. on, is the most important Gothic monument in Norway and was Northern Europe´s most important Christian pilgrimage site during the Middle Ages, and is well worth a visit. Other popular sightseeing spots in the city centre include the Old Town Bridge (Gamle Bybro), Bakklandet, Kristiansten Fortress, and the wharves to name a few. Please visit trondheim.com for more information.

GEOLOGICAL SURVEY OF NORWAY (NGU)

The Geological Survey of Norway (NGU) is located at Leiv Eirikssons vei 39, in the scenic area of Lade, approximately 4 km from the city centre. It can be reached from Trondheim city centre by public buses number 3 and 4 (both with destination LADE). Please leave the bus at the bus stop called RINGVE SKOLE from where you can see a sign showing the direction to NGU (8-12 minutes walking distance). A bus ticket costs 50 NOK.

Estimated price from the city centre to NGU by taxi is 150-200 NOK. Trønder Taxi can be reached by phone at the following number: (+47) 07373.



Map of Trondheim showing the location of Thon Hotel Gildevangen and the Geological Survey of Norway (NGU). Insert shows the location of Ringve skole bus stop and NGU.

REGISTRATION & ICEBREAKER

The icebreaker will be held at NGU on Monday, May 23rd, between 18:00 and 20:00, where light food and beverages will be served. Participants can register at the icebreaker or, alternatively, on the morning of Tuesday, May 24th.

Upon arrival, we will welcome you at the main entrance to NGU.

CONFERENCE DINNER

The conference dinner will be held at NGU on Thursday, May 26th, between 18:30 and 21:00, starting immediately after Poster Session 2.

NOTES ON ORAL & POSTER PRESENTATIONS

Oral presentations should be about 15 minutes in duration, with a few minutes for questions. Powerpoint presentations should be uploaded to the auditorium computer prior to the start of each session. Technical assistance will be provided.

Poster presentations will take place in the NGU Library following the conclusion of oral presentations on Tuesday, May 24th and Thursday, May 25th. Participants are also encouraged to visit the posters during the coffee breaks.

FIELD EXCURSION

Organisers: Reidulv Bøe, Johan Faust, Louise Hansen, Fredrik Høgaas, Lars Olsen, Anders Romundset

Date: Wednesday, May 25, 2016

Pick-up: 09:00 at Thon Hotel Gildevangen

Drop-off: Around 16:00-17:00 at Thon Hotel Gildevangen

The field trip will take the participants by bus to various localities in the vicinity of Trondheim. There will be six stops, including the lunch break, where we will get warm food at a restaurant. Driving distance between localities is up to half an hour.

We will visit relevant localities and discuss aspects of the landscape development and glaciation history of the Trondheimsfjord area. Topics that will be covered include ice-marginal deposits from the Younger Dryas, raised marine deposits and shorelines, quick clay slides and seismic stratigraphy from the shelf offshore Trondheim.

Map of the Trondheim area and localities we will visit (numbered). The darker blue areas show land that was inundated by the sea at the end of the last deglaciation - i.e. areas that are below the marine limit. Both NGU and the hotel are marked by arrows. The asterisk shows the position of our lunch site Tyholttårnet.

SCHEDULE

MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY
	INTRODUCTION & WELCOME 09:00-09:10 **KEYNOTE:** ***ANNA HUGHES*** 09:10-09:40 **SESSION 1** 09:10-11:00	**FIELD EXCURSION** 09:00-17:00	**INTRODUCTION** 09:00-09:10 **SESSION 5** 09:10-10:50	**INTRODUCTION** 09:20-09:30 **KEYNOTE:** ***FRANK NIESSEN*** 09:30-10:00 **SESSION 9** 09:30-11:00
	COFFEE 11:00-11:20		COFFEE 10:50-11:20	COFFEE 11:00-11:30
	SESSION 2 11:20-13:00		**SESSION 6** 11:20-13:00	**SESSION 10** 11:30-12:50 **CONCLUDING REMARKS** 12:50-13:00
	LUNCH 13:00-14:00		LUNCH 13:00-14:00	LUNCH 13:00-14:00
	SESSION 3 14:00-15:00		**KEYNOTE:** ***THOMAS CRONIN*** 14:00-14:30 **SESSION 7** 14:00-15:30	
	COFFEE 15:00-15:30		COFFEE 15:30-15:50	
	SESSION 4 15:30-16:10		**SESSION 8** 15:50-16:40	
	POSTER SUMMARIES 16:10-16:40 **POSTER SESSION 1** 16:40-18:00		**POSTER SUMMARIES** 16:40-17:10 **POSTER SESSION 2** 17:10-18:30	
REGISTRATION & ICEBREAKER (NGU) 18:00-20:00 ...			**CONFERENCE DINNER (NGU)** 18:30-21:30 ...	

CONFERENCE PROGRAMME

MONDAY, MAY 23

	REGISTRATION & ICEBREAKER
18:00-20:00	*Location: Geological Survey of Norway, Leiv Eirikssons vei 39, Trondheim*

TUESDAY, MAY 24

	WELCOME & INTRODUCTION
09:00-09:10	*M. Smelror & L.R. Bjarnadóttir*

	SESSION 1
09:10-09:40	**KEYNOTE: DATED: Deciphering the chronology and evolution of the Eurasian ice sheets** *A.L.C. Hughes, R. Gyllencreutz, J. Mangerud, J.I. Svendsen*
09:40-10:00	**Causes of asynchronous glacial maxima of the last Scandinavian Ice Sheet** *E. Larsen, O. Fredin, A. Lyså , D. Ottesen*
10:00-10:20	**Reconstructing Weichselian ice sheet dynamics and extent in the eastern Barents Sea based on marine geophysical data** *M. Winsborrow, L. Polyak, V. Gatuallin, H. Patton, A. Hubbard, K. Andreassen*
10:20-10:40	**Submarine Landforms and Glacimarine Sedimentary Processes in Lomfjorden, Svalbard** *K. Streuff, C. Ó Cofaigh, R. Noormets, J. Lloyd*
10:40-11:00	**Younger Dryas-Holocene glacial advance in De Geerbukta, NE Spitsbergen: climate controlled, or glacial system tuning to Holocene mode?** *Ó. Ingólfsson, W. Farnsworth, A. Schomacker, L. Håkansson, L. Allaart*

11:00-11:20	COFFEE BREAK

	SESSION 2
11:20-11:40	**Dynamic Holocene history of a Spitsbergen fjord-system, western Svalbard** *W.R. Farnsworth, Ó. Ingólfsson, R. Noormets*
11:40-12:00	**Buried iceberg-keel scouring features in the southern Spitsbergenbanken, NW Barents Sea** *M. Zecchin, M. Rebesco, R.G. Lucchi, M. Caffau, H. Lantzsch, T.J.J. Hanebuth*
12:00-12:20	**Timing and frequency of glacigenic-debris flows on the Bear Island Fan – implications for the growth and decay of the Barents Sea Ice Sheet** *E. Pope, P. Talling, J. Hunt, J. Dowdeswell*
12:20-12:40	**Characteristics of submarine eskers observed at Ingøydjupet, SW Barents Sea using results of high resolution seismic and bathymetric mapping** *S. Chand, T. Thorsnes, A. Lepland, H. Brunstad*
12:40-13:00	**New chronological constraints on the deglaciation of northernmost and southernmost Norway based on in-situ cosmogenic nuclides** *O. Fredin, N. Akçar, A. Romundset, R. Reber, S. Ivy-Ochs, P. Kubik, D. Tikhomirov, M. Christl, F. Høgaas, C. Schlüchter*

13:00-14:00	LUNCH

	SESSION 3
14:00-14:20	**Mega deposits and erosive features related to the glacial lake Nedre Glomsjø outburst flood, southeastern Norway** *F. Høgaas, O. Longva*
14:20-14:40	**Preliminary results from a comprehensive isolation basin study at the south coast of Norway** *A. Romundset, F. Høgaas, T. Lakeman, O. Fredin*
14:40-15:00	**Fast but short-lived retreats and long-lived halts or re-advances of the western margin of the Scandinavian Ice Sheet** *J. Mangerud, J.I. Svendsen, A.L C. Hughes*
15:00-15:30	COFFEE BREAK

	SESSION 4
15:30-15:50	**Geophysical investigation of the western North Sea** *E. Grimoldi, D. Roberts, D. Evans, H. Stewart*
15:50-16:10	**Modelling the advance and demise of the Late Weichselian ice-sheet complex across northern Eurasia** *H. Patton, K. Andreassen, A. Auriac, M. Winsborrow, A. Hubbard*

	POSTER SESSION 1
16:10-16:40	**Oral Poster Summaries** *Various*
16:40-18:00	**Poster Session 1**

WEDNESDAY, MAY 25

	FIELD EXCURSION
09:00-17:00	*Pick-up/Drop-off: Thon Hotel Gildevangen*

THURSDAY, MAY 26

	INTRODUCTION
09:00-09:10	*L.R. Bjarnadóttir*

	SESSION 5
09:10-09:30	**Pockmarks in the southwestern Barents Sea and Finnmark fjords** *R. Bøe, L. Rise, V.K. Bellec, S. Chand*
09:30-09:50	**Dating the collapse of the Scandinavian Ice Sheet using CH4-derived carbonate crusts from the Barents and Norwegian Seas** *A. Lepland, A. Cremiere, D. Sahy, S.R. Noble, D.J. Condon, S. Chand, H. Brunstad, T. Thorsnes*
09:50-10:10	**How are large (>400 km3) submarine landslides related to the growth and decay of Arctic ice sheets?** *P. Talling, C. Watts, A. Mozzato, J. Allin, S. Bondevik, H. Haflidason, D. Tappin, E. Pope, J. Hunt, M. Cartigny, J. Dowdeswell, D. Long, N. Baeten, J. Stanford*
10:10-10:30	**The glacial history of an active volcanic island - Jan Mayen** *A. Lyså, E. Larsen, N. Akçar, J. Anjar, S. Björk, M. Ludvigsen*

10:30-10:50	**Deglaciation of a major palaeo-ice stream in Disko Trough, West Greenland** *K.A. Hogan, <u>C. Ó Cofaigh</u>, A.E. Jennings, J.A. Dowdeswell, J.F. Hiemstra*
10:50-11:20	COFFEE BREAK
	SESSION 6
11:20-11:40	**Wisconsinan Glacial Dynamics of Cumberland Peninsula, Baffin Island, Arctic Canada** *<u>A. Margreth</u>, J.C. Gosse, A.S. Dyke*
11:40-12:00	**Deglaciating the western Canadian Arctic: linking terrestrial and marine records of retreating ice margins and catastrophic ice shelf behaviour** *<u>M.F.A. Furze</u>, A.J. Pieńkowski, K.A. Nichols, M.S.R. Esteves, A. Garrett, R. Bennett, E. King, A.G. Cage*
12:00-12:20	**Deposition of widespread ice-rafted debris at the Allerød-Younger Dryas transition by the Amundsen Gulf Ice Stream, Canadian Arctic Archipelago** *<u>T.R. Lakeman</u>, A.J. Pienkowski, F.C. Nixon, M.F.A. Furze, S. Blasco, J.T. Andrews*
12:20-12:40	**An 11,000-year record of driftwood delivery to the western Canadian High Arctic: implications for oceanic-atmospheric circulation, local sea-ice severity & RSL rise** *<u>F.C. Nixon</u>, J.H. England*
12:40-13:00	**Postglacial environmental succession of Nettilling Lake (Baffin Island, Canadian Arctic) focusing on paleo-salinity changes inferred from diatom silica ($\delta^{18}O_{diatom}$).** *<u>H. Meyer</u>, B. Narancic, B. Chapligin, R. Pienitz*
13:00-14:00	LUNCH
	SESSION 7
14:00-14:30	**<u>KEYNOTE</u>: Deglacial sea-level history of the western Arctic Ocean** *<u>T. Cronin</u>, M. Jakobsson, N. Barrientos, M. O'Regan, F. Muschitiello, J. Backman, A. Koshurnikov, C. Pearce, L. Gemery, M. Toomey*
14:30-14:50	**Paleoenvironmental variability in the western Bering Sea during the last deglaciation** *<u>E.A. Ovsepyan</u>, E.V. Ivanova, E.V. Dorokhova, D. Nürnberg, L. Max, R. Tiedemann*
14:50-15:10	**Planktonic foraminifera (Neogloboquadrina pachyderma) signal Atlantic-sourced water inflow in the early Holocene Northwest Passage** *<u>A.J. Pienkowski</u>, A.G. Cage, M.F.A. Furze, A.S. de Figueiredo Martins, J. England, B. MacLean, S. Blasco*
15:10-15:30	**Changes of sea-ice cover on the East Greenland Shelf (73°N) over the last 5200 years – a biomarker reconstruction** *<u>H. Kolling</u>, R. Stein, K. Fahl, K. Perner, M. Moros*
15:30-15:50	COFFEE BREAK
	SESSION 8
15:50-16:10	**Trondheimsfjord sediments reveal North Atlantic Oscillation dynamics of the past 2800 years** *<u>J.C. Faust</u>, K. Fabian, J. Giraudeau, J. Knies*
16:10-16:30	**Ancient environmental DNA: a paleoceanographer's perspective** *<u>J. Pawłowska</u>, F. Lejzerowicz, M. Łącka, M. Zajączkowski, J. Pawlowski*
16:30-16:40	**Kongsberg Maritime Presentation** *<u>Atle Gran</u>*

	POSTER SESSION 2
16:40-17:10	**Oral Poster Summaries** *Various*
17:10-18:30	**Poster Session 2**

	CONFERENCE DINNER
18:30-21:30	*Location: Geological Survey of Norway, Leiv Eirikssons vei 39, Trondheim*

FRIDAY, MAY 27

	INTRODUCTION
09:20-09:30	*L.R. Bjarnadóttir*

	SESSION 9
09:30-10:00	**KEYNOTE: The puzzle of grounded Pleistocene ice in the Arctic Ocean and the exhumation of Miocene sediments** *F. Niessen, R. Stein, L. Jensen, M. Schreck, J. Matthiessen, K. Fahl, M. Forwick, C. Gebhardt, M. Kaminski, G. Knorr, I. Sauermilch, W. Jokat, G. Lohmann, J. Kuk Hong, L. Polyak, S.-I. Nam*
10:00-10:20	**A pan-Arctic ice shelf during late Marine Isotope Stage (MIS) 6: Fact or fiction?** *J. Knies, R. Spielhagen*
10:20-10:40	**Siberian glacial impacts on the Arctic Ocean: a case study of the Middle Weichselian glaciation** *L. Polyak, F. Niessen, S.-I. Nam, M. Schreck, G. Dipre, J. Ortiz, R. Spielhagen*
10:40-11:00	**Nutrient Utilization in the Northern Polar Ocean and its Relation to Present and Past Warm Climate Conditions** *H. Bauch, B. Thibodeau, T.F. Pedersen*
11:00-11:30	COFFEE BREAK

	SESSION 10
11:30-11:50	**Emergence of the modern Nordic Seas circulation in the Early Pliocene related to ocean gateway changes** *S. De Schepper, M. Schrek, K.M. Beck, J. Matthiessen, K. Fahl, G. Mangerud*
11:50-12:10	**North Atlantic water influence and sea surface water warming during the late Pliocene in the marginal Arctic Ocean (Site 911A, Yermak Plateau)** *K. Grøsfjeld, S. De Schepper, J. Knies*
12:10-12:30	**Glacial and climate history in the Polar Urals, Russian Arctic** *J.I. Svendsen, H. Haflidason*
12:30-12:50	**Revision of the Late Quaternary Lake El'gygytgyn level fluctuations** *G. Fedorov, A.A. Andreev, E. Raschke, V. Wennrich, M. Melles*

	CONCLUDING REMARKS
12:50-13:00	*L.R. Bjarnadóttir & C. Ó Cofaigh*
13:00-14:00	LUNCH

POSTER PRESENTATIONS

POSTER SESSION 1 - TUESDAY, MAY 24

Combining terrestrial and marine glacial archives – a geomorphological map of Nordenskiöldbreen forefield, Svalbard

L. Allaart, N. Friis, Ó. Ingólfsson, A. Schomacker, L. Håkansson, R. Noormets

Mass movements on the SW Barents Sea margin - preliminary results

N.J. Baeten, J. Knies, L. Rise, V. Bellec, S. Chand, R. Bøe

Bioclastic sediments and cold-water coral reefs in the Norwegian Sea - Links between glacial landforms and reef ecosystems

V. Bellec, T. Thorsnes, R. Bøe, L.R. Bjarnadóttir

Glacial dynamics in Mohnbukta east Spitsbergen inferred from the submarine landform record

A.E. Flink, R. Noormets, P. Hill, N. Kirchner

Morphology and sedimentary processes on the continental shelf edge and slope north of Nordaustlandet, Svalbard

O. Fransner, R. Noormets, A.E. Flink, K.A. Hogan, J.A. Dowdeswell

Event stratigraphic interpretation of high-resolution, marine seismic data from Leirfjorden, North Norway.

L. Hansen, R. Bøe

A shear-wave, reflection seismic study of the fjord-valley fill below urban ground in Trondheim, Mid Norway

L. Hansen, J.S. L'Heureux, G. Sauvin, U. Polom, I. Lecomte, M. Vanneste, O. Longva, C.M. Krawczyk

DATED-2: updating the Eurasian Ice sheet chronology and time-slice reconstructions

A.L.C. Hughes, R. Gyllencreutz, J. Mangerud, J.I. Svendsen

Lake Nordlaguna, Jan Mayen: the potential for a palaeoclimate record from the island

E. Larsen[1,2], A. Lyså[1], J. Anjar[2] and M. Ludvigsen[3]

Thermogenic origin of hydrocarbon seeps in central Spitsbergen fjords, Svalbard

M. Liira, R. Noormets

Age of the Younger Dryas ice-marginal substages in Mid-Norway — Tautra and Hoklingen, based on a compilation of 14C-dates

L. Olsen, F. Høgaas, H. Sveian

Sea-floor morphology and sedimentary processes along the Norwegian Channel Ice Stream

D. Ottesen, C.R. Stokes, R. Bøe, L. Rise, O. Longva, T. Thorsnes, O. Olesen, T. Bugge, A. Lepland, O. B. Hestvik

Modeling the post-LGM deglaciation of the Scandinavian-Barents Sea Ice Sheet; a model intercomparison approach

M. Petrini, N. Kirchner, F. Colleoni, A. Camerlenghi, M. Rebesco, R. Lucchi, R. Noormets, E. Forte

Geological and Geomorphologic Features of the Area of the Kandalaksha Gulf (White Sea, Russia) as Formed by Deglaciation and Neotectonic Movements

M.A. Romanovskaya, N.I. Kosevich, D.D. Movchan

Downslope and alongslope sedimentary processes on a high latitude continental margin: NW Barents Sea

L. Rui, M. Rebesco, A. Caburlotto, J.L. Casamor, R. Lucchi, A. Camerlenghi, R. Urgeles, K. Andreassen, T. Hanebuth, A. Ozmaral, D. Accettella

POSTER SESSION 2 - THURSDAY, MAY 26

Palynological results from the Lake Ladoga postglacial-glacial-preglacial sediment record

A.A. Andreev, L.A. Savelieva, L. Shumilovskikh, R. Gromig, V. Wennrich, G. Fedorov, D.A. Subetto, S. Krastel, B. Wagner, M. Melles

Ocean forcing of the Greenland Ice Sheet on centennial time scales

C.S. Andresen, L.M. Dyke, U. Kokfelt, F. Vermassen, D. Wangner, M.-S. Seidenkrantz

Dating the glacial activity on Jan Mayen using cosmogenic surface exposure dating with ^{36}Cl

J. Anjar, N. Akçar, E. Larsen, A. Lyså, C. Vockenhuber

Reconstruction of Late Quaternary paleoceanographic settings in the central Arctic Ocean: Insights from study of ice-rafted debris composition

E. Bazhenova, A. Kudryavtseva, E. Voronovich, A. Krylov, R. Stein

Late Quaternary deglaciation in the Arctic Ocean: evidences from microfossils

K. Carbonara, K. Mezgec, G. Varagona, M.E. Musco, R.G. Lucchi, G. Villa, R. Melis, C. Morigi

Holocene variation in the onset of the Neoglacial cooling off eastern Greenland from Fram Strait to Cape Farewell

C. Dylmer, M. Miles

A new infrastructure for the paleoclimatic community: A fully automated 2G SQUID cryogenic magnetometer at the Geological Survey of Norway

K. Fabian, M. Klug, J. Knies

Reconstructing Little Ice Age sea surface temperatures in Sermilik Fjord, SE Greenland

U. Kokfelt, C.S. Andresen, M.-A. Sicre, V. Klein, F. Kaczmar, L.M. Dyke, F. Vermassen, D. Wangner

Development of proxy methods for past climate reconstruction in the Barents Sea

D. Koseoglu, S.T. Bell, J. Knies

Alkenone-based reconstruction of sea surface conditions since last glacial times off SW Svalbard

M. Łącka, M. Cao, A. Rosell-Melé, J. Pawłowska, M. Kucharska, M. Forwick, M. Zajączkowski

Paleoenvironmental reconstruction of Postglacial and Holocene events in the eastern Fram Strait inferred from benthic microfossils and IRD data

Y. Ovsepyan, E. Taldenkova, N. Chistyakova, A. Stepanova, R.F. Spielhagen, K. Werner, J. Müller

Size matters: the response of foraminfera test size to changing climate

J. Pawłowska, M. Łącka, N. Szymańska, M. Kucharska, A. Kujawa, M. Zajączkowski

The Greenland Ice Sheet during the Last Interglacial: Coupling ice and atmosphere

A. Plach, K.H. Nisancioglu

Late Holocene land-sea interactions and coastal environments in the Laptev Sea region as revealed from pollen and non-pollen palynomorphs (NPP) spectra in marine sediment cores

O. Rudenko, H.A. Bauch, V. Yenina

Variability of water masses and ice coverage in the last 200 ky on the western Lomonosov Ridge

R. Spielhagen, R. Stein, A. Mackensen

Benthic foraminifera for the study of the deglaciation post LGM in the south- western Svalbard slope (Arctic Ocean)

G. Varagona, R. Melis, C. Morigi, M.E. Musco, R.G. Lucchi, K. Mezgec, K. Carbonara, Giuliana Villa

LIST OF ABSTRACTS

Combining terrestrial and marine glacial archives – a geomorphological map of Nordenskiöldbreen forefield, Svalbard

L. Allaart[1,2], N. Friis[1,3], Ó. Ingólfsson[1,4], A. Schomacker[2], L. Håkansson[1,2], R. Noormets[1]

[1]*Arctic geology department, University Centre in Svalbard, Norway*
[2] *Department of Geology and Mineral Resources Engineering, Norwegian University of Science and Technology, Trondheim, Norway*
[3] *Department of geosciences and natural resource management, University of Copenhagen, Denmark*
[4] *Institute of Earth Sciences, University of Iceland, Reykjavík, Iceland*

Nordensköldbreen is a polythermal, tidewater glacier located in inner Billefjorden, central Spitsbergen, where it terminates in Adolfbukta bay. This on-going MSc project aims to produce a high-resolution geomorphological map of the recently deglaciated area in front of Nordenskiöldbreen and a landsystem model for a polythermal tidewater glacier, with descriptions and interpretations of sediment-landform associations.

A holistic approach is taken, and the map is created in ArcGIS software based on analysis of aerial images (2009) and high-resolution swath bathymetry (2009) from the fjord. Ground-thruthing was carried out through field campaigns in August 2014 and 2015. Glacier front position lines are reconstructed from historical data, aerial imagery and satellite images.

The study contributes to an improved understanding of Svalbard glaciers and their response to climate fluctuations and is a part of the larger research project: "Holocene history of Svalbard Ice Caps and Glaciers" (see Research in Svalbard (RIS) database at:

http://www.researchinsvalbard.no/project/7567).

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Palynological results from the Lake Ladoga postglacial-glacial-preglacial sediment record

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The German-Russian project PLOT (PaleolimnoLOgical Transect) investigates the Late Quaternary climatic and environmental history along a transect crossing Northern Eurasia. Within the scope of a pilot phase for the project funded by the German Federal Ministry of Education and Research, we were able to investigate Lake Ladoga, the largest lake in Europe (ca 18.000 km^2), located close to St. Petersburg. Although the late glacial and Holocene history of the lake and its vicinity was already studied over the past decades (e.g. Subetto et al., 1998 and references therein), the older, preglacial lake history remained unknown. It is assumed that during the Last Interglacial (Eemian) Lake Ladoga was part of a precursor of the Baltic Sea, which had a connection via Ladoga and Onega Lakes to the White Sea.

A seismic survey in August 2013 revealed acoustically well stratified Holocene muds overlaying rather transparent postglacial varves more than 10 m thick. The varves usually are bordered by a hard reflector underneath that may represent coarse-grained sediments or a till, which in most areas is not penetrated by the acoustic waves. Sediment coring at two sites in western Ladoga Lake confirmed the seismic interpretation of the postglacial sediment succession.

The sediments studied in a 22.7 m lake core were subdivided into V lithological units. Unit Ia (ca. 22.78-21.25 m) consists of fine-coarse sand with pebbles, Unit Ib (ca. 21.25-20.95 m) - silty clay with intercalated sand layers, Unit II (ca. 20.95-20 m) - silty clay with fine-coarse sand, Unit III (ca. 20-13.3 m) - sand with sporadically occurring coarse-sand and clay lenses, Unit IVa (ca. 13.3-12.09 m) - alternating clay and sand layers, Unit IVb (ca. 12.09-2.11 m) - laminated clays with intercalated fine sand layers, Unit Va (ca. 2.11-1.75 m) - silty clay, Unit Vb (ca. 1.75-0 m) - laminated silty-clay with fine sand.

These sediments were also palynologically investigated. In addition to traditional pollen analysis, non-pollen-palynomorphs such as cysts of dinoflagellates, algae remains, and fungi spores, providing additional palaeoenvironmental information about the lake and its catchment were recorded. The revealed pollen assemblages can be subdivided into 8 main pollen zones (PZ) described below.

The lowermost sediments (PZ 1, ca. 22.7-21.9 m, lithological Unit Ia) containing few pollen and cannot be used for environmental reconstructions. Pollen concentration is much higher in PZ 2 (ca. 21.9-20 m, lithological Units Ib and II). *Betula* and *Alnus* dominate the zone but *Pinus* and broad-leaved taxa (*Carpinus*, *Quercus*, *Corylus*, *Ulmus*, *and Tilia*) are also common. Pollen concentration is also high in PZ 3 (ca. 21.9-12.9 m, lithological Unit III). *Betula* and *Alnus* also dominate in this zone but *Pinus*, *Picea*, and broad-leaved taxa are also numerous. Pollen assemblages indicate that the sediments of PZs 2 and 3 were formed during an interglacial with climate conditions more favorable compared to the Holocene. The studied sediments also contain numerous fresh water green algae remains of *Pediastrum* and *Botryococcus* as well as cysts of marine dinoflagellates and brackish water acritarchs (prasinophytes *Cymatiosphaera* and *Micrhystridium*). Dinocyst assemblages are poor in species, presented mostly by *Spiniferites ramosus* s.l. and *Lingulodinium machaerophorum*. Very short processes of the latter species indicate rather low salinity (Mertens et al. 2012). These non-pollen-palynomorphs document that Lake Ladoga was a part of brackish-water corridor between the Baltic and the White Seas during the Last Interglacial (Miettinen et al., 2014 and references therein).

Pollen concentration is extremely low in PZ 3 (ca. 12.9-8 m, lithological Unit IVa-b). The zone is dominated mostly by pollen of herbs (*Artemisia*, Poaceae, Cyperaceae, Chenopodiaceae), although *Betula*, *Alnus*, and *Pinus* also common. We assume that the PZ 4 pollen assemblages were accumulated during the Late Glacial when an extensive periglacial Baltic Ice Lake was extended along the southeastern margin of the Scandinavian Ice Sheet having Lake Ladoga as its north-eastern bay starting at ca 15000 cal yr BP (Subetto et al., 1998 and references therein).

Pollen concentration is slightly higher in PZ 5 (ca. 8-5.9 m, lithological Unit IVb). The zone is also dominated mostly by pollen of herbs, *Betula*, *Alnus*, and *Pinus* but is also characterized by rather significant *Picea* pollen contents pointing to more favorable climate conditions. This climate amelioration is also evidenced in other regional pollen records where it is radiocarbon dated to the Allerod.

The potential Younger Dryas (PZ 6, ca. 5.9-2 m, lithological Unit IVb) sediments are characterized by high percentages of herb pollen (mainly *Artemisia* and *Chenopodiaceae*) indicating the dry and cold climate. *Betula*, *Pinus*, and *Alnus* predominate among the arboreal pollen suggesting the tundra-steppe vegetation in the lake catchment. Regularly observed pollen of broad-leaved taxa are of redeposited origin.

Pollen concentration is drastically increased in PZ 7 (ca. 2-1.1 m, lithological Unit Ia-b). The revealed early Holocene pollen assemblages are characterized by increased *Pinus* and Polypodiaceae contents, while Poaceae, Cyperaceae, and, especially *Artemisia* and Chenopodiaceae gradually disappeared from the spectra. PZ 8 (ca. 2-1.1 m, lithological Unit Ib) is characterized by further increase in *Pinus* and *Alnus* pollen contents as well as by significant peak in *Picea* percentages. The revealed pollen and non-pollen-palynomorphs assemblages well reflect environmental changes during the late Eemian, late Glacial, and Holocene.

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Ocean forcing of the Greenland Ice Sheet on centennial time scales

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In recent years accelerated melt of the Greenland ice sheet has caused great concern as to its response and the associated sea level rise as climate continues to warm in the future. It has been hypothesized that a contraction of the North Atlantic subpolar gyre with a westward movement of warm waters and their spilling onto the Greenland shelf in the late 1990s, caused marine terminating glaciers in both Southeast and West Greenland to following thin, retreat and accelerate (Holland et al. 2008, Straneo et al. 2010). This event may have been matched in magnitude by ocean and glacier changes occurring around the 1930s-1940s and thus may link the observed changes with the Atlantic Multidecadal Oscillation (Andresen et al. 2012, 2013b). However, knowledge is still lacking in terms of the longer-term timescales involved in ocean forcing of the Greenland Ice Sheet. Such knowledge is important for understanding the future interplay between anthropogenic climate changes and natural modes of climate variability.

Here we compare the discharge from two marine terminating glaciers situated in West and Southeast Greenland (Jakobshavn Isbræ and the Køge Bugt Glacier complex, respectively) over the past 6000 years as reconstructed from marine sediment cores. We look into the ocean forcing over this time period and evaluate if the glaciers in West and Southeast Greenland responded synchronously to changes in the subpolar gyre on centennial timescales.

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Dating the glacial activity on Jan Mayen using cosmogenic surface exposure dating with ^{36}Cl

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Jan Mayen is the northernmost island on the North Atlantic ridge, situated 550 km north of Iceland. Glacial sediments and landforms are relatively common on the island but so far only the youngest moraine system, corresponding to the little ice age, have been dated.

In this project we use cosmogenic surface exposure dating with ^{36}Cl to extend the glaciation chronology on Jan Mayen. A total of 43 samples have been sampled from landforms ranging from the fresh little ice age moraines to the older till surfaces on central Jan Mayen. So far 23 of the samples have been analyzed. These samples give mostly reasonable ages that are consistent with the relative ages of the landforms. However, the lack of independent age control and the limited knowledge of the paleoenvironmental history of Jan Mayen means that it is challenging to constrain key variables such as local production rate, isostatic rebound or erosion. Here we discuss the problems and potential for ^{36}Cl dating on Jan Mayen and present the first results.

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Mass movements on the SW Barents Sea margin - preliminary results

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Swath-bathymetry, high-resolution seismic data and a 14 meter long Calypso core are used to study the mass movements and their relation to subsurface stratigraphy on the SW Barents Sea slope.

The SW Barents Sea slope is characterised by large numbers of glacigenic debris flow lobes interbedded with stratified glaciomarine and marine sediments. The glacigenic debris flows are characterised by a uniform, transparent seismic signature. Numerous channels, depositional lobes and small mass movements are visible on the seafloor.

An almost 14 m long Calypso core (from 949 m water depth) penetrated the package of the acoustically stratified sediments visible on the high-resolution seismic data. This stratified sequence corresponds to a package of both stratified and transparent massive units directly north-west of the core location.

The Calypso core comprises mostly undisturbed massive and laminated sandy clay commonly containing ice-rafted debris. A few intervals of remobilized sediments are characterized by relatively high wet-bulk density and shear-strength values. The most prominent remobilized interval between 7.2-7.4 m depth can be correlated to a large glacigenic debris flow, and was dated to have been

deposited before 31.4 cal. BP. The Barents Sea Ice Sheet probably extended to the continental shelf break at this time.

A 50 cm thick interval with well sorted sand between 7.4-7.9 m depth could have been deposited by traction currents, forming sandwaves along the continental slope. Areas with sandwaves are currently found on the seabed higher up on the continental slope (at 475-800 m water depth).

The lowermost 2 m of the core most likely penetrated into a glacigenic debris flow unit below the stratified glaciomarine sediments visible on the high-resolution seismic data.

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Nutrient Utilization in the Northern Polar Ocean and its Relation to Present and Past Warm Climate Conditions

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The degree of surface ocean stratification in the high latitudes plays a critical role in the Earths' climate not only through influencing the rate of North Atlantic deepwater producion and thus the ventilation of the deep sea and circulation of the global ocean, it also has a direct feedback on surface heat transfer to the Polar North. However, the response of upper stratification in a crucial region such as the Nordic Seas to near-future hydrologic forcing, as surface water in the polar ocean warms and freshens due to global temperature rise and glacier demise, is still unresolved. In this study we paired bulk sediment $\delta^{15}N$ isotopic signatures with planktic foraminiferal assemblages across three major interglacials, each of which could be viewed as an analogue of the present. The isotope vs. foraminifer comparison defines stratification-induced variations in nitrate utilization between and within all of these warm periods and signifies changes in the thickness of the mixed-layer throughout the previous interglacials. As the thickness directly controls the depth-level of Atlantic water inflow, the changes recorded here suggest that drastic variations in freshwater water input associated with each preceding glacial terminations caused the Atlantic water to flow at greater depth. Our results therefore indicate an involvement of glacial ice sheet size, and subsequent specific melting history, on interglacial climate development. It is further suggested that any future increase in freshwater flux into the Polar Ocean (e.g., from Greenland/Eurasia) would not necessarily stop by itself the poleward advection of Atlantic water.

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Reconstruction of Late Quaternary paleoceanographic settings in the central Arctic Ocean: Insights from study of ice-rafted debris composition

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This study is based on core sediment records from the central Arctic Ocean spanning the last two glacial/interglacial cycles (~ 200.000 years). Sediment cores were recovered during the PS72 (2008) and PS87 (2014) Expeditions of the German RV "Polarstern": PS72/340-5 and PS72/344-3 - at the Mendeleev Ridge, PS87/023-1, PS87/030-1 and PS87/056-1 - at the Lomonosov Ridge. Study area is

located in the frontal zone between the two major systems of surface currents in the Arctic Ocean, the Beaufort Gyre and the Transpolar Drift. Therefore, these sites can be used to study changes in the trajectories of ocean currents and sea ice/iceberg drift.

Our current research is focused on petrographic classification of coarse grains (> 0.5 mm) presumably representing ice-rafted debris. Identification of grains was performed at the Otto Schmidt Laboratory for Polar and Marine Research (St.Petersburg) using the optical binocular Olympus SZX-12. Additionally, grain surface is treated with HCL 10%-solution to check for the presence of detrital carbonates. Clast types were classified following the published studies from the Arctic Ocean which utilized the same size fractions (Bischof et al., 1996; Phillips and Grantz, 2001; Taldenkova et al., 2010).

In core PS72/340-5 from the Mendeleev Ridge, grains > 2 mm are mostly represented by clastics (sandstones), carbonates, quartz and quartzites. Occasionally, other grains such as granitoids, shales and chert were found. Larger dropstones (> 2 cm) from the Mendeleev Ridge are mainly represented by dolomite. Morphometry of these dropstones clearly indicates iceberg transportation. In core PS72/344-3 (close to the East Siberian Sea continental margin) grains > 2 mm are almost absent. In the 0.5-2 mm fraction, quartz grains and sandstones dominate, and carbonate grains are present in some layers.

In core PS87/023-1 at the North American margin, grains > 2 mm are dominated by carbonates and sandstones with occasional occurrence of shales, granitoids and quarzites. In cores PS87/056-1 and PS87/070-1 (central Lomonosov Ridge) the number of grains > 2 mm sums up to 5. In the fraction 0.5-2 mm quartz grains and shales dominate; sandstones, quarzites and coal are common. Carbonate grains were found in several intervals in both cores. At the Lomonosov Ridge, collected dropstones mostly represent sandstones and quartzites, as well as gneiss and shales. Morphometry of these dropstones indicate iceberg and sea-ice transport, some material has evidence of riverine transport.

Contribution from different IRD source areas will be statistically estimated to reconstruct sediment pathways and paleoceanographical settings in the central Arctic Ocean. Obtained results on the IRD composition will be compared to the grain-size composition and bulk mineralogy, as well as to geochemical provenance indicators in sediments previously investigated at the Alfred Wegener Institute for Polar and Marine Research (Bremerhaven).

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Bioclastic sediments and cold-water coral reefs in the Norwegian Sea - Links between glacial landforms and reef ecosystems

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The Norwegian seabed mapping programme MAREANO (www.mareano.no) investigates Norwegian offshore areas. MAREANO has acquired a suite of marine data sets such as multibeam bathymetry and backscatter, seabed samples, videos of the seafloor and high resolution shallow seismic profiles. These data provide the basis for mapping geology, sedimentary processes and habitats on the seafloor.

On the Norwegian continental shelf, a huge number of coral reefs with live *Lophelia pertusa* and other corals have been found (Fosså et al., 2002). These coral reefs are in most places associated with mounds and ridges composed mainly of bioclastic sediments, originating from the breakdown of corals and other organisms with carbonate shell. Live corals are often found in the upstream parts of the bioclastic mounds and ridges. In addition, we find bioclastic sediments surrounding the ridges and mounds in varying degree. Bioclastic sediments have been identified on multibeam data between c. 63° N and as far north as Fugløybanken at 70°32′ N (Fig. 1). A total area of more than 150 000 km^2 has been mapped, and bioclastic sediments cover around 1500 km^2. Within this area, mounds and ridges with bioclastic sediments constitute c.150-250 km^2 (Bellec et al., 2014).

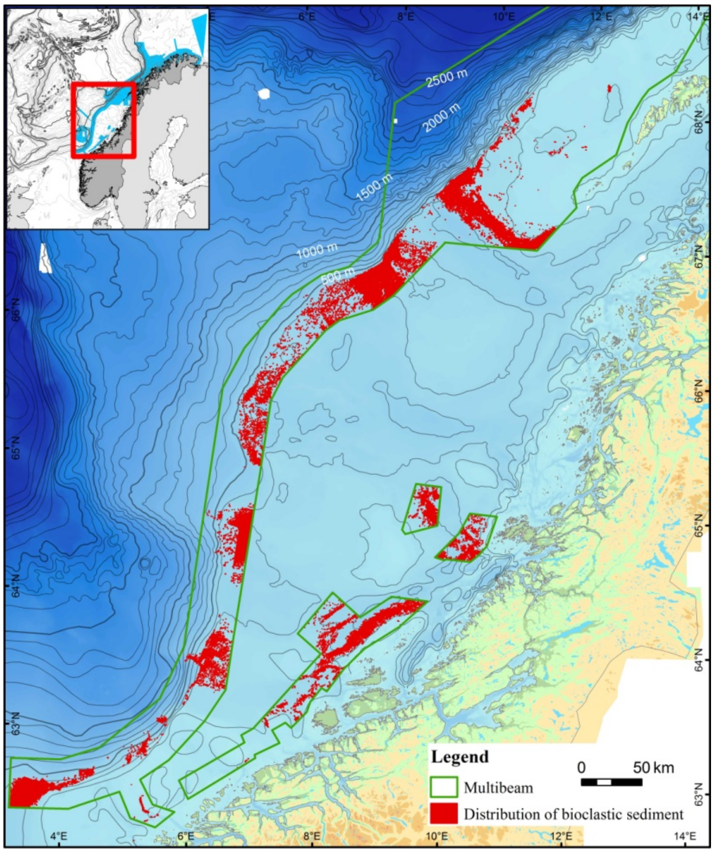

Figure 1. Distribution of bioclastic sediments (coral reefs, coral gravel and sand) between 63° and 68° N based on interpreted multibeam data.

Acoustic mapping is a powerful tool for mapping mounds and ridges with associated bioclastic sediments, even when ground truthing is limited, as the mounds can easily be distinguished from the surrounding seafloor based on morphology and acoustic signature. The mounds are from a few meters high and up to 1 km long, and can be recognized in 5 m bathymetry grids when they are wider than about 20 m. Interpretations without ground truthing were compared with the spatial distribution of confirmed occurrences of coral reefs and bioclastic sediments, based on more than 80 MAREANO video transects. This revealed a high match between interpreted mounds and mounds observed to host cold water coral reefs.

The cold-water coral reefs on the Norwegian shelf are post-glacial features which established across the entire 3000 km long Scandinavian shelf at c.10 ka BP (López Correa et al., 2011). They are important Holocene features, which preferentially form on hard substrates and protruding seabed features. We see that there is a strong correlation the occurrence of bioclastic mounds and ridges (including in many places live cold-water coral reefs) and glacial landforms, e.g. ridges, moraines and iceberg ploughmark berms formed during the last deglaciation of the area (Thorsnes et al., in press). This highlights the importance of palaeo-processes for distribution of vulnerable ecosystems such as cold-water coral reefs, during the Holocene and present.

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Pockmarks in the southwestern Barents Sea and Finnmark fjords

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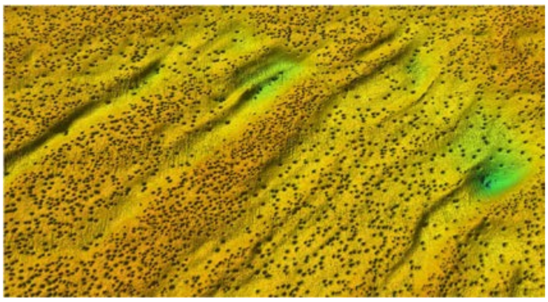
A large and diverse dataset, including data from the MAREANO mapping program (www.mareano.no), has been compiled and analysed in the Barents Sea and Finnmark fjords in order to map and characterise pockmarks. The main data sources are regional side-scan sonar and deep-towed boomer lines, and extensive multibeam bathymetry.

Small to medium-size pockmark fields are found in several basins west of Nordkappbanken. The most extensive one occurs in Ingøydjupet, where the largest pockmarks are almost 100 m wide and 8 m deep. Small to medium-sized pockmarks of 20-50 m width and 2-5 m depth are however more common. Pockmark density is typically 150-200 per km^2. North of the Finnmark coast, between Magerøya/Nordkapp and the Russian border, pockmark distribution is nearly continuous. The density is typically 300-600 per km^2, and most pockmarks are small (15-40 m wide and 1.5-4 m deep).

Recent studies suggest that the pockmarks in the southwestern Barents Sea were formed by seabed expulsion of gas due to dissociation of gas hydrates during the last deglaciation. Gas is locally observed to leak from the seafloor, but not from pockmarks, suggesting recent inactivity. We further explore the possibility that the pockmarks were formed during a short-lived event and that they are preserved due to low sedimentation rates and turbulent ocean currents keeping them open.

Numerous small pockmarks have also been found in four of the Finnmark fjords. They are most common in Varangerfjorden and Porsangerfjorden, where Proterozoic rocks subcrop beneath the Quaternary sediment cover. The Proterozoic rocks have no potential for gas generation and the pockmarks are most likely related to groundwater seepage.



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Late Quaternary deglaciation in the Arctic Ocean: evidences from microfossils

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Integrated micropaleontological and sedimentological analyses on calcareous nannofossils, diatoms, planktonic and benthonic foraminifera and clay mineral assemblages have been performed on three sediment cores (Tab. 1), collected during the EGLACOM and CORIBAR projects from the Storfjorden-Kveithola depositional system (NW Barents Sea, Fig. 1). The recovered cores contain a thick sedimentary sequence that includes well preserved Holocene interglacial sediments. The lithological sequence and the magnetic susceptibility are consistent between the EGLACOM and CORIBAR cores, allowing the construction of a preliminary age model. The upper part of the CORIBAR core was directly related to the Holocene sequence contained in core EG-03, whereas the lower part was correlated to the post LGM sequence contained in core EG-02. We specifically report on the results from the Holocene interval that is characterized by a clear reprise of the North Atlantic Current (NAC) strength. The planktonic microfossil patterns of distribution are coherent with the trend of smectite content in the clay mineral assemblage that is mainly transported by the NAC, therefore high contents are associated to a vigorous current (Junttila et al., 2010). The presence of nannofossils in the sediments is a clear indication of open-water/seasonal sea ice conditions as the nannofossils, unlike some diatom species, were photosynthetic algae that can not live under permanent sea-ice coverage. The nannofossil assemblages during the Holocene, are dominated by *Emiliania huxleyi* specimens smaller than 4 µm, confirming the deglaciation trend. The diatom assemblages are dominated by *Chaetoceros* resting spores, related to stratified waters in association with ice melting at the beginning of Holocene. The presence of the diatom *Coscinodiscus* spp. and a more diversified planktonic foraminiferal assemblage, with *Neogloboquadrina pachyderma* (s), *N. incompta* and *Globigerina bulloides*, indicating subpolar conditions, confirm the onset of warm environmental period that were associated to the Holocene Thermal Maximum. Minor climatic fluctuations with inversed trends within the Holocene are well depicted by the microfossils assemblages and distribution of the smectite clay mineral.

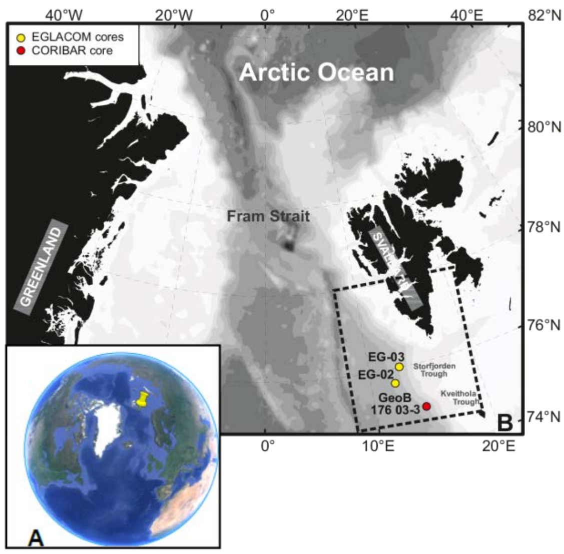

Figure 1. A) Location of the study area. B) The box indicates the study area in detail. Yellow dots indicate EGLACOM core location, red dot indicates CORIBAR core location.

Table 1. Core ID, EG=EGLACOM cores; GeoB=CORIBAR core.

Core ID	Water depth (m)	Location	Total recovery (cm)
EG-02	1722	Middle slope (Storfjorden)	305
EG-03	1432	Middle slope (Storfjorden)	291
GeoB 17603-3	1430	Middle KveitholaTrough	990

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Characteristics of submarine eskers observed at Ingøydjupet, SW Barents Sea using results of high resolution seismic and bathymetric mapping.

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Eskers are landform features formed under the glaciers and of interest due to their specific characteristics related to glaciers. Studies of eskers have been a matter of interest since they are related to late glacial environments and fluvial sedimentary processes (Banerjee and McDonald, 1975). The eskers are typically oriented parallel to topographic contours with the slope of the glacier controlling the esker paths (Syverson et al., 1994). This makes the eskers important since they can be used to decipher the hydraulic gradient under the glacier and also the geometrical parameters of the glacier. The SW Barents Sea is well known for glaciations and a detailed reconstruction of the late Weichselian maximum and subsequent deglaciation was proposed for this area (Winsborrow et al., 2010). Our study area falls in the western part of the SW Barents Sea, the Loppa High. A large number of eskers were mapped using multibeam bathymetry and sub bottom profiler data from the Ingøydjupet depression at Loppa High, SW Barents Sea. The eskers are oriented in the NE-SW direction. They appear as linear features within the bathymetric depression even though part of the depression is filled with postglacial sediments. In this study we analyse the nature of these eskers using high resolution sub bottom profiler seismic data acquired across some of the eskers. The eskers appear with high backscatter in some areas, but in most places they are covered by postglacial sediments giving similar backscatter as the surrounding seafloor. Correlation of high resolution seismic and backscatter shows that wherever they are close to the seafloor, they give high backscatter implying that the esker is composed of harder and more coarse-grained material. The sediments flanking the eskers also show that they formed as highs on relatively flat seafloor under the ice and probably represent melt water channels formed within ice as a confined space.

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KEYNOTE: Deglacial sea-Level history of the western Arctic Ocean

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We analyzed micropaleontologic assemblages (benthic, planktic foraminifera and ostracodes) using radiocarbon chronology to reconstruct deglacial relative sea level (RSL) history in the Eastern Siberian Sea. We focused on gravity and piston cores (120 to 964 mwd) on the continental shelf and upper slope from Leg 2 of the 2014 SWERUS-C3 Expedition. Radiocarbon dates on mollusks and benthic foraminifera indicate deposition during the late deglacial from at least 13 ka to about 10 ka. Foraminiferal (*Buccella frigida*, *Cassidulina reniforme*, *Elphidium* spp., *Islandiella teretis*) and ostracode *Acanthocythereis dunelmensis, Cytheromorpha macchesneyi, Sarsicytheridea punctillata* and *Paracyprideis pseudopunctillata* assemblages and sparse planktic foraminifera all indicate shallow, inner continental shelf environments during deglacial sea-level rise. We will compare the E. Siberian Sea RSL curve with that from the nearby Laptev Sea and evaluate their significance for Eurasian ice sheet reconstruction and glacio-isostatic adjustment models for this region of the Arctic.

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Emergence of the modern Nordic Seas circulation in the Early Pliocene related to ocean gateway changes

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The modern Nordic Seas circulation – with inflow of warm Atlantic waters in the east and export of cool and fresher Arctic waters in the west – was likely initiated during the Early Pliocene (e.g. Bohrmann et al. 1990). However, a precise timing, encompassing mechanism and conclusive data remained elusive. We collected dinoflagellate cyst and acritarch records from the Norwegian and Iceland Seas to investigate the Nordic Seas surface circulation during the Early Pliocene (De Schepper et al., 2015). Our results show that dinoflagellate cyst assemblages in the Norwegian and Iceland Seas are comparable prior to 4.5 Ma, but thereafter develop independently. Around 4.5 Ma, our records show a major dinoflagellate cyst assemblage turnover and productivity decrease, and a Nordic Seas-wide cooling in Iceland, the Iceland Sea and Norwegian Sea. This is also the time when cool-water Pacific mollusks appear firstly in the Tjørnes section on Iceland (Durham & MacNeil 1967; Verhoeven et al. 2011), evidencing a transarctic migration of cool-water Pacific mollusks. Together this suggests a flow of Pacific water into the Nordic Seas along the East Greenland Current pathway and the emergence of a zonal sea surface temperature gradient characteristic for the modern Nordic Seas circulation.

The observed changes in the Nordic Seas at 4.5 Ma precede North Atlantic and global cooling by 500,000 years, but occur in sync with reconfigurations at the Northern Hemisphere Pacific–Atlantic

ocean gateways (Central American Seaway, Bering Strait). We therefore propose that changes at these gateways triggered the development of a modern-like surface circulation in the Nordic Seas, which is essential for North Atlantic Deep Water formation and a precursor for more widespread Greenland glaciation in the late Pliocene.

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Holocene variation in the onset of the Neoglacial cooling off eastern Greenland from Fram Strait to Cape Farewell

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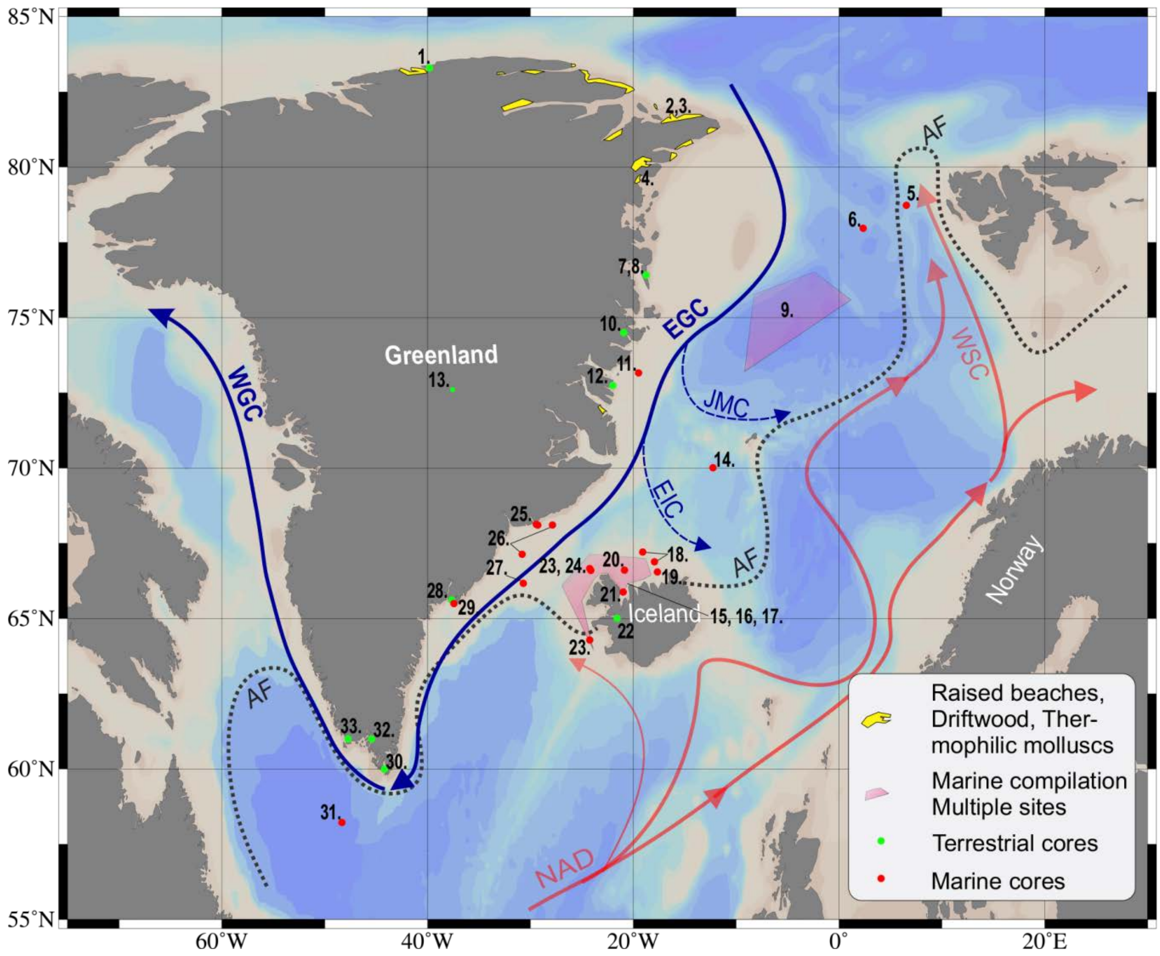
The eastern Greenland area, here comprised by the Greenland Sea, the Icelandic Plateau, the east Greenland shelf and the coastal area of eastern Greenland (58^0N-84^0N), is a key region within the global climatic system as unusual outflows of freshwater and sea ice from the Arctic Ocean pass through this area with the East Greenland Current (EGC) and hence contributes significantly to the freshening of the surface waters off Greenland and in the Labrador Seas. Fresher surface waters changes the stratification and density contrast and hence modulates the strength of the Atlantic Meridional Overturning Circulation (AMOC) with potential dramatic impacts on the global climate. Despite the importance of this region, our understanding of natural climatic and oceanographic variability in this region is limited.

The Holocene interglacial climate of the Northern Hemisphere is overall considered to be fairly stable on centennial to millennial time scales compared to the dramatic changes of earlier glaciations and are governed by the overall declining summer insolation. Nevertheless a significant amount of studies have disputed the timing and extent, as well as the importance of different climatic periods during the Holocene. There is a general consensus that during the mid-Holocene period the global climatic system was marked by dramatic changes at the transition from the Holocene Thermal Maximum (HTM) in to the so-called “Neoglaciation” (NEO). In the northeastern North Atlantic, mid-Holocene changes are suggested to be governed by a major reorganization of the surface circulation patterns, which involved changes in both the strength and the direction of the EGC and the North Atlantic Current, modulations in the deep-water formation, and in the freshwater contribution to the Nordic Seas, which ultimately resulted in a modern-like hydrological circulation.



Despite the importance of these proposed changes in the climate system, only a few reconstructions (e.g., Kaufmann et al., *Quat. Sci. Rev.* 23, 529–560, 2004) of major millennial-scale Holocene changes in eastern Greenland have used more than a handful of data records. Previous attempts to constrain the Holocene paleoclimatic changes east of Greenland are often highly fragmentary, focused on isolated records, and with uncertainties from using a single proxy rather than a multi-proxy approach. In recent decades an increasing number of onshore and offshore records have been developed along and near the EGC pathway, hence there is now an unprecedented opportunity to identify past changes and linkages in this important and exceptionally complex regional system.

Our study aims at establishing the temporal and spatial extent of the HTM/NEO transition east of Greenland from Fram Strait to Cape Farewell by applying a data-synthesis approach to past and newly developed onshore and offshore records in order to achieve a more comprehensive overview of the timing and nature of this major Holocene transition. We have compiled and evaluated over ~200 disparate marine and terrestrial records and selected 33 records (see figure) for analysis based on multiple criteria. Special emphasize has been made on establishing a comprehensive dataset with a more evenly distributed spatial extent and inclusion of more marine records compared to previous studies in this region. Hence our study provides a new overview of the HTM/NEO transition east of Greenland. There is a clear time-transgressive initiation of the Neoglaciation, with a generally earlier onset towards higher latitudes. There are also latitudinal differences in the variability of the HTM/NEO onset, with the largest variability apparent in records south of 70 ^{0}N, plausibly related to atmospheric–oceanic dynamics related to circulation of sea ice, polar waters and temperate Atlantic Water in the region.

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A new infrastructure for the paleoclimatic community: A fully automated 2G SQUID cryogenic magnetometer at the Geological Survey of Norway

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To unravel climate forcing factors and associated paleoenvironmental changes in sedimentary archives on different time scales, the paleoclimatic community requires (A) a robust stratigraphic framework, (B) a multitude of process-related, physical, chemical, and biological parameters, and (C) and high-resolution analytical capacities to be able to process large sample collections on millennial to centennial time scales. The Geological Survey of Norway (NGU) and "CAGE – Centre for Arctic Gas Hydrates, Environment, and Climate" at the University of Tromsø, The Arctic University of Norway have recently set up a new, large-scale infrastructure for magnetic characterization of sediments in Trondheim.

A fully automated 2G SQUID cryogenic magnetometer enables paleomagnetic and magnetic proxy studies involving processing of large sample collections while simultaneously ensuring high quality data that are produced as reproducible as possible. Similar systems are operational at the universities of Bremen (Germany) and Utrecht (Netherlands). The new NGU magnetometer is equipped with 'in-line' alternating field (AF) demagnetization, a direct-current bias field coil along the co-axial AF demagnetization coil for the acquisition of anhysteretic remanent magnetization (ARM) and a long pulse-field coil for the acquisition of isothermal remanent magnetization (IRM). Samples are contained in dedicated low-magnetic holders or sample boxes that are manipulated by a pick-and-place unit. Typically, about 300 paleomagnetic samples can be AF demagnetized and analyzed per week. The versatility of the system is illustrated by several examples of paleomagnetic and rock magnetic data processing.

During the conference, we will invite the delegates to join us on a tour through the laboratory facilities and to stimulate discussion on future collaborations.

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Dynamic Holocene history of a Spitsbergen fjord-system, western Svalbard

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Evidence of a dynamic Holocene history is preserved in both the terrestrial and marine archives of St. Jonsfjorden, a small fjord-system on the west coast of Spitsbergen. High resolution marine geophysical data paired with recent (2009) terrestrial aerial images aided in the development of a geomorphological map highlighting an intricate glacial and sea level history of the entire fjord-system combining its submarine as well as subaerial environments. Stratigraphic logs of exposed terrestrial sections as well as marine sediment cores provide insight into the rapid transition from deglaciation to the Holocene (marine) Thermal Optimum as well as the onset and climax of the Neoglacial-Little Ice Age in the St. Jonsfjorden. Identification and dating (ca. 9.8 ka BP) of a thermophilous mollusc (*Modiolus modiolus*) suggests rapid migration north by the relatively warm water species shortly following deglaciation. The date additionally suggests *Modiolus modiolus* populated the region over

500 years earlier than previously believed. The youngest age of radiocarbon dated shells (ca. 780 BP) deposited in a coastal push moraine of marine sediments constrains a Neoglacial advance of Osbornebreen, the main marine terminating glacier system present in St. Jonsfjorden today. Presently the Osbornebreen terminus is located over 8.5 km up-fjord from its Neoglacial maximum and cross-cutting relations suggest numerous advances of smaller local glaciers subsequently. Glacial deposits, landforms and their cross-cutting relationships visible in both terrestrial and marine settings suggest a complex and dynamic history through the later part of the Holocene.

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Trondheimsfjord sediments reveal North Atlantic Oscillation dynamics of the past 2800 years

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The North Atlantic Oscillation (NAO) is the leading mode of atmospheric circulation variability in the North Atlantic region. Associated shifts of storm tracks, precipitation and temperature patterns affect energy supply and demand, fisheries and agricultural, as well as marine and terrestrial ecological dynamics. Long-term NAO reconstructions are crucial to better understand NAO variability in its response to climate forcing factors, and assess predictability and possible shifts associated with ongoing climate change.

Fjord deposits have a great potential for providing high-resolution sedimentary records that reflect local terrestrial and marine processes. A recent study of instrumental time series revealed NAO as main factor for a strong relation between winter temperature, precipitation and river discharge in central Norway over the past 50 years. Here we use the gained knowledge to establish the first high resolution NAO proxy record from marine sediments. By comparing geochemical measurements from a short sediment core with instrumental data we show that marine primary productivity proxies are sensitive to NAO changes. Conditioned on a stationary relation between our climate proxy and the NAO we establish the first high resolution NAO proxy record (NAO_{TFJ}) from marine sediments covering the past 2,800 years. The NAO_{TFJ} shows distinct co-variability with climate changes over Greenland, solar activity and Northern Hemisphere glacier dynamics as well as climatically associated paleo-demographic trends.

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Revision of the Late Quaternary Lake El’gygytgyn level fluctuations

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Lake El’gygytgyn is located in a meteorite impact crater of 18 km diameter, which was formed about 3.6 Ma ago in central Chukotka, Russian Arctic (67°30´N, 172°5´E) approximately 100 km north of the Arctic Circle (for details see Melles et al., 2012 and references therein).

According the previous geomorphologic and geological studies (Glushkova, 1993) the Lake El'gygytgyn area was never glaciated and sedimentation in the lake presumably has been continuous since its formation. In the winter season of 2008–2009, deep drilling in the impact crater recovered long cores embracing both the 318 m lacustrine sediment sequence (core 5011-1) from the center of the basin (for details see Melles et al., 2011) and the 141.5 m permafrost sequence (core 5011-3) outside the lake talik (for details see Melles et al., 2012; Schwamborn et al., 2012). These cores provide the longest terrestrial paleoenvironmental records from the Arctic, starting in the warm middle Pliocene (Melles et al., 2011, 2012; Brigham-Grette et al., 2013).

This work is focused on reconstruction of the Late Quaternary lake-level history based on previously published data and a new obtained data.

Although, late Quaternary level history of Lake El'gygytgyn widely discussed in recent time (Glushkova and Smirnov, 2007; Fedorov et al., 2008; Schwamborn et al., 2008; Glushkova et al., 2009; Juschus et al., 2011; Schwamborn et al., 2012; Bischoff et al., 2014), a number of questions concerning timing of the high and low level stand events and, especially, relations of these events to climate changes remain unsolved.

The new results presented in this work are based on a new interpretation of the lithology of the shallow-water sediment cores LZ1027 and LZ1028 described by Juschus et al. (2011) as well as new pollen records from these cores and new IRSL dates from the deposits of the 10 m terrace above modern lake-level and new interpretation of the pollen spectra from these deposits, previously published by Glushkova et al. (2009).

Finally, the new obtained results and revision of all available data allows us to make following conclusions:

1. Lake El'gygytgyn level changes are climate driven with tendency to abrupt rising in very beginning of warm stages and gradual lowering after climatic optimum with peak of low stand in cold and dry stages.
2. The lake is sensitive to both precipitation controlling water income and temperature, controlling ice cover and wave's activity. The highest lake level stands have occurred during the warm and moist intervals, while lowest lake level stands were associated with cold and dry intervals. During the warm and dry and cold and moist intervals were occurred gradual lowering or insignificant fluctuating.
3. The reconstructed lowermost lake level position was associated with MIS 6 when level dropped down at least for 50 m. Most likely this was associated with formation of outflow to Enmyvaam River during the high MIS7 lake level stand and subsequent deep erosion.
4. The modern morphology of the crater with preserved terraces in southern part was formatted since Middle Pleistocene after opening of outflow. The modern shelf in lake bathymetry formatted during low stands during the MIS 6, 4 and 2 intervals.
5. The Holocene sedimentation on modern shelf prevented by strong lake currents

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Glacial dynamics in Mohnbukta east Spitsbergen inferred from the submarine landform record

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Many of Svalbard´s fjords accommodate tidewater glaciers, of which several have been inferred to be of surge-type (Ottesen et al. 2008; Flink et al. 2015). The glacial history of the fjords on western Svalbard has been relatively well studied, with geophysical and sedimentological methods (Ottesen & Dowdeswell 2006; Ottesen et al. 2008). The glacial history of the fjords and bays on the east coast of Spitsbergen is, however, considerably less well-known, mainly because these areas are covered by sea ice during large parts of the year. Therefore, studies of fjords in the less well-known eastern Svalbard can shed light on how the different oceanographic, weather and sea ice conditions have affected the glacier dynamics and deglaciation history there as compared to western Svalbard.

We present the first detailed study of a small fjord, Mohnbukta, on the east coast of Spitsbergen. The glacial history of Mohnbukta has been studied with multibeam-bathymetric data collected in 2013 and sediment cores obtained during a field-campaign in 2014. Presently three tidewater glacier, Heuglinbreen, Hayesbreen and Köningsbreen calve into Mohnbukta. Hayesbreen has surged sometime between 1901 and 1910 (Lefauconnier & Hagen 1991). During the surge, the glacier front reached at least 13 km further out to the fjord compared with its present position, but the maximum stage of the surge has not been recorded.

The submarine landform assemblage in Mohnbukta consists of glacial lineations, two large terminal moraine ridges, with debris-flow lobes on their distal slopes, and two sets of very well preserved crevasses-squeeze ridges. The crevasse-squeeze ridges in the inner basin (on the glacier proximal side of the innermost ridge) have similar dimensions (1-3 m high, 10 m wide and 20-100 m long) as earlier described crevasse-squeeze ridges in Svalbard fjords (Ottesen et al. 2008; Flink et al. 2015) and adjacent coastal areas (Lovell et al. 2015). The ridges in the outer basin are however significantly larger, with mean heights of 6 m, widths between 20-80 m and lengths of 200-400 m. The crevasse-squeeze ridges suggest that the landform assemblage was probably produced during a glacier surge, thus indicating that at least two surges have taken place in Mohnbukta. The landform assemblage differs from characteristic surging landform assemblages on the west coast, by the lack of retreat moraine ridges (cf. Ottesen et al. 2008; Flink et al. 2015). The lacking retreat moraine ridges together with the well-preserved crevasses-squeeze ridges suggest that the glacier front was floating or close to flotation during its surge retreat phase. An aerial image from 1936 shows tabular icebergs calving off the glacier front further supporting that the terminus was close to flotation during the retreat phase after the 1901 surge.

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Morphology and sedimentary processes on the continental shelf edge and slope north of Nordaustlandet, Svalbard

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A marine-based Svalbard-Barents Sea Ice Sheet (SBIS) was covering the Barents Sea and Svalbard archipelago during the last glacial maximum (LGM) (Siegert et al., 2001). The ice-sheet was drained by ice streams flowing in cross-shelf troughs to the shelf edge during the full-glacial conditions (Ottesen et al., 2007). The ice streams, reaching the continental shelf edge, had significant impact on the morphology and sedimentary processes there by delivering diamict-dominated sediments and depositing large sediment fans at the mouths of cross shelf troughs, so called Trough Mouth Fans (TMFs) (e.g. Vorren et al., 1988; Batchelor & Dowdeswell, 2014).

The knowledge about the glacial dynamics and deglaciation history of the northern Svalbard margin is scarce (Knies et al., 1999; Chauhan et al., 2015). The aim of this study is to shed light on the morphology and sedimentary processes at the shelf edge and continental slope north of Nordaustlandet in order to improve the understanding of the northern Svalbard continental margin development and its links to the Svalbard-Barents Sea ice sheet evolution. High-resolution multibeam, shallow subbottom acoustic (chirp) and 2D airgun seismic data have been used to investigate the sedimentary architecture and morphology of the shelf edge and slope off Kvitøya and Albertini Troughs north of Nordaustlandet.

Although the submarine landform record documented by previous studies suggests that both Kvitøya, as well as Albertini Troughs were occupied by ice streams during the LGM (Hogan et al., 2010; Noormets et al., 2012), the continental shelf edge and upper slope morphology is remarkably different at the mouths of these troughs. The continental shelf edge off Kvitøya Trough features a large outwards bulging TMF whereas the Albertini Trough mouth is cutting back into the shelf edge rather than bulging outwards. Previous research has shown that the rifted continental margin off Albertini Trough is down-faulted (Geissler and Jokat, 2004). However, the 2D seismic data show a number of sediment packages forming foresets typical to progradational TMFs off both the Kvitøya and the Albertini Troughs, suggesting ice-flow throughout several glaciations there.

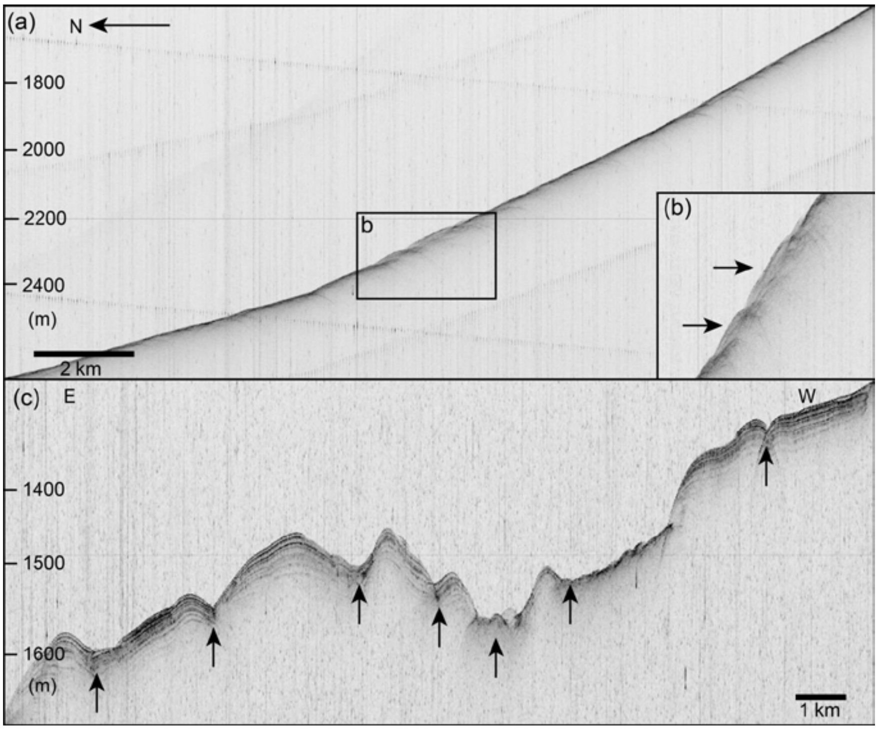

Figure 1. (a) Chirp profile across the continental slope off Kvitøya Trough. (b) Magnification of a section of (a) shows two sediment mass flow lobes (arrowed) (c) Chirp profile along the mid-lower continental slope off Albertini Trough shows a part of the western set of gullies (arrowed) cutting locally into acoustically laminated sediments.

Two sets of gullies on the eastern and western flanks of the Kvitøya TMF respectively, may have been formed by gravity-driven sediment-laden meltwater flows and acted as conduits for downslope sediment transfer from the shelf edge to the lower slope during full glacials (e.g. Dowdeswell et al., 2008; Noormets et al., 2009; Gales et al., 2013). This is supported by the relatively steep upper continental slope facilitating the formation of gravity-driven sediment-laden meltwater flows and hummocky sediment architecture of the lower slope representing the stacked accumulation of sediments deposited from these flows, being consistent with the theory where ice stream-dumped sediments bypass the upper slope through the gully systems and accumulate on the less steep lower slope (Noormets et al., 2009).

The morphology and sediment architecture of the continental shelf edge and slope suggest that a considerably more active ice stream was flowing through Kvitøya Trough delivering large amount of sediments to the shelf edge and forming a TMF with associated gully systems whereas there was a less active ice flowing in the adjacent Albertini Trough. Alternatively, the down-faulted continental margin off the Albertini Trough provided larger accommodation space for glacial sediments inhibiting the TMF formation there as compared to the adjacent Kvitøya Trough mouth.

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New chronological constraints on the deglaciation of northernmost and southernmost Norway based on in-situ cosmogenic nuclides

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The northernmost coastal areas of Scandinavia hold a unique record of end moraines that are more or less coast-parallel and can be followed over long distances. Several of the most prominent end moraines were mapped and described by exploring geologists already over a hundred years ago. Since the very earliest descriptions, raised shorelines were used for correlating sets of end moraines between different fjords, and also for relative dating of the halts in deglaciation (sub-stages) that produced the end moraines. The retreat chronology of Northern Norway has attained renewed interest during the last few years, as the fjords of Finnmark constitute a valuable analogue to the currently deglaciating coastline of Greenland. Also, a great body of work from the Barents Sea offshore Finnmark is now present, and chronological uncertainties in ice sheet reconstructions are particularly present near the coast. Still, up until today little effort has been put into improving the deglaciation history of Finnmark by direct dating. With the aim to improve this, we conducted a field campaign from the outer coast to the inland of eastern Finnmark to collect samples from end moraines for terrestrial cosmogenic dating. We measured the concentration of ^{10}Be (N=22) and ^{36}Cl (N=18) from boulders located at the crest of major moraine ridges at the localities Porsangen, Kongsfjorden, Vardø and Kirkenes. Also, a ^{36}Cl depth-profile based on 7 bag samples was obtained from a glaciofluvial deposit at Tana bru. Our results generally confirm the ages that have been suggested from previous reconstructions based on shoreline correlation, with a steady retreat from the the coast at around 15.5 ka to a distinct Younger Dryas stage at Kirkenes.

The status is similar for southernmost Norway with very little absolute chronological control of the deglaciation, despite direct proximity to the contentiously discussed Norwegian channel ice stream. Southern Norway was mapped by the famous glacial geologist Bjørn Andersen already in the early 1950s, using basic aerial photographs and topographic maps. Andersen reconstructed two distinct

glacial sub-stages (the Lista stage and Spangereid stage) that were older than the Younger Dryas (YD), and one main glacial stage of assumed YD age (the Ra stage). This interpretation has remained untested and is still used in reconstructions of the Fennoscandian ice sheet. In this study we test the reconstruction of Andersen by remapping the whole area using newly aquired LiDAR data (high resolution laser scanning of terrain), together with in-situ cosmogenic nuclide exposure ages of boulders on marginal moraines. The study comprises mapping of more than 6000 km^2 of forested and dissected landscape, measurement of ^{10}Be concentrations (N=53) from boulders/bedrock, one cosmogenic ^{10}Be depth profile in a coarse-grained glaciofluvial deposit, and finally one lake record.

Our study shows that the oldest of Andersen's glacial stages, the Lista stage on the outermost south coast, likely should be rejected since it consists of consolidated subglacial till and therefore is not an end moraine system. However, our ^{10}Be depth profile shows that this area probably was ice free already by around 19 ka BP, almost 4 ka earlier than previously thought. At the same time the ice sheet surface slowly lowered, and the first inland hills of about 450 m. asl. became ice free at around 17 ka BP. Ice retreat continued slowly 10-15 km inland and halted as a calving fjord stage at the Spangereid stage with an approximate age of 15 ka BP. The subsequent deglaciation appears to have been very rapid where the ice front retreated 30-50 km inland to a position inside of the Ra stage, until a readvance in Older Dryas around 14.5 ka BP. The ice front might have retreated inland again in the Bølling-Allerød interstadial, but readvanced to almost exactly the same position in the early YD and with possible oscillations until late YD. The complexity of the cosmogenic exposure ages from the Ra moraine system is supported by LiDAR mapping that often shows multiple moraine ridges that sometimes onlap each other and sometimes are separated by as much as 5 km.

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Deglaciating the western Canadian Arctic: linking terrestrial and marine records of retreating ice margins and catastrophic ice shelf behaviour

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Over the last two decades, significant advances have been made in reconstructing western Canadian Arctic Late Wisconsinan ice extent and retreat patterns from terrestrial island-based records. This has included a reassessment of the extent of (cold-based) ice, flow trajectories and retreat patterns, isostatic loading, and the refinement of chronologies. The result is an emerging integrated model of Last Glacial Maximum to Holocene environmental change across the islands of the western Canadian Arctic Archipelago such as Victoria, Banks, Melville, Eglington, and Prince Patrick islands.

Largely absent from this evolving regional synthesis has been data from the marine channels themselves, in particular Viscount Melville Sound and M'Clure Strait, collectively forming western Parry Channel (the main axis of the Northwest Passage). Given the importance these channels have played in governing ice export and ice sheet stability, Arctic Ocean sediment delivery, and the evolution of Holocene Pacific-Arctic-Atlantic watermass exchange, this represents a major missing piece of the Archipelago jigsaw. Now beginning to be addressed by the much-need acquisition and analysis of piston core records and geophysical data, the assessment of these new records in the context of adjacent terrestrial histories presents major challenges given issues of chronological context and spatial coverage. Nevertheless, a marine-based picture of ice retreat dynamics is beginning to emerge that broadly confirms and expands upon the island-based late Quaternary history of the region.

In Viscount Melville Sound, this integration of terrestrial and marine records is illustrated by ongoing investigations into the deglacial Viscount Melville Sound Ice Shelf (VMSIS). Geomorphic and sedimentological research from the coasts of Victoria, Melville, and Banks islands has demonstrated the retreat of grounded glacial ice from this >100,000 km^2 basin by ~13.5 cal ka BP. This was followed by the re-establishment of a floating iceshelf impinging on the coasts of Viscount Melville Sound ~10.6 cal ka BP. Evidence includes extensive and impressive coast-parallel ice shelf moraines, shelly till deposits, and associated epishelf lake sediments generated by shallow water grounding and on-shore movement of floating ice. Molluscan chronologies from Victoria and Melville Island coasts suggest the establishment of the ice shelf was extremely rapid, persisting for some 200 years from ~10.6 to ~10.3 cal ka BP, and subsequently undergoing an equally rapid collapse.

These terrestrial data are now complemented by core records from central Viscount Melville Sound where two long Geological Survey of Canada / ArcticNet piston cores permit a sedimentological and biostratigraphic perspective on deglacial sediment dynamics in the region. Taken from along the main axis of ice streaming into Viscount Melville Sound, the cores display litho- (IRD species), bio- (foraminifera and biogenic silica), and chrono-stratigraphies (15 foraminiferal ^{14}C dates) that attest to regional deglaciation followed by glacimarine conditions and subsequent rapid ice shelf formation and collapse correlating with the terrestrially-described VMSIS. Further, the core record hints at a younger ice shelf collapse postdating the VMSIS and perhaps correlating with ice stream flow sets documented from nearby M'Clintock Channel. Thus, the seafloor stratigraphy of central Viscount Melville Sound supports terrestrial interpretations for the occupation of the basin (>100,000 km2) by a rapidly advancing ice shelf during regional deglaciation. These data also suggest that by the time floating ice reached central Viscount Melville Sound, it was largely free of basal debris, the extensive moraines and till belts the ice shelf built around the coasts of the Sound being of locally derived and reworked materials.

The formation of such an ice shelf requires still contiguous Laurentide and Innuition grounded ice to the east across western Barrow Strait as well as buttressing by pervasive sea ice to the west in order to develop. Such conditions could well have been provided during the Younger Dryas, resulting in the thickening and advance of the M'Clintock ice stream and extensive sea-ice cover. The subsequent surge-like behaviour that fed the iceshelf, however, ultimately results in irreparable draw-down of the NW sector of the Laurentide Ice Sheet and contributes to unsuturing of Laurentide and Innuition ice to the east. This permits the establishment of west-east oceanic through-flow through the archipelago and climatically important oceanographic exchange between the Arctic Ocean and Baffin Bay.

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Geophysical investigation of the western North Sea

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The NE coast of England is a region that was overrun by the British and Irish Ice Sheet (BIIS) multiple times during the Pleistocene, and that was also influenced by numerous ice streams and flow phase switches during the Last Glacial Maximum (LGM). However, despite recent improvements in our understanding of the onshore glacial history of the region, we still know little about ice sheet history offshore in the western North Sea, and in particular about the dynamic behaviour of the North Sea Lobe (NSL). New geophysical investigations (multibeam bathymetry and 2D seismic profiles), offshore from County Durham and Northumberland, now provide an opportunity to redress this imbalance.

This study aims to: (1) provide an assessment of new seismic and bathymetric data from the Blyth survey area and (2) provide a new reconstruction of the advance and retreat behaviour of the NSL.

Six seismic facies were identified in the Blyth survey area and reveal the presence of pre-Quaternary strata (Units 1 – 3) overlain by two units (Unit 4 and 5), which, based on their acoustic characteristics, have been interpreted as glacial units and have been correlated to the Wee Bankie and St Abbs formations, respectively (Gatliff et al., 1994). These two facies, located in the easternmost part of the survey, are 10 – 12 ms thick and characterized by chaotic internal reflectors and undulatory upper boundaries. Unit 4 is thought to be the Wee Bankie Formation, which has been correlated to the Bolders Bank Formation to the east and to the Horden Till (mapped onshore, in east County Durham) (Cameron et al., 1992, Davies et al., 2012a, Livingstone et al., 2012). Its deposition is thought to be related to the movement of the NSL during the Dimlington Stadial. Unit 5 has been correlated to the St Abbs Formation, a post-LGM deglacial glaciomarine unit. A second possible interpretation would infer Unit 5 to be also a till, given that it is acoustically very similar to Unit 4. If unit 5 is in fact a till, it would necessary mean that its deposition took place after the Dimlington Stadial, since the unit is stratigraphically above Unit 4. A third scenario suggests that both seismic facies could be older than Late Weichselian and could belong to previous Pleistocene glaciations. Evidence of older glaciations has been found on County Durham with the presence of the Ash Gill Member of the Warren House Gill Formation, which was interpreted as MIS 8 in age or older (Davies et al., 2012b). Unit 4 could therefore correlate with this and Unit 5 could be correlated with a more recent till, deposited during the Late Weichselian, thus replicating offshore the same stratigraphic sequence observed onshore. Unit 6 is the uppermost facies of the sequence and has been divided into two separate units: Unit 6a, correlated to the Forth Formation, and Unit 6b at the top, interpreted as composed of Holocene sediments.

Additional research based on 2D seismic profiles and sedimentological data collected during the Britice-Chrono JC123 survey, together with BGS 2D seismic records in the area and bathymetry data gathered from the UK Hydrographic Office, provides further information on the glacial geophysical and sedimentary signature in the western North Sea. Streamlined, exposed bedrock on the seafloor is overlain in places by distinctive till wedges which infer periodic standstills/re-advances of the NSL as it retreated north westwards parallel with the coast. It is hoped that new OSL/^{14}C dates will provide the first age controls on this late phase oscillatory behaviour of the NSL.

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North Atlantic water influence and sea surface water warming during the late Pliocene in the marginal Arctic Ocean (Site 911A, Yermak Plateau)

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At Yermak Plateau Site ODP 911A in the marginal Arctic Sea, 21 samples were analyzed for marine palynology from an interval within the Piacenzian Stage (Late Pliocene). The samples are located between 425.82 and 410.3 meters below sea floor. They span in age from >3.0 to <2.78 Ma.

The sediments contain abundant terrestrial palynomorphs, including pollen and spores which dilute the *in situ* marine palynomorphs. While dinoflagellate cyst concentrations were generally low, sufficient dinoflagellate cysts were present in the samples to reconstruct the surface water conditions. In addition, several stratigraphic markers (mainly acritarchs) were recovered and these provide more detail on the mid- to late Pliocene age model for the site (Mattingsdal et al., 2014). Consequently, our new data allow a better control on the timing of North Atlantic water (NAW) influence, sea ice cover and sea surface temperature at the site.

The strong dominance of cysts of *Protoceratium reticulatum* shows that from ~2.91 Ma up to ~2.84 Ma, warm North Atlantic waters noticeably influenced the site. Significant numbers of the mild-temperate to tropical *Operculodinium israelianum*, which is almost always reported in regions with summer sea surface temperatures above 10˚C (Zonneveld et al., 2013), suggest that summer sea surface temperatures were generally high during this time interval. The absence of the sea ice indicator species *Islandinium minutum* during this time interval further indicates sea ice free conditions. Consequently, the seasonal temperature gradient was generally weak. However, at ~2.9 Ma (412.23 mbsf) *O. israelianum* and *I. minutum* co-occur in the same assemblage suggesting a steep seasonal gradient: *I. minutum* reflects Arctic surface waters and sea ice, whereas *O. israelianum* and several other thermophilous dinoflagellate cyst taxa suggest summer surface temperatures higher than modern After ~2.8 Ma the North Atlantic Water influence reduced significantly and surface water temperatures decreased. Occasionally, summer sea surface temperatures reached 10–12 °C based on the presence of *Lingulodinium machaerophorum* (Lewis and Hallett, 1997; Zonneveld et al., 2013).

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Event stratigraphic interpretation of high-resolution, marine seismic data from Leirfjorden, North Norway

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A high-resolution (sparker), marine seismic survey in Leirfjorden, North Norway, was carried out in 2013 to improve the understanding of the areas's paleoenvironmental record. Dated cores are not available but known records from surrounding areas provide a chronological framework for interpretation. A seismic profile in extension of the fjord's outlet shows a glacier marginal deposit corresponding to the Younger Dryas Tjøtta stage. During this time Leirfjorden was entirely filled by glacier ice. Deposits predating the Tjøtta stage seem to be preserved in Leirfjorden as also previously recorded for neighboring Ranfjorden. This fill comprises thick, stacked, glacially disturbed deposits overlain by stratified fjord sediments with a marked interval associated with erosion and lenses of debris. The lenses are interpreted as representing reworked glacier deposits that accumulated following the retreat of the Tjøtta stage glacier. The underlying fjord sediments are subsequently of Allerød or early Younger Dryas age. Several marked beds are present in the younger part of the stratigraphy. For example, an interval with high amplitude reflections is interpreted as possibly representing the Nordli glacier readvance. Distinct ponded turbidite beds are interpreted as originating from the Storegga tsunami. In general, the stratigraphy reflects the interplay between glacier activity and fjord sedimentation of interconnected fjord and sound systems.

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A shear-wave, reflection seismic study of the fjord-valley fill below urban ground in Trondheim, Mid Norway

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Onshore, high-resolution, shear-wave seismic reflection data reveal the stratigraphic organization of a fjord-valley fill below paved, urban ground at Trondheim, central Norway. The stratigraphy represents a typical fjord-valley fill of up to 160 m in thickness that is composed of glacio-marine and fjord-marine sediments overlain by deltaic deposits which are draped by an anthropogenic fill. The seismic record reveals evidence of recurrent mass-wasting events that include landslide debris, turbidite deposits and erosion features. A chronological framework for the stratigraphy is provided by existing records from the area and is correlated with marine seismic data and cores. The dataset document the Lateglacial to Holocene development of an emerging fjord and delta system affected by major, mass-wasting events. An interval with high amplitude reflections is correlated to the Younger Dryas Tautra Stage moraine south of Trondheim. The study provides insight into the stratigraphic variability of fjord-valley fills, and highlights the interplay between fjord marine sedimentation, marine abrasion, delta progradation and mass wasting during late stages of fjord filling. The shear-wave seismic data provide information on internal structures as well as some information on sediment properties. The study demonstrates the potentials of the shear-wave seismic technique for onshore studies of fjord-valley fills.

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Deglaciation of a major palaeo-ice stream in Disko Trough, West Greenland

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Recent work has confirmed that grounded ice reached the shelf break in central West Greenland during the Last Glacial Maximum (LGM). Here we use a combination of marine sediment-core data, including glacimarine lithofacies and IRD proxy records, and geomorphological and acoustic facies evidence to examine the nature of and controls on the retreat of a major outlet of the western sector of the Greenland Ice Sheet (GrIS) across the shelf. Retreat of this outlet, which contained the ancestral Jakobshavns Isbræ ice stream, from the outer shelf in Disko Trough was rapid and progressed predominantly through iceberg calving, however, minor pauses in retreat (tens of years) occurred on the middle shelf at a trough narrowing forming subtle grounding-zone wedges. By 12.1 cal. kyr BP ice had retreated to a basalt escarpment and shallow banks on the inner continental shelf, where it was pinned and stabilised for at least 100 years. During this time the ice margin appears to have formed a calving bay over the trough and melting became an important mechanism of ice-mass loss. Fine grained sediments (muds) were deposited alternately with IRD-rich sediments (diamictons) forming a characteristic deglacial lithofacies that may be related to seasonal climatic cycles. High influxes of subglacial meltwater, emanating from the nearby ice margins, deposited muddy sediments during the warmer summer months whereas winters were dominated by iceberg calving leading to the deposition of the diamictons. This is the first example of this glacimarine lithofacies from a continental-shelf setting and we suggest that the calving-bay configuration of the ice margin, plus the switching between calving and melting as ablation mechanisms, facilitated its deposition by channelling meltwater and icebergs 35 through the inner trough. The occurrence of a major stillstand on the inner shelf in Disko Trough demonstrates that the ice dynamical response to local topography was a crucial control on the behaviour of a major outlet in this sector of the GrIS during retreat.

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KEYNOTE: DATED: Deciphering the chronology and evolution of the last Eurasian ice sheets

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Glacial geologists require ice sheet-scale chronological reconstructions of former ice extent to set individual records in a wider context. Ideally such reconstructions are fully documented and are constrained in absolute time to facilitate comparison to records of past environmental changes. To interrogate the physical mechanisms that drive the response and role of ice sheets in such changes, ice sheet, climate and ocean modellers require empirical reconstructions of the size and volume of past ice sheets that also include specified uncertainty estimates. Motivated by these demands, in 2005 we started a project (Database of the Eurasian Deglaciation, DATED) to compile and archive all published dates that constrain the build-up and retreat of the last Eurasian ice sheet complex, including the British-Irish, Scandinavian and Svalbard-Barents-Kara Seas ice sheets (BIIS, SIS and SBKIS respectively). Over 5000 dates were collated, assessed for reliability and used together with published ice-sheet margin positions to reconstruct time-slice maps of the ice sheets' extent, with uncertainty bounds every thousand years between 25-10 kyr ago, and at four additional periods back to 40 kyr ago. Ten years after the idea for a database was conceived, the first version of results (DATED-1) has now been published and the database has been released (Hughes et al. 2016). We observe that: i) both the BIIS and SBKIS achieve maximum extent, and commence retreat earlier than the larger SIS, with only the SIS remaining as a major ice sheet by 14 ka; ii) the eastern terrestrial margin of the SIS reached its maximum extent ~7000 years later than the westernmost marine margin; iii) the combined maximum ice volume (~24 m sea-level equivalent) was reached c. 21 ka; iv) large uncertainties exist; predominantly across marine sectors (e.g. the timing of coalescence and separation of the SIS and BKIS) but also in well-studied areas due to conflicting yet equally robust data. In just three years since the DATED-1 census (1 January 2013), the volume of new information (from both dates and mapped glacial geomorphology) has grown significantly (>1000 new dates). Here, we present the DATED-1 results in the context of the climatic changes of the last glacial and describe plans for the next version of the database, DATED-2.

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DATED-2: updating the Eurasian Ice sheet chronology and time-slice reconstructions

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We present ongoing work to update, maintain and develop the DATED database of dates and time-slice reconstructions of the build-up and retreat of the Eurasian (British-Irish, Scandinavian, Svalbard-

Barents-Kara Sea) ice sheets. Our first compilation and assessment of dates (DATED-1, census 1 January 2013; Hughes et al. 2016) demonstrated that the timing of maximum extent was spatially variable across the ice sheet complex, as was both the timing and rates of ice advance and retreat. Despite the wealth of information accumulated over several decades, it is possible to precisely define the ice-sheet margin in only a few sectors and time-slices. In some locations and time-slices uncertainty in the placement of the ice margin position was found to be as much as several 100 km due to a lack of dates and/or information on the ice sheet geometry. Instances of contradictory evidence also occur. In three years since the DATED-1 census, the volume of new information (both from dates and pattern information) has grown significantly, necessitating a reassessment of the reconstructed time-slice margins. Here we discuss the implications of these additional data for our time-slice reconstructions. DATED-2 will have a planned census date of 1 January 2017, and extend the geographical scope to include the Icelandic Ice Sheet. We invite scientists to inform us about new dates, dates missing in DATED-1 and to criticise our interpretations.

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Mega deposits and erosive features related to the glacial lake Nedre Glomsjø outburst flood, southeastern Norway

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At the end of the last ice age in Norway, a vast lake - *Nedre Glomsjø* - was dammed between the water divide and the remains of the receding ice sheet. As the dam drained, a massive jökulhlaup carved out the impressive canyon *Jutulhogget* and funneled southwards beneath (and within?) the ice sheet. The lake is believed to have emptied a minimum of 75 km^3 of water in a few weeks, producing a peak discharge of c. 360 000 m^3/s - or approximately twice the discharge of the Amazon. The flood probably emerged from the ice sheet c. 130 km south of Jutulhogget, around Elverum, but the flood-related studies are based on localities further 130 km downstream, where grounded icebergs have produced a number of scour marks and gravity craters. Here, the flood age (c. 9.2 ka BP) was found by ^{14}C dating peat drowned by flood sediments (Longva, 1994). In the distance between the boulder deposits close to Jutulhogget to the silt bed (*mjele*) on Romerike, few traces of the outburst flood have been reported. By the aid of airborne LiDAR data and geodatabase tools, we are now able to obtain a better overview of the vast area, which have allowed us to map several hitherto undiscovered traces related to the outburst flood.

We report conspicuous deposits and erosive features (Fig. 1) 5-90 meters above the modern Glomma river bed, e.g. an upper flood level that in some areas is continuously traceable for several km. The level is mostly cut in till and often appear as a distinct ledge backed by a 5-10 m high slope. Large bar landforms drape sections of the valley floor. The most striking are pendant bars (Fig. 1; Malde, 1968; Baker, 1973) - accumulated in the downstream lee-side of obstacles, such as bedrock knolls. The bars are often found in close relation to flushed zones and can be in excess of 3 km long. Peculiar dead-ice topography and ice-block obstacle marks (Russell, 1993), diagnostic of high-energy flood events (Marren and Schuh, 2009), drape some of the bed forms and allow us to interpret palaeoflow on single flood bars. The instant the flood waned, vast flood-derived deposits of sand were mobilised by southerly-tending winds, leading to the formation of very large dune fields. The first century after the flood this region was a highly active periglacial desert. The preliminary mapped flood-related features and landforms cover an area well in excess of 60 km^2, making the Nedre Glomsjø jökulhlaup a landscape-defining event. Additionally, morphological evidence allow us to speculate on the position of the ice margin during the catastrophic drainage event, and hence the deglaciation history of this area.

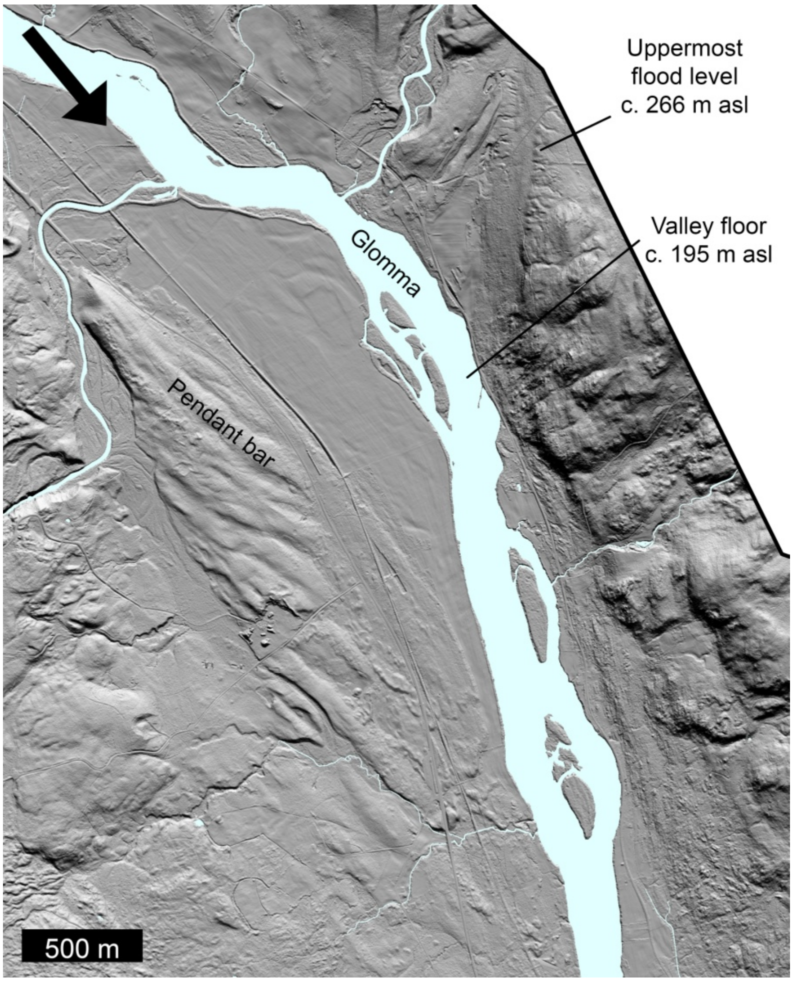

Figure. 1

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Younger Dryas-Holocene glacial advance in De Geerbukta, NE Spitsbergen: climate controlled, or glacial system tuning to Holocene mode?

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A large terminal moraine in De Geerbukta, NE Spitsbergen, fingerprints a major advance by the Gullfakse glacier. The advance has occurred under conditions of high relative sea-level, soon after the regional deglaciation. The advancing glacier and moraine build-up has caused intense glaciotectonic deformation, folding and faulting, of glaciomarine sediments adjacent to the distal side of the moraine. Two radiocarbon dates on paired subfossil molluscs from the glaciomarine sediments give constraining maximum age for this advance close to 12.0 ka BP. Two radiocarbon dates on shell fragments and a whalebone from beach gravels on top of the moraine give a constraining minimum age for the ice advance close to 10.5 ka BP. The altitude of the marine limit in the region is not known, but a raised strandline at ca. 53 m a.s.l. and dated to ca. 10.7 ka BP post-dates the formation of the De Geerbugta moraine. This age envelope puts the De Geerbugta moraine and the advance of Gullfakse glacier very close to the Younger Dryas-Holocene transition. The paleoglaciological implications of this will be discussed: Are we seeing a mass-balance controlled glacial advance, possibly signifying a Younger Dryas glacial event, or is this a reflection of the glacial system seeking new dynamic equilibrium after the rapid (sea-level controlled) regional deglaciation.

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A pan-Arctic ice shelf during late Marine Isotope Stage (MIS) 6: Fact or fiction?

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A compilation of results suggesting the existence of a large ice shelf in the central Arctic Ocean during late Marine Isotope Stage (MIS) 6 (~140 ka) have recently been published by Jakobsson et al. (2016). The idea of a central Arctic ice shelf was brought up by Thomson already in 1888. Only in the 1970s it was rejuvenated, based on findings of marine deposits at elevated sites on northernmost North America (Mercer, 1970) and on morphological features on the circum-Arctic shelves and continents (e.g., Hughes, Denton and Grosswald, 1977). The age of the proposed ice shelf remained unconstrained although the last glacial maximum (LGM) was considered most likely by Grosswald, Hughes and colleagues. Findings of undisturbed late Weichselian sediments on morphological highs in the Arctic Ocean interior and the lack of evidence for large-scale LGM glaciations at many sites in the Amerasian and Eurasian Arctic led to a refusal of the hypothesis of a pan-Arctic glaciation and ice shelf in the LGM by most scientists working in the field.

While the idea of an Arctic ice shelf in the penultimate glacial (late MIS 6, ~140 ka) seems fascinating and is able to explain the findings of disturbed surfaces on many major morphological highs above ~1 km water depth in the Arctic Ocean, the sedimentary records from sites below the postulated ice shelf

holds information which seems not in line with the existence of a ~1 km thick ice mass in the entire Arctic. As one example, we present late MIS 6 proxy data from three sediment cores taken in the early 90ies in water depths from ~500 to 1000 m along the northwestern Barents Sea margin. The sediments have been precisely dated by means of stable oxygen isotopes, paleomagnetic and biostratigraphic constraints. The presence of large numbers of planktic and benthic foraminifera, paleo-productivitiy estimates of >50 $gC*m^{-2}*a^{-1}$ and the presence of the sea ice biomarker IP_{25} in these sediments leave very little doubt that polynya-like conditions in front of the ice sheet margin prevailed rather than the existence of a 1 km thick ice shelf. Second, we present published data on the sediment composition of MIS 6 sediments from the central Arctic Lomonosov Ridge and the Morris Jesup Rise north of Greenland. These deposits hold elevated smectite contents throughout MIS 6, indicating a sediment source on the Kara and Laptev Sea shelves. The resulting transport path seems hardly compatible with a pan-Arctic ice shelf as proposed by Jakobsson et al. (2016) and would rather suggest a transport by drifting icebergs.

In an attempt to reconcile morphologic and sediment core data we discuss possibilities and paleoenvironmental scenarios that may allow to explain the available data. We note, however, that any scenario opens new questions and that further work is needed on the enigma of MIS 6 in the Arctic.

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Reconstructing Little Ice Age sea surface temperatures in Sermilik Fjord, SE Greenland

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Resolving mechanisms controlling the melt of the Greenland Ice Sheet and associated outlet glaciers are in the light of ongoing global warming a major focus research area. Marine sediment cores drilled in fjords with marine terminating glaciers carry information on sedimentological changes that reflect past variability in glacier melt. Alkenones extracted from the same sediment cores may in turn reveal information on past sea surface temperatures. We here present new data that reveal novel insights into the relative importance of oceanographic and atmospheric controls on the melt of a glacier terminating in Sermilik Fjord during the Little Ice Age.

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Changes of sea-ice cover on the East Greenland Shelf (73°N) over the last 5200 years – a biomarker reconstruction

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Over the last decades the extent and thickness of Arctic sea ice has changed dramatically and much more rapidly than predicted by climate models. Thus, high-resolution sea-ice reconstructions from pre-anthropogenic times are useful and needed in order to better understand the processes controlling the natural sea-ice variability. Here, we present the first high-resolution biomarker (IP_{25}, sterols) approach over the last 5.2 ka from the East Greenland Shelf (for background about the biomarker approach see Belt et al., 2007; Müller et al., 2009, 2011). This area is highly sensitive to sea-ice changes, as it underlies the pathway of the East Greenland Current, the main exporter of Arctic freshwater and sea ice that affects the environmental conditions on the East Greenland Shelf and deep-water formation/ convection in the Northern North Atlantic.

After rather stable sea-ice conditions in the mid-Holocene we found a strong increase in sea ice, cumulating around 1.5 ka and associated with the Neoglacial cooling. The general trend especially during the last 1ka is interrupted by several short-lived events such as the prominent Medieval Warm Period and Little Ice Age, characterized by minimum and maximum sea-ice extent, respectively. Using a spectral analysis, we could identify several cyclicites, e.g. a 45-year cyclicity for cold events.

A comparison to similar records from the eastern Fram Strait revealed a slight time lag in the onset of the Neoglacial, but also suggesting the direct link of the East Greenland Shelf area to the Arctic sea-ice/freshwater outflow. A comparison of the biomarker data with a new foraminiferal record obtained from the same site (Perner et al., 2015) suggests that IP_{25} and foraminifera assemblages are probably controlled by rather different processes within the oceanographic systems, such as the sea-ice conditions and, for the foraminifera, water-mass changes and nutrient supply.

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Development of proxy methods for past climate reconstruction in the Barents Sea

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At high latitudes of the Arctic Ocean, sea ice concentration and position of the ice edge have a major influence on the global climate. One major role of sea ice is the modulation of surface air temperature to support local living organisms, both macro- and microscopic. Higher ice abundances generally equate to lower surface air temperatures due to a greater proportion of solar radiation reflected; this mechanism is known as the 'albedo effect'. As such, the 'heat budget' of the high-latitude oceans is greatly influenced by both sea ice concentration/thickness and position of the ice edge. Formation of sea ice also contributes to thermohaline circulation in the North Atlantic, where denser water masses of higher salinity sink to become bottom waters. In contrast, melting of sea ice results in an outflow of low-salinity water to the surface, also influencing oceanic circulation (Parkinson et al., 2001; Budikova, 2009; Dieckmann and Thomas, 2009). Due to these and other fundamental influences of sea ice on climate, the decline of summer (and, more recently, winter) sea ice extent in the polar regions since 1970's is receiving substantial attention. The significance of current trends of decreasing sea ice concentration cannot be fully understood without reconstruction of prior sea ice conditions beyond satellite records. Sea ice provides a rich and dynamic habitat for a variety of living organisms, including primary producers such as diatoms, which, together with other sea ice algae, account for up to 57% of the Central Arctic Ocean's primary production (Gosselin et al., 1997). These diatoms produce chemical fingerprints/signatures collectively known as 'biomarkers', which can be specific to a particular species (i.e. source-specific) and characteristic of environmental conditions in which these species thrive.

A highly-branched isoprenoid (HBI) biomarker, $IP_{25,}$ was identified as a source specific, selective and sensitive biomarker suitable for use as a proxy for palaeoclimatologic applications, including reconstruction of past sea ice conditions (Belt and Müller, 2013). Strong influence of seasonal variation in sea ice extent on IP_{25} concentration was identified (Brown, 2011) – production peaked with diatom populations during the spring algal bloom. Conditions which would prevent diatom growth (e.g. multiyear ice cover) were reflected by complete absence of IP_{25}. The monoene was hence found to be selective towards conditions of seasonal sea ice cover and was used for climate reconstruction in various regions of the Arctic Ocean, including Central Arctic (Xiao et al., 2015), Fram Strait (Müller et al., 2011), Barents Sea (Navarro-Rodriguez et al., 2013) and others. IP_{25} has also been used for reconstruction of sea ice conditions throughout geological time via analyzing well-dated sediment cores with high resolution (1-2 cm depth interval) as far as the early Pleistocene (Stein and Fahl, 2013). Recently, combined analysis of IP_{25} alongside an HBI triene characteristic of open waters allowed for better characterisation of the Marginal Ice Zone (Belt et al., 2015).

A suite of highly branched isoprenoids (HBIs), including IP_{25}, and the value of multi-proxy analysis will be illustrated for the purpose of past climate reconstruction in the Barents Sea. A preliminary record of environmental change corresponding to the Weichselian glaciation, obtained via analysis of a well-dated marine core from the South-Western Barents Sea, will be shown.

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Alkenone-based reconstruction of sea surface conditions since last glacial times off SW Svalbard

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SW Svalbard shelf is a sensitive to climatic changes boundary area where two contrasting water masses form an oceanic polar front, separating colder, less saline and isotopically lighter Arctic Water from warmer, highly saline and $\delta^{18}O$-heavier Atlantic Water. An oceanic front is an excellent area for research of contemporary and past environmental changes (Łącka et al., 2015). The previous research in this area was limited to the reconstruction of postglacial paleoceanographic changes at the sea bottom and on sea surface with qualitative rather than quantitative estimation of the water properties. Conventionally, for the reconstruction of the surface water conditions planktonic foraminifera are used. As in cold Arctic waters the planktonic foraminifera are limited to one species, *Neogloboquadrina pachyderma* (sinistral), which is dwelling in subsurface waters (prefers the water depths below 50 m to 100 m), thus the reconstructed conditions may refer to intermediate rather than surface waters.

The detailed analysis of the sediment core raised from SW Svalbard shelf has shown that there is a lack of micropaleontological record of surface-dwelling organisms used in paleoceanography as diatoms or dinoflagellate cysts. This has encouraged the authors to use alkenones, to trace the conditions of surface water since the last glaciation.

Alkenones are commonly used for calculation of U^{K}_{37} proxy and then used for reconstruction of absolute sea surface temperatures (SST) in the photic zone (Brassell et al., 1986; Prahl and Wakeham, 1987). However, according to Rosell-Mele (1998), when the $\%C_{37:4}$ constitute more than 5% of the total C_{37} alkenones percentage, the calculated temperatures are less reliable. In case of our study the recorded values from Allerød/Younger Dryas period generally exceeds 20%. However, as the percent of $C_{37:4}$ is related to salinity in the Nordic Seas and the North Atlantic, the higher $\%C_{37:4}$ is found in water masses with decreased salinity and vice versa (Rosell-Melé, 1998, Rosell-Melé et al., 2002). Although the $\%C_{37:4}$ index cannot be used to quantitatively reconstruct past variations in salinity, it has potential as a qualitative indicator of polar water mass extent (Bendle et al., 2005). Therefore the percentage of the $C_{37:4}$ alkenones in the total abundance of C_{37} alkenones was used as an tracer to infer variations in the contribution of polar and subpolar conditions (Bendle et al., 2005).

The results point to the constant domination of Polar Water at the surface over Allerød and Younger Dryas. During Last Glacial Termination the conditions on SW Svalbard shelf were similar to those observed today in the central Barents Sea, with submerged inflow of Atlantic Water below the thick layer of colder and less saline Polar Water. At the onset of Holocene there is a sharp decrease in $\%C_{37:4}$ lasting until late Holocene, therefore the calculation of the temperatures for that time interval was possible. In general, we have confirmed that over middle Holocene SW Svalbard shelf was warmer than today, with temperatures ranging between 7-8°C.

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Deposition of widespread ice-rafted debris at the Allerød-Younger Dryas transition by the Amundsen Gulf Ice Stream, Canadian Arctic Archipelago

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Uncertainties regarding the age and origin of shelf and slope sediments in the Beaufort Sea constitute a major barrier to understanding the Late Quaternary evolution of the western Canadian Arctic as well as the nature of paleoclimatic archives elsewhere in the Arctic Ocean basin. Multiple sediment cores collected from the upper slope of the Beaufort Sea and from adjacent Amundsen Gulf provide evidence for rapid, intermittent deposition of discrete ice-rafted debris (IRD) horizons during the last deglaciation (i.e. 16-11 ka BP). The mineralogy of the IRD is defined by new quantitative x-ray diffraction (qXRD) analyses, which confirm a source area in the Canadian Arctic Archipelago. In addition, multiple radiocarbon ages of planktonic and benthic foraminifera constrain the ages of the IRD horizons. Three IRD events are identified in the shelf and slope sediments based on their age, stratigraphic position, and composition. Two, paired, closely spaced IRD horizons (each 10 to 20 cm thick) occur in the upper 230 cm of the sediment cores from Amundsen Gulf and the upper slope. Multiple radiocarbon ages imply that these two, upper IRD horizons were deposited at the Allerød-Younger Dryas transition. A third IRD horizon (up to 30 cm thick) occurs at greater depth in two of the sediment cores from the upper slope.

The age of the IRD horizons and their stratigraphic position in regional subbottom echosounder surveys implies that their deposition was correlative with the dynamical behaviour of the former ice stream in Amundsen Gulf. For example, new multibeam and subbottom data from Amundsen Gulf delineate precise late-glacial ice-marginal positions and highlight multiple phases of rapid ice stream retreat. Seismostratigraphic correlations between regional survey lines and sediment core sites demonstrate that phases of ice stream collapse were contemporaneous with IRD deposition. Further, the age of the two, upper IRD horizons accords with previous inferences of rapid ice stream withdrawal in Amundsen Gulf during regional deglaciation, based on detailed mapping and dating of the glacial geomorphology of Banks and Victoria islands. These new constraints on past ice stream dynamics provide insight into the variables that occasioned deglaciation of the marine channels of the archipelago, and constitute an important analogue for extant ice sheets. Further, recognition of discrete periods of high iceberg fluxes to the Arctic Ocean (during intervals of ice stream retreat) aids in understanding deglacial paleoclimatic archives. Finally, knowledge of the sources and timing of IRD entering the Arctic Ocean (i.e. glacier vs. sea ice) has implications for understanding the stratigraphy of sediment cores recovered from the central basin and elsewhere.

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Asynchronous glacial maxima of the last Scandinavian Ice Sheet

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Reconstructions of ice cover during the time spanning the Late Weichselian maximum show a confluent Eurasian Ice Sheet with the Scandinavian Ice Sheet positioned between the Barents Sea and British-Irish ice sheets. It has been long suspected among glacial geologists that the maximum position was asynchronous, but only recently has it been possible to explore this in some detail (Hughes et al. 2015; Larsen et al. in press). Dates pertaining to the ice margin of the Scandinavian Ice Sheet (SIS) reveals an old (29-25 ka) maximum position along the western flank, whereas a much younger (18-16 ka) maximum position has been delineated along the eastern flank. A time – distance diagram across the SIS shows an oscillatory western ice front, as opposed to a steadily growing and decaying eastern ice margin (Fig. 1). The largest age difference between maximum positions may have been as much as 10 ka between different SIS sectors.

Subglacially formed and relict landforms group systematically in the area of the former ice sheet (Ottesen et al. 2002: Kleman et al. 2008; Larsen et al. 2014). These hold information about subglacial thermal conditions and ice – bed interactions. Accordingly, variations in ice-flow mechanisms and corresponding relative ice-flow velocities across the ice sheet can be deducted (Fig. 2). Furthermore, the distance to the western ice margin on the continental shelf was about one-fourth of the distance to its eastern counterpart. Thus, an asymmetric build-up and eastwards migration of the main ice-divide was suggested more than 60 years ago (Ljungner 1949).

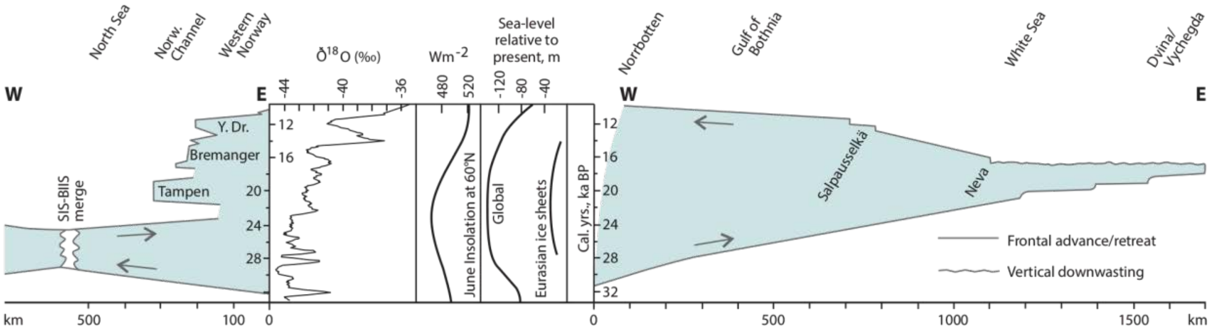

Figure. 1. Fluctuations of the margins of the Scandinavian Ice Sheet drawn as two profiles from the ice inception centers and down-ice on either side (Larsen et al. in press).

Summing up (Fig. 2), the old western maximum age can be explained by short distance to ice inception centers, initial windward ice growth, efficient drainage in ice streams on the Norwegian continental shelf, and the continental shelf break being a barrier to further westwards expansion. The comparably young maximum age on the eastern side can be explained by great distance between ice inception centers and marginal position, low ice-flow velocities mostly by internal deformation in a wide zone east of the ice divide, and low-gradient ice-lobe advance controlled by successive water-filling of sub-basins in proglacial lakes. The inferred ice-flow mechanism in these lobes may have prolonged the ice advance by some 1000 to 3000 years (Larsen et al. in press).

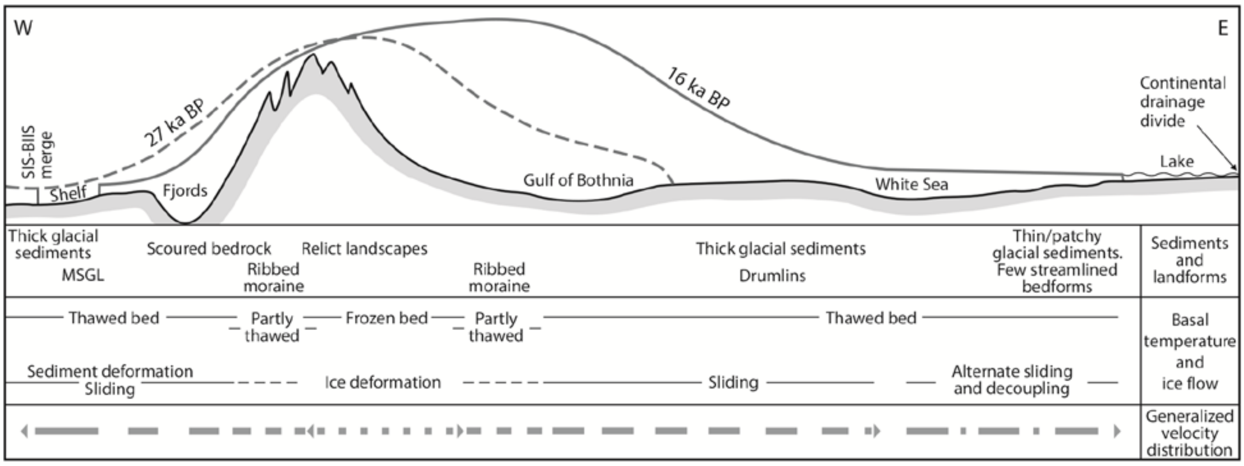

Figure. 2. Generalized terrain profile across Scandinavia with the western glacial maximum at 27 ka BP and the eastern maximum at 16 ka drawn as simplified glacier profiles. The distribution of sediments and landforms, interpreted thermal conditions at glacier bed, ice-flow mechanisms and corresponding generalized, relative ice-flow velocities are given along the same profile. From Larsen et al. (in press).

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Lake Nordlaguna, Jan Mayen: the potential for a palaeoclimate record from the island

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The arctic island of Jan Mayen situated in the Norwegian – Greenland Sea, has an arctic – maritime climate influenced by the northwards flowing Atlantic current and the southwards flowing East Greenland current. It is hypothesized that small shifts in these current systems will greatly influence the climate on Jan Mayen. It follows that the island might be very sensitive to climate change. Therefore lake coring will be performed in April of 2016.

The only lake on the island suitable for coring is Nordlaguna situated ca. 2 m a.s.l. on the western coast. It is separated from the sea by a long and wide beach ridge. Jan Mayen has active volcanism, but it appears likely that no Holocene lava flows entered the lake. Preliminary data indicates that the lake area was just inside the the Last Glacial Maximum limit. Thus, in theory, the lake might hold a long Late Weichselian – Holocene palaeoclimate record. In order to prepare for the drilling we have mapped lake bathymetry, bottom sediments and sediment sources around the lake.

An AUV mounted side scan sonar including other sensors combined with ROV mounted video cameras revealed that the lake is less than 40 m deep and has a very gentle/flat bottom topography in the southwestern part. Mainly fine-grained bottom sediments are found, with occasional blocks. Driftwood that are thrown over the beach ridge in heavy storms are quite frequent. GPR profiling across and along the beach ridge provides evidence that it developed in an end moraine. The postglacial relative sea-level history of Jan Mayen is unknown. Nevertheless, marine sediments is expected in the sediment sequence.

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Dating the collapse of the Scandinavian Ice Sheet using CH_4-derived carbonate crusts from the Barents and Norwegian Seas

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CH_4-derived authigenic carbonate crusts exhibiting characteristic ^{13}C-depleted isotopic signatures were collected from five seepage sites of the North and Barents Sea. The U-Th dating has been attempted on early generation carbonate phases that cement sandy and gravelly sediments as well as late generation phases occurring as botryoidal laminae that fill cavities within carbonate cemented sediments. Obtained U-Th dates indicate that the onset of the precipitation of the early generation carbonate cements in studied crust samples was coincident with the deglaciation of the area and collapse of the Scandinavian Ice Sheet. The CH_4 flux for the carbonate crust formation was likely provided by the large scale dissociation of CH_4 hydrates that abundantly formed in underlying sediments during the last glacial period due to ice sheet loading, but became unstable due to depressuring effects during deglaciation. The main episode of CH_4 seepage and carbonate crust formation that was initiated by the ice sheet collapse continued for 7-10 kyr after deglaciation as the gas hydrate stability zone continued to thin in response to sea-level change, isostatic rebound and bottom water warming. Formation of CH_4-derived authigenic carbonate crusts on glaciated continental margins with grounded ice can be related to CH_4 fluxes from the destabilizing subsurface hydrate reservoirs to the seafloor. These carbonates can be dated using the U-Th method, affording the opportunity to constrain the absolute timing of the onset of carbonate precipitation and the ice sheet collapse.

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Thermogenic origin of hydrocarbon seeps in central Spitsbergen fjords, Svalbard

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Pockmarks are widespread features on continental margins suggesting extensive venting of hydrocarbon-rich fluids at the seafloor, although the formation mechanisms of pockmarks and their dynamics are not well understood in many areas (Judd & Hovland, 2007). It is not always clear whether pockmarks are currently active on the modern sea floor, i.e. fluids are currently seeping, or if they are inherited from an earlier seepage. The submarine hydrocarbon seeps originate either from shallow (biogenic) or deep (thermogenic) sources (Judd & Hovland, 2007). Pockmarks in Isfjorden area have been described previously by Forwick et al. (2009), and shown to be linked to deep, bedrock sources by Roy et al. (2012, 2015) using seismic data. Knies et al. (2004) presented geochemical evidence about migrated hydrocarbons in Isfjorden and in the Barents Sea east of Spitsbergen. They proposed that hydrocarbons from deep source (thermogenic) are responsible for the creation of pockmarks in Isfjorden. There are several organic-rich layers in Isfjorden bedrock, mainly Triassic and Jurassic. These source rocks extend from Isfjorden area to the east coast of Spitsbergen and to the Barents Sea.

This study is based on gas samples from 11 sediment cores from different areas that have been deemed to be affected by seafloor seeps by previous geophysical investigations (Roy et al., 2012; 2015). Coring from selected pockmarks in Adventfjorden, Grønfjorden, Nordfjorden and

Tempelfjorden was carried out in 2014 and 2015. Also samples from Mohnbukta in eastern Spitsbergen were collected to compare the hydrocarbon venting systems in the west and east of Spitsbergen.

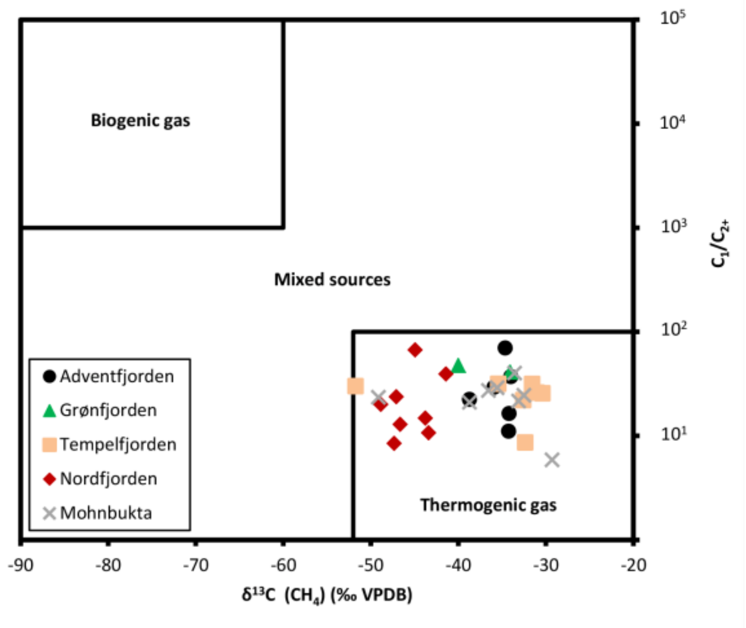

Figure 1. The ratio of methane (C_1) to higher hydrocarbons (C_{2+}) plotted against the carbon isotopic composition of methane of all analyzed samples.

Methane concentration in all cores increases somewhat with depth and showed differences between pockmarks and undisturbed seabed (only exceptions are Mohnbukta and Adventfjorden site). The methane carbon stable isotope ($\delta^{13}C$) ratio in collected gas samples is fairly uniform and showed no clear difference between pockmarks and reference cores at the same locations. Together with methane (C_1), also ethane and small amounts of higher volatile hydrocarbons (C_{2+}) were measured. In most samples, ethane concentrations were 9–87 ppb (average 37 ppb) (except for one outlier -153). Traces of propane were also observed. Unlike methane concentration profiles, ethane concentrations don't show down-core increasing trend. The methane to ethane and propane ratios (C_1/C_{2+}) had in all samples values below 100 (average 24; Figure 1).

The molecular ratios of methane to higher volatile hydrocarbons (C_1/C_{2+}) that exceed 1000, and stable carbon values ($\delta^{13}C$ CH_4) less than −50‰ generally indicate a gas from a microbial source (Claypool & Kvenvolden, 1983). However, a gas with a C_1/C_{2+} ratio less than 1000 and a stable carbon isotope composition ($\delta^{13}C$ CH_4) of greater than −50‰ indicate the addition of a gas from a thermogenic source (Figure 1).

Geochemical characterization of migrating hydrocarbons in the Isfjorden area and in Mohnbukta revealed active fluid system in the subsurface. Thermogenic methane and higher homologies are seeping from pockmarks as well as from adjacent undisturbed seafloor. These results, particularly the down core increasing methane concentrations strengthen the previous suggestion that active source rocks exist in Svalbard and that the fault systems are the main conduits for the upwards migrating gaseous hydrocarbons and hence the cause for the thermogenic gas anomalies in the shallow sub-surface sediments.

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The glacial history of an active volcanic island - Jan Mayen

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The volcanic island of Jan Mayen, situated in the Norwegian – Greenland Sea, has an arctic – maritime climate influenced by the northwards flowing Atlantic current and the southwards flowing East Greenland current. Small shifts in these current systems will likely influence the climate on Jan Mayen which suggests that the island could be very sensitive to climate change. In 2015 we started a project funded by the Research Council of Norway to investigate glacial and climate history of the island. Below we report preliminary results of the glacial history.

Presently, the active volcano Beerenberg has an ice cap with several outlets, some of them reaching down to sea-level. The Little Ice Age (LIA) marginal moraines are well developed, and preliminary ^{36}Cl cosmogenic dates give reasonable LIA ages. Whether or not the entire island has been ice-covered previously has been a matter of controversy. A moraine ridge at present sea-level are interpreted to represent either the Last Glacial Maximum (LGM) or an early deglacial stage, and an associated marine terrace correspnds to the marine limit. This, in addition to other geomorphological observations, are taken to indicate that the entire island was ice-covered, and that glaciers extended at least down to present sea level. ^{36}Cl cosmogenic dates indicate that glaciers had retreated considerably by some 18 – 19 ka BP.

The only lake on the island suitable for coring is Nordlaguna situated ca. 2 m a.s.l. on the western coast. The lake area was just inside the above mentioned moraine ridge and might hold a Late Weichselian – Holocene palaeoclimate record. In order to prepare for the drilling we have mapped lake bathymetry, bottom sediments and sediment sources around the lake. Lake coring is planned for April 2016 and if successful, preliminary results may be reported.

Stratigraphic investigations indicate that the island was covered by ice also prior to LGM. In coastal sections at several locations, glacigenic diamictites at stratigraphic position below LGM are found in association with lava flows. Interaction between glaciers and volcanic eruptions cause complex sediment associations, but also provide opportunity for dating glacial events. Ar/Ar dating is in progress in order to constrain pre-LGM glacial events.

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Fast but short-lived retreats and long-lived halts or re-advances of the western margin of the Scandinavian Ice Sheet

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The front of the Norwegian Channel Ice Stream retreated fast upstream from the LGM position at the shelf edge and reached the Troll core site by 18.5 cal ka according to the marine ^{14}C chronology (Sejrup et al., 1995), or alternatively before 20 ka BP according to ^{10}Be exposure ages from Utsira (Svendsen et al., 2015). However, the coast adjacent to Troll remained ice covered until 15 cal ka BP and no ice-marginal deposits have yet been identified from the intervening 3500 or 5000 years. A postulated Older Dryas re-advance across the Blomvåg Site, NW of Bergen, (Mangerud et al., 2011) is now falsified, but around the mouth of Hardangerfjorden an Older Dryas re-advance is still postulated (Mangerud et al., 2016). We present 90 ^{14}C dates from shell-bearing tills or sub-till sediments from 35 different sites showing an up-fjord (60 km) retreat during the Allerød and a subsequent Younger Dryas re-advance in the area between Hardangerfjorden and Sognefjorden. This re-advance obtained its maximum extent at the very end of the Younger Dryas, and then it was almost reaching the open ocean again, meaning there was almost no net retreat for more than 8000 (alternatively 6500) years, i.e. between 20 (alternatively 18.5) and 11.5 cal ka BP. Subsequently the ice margin retreated 120-170 km up to the fjord heads at rates of 240-340 m yr^{-1} during the first 500 years of the Holocene (Mangerud et al., 2013).

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Wisconsinan Glacial Dynamics of Cumberland Peninsula, Baffin Island, Arctic Canada

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Cumberland Peninsula on Baffin Island displays a rich record of the dynamics and interaction of three different ice masses: the northeastern fringe of the Laurentide Ice Sheet (LIS), the expanded Penny Ice Cap (PIC) and an alpine glacier complex. Owing to the accessibility of the coast, these records have been intensely studied (e.g., Dyke et al. 1982, Kaplan et al., 2001), leading to the development of several conceptual ice sheet models (Fig. 1a). An early model of a single-dome LIS building from northeastern Canada (Flint, 1943) was replaced by a minimum ice sheet model (Ives, 1978) proposing that many upland areas remained ice-free and served as refugia for fauna and flora ('Nunatak Hypothesis'). Resolution of this and subsequent conflicting evidence for last glacial ice coverage of plateaus from Sangamonian (Eemian) through to Holocene was suggested with an intermediate ice sheet extent model (Goldilocks Model, Miller et al., 2002) which benefitted from the concept of selective linear erosion (Sugden and Watts, 1977), mostly coastal terrestrial cosmogenic nuclide (TCN) data, numerical ice sheet modeling, and lake records. With a scarcity of chronology from the interior, the model assumed that most of the peninsula was covered by the LIS with few alpine outlet glaciers occupying valleys along the northeastern coast.

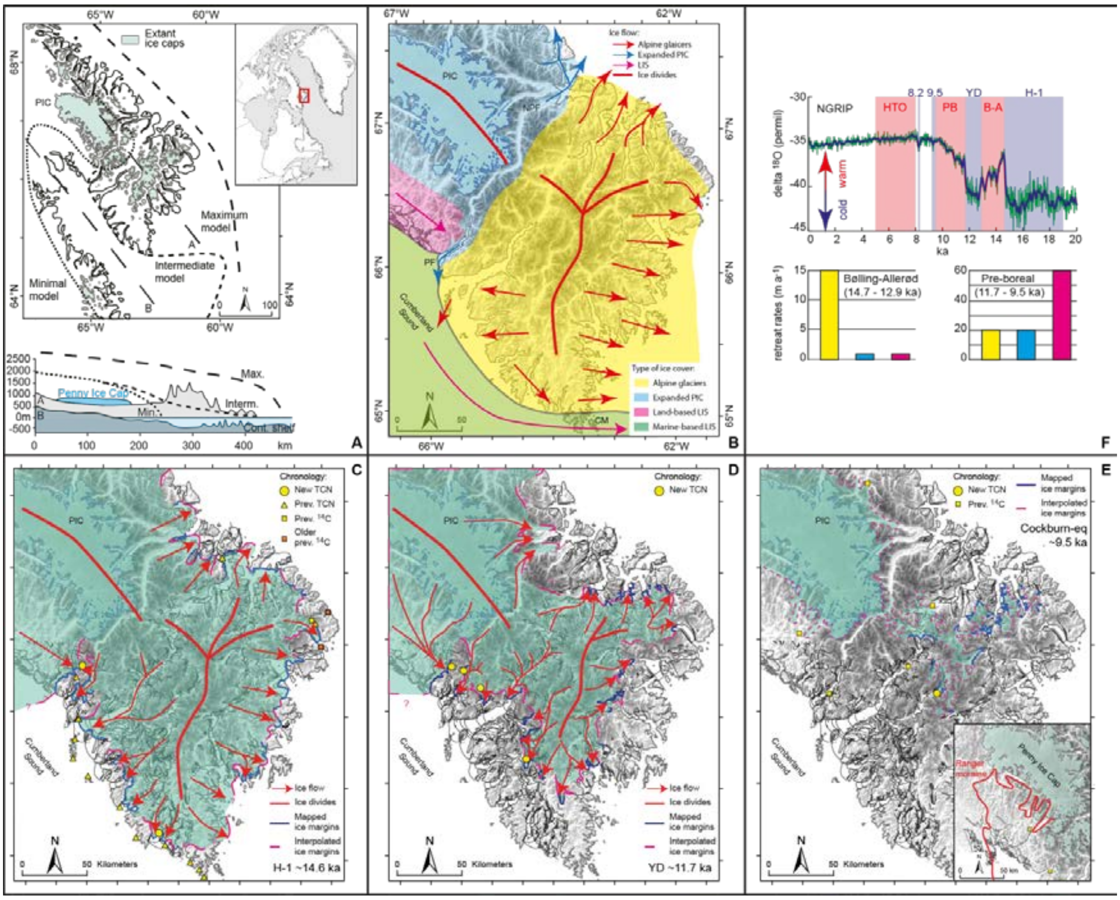

Figure 1. A. Location map and conceptual ice sheet models. B. Inferred ice cover during LGM. C-E. Ice margin position during H-1, YD, and Cockburn-equivalent cooling events. F. Estimated retreat rates (color coding as in B) with $\delta^{18}O$ record from NGRIP (Vinter et al. 2006).

New, high-resolution mapping of glacial deposits by the Geological Survey of Canada combined with field observations in 2009-2010 reveal that most of Cumberland Peninsula was covered by an independent alpine glacier system of valley glaciers and ice caps with only the southernmost tip being overridden by the LIS Cumberland Sound Ice Stream and the land-based LIS merely buttressing against a slightly expanded PIC to the west of the peninsula (Fig. 1b). New and previous TCN and radiocarbon dates are used to reconstruct ice margin positions of all three glacier types for the most prominent late glacial cooling events (Heinrich Event 1 (H-1), Younger Dryas (YD), and Cockburn-equivalent, Fig. 1c-e). Post-Last Glacial Maximum (LGM) ice retreat rates derived from these maps indicate that the alpine glacier complex responded sensitively to warmer temperatures during the Bølling-Allerød (B-A) interstadial, while the PIC and LIS remained nearly unaffected (Fig. 1f). However, after re-advance of ice margins during the YD cold interval, the land-based LIS receded quickly during the following Pre-boreal (PB) interstadial, while the PIC and alpine glacier complex retreated at slower rates. The ice-margin reconstructions also reveal an asymmetric retreat pattern of the alpine glacier complex and a related northward shift of the ice divide (Fig. 1c-e). Delayed recession along the northeastern coast might be associated with higher precipitation in relation to decreasing sea ice cover offshore. Increasing sea ice cover after the Holocene Thermal Optimun (HTO) led to the expansion of local, cold-based ice caps, which responded sensitively to changes in equilibrium line altitude during the Neoglacial, partly induced by cooling related to a combination of large volcanic eruptions and low solar activity (Margreth et al. 2014). Generally, our observations support previous notions that smaller alpine systems respond more sensitively to climate variability, but that larger ice masses disintegrate quickly once recession had started.

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Postglacial environmental succession of Nettilling Lake (Baffin Island, Canadian Arctic) focusing on paleo-salinity changes inferred from diatom silica ($\delta^{18}O_{diatom}$).

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The need for better understanding of long-term climate and environmental variability in the Foxe Basin (Nunavut, Canada) is highlighted by the major environmental changes in this highly sensitive region, which occupies a transitional position between areas undergoing drastic and more subtle changes in the High and Low Canadian Arctic over the course of the last millennium, respectively. However, high-resolution long-term climate records remain scarce in the Foxe Basin region even though it is of key importance to understanding Holocene climate evolution since the last deglaciation. In order to reconstruct the regional postglacial climatic and environmental variability, we adopted a multi-proxy paleolimnological approach analysing sedimentary records retrieved from Nettilling Lake on southern Baffin Island, involving elemental geochemistry from high-resolution μ-XRF analyses, diatom assemblage composition and oxygen isotope records from fossil diatom silica ($\delta^{18}O_{diatom}$). The oxygen isotope composition of diatoms ($\delta^{18}O_{diatom}$) yields extremely large $\delta^{18}O_{diatom}$ variations in the core of more than 13‰ which are mainly driven by changes in the isotopic composition of the lake water due to a shift from glacio-marine to brackish (at ca. 7400 yr cal BP) towards lacustrine conditions (at ca. 6000 yr cal BP) associated with decreasing salinity also documented by shifts in the composition of diatom assemblages. Our study provides evidence that paleo-salinity can be inferred from $\delta^{18}O_{diatom}$. Additionally, in the lacustrine section of the core,, $\delta^{18}O_{diatom}$ may also serve as a proxy for past air temperatures recording a late Holocene cooling of about 4°C for the greater Baffin region. Furthermore, the results obtained from our study provide new insights into the timing of regional glacier retreat (ca. 8300 cal BP) and the duration of the postglacial marine invasion (from ca. 7400 cal BP to ca. 6000 cal. BP), thereby complementing ongoing research of postglacial environmental dynamics in the Foxe Basin and on south-western Baffin Island.

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KEYNOTE: The puzzle of grounded Pleistocene ice in the Arctic Ocean and the exhumation of Miocene sediments

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Since about 15 years a growing number of evidence is found in water depth up to more than 1000 m of the Arctic Ocean that grounding of ice has occurred in various places including the "Beringian" continental margin north of the present Chukchi and East-Siberian seas and the Lomonosov Ridge. These landforms include moraines, drumlinized features, glacigenic debris flows, till wedges, mega-scale glacial lineations (MSGL), and iceberg plough marks (Polyak et al. 2001, Niessen et al. 2013, Dove et al. 2014, Jakobsson et al. 2014). They suggest that thick ice has occurred not only on nearly all margins of the Arctic Ocean but also covered pelagic areas. In a recent paper, Jakobsson et al. (2016) present more evidence of ice-shelf groundings on bathymetric highs in the central Arctic Ocean, thereby revitalising an old modelling concept of a kilometre-thick ice shelf extending over the entire central Arctic Ocean (Hughes et al. 1977) now dated to Marine Isotope Stage (MIS) 6. Other (including our) studies, however, suggest that the pattern, and, in particular, the timing of these glaciations is more complex. Most recent discoveries on the Lomonosov Ridge have not only gained different information on Pleistocene glaciations but also allowed for the first time to reconstruct upper Miocene Arctic Ocean sea-ice and SST conditions. This became possible since submarine sliding (likely associated with ice grounding) led to removal of younger sediments from steep headwalls and thus exhumation of Miocene to early Quaternary sediments close to the seafloor, allowing the retrieval and analysis of such old sediments by gravity coring (Stein et al. 2016).

Submarine glacial landforms from the western and central Arctic Ocean were discovered and investigated during the cruises of RV "Polarstern" in 2008 and 2014, and RV "Araon" in 2012 and 2015. Orientations of some of these landforms suggest that thick ice has flown north into the deep Arctic Ocean from the continental margin of the East Siberian Sea repeatedly (Niessen et al. 2013), thereby grounded on plateaus and seamounts of the Medeleev Ridge. In addition, hydro-acoustic data is presented from the Lomonosov Ridge (Siberian side to close to the North Pole), which support the hypothesis of widespread grounding of ice in the Arctic Ocean, of which the sources are still difficult to determine. The data suggest that thick ice-shelves could have developed from continental ice sheets on a nearly circum-arctic scale, which disintegrated into large icebergs during glacial terminations.

On the slopes of the East Siberian Sea and/or on the Arlis Plateau, three northerly-directed ice advances occurred, which are dated by sediment cores using the chronology of brown layers (B1 to B7) as suggested by Stein et al. (2010). According to our age model, the latest advance is slightly older than B2 (MIS-3/4), which has been interpreted as MIS-6 by Jakobsson et al. (2016). A larger well-constrained glaciation has occurred during MIS-4, of which an ice shelf grounded to 900 m on the Arlis Plateau. In the western Arctic Ocean, the oldest datable ice advance has an intra-MIS-5 age. In our data, the chronology of older ice advances along the East Siberian margin are not well constrained but may extend back as far as MIS-16. In contrast, cores from the southern and central Lomonosov Ridge indicate that the youngest ice grounding there has occurred during MIS-6. This grounding was less intense than previous ice-shelf groundings in the area, of which the chronology remains speculative until longer cores become available.

Along the Lomonosov Ridge, detailed bathymetric mapping between 81° and 84°N exhibit numerous amphitheatre-like slide scars, under which large amounts of Cenozoic sediments were remobilized into mass-wasting features on both the Makarov and Amundsen sides of the ridge. In areas shallower than 1000 metres, slide scars appear to be associated with streamlined glacial lineations, whereby some of the bedforms have been removed by sliding. It appears that at least some of the mass-wasting events have been triggered by moving and/or loading of grounded ice. Sub-bottom seismic profiling discovered at least three generations of debris-flow deposits near the ridge, which were generated by the slides. In places, the nearly randomly distributed slide scars and debris-flow deposits make it hard to interpret past ice-flow directions from landforms and re-deposited sediments. The pattern allows interpretation of both directions off East Siberia (e.g. Jakobsson et al. 2016) and off Eurasia (e.g. Polyak et al. 2001) towards the central Arctic Ocean.

Underneath the slide scars escarpments of up to 400 m in height were formed. Near the southern end of the Lomonosov Ridge the last exhumation of old sediments has occurred during MIS-6. Some of the old sediments recovered in 2014 were studied in more detail (Stein et al., 2016). We can show for the first time that the mid/late Miocene central Arctic Ocean was relatively warm (4-7°C) and ice-free during summer, but sea ice occurred during spring and autumn/winter. A comparison of our biomarker proxy data with Miocene climate simulations seems to favour relatively high late Miocene atmospheric CO_2 concentrations.

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An 11,000-year record of driftwood delivery to the western Canadian High Arctic and implications for Arctic oceanic-atmospheric circulation, local sea-ice severity and recent relative sea-level rise

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A new collection of radiocarbon dated driftwood sampled from the modern and raised shorelines of Melville and Eglinton islands (western Canadian High Arctic) is presented and compared to larger driftwood collections from other parts of the Canadian Arctic Archipelago (CAA) and Greenland. By documenting the species (provenance) and spatio-temporal distribution of driftwood at various sites across the Arctic, regional characterizations of former sea ice conditions and changes in Arctic Ocean circulation patterns may be deduced. The earliest postglacial invasion of the CAA by driftwood is recorded on central Melville Island at ca. 11 cal. ka BP, suggesting that the modern circulation pattern of Arctic Ocean surface water southeast through the archipelago was established >1000 years earlier than previously proposed. Throughout most of the Holocene until ca. 1.0 cal. ka BP, the rate of driftwood delivery to the western Arctic islands was low (1 stranding event per 200 years) and intermittent, with the longest break in the record occurring between ca. 3.0 and 5.0 cal. ka BP. This 2000-year hiatus is attributed to a period of colder temperatures causing severe sea ice conditions and effectively making the coasts of the western Arctic islands inaccessible. After ca. 1.0 cal. ka BP, driftwood incursion increased to maximum Holocene levels (1 stranding event every 20 years). Driftwood, identified to the genus level as *Larix* (Larch), that was delivered at this time suggests that the Trans Polar Drift current was regularly in its most southwestern position, related to a dominantly positive Arctic Oscillation mode. The Little Ice Age appears to have had little impact on driftwood entry to the western Canadian Arctic Archipelago, indeed the general abundance in the latest Holocene may record infrequent landfast sea ice. Driftwood from the western half of the study region (up to ca. 3.0 cal. ka BP) also provides an independent record of late Holocene transgression (following

postglacial regression to a lowstand) as it is accumulating in the modern sea-ice push zone together with contemporary timber due to excavation and re-deposition during recent relative sea-level rise.

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Age of the Younger Dryas ice-marginal substages in Mid-Norway – Tautra and Hoklingen, based on a compilation of ^{14}C-dates

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The ice-marginal Tautra and Hoklingen Substages in the Trøndelag counties, Mid-Norway, have for a long time been referred to as of early and late Younger Dryas (YD) age, respectively. The basis for this is the regional distribution and morphological correlations of the associated moraines and a number of ^{14}C- datings, mainly of marine shells, previously presented in different papers and map-sheets. In this poster we present the main results from a recent overview article (Olsen et al. 2015) with a collection of all ^{14}C-dates associated (more or less accurately) with the Tautra and Hoklingen Substages, a number of 49 and 27 respectively. Using all these dates for a first approximation constrain the Tautra Substage to the age interval 13000 – 12500 cal yr BP and the Hoklingen Substage to 12180 –11600 cal yr BP. Improved accuracy of the age intervals can be obtained by further weighing of geology and stratigraphical positions of the dates. Omitting of dates considered to be slightly too old or too young to be strictly representative, have reduced the number of representative dates for Tautra to 24 and for Hoklingen to 22.

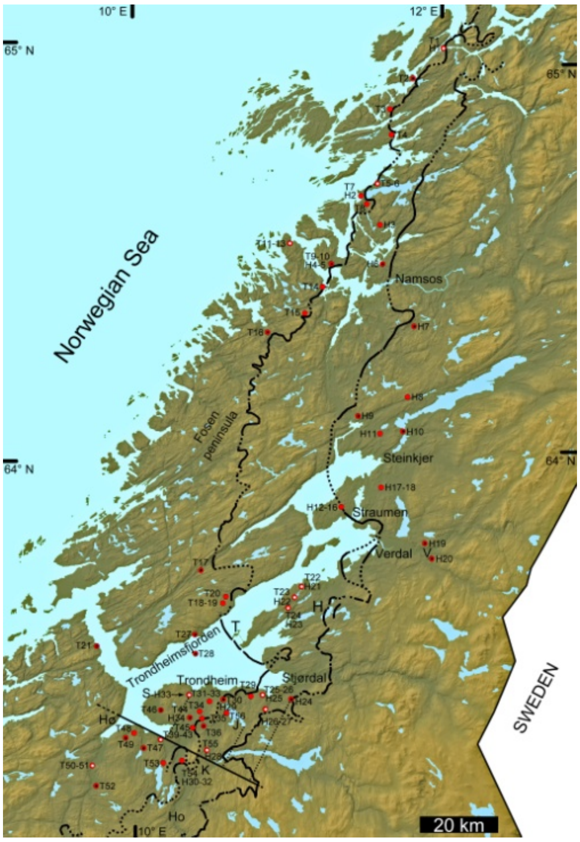

Figure 1. Coloured relief image of most of the Trøndelag region, with locations of ^{14}C-dated samples used to constrain the ages of the Tautra (T-samples) and Hoklingen (H-samples) ice marginal substages (black continuous and stippled lines). Profile line for the associated projected shorelines is also indicated. For details, see Olsen et al. (2015).

The corresponding age intervals are now 12900 – 12620 cal yr BP and 12180 – 11760 cal yr BP, for Tautra and Hoklingen respectively. The Vedde Ash Bed, with established age 12066 ± 42 cal yr BP in western Norway, and dated near Trondheim to 12055 ± 35 cal yr BP, is recorded distally to the Tautra Substage and between the Tautra and Hoklingen Substage deposits, but not closer distally than 5 km and not proximally to the latter. This suggests that the age of the Hoklingen Substage is slightly younger than 12060 cal yr. Shore displacement data in the Trondheim region show a slow regression during Late Allerød and the entire YD, and support the weighed, more accurate age intervals for the Tautra Substage and the interval between the Tautra and Hoklingen Substages.

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Sea-floor morphology and sedimentary processes along the Norwegian Channel Ice Stream

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We have compiled several regional and detailed bathymetric data sets together with 2D and 3D seismic data to investigate the landform assemblages and sedimentary processes along the former path of the Norwegian Channel Ice Stream (NCIS). At the broad scale, the glacial geomorphology and sedimentary architecture reveals three different zones along the ice-stream path, characterized by: (1) glacial erosion in the onset zone and inner shelf area, (2) sediment transport through the main trunk of the ice stream across the mid-shelf, and (3) a zone of deposition towards the outer continental shelf edge. Along the first 400 km of the ice stream bed (outer Oslofjord-Skagerrak-Stavanger) a major overdeepening is associated with suites of crag-and-tail features at the transition to crystalline bedrock, together with evidence of glaciotectonic thrusting in the form of hill-hole pairs. Here we interpret extensive erosion of both sedimentary rocks and Quaternary sediments. This zone is succeeded by an approximately 400 km long zone, through which most of the sediments eroded from the inner shelf were transported, rather than being deposited. We infer that sediment was transported subglacially and is likely to have been advected downstream by soft sediment deformation. The thickness of till of inferred Weichselian age generally varies from 0 and 50 m and this zone is characterized by mega-scale glacial lineations (MSGLs) which we interpret to be formed in a dynamic sedimentary system dominated by high sediment fluxes, but with some localized sediment accretion associated with lineations. Towards the shelf break, the North Sea Fan extends to the deep Norwegian Sea, and reflects massive sedimentation of glacigenic debris onto the continental slope. Numerous glacigenic debris flows accumulated and constructed a unit up to 400 m thick during the Last Glacial Maximum.

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Paleoenvironmental variability in the western Bering Sea during the last deglaciation

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Seasonally sea-ice covered Bering Sea is known to be a sensitive region to study rapid climatic oscillations. Relatively high sedimentation rates on submarine rises and continental margins above the shallow lysocline save detailed the information about paleoenvironmental variability within the far North Pacific realm.

In the framework of current investigation, we compare paleoceanographic conditions reconstructed from benthic and planktic foraminiferal data as well as sedimentary records from two cores retrieved in the central and southern parts of the Shirshov Ridge, western Bering Sea, during "*Sonne*" cruise in 2009. One core SO201-2-85KL (57^{0}30.30'N, 170^{0}24.79'E, w.d. 968 m), hereafter 85KL, is taken from the depression on the top of the ridge. The site is located at the lower boundary of the oxygen minimum zone. Benthic and planktic foraminiferal assemblages as well as gravel distribution from this core have been previously studied (Ovsepyan et al., 2013). Additionally, grain-size analyses of the terrigenous part of fraction have been carried out using laser diffraction particle size analyzer SALD 2300. Another core SO201-2-77KL (56°19,90'N, 170°41,97'E, w.d. 2163 m), hereafter 77KL, is retrieved from the southern part of the Shirshov Ridge. This site is bathed by deep waters originated from the open North Pacific and located well below the oxygen minimum zone. Microfossil and grain-size analyses are performed in every 10 cm to obtain time-resolution 500-900 years.

Paleoenvironmental changes have been reconstructed for the following short intervals: Last Glacial Maximum (LGM; >20 kyr), Early Deglaciation (20-17.5 kyr), Heinrich I interval (17.5-14.8 kyr), Bølling/Allerød (14.8-12.9 kyr), Younger Dryas (12.9-11.7 kyr), Early (11.7-9.2 kyr), Middle (9.2-6 kyr) and Late Holocene (6-0 kyr).

The LGM was characterized by a low sea-surface bioproductivity as inferred from a dominance of "phytodetritus species" *Alabaminella weddellensis* in both cores. However, indicators of high organic matter flux, i.e. *Bulimina tenuata*, *Stainfortia fusiformis*, *Globobulimina* spp., are also found in the LGM assemblages in the core 77KL. This might point to higher bioproductivity conditions above the southern part of the Shirshov Ridge as compared to the central one. As seen from the abundance of coarse terrigenous material in both cores, drifted sea ice cover was present in the western Bering Sea during the LGM, however, it was probably less dense above the southern part of the ridge. A strong prevalence of suboxic benthic group (according to (Kaiho, 1994)) in both cores mirrors rather well-oxygenated intermediate and deep waters.

During the Early Deglaciation, a simultaneous slight enhancement of sea surface bioproductivity is reconstructed from an increase in planktic and benthic foraminiferal accumulation rates (in the core 85KL) and high-productivity species percentages (in the core 77KL) at 19.5-19 kyr. This might be related to either sea ice retreat or upwelling of nutrient-rich deep waters into the surface layer. Paleoceanographic conditions during 19-17.5 kyr and the LGM were rather similar.

The onset of Heinrich I interval (17.5-17 kyr) was marked by another peak in bioproductivity, analogous to one at 19.5-19 kyr. However, bioproductivity became low again after 17 kyr. Absence of coarse terrigenous particles in the core 77KL points to sea ice expansion during the Heinrich I interval. Drifted sea ice probably melted far to the south from the station 77KL. This conclusion is in agreement with the previously published IP_{25} records, diatom data and calculated sea surface temperatures for the 77KL (Max et al., 2012; Méheust et al., 2015).

At the beginning of Bølling/Allerød, rapid increase in percentages of high-productivity species and dysoxic group of benthic foraminifers are registered in the core 77KL. This data points to a sea-surface bioproductivity rise above the southern part of Shirshov Ridge. Relatively low oxygen conditions developed at 2 km water depths in the southwestern Bering Sea, but occurrence (about 20-30%) of specimens from suboxic group suggests that oxygen depletion was not dramatic. Increase in bioproductivity and decrease in oxygen content are detected ~0.9 kyr later above the central part of Shirshov Ridge than above the southern one. This delay might mirrors the time of gradual sea ice retreat from station 77 KL to 85KL during the global warming and sea level rise after harsh environmental conditions during the Heinrich I.

The Younger Dryas event is characterized by a slight decrease in bioproductivity reconstructed from benthic foraminiferal abundance and accumulation rates. This might be caused by sea ice expansion inferred from the sedimentary data. However, presence of high-productivity species and elevated benthic foraminiferal accumulation rates in the core 77KL point to higher organic matter flux to the sea floor in the southern part of the ridge at the end of Younger Dryas. This might indicate that the sea ice melted between sites 77KL and 85KL although some ice floes could reach the southern site. Based on the distribution of oxygen-related groups, moderate bottom-water oxygenation is suggested for the intermediate depths at ~1 km water depth whereas no changes in relative oxygen content are found at 2 km below sea level.

For the Early Holocene, bioproductivity rise above the central and southern parts of the Shirshov Ridge and oxygen depletion of the intermediate waters are reconstructed from foraminiferal assemblages. Strong dominance of the dysoxic group in the 85KL indicates that oxygen content at the intermediate depths was much lower during the Early Holocene than during the Bølling/Allerød.

The Middle and Late Holocene records are available only in the core 77KL. During these intervals, a gradual decrease in organic matter supply to the sea floor and an increase in deep-water oxygenation are suggested from benthic foraminiferal assemblages. Rare drifted sea ice most likely reached 77KL station during the Middle - Late Holocene as follows from the occurrence of some terrigenous coarse material in the core.

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Paleoenvironmental reconstruction of Postglacial and Holocene events in the eastern Fram Strait inferred from benthic microfossils and IRD data

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In order to reconstruct climate variability and interaction between Arctic and Atlantic water masses in the eastern Fram Strait since last postglacial times microfossil and IRD records were investigated in core MSM5/5-723-2 (79°09.66 N, 5°20.27 E) from the water depth of 1359 m. The core site is located directly beneath the pathway of the West Spitsbergen current that carries Atlantic water in the upper 600 m and in close vicinity to the former ice sheets and modern winter sea-ice margin. The total length of the core is 950 cm, we investigated the upper 677 cm. Additional AMS14C datings obtained in 2015 and new data on lithology and benthic foraminifers allowed us to establish the sound age model for the studied core interval back to 18.5 cal.ka and to draw preliminary conclusions on paleoenvironmental evolution of the eastern Fram Strait continental slope.

The calculated linear sedimentation rates show extremely low values for the time interval 15-18.5 cal.ka. It might be related to the generally cool climate conditions with low precipitation causing glacial retreat and reduced inflow of Atlantic waters. Low IRD flux during the time interval prior to 15 cal.ka gives evidence for relatively cold climate conditions inhibiting iceberg calving. Climate warming and sea-level rise at the onset of the Bølling interstadial resulted in the sharp increase in sedimentation rates up to 100 cm/10^3 yrs. Rapid ice sheet retreat and iceberg calving is reflected by the highest IRD flux 13.5-15 cal.ka. The layer of fine-grained laminated sediments produced by meltwater plumes dated back to 14.2-14.4 cal.ka in core MSM5/5-723-2 serves as one of the tie-points for stratigraphical correlation of sediments in the northeastern Fram Strait. These features have been observed in many records from the region (Ebbessen et al., 2007; Jessen et al., 2010; Rasmussen et al., 2012; Telesiński et al., 2015). The next prominent but smaller than the Bølling-Allerød IRD peak characterizes the Younger Dryas cold stage that in our record dates back to 12-12.8 cal.ka. At 11.5-11.7 cal.ka the last small deglacial IRD peak likely signifies Pre-Boreal oscillation (though with slightly different timing), a short cooling at the onset of Holocene before the final warm-up. IRD is almost absent in the early Holocene between 10.5 and 7 cal.ka. It starts to gradually increase since about 5 cal.ka manifesting late Holocene climate cooling, but the Holocene IRD increase is by no means comparable with the deglacial IRD input.

The variability in the composition of benthic microfossil assemblages supported by cluster analysis reveals 4 characteristic benthic assemblages replacing each other upcore within the studied section. Deglacial benthic foraminiferal assemblage existed from 18.5 to 12.3 cal.ka and was strongly dominated by Atlantic water indicator species *Cassidulina neoteretis* (Lubinski et al., 2001) reaching up to 80-90%. Other common species were represented by typical Arctic marine forms *Cassidulina reniforme, Elphidium clavatum* and, in the later part, *Melonis barleeanus* and *Stainforthia feylingi*. This assemblage indicates strong meltwater-induced stratification, extensive sea-ice cover, high accumulation rates and turbid waters due to meltwater plumes and a strong subsurface inflow of Atlantic water. Similar conditions are manifested by the occurrence of *Polycope* spp. among ostracods that reach their highest representation during the 14.2-14.4 cal.ka meltwater event. At around 12.8 cal.ka an enhanced sea-ice marginal productivity and hence location of the seasonal sea-ice limit close to the core site is indicated by a peak of *Nonion labradoricum*.

Transitional assemblage aging back to 12.3-11.5 cal.ka shows an increase in species diversity and a change in the dominant species from *C. neoteretis* to *C. reniforme,* a marine cold-water Arctic species of very high ecological tolerance generally preferring colder waters than *C. neoteretis*. This change together with the first occurrence of deep-water species, an epifaunal *Cibicidoides wuellerstorfi* and a shallow infaunal *Oridorsalis umbonatus,* reflects the onset of deep-water convection after the freshwater input during the Younger Dryas has ceased.

Early-Mid Holocene assemblage (11.5-5.7 cal.ka) shows a drastic change to the dominance of *C. wuellerstorfi* and *O. umbonatus*. This manifests appearance of Atlantic Water on the surface, active Atlantic meridional overturning circulation and formation of cold, saline well-oxygenated Atlantic intermediate water. Thermal optimum and high productivity are indirectly evidenced by high benthic foraminiferal flux and high percentage of phytodetritus species *Epistominella exigua*. C. *neoteretis* almost disappeared from the record in the early Holocene, then it re-appeared but anyway remained less common than *C. reniforme*.

Mid-Late Holocene assemblage (5.7 cal.ka - present) gives evidence for growing cooling trend (increase in *E. clavatum*), increasing sea-ice and water stratification due to summer sea-ice melting. As seen from a considerable reduction in the relative representation of *C. wuellerstorfi* and *O. umbonatus* from 20-30% to less than 10% the strength of deep-water convection reduced compared to the early Holocene.

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Modelling the advance and demise of the Late Weichselian ice-sheet complex across northern Eurasia

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The Eurasian ice-sheet complex (EISC) represents the culmination and consolidation of three wholly distinct and semi-independent ice masses - the Celtic, Fennoscandian and Barents Sea ice sheets - that repeatedly occupied much of northern Eurasia throughout the Quaternary. We present experiment results from a higher-order, 3D thermomechanical model applied at a horizontal resolution of 10 km to investigate the growth and decay of this ice complex during the Late Weichselian (37-8 ka BP).

By fine-tuning atmospheric forcing to accurately reproduce the heterogeneous climate of the three major accumulation centres, our optimum experiments reveal rapid growth of the EISC following climate deterioration in the Ålesund/Tolsta interstadial (c. 37 ka BP), with Fennoscandian and Celtic ice first advancing to the continental shelf break by 29 ka B.P. Maximum extension of the EISC is asynchronous; whilst the complex reaches its maximum extent and volume c. 22.7 ka BP (5.54 Mkm^2 and 7.54 Mkm^3 respectively), the ice sheet continues to expand across its eastern margins until c. 19.5-

21 ka BP. Precipitation-shadow and starvation effects amplify this asynchrony, although it is contrasting topographic across its main nucleation centres that renders the primary driver for this behaviour. Expansion of the marine-based sectors Barents Sea ice sheet is driven by a reduced sensitivity to calving losses, particularly along the Arctic Ocean margin where low eustatic sea-level combines with cold sub-surface ocean temperatures and buttressing effects from perennial sea ice during build-up of the ice sheet.

Atmospheric forced ice surface melting and marine calving losses combine to drive rapid mass loss and deglaciation across the EISC post-LGM, particularly for the climatically sensitive Celtic domain. Repeated cycles of switching fast-flow, chiefly via the Norwegian Channel, Baltic Sea and Bjørnøyrenna, resonate nicely with the geological palimpsest evident today as the retreating and thinning ice margins adjusted to migrating ice divides and underlying topography. A strong Younger Dryas signal is observed with the readvance of Fennoscandian and Scottish ice sheets, though this becomes dampened at higher latitudes. Comparison of model output against Glacial Isostatic Adjustment modelling reveals that the predicted pattern and timing of ice loading across the Barents Sea during the Late Glacial neatly encompasses all empirical observations of isostatic rebound across the Eurasian Arctic.

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Size matters: the response of foraminfera test size to changing climate

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The main aim of the presented study was to determine how the size structure of benthic community off west Spitsbergen responded to climate-driven environmental changes since the last glaciation. The size of particular foraminifera species is variable and strongly dependent on e.g., oxygen conditions, organic carbon flux to the seabed, and temperature. All of these environmental parameters changed since the last glacial times according to the Atlantic and Arctic water mass balance along the Spitsbergen coast. It is well known that benthic foraminifera community structure in the North Atlantic and Arctic region varied in the postglacial and Holocene sediments in terms of species composition and diversity. However, the response of foraminifera tests sizes to changing climate have not been explored. The patterns of increasing size with declining temperatures are commonly referred to as Bergmann's rule and it refers to patterns observed along thermal or geographical clines. In our case, the main hypothesis was that Late Weichselian and Holocene temperature variations induced foraminifera size changes, i.e. elevated temperatures caused size reductions in large range of foraminifera species.

Herein, we present results from two ~ 14 000-years-old sediment cores located on south-west Spitsbergen shelf off Hornsund and Storfjordrenna. We have chosen six foraminifera species that occurred most abundantly in the Holocene: *Cassidulina reniforme*, *Cibicides lobatulus, Elphidium excavatum, Islandiella norcrossi, Melonis barleeanum* and *Nonionellina labradorica*. Two dimensions: the width and the length (i.e. the longest and the shortest diameter) were measured in 30 specimens of chosen species in each sample. The test volume was approximated by formulae based on 0.5 times the volume of a sphere (4/3πr3).

In both analyzed cores, all the chosen species showed roughly similar trend in the changes of the test size. During the Yonger Dryas interstadial (YD, ~12 800 – 11 500 cal yr BP) and in the mid- to late Holocene (~ 5000 – 1000 cal yr BP) foraminifera test volume was noticeably higher. During both mentioned periods, the Atlantic water was absent or its presence was less pronounced in the study area. YD was characterized by the enhanced water stratification and the presence of extensive sea-ice cover episodically limiting icebergs drift. In the mid- to late Holocene transition, a gradual cooling occurred and was accompanied by the glaciers advances. Conditions in the surface waters were polar and ice cover was more extensive than in the preceding period. In our case, there is a tendency of foraminifera test size to increase with a temperature decrease. However, it is likely that the variation in foraminifera test size is linked to the combination of temperature-related environmental variables e.g., ice cover and productivity.

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Ancient environmental DNA: a paleoceanographer's perspective

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Ancient DNA (aDNA) is defined as DNA retrieved from biological material such as archived bones, scales, preserved seeds, or retrieved directly from environmental samples such as sediments, ice or permafrost. An aDNA approach was successfully applied for tracing the Holocene history of diverse groups of organisms, including foraminifera (e.g., Lejzerowicz et al., 2013; Pawłowska et al., 2014, 2015). The results of these studies were very promising showing that the marine sediments are an excellent DNA repository, that can be used for the assessment of marine biodiversity and for the reconstruction of past environmental changes. However, these early studies also raised some questions about the accuracy of aDNA approach and the interpretation of the obtained data. The most important issues were 1) the accuracy of the aDNA approach in determining the foraminiferal diversity compared to morphological method; 2) the match in terms of stratigraphic occurrence for fossil species with the respect to their aDNA sequences; 3) the quantitative interpretation of aDNA data; 4) the potential of foraminiferal aDNA, especially non-fossilized monothalamous taxa, as a paleoenvironmental proxy. Here, we raised these issues, using the example of two studies of foraminiferal aDNA preserved in subsurface sediment samples from Svalbard.

To evaluate the possible use of foraminiferal DNA as environmental proxy we analyzed two sediment cores from Hornsund fjord and Strofjorden, spanning 1000 years and 7000 years, respectively (Pawłowska et al., 2014; 2015; Pawłowska et al., *unpubl.*). The investigation was completed with the use of classical paleoceanographic proxies and strengthened by the analysis of foraminiferal aDNA. Our studies confirmed the occurrence of aDNA in downcore sediment samples and supported the existence of extremely diverse foraminiferal assemblages. Most of the species that dominate the fossil assemblages were also found in the aDNA record, however, the number of aDNA sequence reads and fossil specimens in the corresponding samples differed considerably. To infer the species abundance from the sequence data is one of the most challenging issues of the aDNA studies, as it is not possible to establish the direct relationship between the number of specimens and the number of DNA sequences. The absolute number of sequences should be interpreted with caution; however, it is possible to identify the dominant species based on the sequence proportion

The most striking results of our studies was the extraordinary richness of the foraminiferal community revealed by the aDNA approach, mainly due to the detection of non-fossilized monothalamous taxa. Moreover, the data inferred from molecular analyses correlated well with environmental changes and revealed even small variations in e.g., glaciers fronts positions and water mass balance that were not clearly indicated by the fossil foraminifera record. Monthalamids seems to be reliable paleoenvironmental indicators, more sensitive than hard-shelled taxa. By including monothalamids identified in the aDNA record, we increased the number of potential proxy species. The obtained results allowed us to distinguish monothalamids that are indicators of e.g., glacier-proximal, glacier-distal and highly productive environments. The combination of ancient DNA studies with the analysis of microfossils and other proxies could provide a powerful means to reconstruct past environments more comprehensively. Moreover, the recent development in the field of ancient DNA research has led to a greater understanding of both the power and the limitations of the analytical techniques meaning that more robust reconstructions are possible.

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Modeling the post-LGM deglaciation of the Scandinavian-Barents Sea Ice Sheet; a model intercomparison approach

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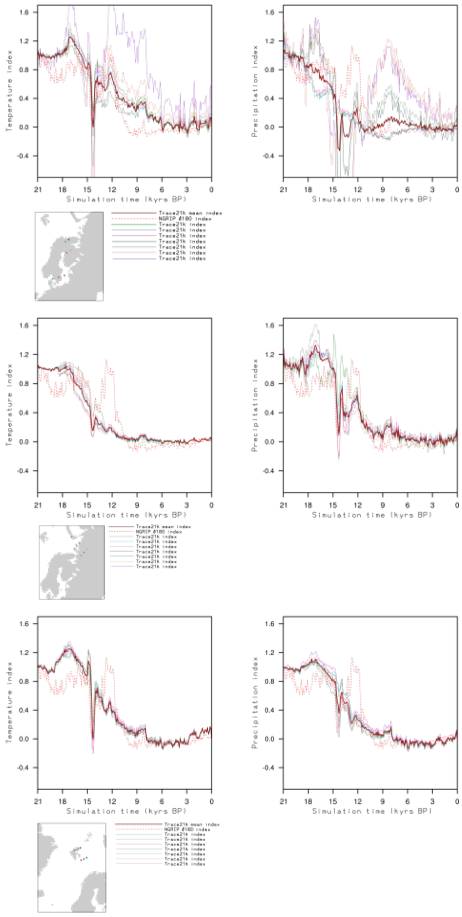
We aim at simulating the last deglaciation of the Scandinavian-Barents Sea (SBS) ice sheet. In particular, we focus on the Storfjorden and Bear Island ice streams, for which marine geological evidence suggests that they played an important role in the retreat of the ice sheet from the continental shelf edge during the last deglaciation, e.g., Rebesco et al. 2014, Lucchi et al. 2013, Ingólfsson and Landvik (2013). Two hybrid SIA/SSA numerical ice sheet models are employed, GRISLI, Ritz et al. 2001, and TARAH, Pollard and DeConto 2012. These models differ mainly in the complexity with which grounding line migration is treated.

The ice models are forced, from a spun-up initial condition, with spatially and temporally variable precipitation, surface air temperature, ocean temperature and ocean salinity fields. Climate forcing is interpolated by means of climate indexes between the Last Glacial Maximum (LGM) and the pre-Industrial (PI) climate. Regional climate indexes are constructed based on the non-accelerated deglaciation transient experiment carried out with CCSM3, Liu et al. 2009. Several indexes representative of the climate evolution over Siberia, Svalbard and Scandinavia are employed. The impact of such refined representation as opposed to the common use of the NGRIP δ18O index for transient experiments is analysed.

In this study, the ice-ocean interaction is crucial to reconstruct the deglaciation scenario in the area of the Storfjorden and Bear Island ice streams. To investigate the sensitivity of the ice shelf/stream retreat to ocean temperature, we allow for a temporal and a (vertical) spatial variation of basal melting under the ice shelves, using an implementation based on Martin et al. 2011 and simulated ocean temperature and salinity from the TraCE-21ka coupled climate simulation.

In this presentation, we will show work in progress, address open issues, and sketch future work. In particular, we invite the community to suggest possibilities for model-data comparison and integration.



Figures 1, 2 and 3. Plot of climate indexes based on TraCE21ka climate simulation against time for mean annual surface air temperature (left panel) and mean annual precipitation (right panel) over Scandinavia (1), Siberia (2) and Svalbard (3). Indexes take 1 value at LGM and 0 value at PI. In dashed red, NGRIP δ18O based index is plotted.

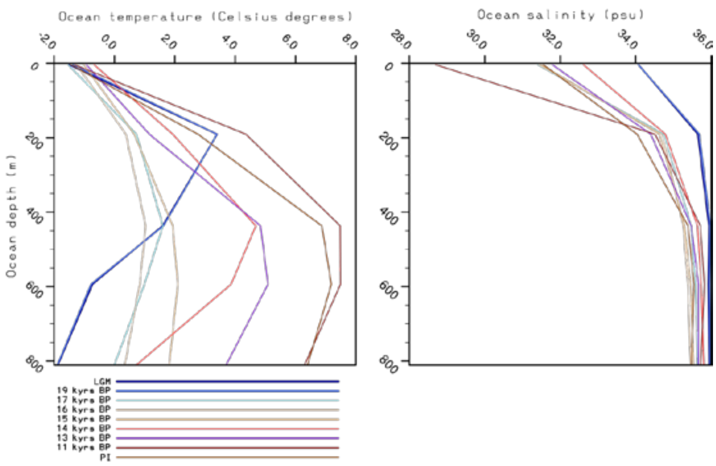


Figure 4. Vertical profiles of simulated ocean temperature (left panel) and ocean salinity(right panel) at different time slices from TraCE21ka climate simulation.

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Planktonic foraminifera (*Neogloboquadrina pachyderma*) signal Atlantic-sourced water inflow in the early Holocene Northwest Passage

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Four marine piston cores from central Parry Channel, the east-west axis of the historical Northwest Passage, were investigated for sedimentology, micropalaeontology, and biogeochemistry (total of 52 AMS radiocarbon dates). These records uniformly show the prominent early Holocene (~10 cal ka BP) appearance of planktonic foraminifera immediately following deglaciation. These planktonic foraminifera populations are exclusively composed of *Neogloboquadrina pachyderma* (sensu Darling et al., 2006), including morphotypes previously described from the Arctic Ocean (Eynaud et al., 2009), and aberrant, right-coiling forms. Today, planktonics are rare in this region, dwelling in adjacent offshore areas influenced by Atlantic water such as Baffin Bay. The early Holocene planktonic foraminifera signal is interpreted as reflecting the inflow of deep Atlantic-sourced water into the archipelago, likely facilitated by higher deglacial sea-levels (due to glacio-isostatic depression; Dyke et al., 1991) permitting increased flow across inter-channel sills at the marine entrances to the Canadian Arctic Archipelago (CAA). The planktonic influx intervals are accompanied by the benthic foraminifers *Cassidulina neoteretis*, an indicator of chilled Atlantic water (Jenning et al., 2006), and *Cibicides lobatulus*, an indicator of increased bottom currents (Husum & Hald, 2004). Collectively, this indicates an early Holocene oceanographic circulation and water mass structure different from today, marked by greater oceanic connection to adjacent basins, notably Baffin Bay.

Though the precise pathway of Atlantic water is cryptic, an eastern source via Baffin Bay Atlantic Water is likely, given shallow palaeo-water-depths to the west across the oceanographically critical Lowther sill. As glacio-isostatic rebound progresses, deeper waters carrying planktonics are progressively excluded from the central CAA as channels and sills shoal. Essentially modern oceanographic circulation is established by ~6 cal ka BP. This early Holocene planktonics peak is noted throughout Parry Channel, from Lancaster Sound in the east to as far west as southern McDougall Sound/Barrow Strait. This suggests that planktonic foraminifera may constitute a valuable regional marker for the entry of Atlantic-derived oceanic waters upon deglaciation into the CAA. Furthermore, the signal highlights the potential for major oceanographic change in complex archipelago settings occurring independently of climatic forcing.

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The Greenland Ice Sheet during the Last Interglacial: Coupling ice and atmosphere

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The Greenland Ice Sheet (GrIS) is an important player in the Arctic environment. The GrIS interacts dynamically with its surroundings on a wide range and has the potential to influence the global sea level or even the atmospheric circulation due to its ice thickness of several thousand meters. This study is focusing on the shape and evolution of the GrIS during the Last Interglacial (LIG; about 125,000 years ago). The climate of the LIG was substantially warmer than today and is often used as a possible equivalent for a warmer future climate caused by anthropogenic climate change. Knowing how the GrIS evolved in this warmer climate will help to understand its behaviour and this knowledge can be used to improve future predictions for global sea level rise and also influences on atmospheric and climate dynamics.

Many studies have looked at the evolution of the GrIS during the LIG in the past. An overview is given in the most recent assessment report of the Intergovernmental Panel on Climate Change (IPCC AR5) in the context of sea level rise in the past due to melting of the GrIS. The report reveals big differences between these studies in terms of GrIS extent and the resulting sea level rise. The modelled extent and shape of the GrIS vary strongly in these previous studies. This study is part of a PhD project that is trying, amongst other things, to improve the estimate for the GrIS during the LIG and also understand why the previous studies show such different results. A hypothesis is that the main cause for these

differences is the various methods used to calculate the surface mass balance. The dynamics of the GrIS is modelled using the Ice Sheet System Model (ISSM).
The study gives a more exhaustive review of previous work on the GrIS during the LIG. The focus is thereby given to the method used to calculate the surface mass balance. Different methods to couple the ice sheet and the atmosphere are discussed.

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Siberian glacial impacts on the Arctic Ocean: a case study of the Middle Weichselian glaciation.

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In addition to the recognized influence of the North American and Barents-Kara ice sheets on the western and eastern Arctic Ocean, respectively, recent seafloor geophysical data increasingly indicates repeated impact of multiple glacial flows from the East Siberian and Chukchi ice centers, which may have formed a unified East Siberian Ice Sheet (ESIS) (Niessen et al., 2013; Jakobsson et al., 2014). While the stratigraphy of these events yet needs to be developed, existing geophysical and sediment-core data suggest that these ice sheets had a limited extent during the Last Glacial Maximum (LGM), but were potentially more expansive during earlier glaciations (Polyak et al., 2007; Niessen et al., 2013). In particular, very large ice sheets encircling the western (Amerasian) Arctic Ocean have been proposed for Marine Isotope Stage (MIS) 6 based on a prominent deep-sited erosion of the Lomonosov Ridge constrained to this time (Jakobsson et al., 2016). These results are consistent with recent numerical modelling that indicates the existence of ESIS, probably connecting to the Barents-Kara Ice Sheet further west, during some glaciations exemplified by MIS 6 (Colleoni et al., 2016). These advances beg for a thorough investigation of extent, timing, and provenance of specific glacial events, which remain poorly resolved, resulting in fundamental gaps in our understanding of the Arctic glacial history.

New insights can be gained from sediment cores and geophysical data collected in recent years from the Arctic Ocean areas adjacent to the East Siberian margin. In particular, a 14-m-long core ARA06C-04JPC raised from the Chukchi Basin (R/V Araon, 2015) provides a continuous record of proglacial deposition extending nearly to the bottom of the Middle Pleistocene. Two prominent dark-gray units were attributed to a massive proglacial deposition related to collapse of ESIS formed during MIS4 and MIS12 or older; yet older event is identified from subbottom profiler records. A number of cores from the western Arctic Ocean provide material for correlating these events, especially for the MIS4 event. We present initial data from 04JPC along with correlative stratigraphies that provide an Arctic-wide context for the impact of the MIS4 ESIS event. The Chukchi Basin record indicates that the ice-sheet collapse initially produced a hyperpycnal underflow (dark gray unit) followed by pulsed overflow/meltwater discharge, probably from drainage of a large proglacial lake. Trans-Arctic correlations show that this stratigraphy postdates MIS4 deglacial deposits originating from the Barents-Kara margin, thus indicating an earlier deglaciation in that region.

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Timing and frequency of glacigenic-debris flows on the Bear Island Fan – implications for the growth and decay of the Barents Sea Ice Sheet

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The dynamics and retreat of the Late Weichselian (29,000 – 14,000 years before present) ice-sheets are quite well constrained because relatively well-preserved and dated sediments and submarine geomorphology allow reconstruction of ice-sheet history. However, the most recent glacial advance and retreat reworked earlier sediments and overprinted older geomorphology, thereby obscuring the record of past ice behaviour. It is therefore difficult to reconstruct the timing of advance and retreat cycles and ice-stream dynamics of ice-sheets beyond the Late Weichselian. The archive of former continental-slope sediments which make up trough-mouth fans provides an alternative method for understanding the growth and decay of Arctic ice-sheets, especially when they are most likely at the shelf edge. Here, we consider the ages of large glacigenic-debris flows on the Bear Island Fan and attempt to reconstruct the history of the Barents Sea Ice Sheet from these deposits.

We analyse glacigenic-debris flow deposits from four cores collected from the northern end of the Bear Island Trough-Mouth Fan. The age and frequency of these glacigenic-debris flows has been reconstructed using a combination of radiocarbon dating, geochemical proxies for regional oxygen isotope stratigraphy curves and a coccolith biostratigraphy. The geochemical composition of the flow deposits has also been analysed and compared to sediments in other parts of the Barents Sea.

Glacigenic-debris flows deposits were emplaced in four distinct clusters. The youngest of these clusters occurred between 26,000 and 20,000 Cal year Before Present (BP) and is consistent with proposed dates for the initial advance to the shelf edge of the Late Weichselian Barents Sea Ice Sheet. Two other clusters of debris-flow deposit emplacement occurred during the Weichselian. The younger set of deposits occurred between 39,400 and 36,000 Cal years BP. The older set of deposits occurred between 68 and 60,000 Cal years BP. The largest number and thickest deposits are dated to later than 128,000 Cal years BP and are associated with the Late Saalian glaciation of the Barents Sea. From the timing, thickness and number of these deposits we are able to reconstruct the history of the Barents Sea Ice Sheet in the Bjørnøyrenna cross-shelf trough and discuss the implications for ice-sheet dynamics during the last 140,000 years.

Further analysis of the geochemical composition of the mud fraction of the debris-flows showed two distinct composition clusters. One cluster is associated with debris-flows which occurred during the Weichselian. The second is associated with debris-flows which occurred during the Saalian. Using geochemical data from other cores around the Barents Sea we show that the flow direction of the Bjørnøyrenna Ice Stream likely changed between the Weichselian and the Saalian glaciation.

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Geological and Geomorphologic Features of the Area of the Kandalaksha Gulf (White Sea, Russia) as Formed by Deglaciation and Neotectonic Movements

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The White Sea, of which the Kandalaksha Gulf is part, is one of the youngest Arctic Seas. It came into being just 10 thousand to 12 thousand years ago following the retreat of the latest ice shield from the East European Platform. Since the Riphean, the tectonic evolution of the area has been driven by tectonic movements in the Onega-Kandalaksha graben and rift system. Since the Oligocene, intensified neotectonic rifting has been at work, extending and ramifying the preceding rift system. Throughout the current postglacial epoch, the area's neotectonic evolution has been strongly influenced by postglacial isostatic rebound of the Fennoscandian Shield. Over the Holocene, the Kandalaksha Gulf area has risen by up to 100 plus meters.

Geologically, there are two structural storeys beneath the seafloor of the Kandalaksha Gulf: 1) crystalline bedrock of the Archean White Sea complex; 2) a cover of sediment consisting of three layers - Riphean sandstones, terrigenous Vendian deposits and a cloak of Pleistocene and Holocene deposits and sediments (glacial drifts, transitional glaciomarine sediments and purely marine sediments).

Seismic profiling carried out in parts of the Kandalaksha Gulf has enabled us to identify five rock complexes reflective of the twists and turns of the geological history of the White Sea area (Romanovskaya et al, 2012). *Seismocomplex 1*, or the parent rock. These granite-gneisses from the Archean represent a crystalline foundation which reaches up to the bottom surface in some places only. *Seismocomplex 2*, made of glacial moraine deposits from the glacial stage. *Seismocomplex 3*, made of glaciolacustrine sand and clay deposits from the glaciolimnetic stage (the Allerod). The sediment came from several freshwater lakes filled with glacial water. *Seismocomplex 4* consists of fine late-postglacial terrigenous sediment from the glaciothalassic stage (the late Dryas). The sediment (in the form of abundant and mostly uniform silt) came from a mass of seawater hidden beneath a thick ice shield. *Seismocomplex 5* consists of the most recent marine sediment - a layer of silt with uneven but generally very low thickness. This sediment came from the transitional stage (the pre-Boreal and the Boreal time) and the thalassic stage (the middle and the late Holocene). At the latter stage, marine-type sediment accumulation reigned supreme.

In seabed troughs located in the southeast of the Kandalaksha Gulf, sediment layers up to over 150 m thick have been discovered. The sediment there is very complex structurally and highly heterogeneous lithologically, chronologically and genetically. It mostly comes from the current stage of sediment accumulation, which started with the disappearance of the latest North European ice shield. At this stage, sea currents and the biota played increasingly important roles. This thick and complex sediment layer is a product of the unstable geography and unstable tectonics of the White Sea in the Quaternary period.

Historically, all segments of the graben labyrinth (or, shall we say, mosaic) of the Kandalaksha Gulf area have been impacted by countless small- and large-scale and often conflicting neotectonic movements. Accordingly, lots and lots of small and medium-size islands are to be found in the Gulf - some of them accumulative in origin, but most tectonic (neotectonic) and only slightly modified by accumulation and abrasion. Our recent studies discovered convincing evidence of this (Kosevich, 2015, 2016).

Overall, the Kandalaksha Gulf islands were shaped by joint action of tectonic forces, gravity, moving glaciers, waves, currents, tides, surges, lake water and living organisms (both marine and land). (Kosevich, 2015, 2016).

The results of our geological, geophysical and geomorphological exploration strongly emphasize the role of neotectonics in the land- and seascape evolution of the Kandalaksha Gulf area during the Postglacial epoch.

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Preliminary results from a comprehensive isolation basin study at the south coast of Norway

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We present preliminary results from a recent coring campaign close to the town Tvedestrand at the south coast of Norway, ca. 180 km SW of Oslo. The main motivation of this study is to construct a high resolution local relative sea level (RSL) curve, as well as to improve our understanding of the regional pattern of RSL change along this coastline. The distance to the nearest existing RSL curves is approximately 100 km both to the north and south (Stabell 1980; Sørensen et al. 2014; Romundset et al. 2015). The field area is located ca. 10 km inside the Younger Dryas Ra end moraine which is submerged below present sea-level along this stretch of the Norwegian coastline. We cored and analysed a series of more than 20 isolation basins that are closely located in a hilly bedrock-dominated landscape ideally suited for basin studies of this kind. All investigated basins are relatively small and deep and have well-defined bedrock thresholds that we leveled using a dGPS. The basins are spread along the entire elevation range from (and slightly above) the marine limit at c. 85 m asl. down to the present shoreline. The isolation sequences were analysed for macroscopic remains of plants and animals that are specific to marine, brackish and lacustrine environments. Remains of terrestrial plants were identified and picked for radiocarbon dating. Several dating samples were prepared across each identified boundary, allowing for a firm chronology of isolation events. From several basins we also cored through glaciomarine sediments down to bedrock and picked shells from near the base of the sequences that yield minimum ages for when the area became ice-free. Both the deglaciation chronology and the relative sea level history of the area will be discussed in the talk.

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Late Holocene land-sea interactions and coastal environments in the Laptev Sea region as revealed from pollen and non-pollen palynomorphs (NPP) spectra in marine sediment cores

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Understanding the ongoing changes in Siberian Arctic and assessing the possible future variability demands improved reconstructions of Holocene environmental history including various parameters. Variability and extent of freshwater influxes into the shelf as well as temporal changes in river runoff, inland coastline retreat and climate-induced coastal plant cover transformation are among them. A viable and effective approach to reconstruct these parameters is to study variability in abundance and species composition of indicative fossil remains enclosed in marine sediments (e.g., pollen of seaside halophytes, long-distant wind-transported pollen, freshwater and marine palynomorphs, etc.). It is of particular importance for continental margins as these sediment records are often with increased temporal resolution (Hooghiemstra et al., 2006). The fact that the Siberian Arctic is poorly populated and therefore human impact on high-latitude vegetation remains virtually insignificant - at least until very recently - makes high-resolution pollen records, including those from adjacent shelf seas, an important source of information about the natural factors responsible for vegetation changes, particularly as they relate to centennial- and millennial-scale climate variability.

Here we present new pollen and NPP data from two AMS^{14}C-dated marine sediment cores, PM9482-2 and PS51/80-3, extending back to *c.* 2.8 and 6.3 cal. ka, respectively (Bauch et al., 2001). PM9482-2 core was taken from north of the Lena Delta, and within the outflow influence of the Tumatskaya branch. PS51/80-3 core was obtained from northeast of the Lena Delta, close to the Trofimovskaya branch, Core sampling in 3-4 cm intervals allowed centennial-to-decadal reconstruction of environmental changes in the Laptev Sea shelf and its hinterland.

Data obtained indicate species-rich fossil assemblages featured by predominance of pollen of plants indicative for floodplain vegetation (*Alnus viridis*, Cyperaceae and *Betula nana*-type) over pollen of conifers and tundra herbs throughout both sections, thus giving evidence for river runoff predominance over aeolian transportation in contributing to marine pollen spectra formation. Also throughout both core sections the abundances of freshwater colonial algae of genus *Pediastrum* and *Botryococcus* as one of the main biological indicators of river input onto the Siberian shelf seas are much higher than those of marine cysts of dinoflagellates. Cysts of dinoflagellates appear in both sections since *c.* 4-4.5 cal. ka, with peak values up to 9×10^2 grains/g of dry sediment pointing to establishment of marine conditions at the study sites. Two distinct peaks in both pollen and freshwater algae concentration exceeding 80×10^3 and $7.5\text{-}14.5\times10^3$ grains/g of dry sediment, respectively, were revealed and dated to 5.2 and 1.6 cal. ka. They might be associated with the warm/wet climate pulses causing particularly strong fresh-water influxes from the Lena River, bringing higher amounts of suspended organic matter onto the shelf.

A significant drop in pollen concentration together with a similar decrease in abundance of floodplain and tundra shrubs in favor of long-distant wind-blown *Pinus* pollen since 1.6 cal. ka points to decreasing pollen productivity of tundra plants due to climate deterioration in the late Subatlantic period, thus being in line with other palynological data from Northern Yakutia (Andreev et al., 2001; 2011; MacDonald et al., 2008). At the same time, the persistent input of freshwater green algae might indicate that this general trend in cooling was accompanied by a steady, north- and northeastward river water transfer through the Lena Delta.

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Downslope and alongslope sedimentary processes on a high latitude continental margin: NW Barents Sea

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The development of high latitude continental margin has been mainly controlled by glacigenic processes during the glacial maxima. Superimposed to these, there are both downslope and alongslope sedimentary processes (turbidites and contourites). This study is part of a PhD project, aiming to study the relationships between the glacial sedimentary input and the water circulation in NW Barents Sea (Kveithola to Isfjorden Trough Mouth Fans). This portion of the Barents Sea has been the target of several surveys in the last decade: SVAIS (R/V Hesperides) in 2007, EGLACOM (R/V OGS Explora) in 2008, GLACIBAR (R/V Jan Mayen) in 2009, CORIBAR (R/V Maria S. Merian) in 2013, PREPARED (R/V G.O. Sars) in 2014 and the EDIPO and DEGLABAR cruises (R/V OGS Explora) in 2015. These cruises allowed the acquisition of a wealth of new multibeam data that are now jointly processed at OGS (Figure 1). During the most recent EDIPO and the DEGLABAR cruises, from 20th September to 5th October 2015, we have been able to collect geophysical data, in particular Multibeam data, Sub-bottom profiles and Multichannel seismic profiles, as well as oceanographic data, including CTD and ADCP profiles. The EDIPO/DEGLABAR cruise focused the study of two areas in particular: the first one being the one W-SW of Isfjorden, on the Isfjorden TMF; the second one at SW of the Kveithola trough, on the INBIS channel. The INBIS channel originates from a series of tributary canyons, converging in a trunk-type channel, leading to a deep sea lobe system. The INBIS channel is inferred to have been produced by turbidity flows, flowing from tributary canyons incising the upper part of the continental slope between Bear Island TMF and Kveithola TMF. The INBIS channel is a very peculiar structure in the Barents Sea; channel systems are in fact rare on the Northern Norwegian margin and confined to the INBIS and Lofoten Basin channels. At W-SW of Isfjorden there is the evidence of alongslope sedimentary process, in the form of the Isfjorden drift. This structure is asymmetric, with a limited vertical relief. It is elongated alongslope, subparallel to the contour, due to the main current in that area, the north-flowing West Spitsbergen current. The analysis of the EDIPO/DEGLABAR data, integrated with all the other available information will allow to contribute to the comprehension of the relationships between the glacial sedimentary input and the water circulation in NW Barents Sea.

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Variability of water masses and ice coverage in the last 200 ky on the western Lomonosov Ridge

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A number of studies have reported on paleoenvironmental changes in the Arctic Ocean during the last two interglacial-glacial cycles based on water mass proxies obtained from high-resolution sampling of sediment cores from the central and eastern Arctic Ocean. However, microfossil and isotopic records records from the western central Arctic (i.e., between Greenland and the North Pole) are still rare.

Here we present first results from a ~260 cm long combined record of a box core and a kasten core from near the crest of the Lomonosov Ridge at 88°40'N, 61°30'W (station PS87/030). According to a preliminary age model based on microfossil occurrences (e.g., *Bulimina aculeata*) and coarse fraction contents, the investigated sequence covers the last ~200,000 years. It can be correlated to records of similar resolution from the eastern central Lomonosov Ridge and the Morris Jesup Rise. Together, they give a more complete picture of environmental variability in the central Arctic than before. The new grain size record shows several well-defined coarse layers with abundant ice-rafted detritus (IRD) which reflect the history of circum-Arctic ice sheets. It very much resembles the record from the Morris Jesup Rise which suggests a significant influence of icebergs from North America and Greenland on the glacial sedimentation pattern. The planktic foraminifer assemblages are almost monospecific throughout, containg almost exclusively the polar species *Neogloboquadrina pachyderma*. The IRD-rich layers are barren or low in content, but several layers foraminifer-rich layers are found, in particular just below the IRD layers. This is interpreted as a rapid transition from strong near-surface Atlantic Water inflow with seasonally partly open waters to a dense sea ice coverage with abundant icebergs and possibly a low salinity in the near surface waters which did not allow a survival and reproduction of planktic foraminifers. The planktic oxygen and carbon isotope records allow to identify several freshwater events, characterized by low $\delta^{18}O$ and $\delta^{13}C$ data. They can be correlated to the decay of ice sheets surrounding the Arctic Ocean and may, in part result from the discharge of freshwater from previously ice-dammed lakes.

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Submarine Landforms and Glacimarine Sedimentary Processes in Lomfjorden, Svalbard

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Swath bathymetric, subbottom profiler and lithological data from Lomfjorden, Svalbard, provide the first insights into the dynamics of tidewater glaciers and associated glacimarine sedimentary processes in east Spitsbergen fjords. Three landform-sediment assemblages are distinguished: (1) the Last Glacial Maximum (LGM) Assemblage, (2) the Holocene Assemblage, and (3) the Little Ice Age (LIA) Assemblage. The LGM assemblage contains glacial lineations and drumlins as well as recessional moraines and De Geer moraines. These landforms were deposited during fast advance and subsequent slow, step-wise retreat of a large ice stream draining the Svalbard-Barents Sea Ice-Sheet through Lomfjorden during the last glacial. The Holocene assemblage was formed after deglaciation

and comprises (a) submarine channels located along the fjord walls, which are related to erosion by meltwater, (b) large sediment lobes related to inputs from downslope mass-transport, c) laminated clayey silt and silty clay sediments, which in some areas appear interbedded with sandy beds, and in some areas were bioturbated subsequent to deposition, and e) extensive zones of iceberg ploughmarks on the seafloor that were formed from deep-keeled icebergs calved off the local tidewater glaciers. The fine-grained sediments within this assemblage were delivered to the core sites by meltwater plumes exiting the local tidewater glaciers throughout the Holocene. Laminated muds reflect proximal to distal glacimarine environments, and the abundant sandy beds interbedded with clayey silt attest to the frequent occurrence of turbidites in the inner fjord, which may have been related to a higher-energy depositional environment, for example related to ice-marginal conditions. The LIA assemblage is composed of a small number of submarine recessional moraines and two terminal moraines with associated debris lobes. These landforms were deposited in front of three of the glaciers, which flowed into Lomfjorden during their respective LIA advances. The restricted extent of the LIA Assemblage indicates that the glacier fronts either retreated far beyond their present positions during deglaciation, or that they underwent only minor re-advances during the LIA. This is at odds with the much larger LIA extents of glaciers in west Spitsbergen, and our data therefore suggest that glaciers in east Spitsbergen responded differently to climate forcing.

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Glacial and climate history in the Polar Urals, Russian Arctic

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We here present discoveries and research perspectives that have emerged as a result of our long-lasting field based investigations in the Polar Urals in the Russian Arctic. The investigations will now be continued within the framework of a recently started research project termed CHASE (Climate History along the Arctic Seaboard of Eurasia) financed by the Research Council of Norway. We are addressing climate variability in the Eurasian Arctic throughout the last glacial-interglacial cycle up to the present and the impact this variability had on glaciers, landscapes, ecosystems, and early human occupation. Our previous attempts to reconstruct the changing environment have been hampered by the lack of well-dated and continuous sediment records with a sufficiently high resolution that can supplement the more fragmentary data from moraines and exposed strata along river banks and in coastal cliffs. We have therefore long sought for suitable archives from arctic lakes that may be used to constrain the timing of the glacial variations and give us new and detailed data for reconstructing the climate evolution and the paleoenvironment. In the CHASE project we are now investigating some unprecedented high-resolution lake records from the Polar Urals covering tens of thousands years. A large number of high-resolution seismic profiles revealed that the largest and deepest of these mountain lakes, Bolshoye Shuchye, contains up to 120 m of acoustically laminated sediments. Seismic profiles and sediment cores have brought to light entirely new research questions that we now will pursue. This includes possible traces of some dramatic lake level fluctuations with a possible low stand several tens of meters below the present level that seems to have been attained prior 25 ka, most likely during the transition between MIS 2 and -3. Based on the available data from adjacent areas in the Polar Urals there is good evidence to suggest that a complex of sizeable ice caps formed over the mountain chain during MIS 4 (70-60 ka) eventually merging with the Barents-Kara Ice Sheet (Svendsen et al. 2014). Following the subsequent deglaciation during an early stage of MIS 3 the studied lake basins seems to have been permanent ice free up to the present. The restricted mountain glaciers that formed in the catchment areas during the last glaciation (MIS 2) appears to have melted away in response to the Bølling climate warming, and during the Holocene climatic optimum no glaciers existed in the mountains. For the further work with the lake records we will apply a multidisciplinary approach that in addition to seismic data and sediment stratigraphic investigations

will include palynology (pollen and algae), analyses of ancient DNA of plant remains and compound-specific isotope analyses ($\delta\ ^{2}H$, $\delta^{18}O$) for reconstructing the vegetation-, temperature- and precipitation history.

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How are large (>400 km³) submarine landslides related to the growth and decay of Arctic ice sheets?

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Submarine landslides on glaciated margins can be far larger than terrestrial landslides and may produce very damaging tsunami. For example, the Storegga Slide that occurred 8,150 years ago remobilised over 3,000 km^3 of material from the Norwegian Margin, generating a major tsunami that locally ran-up to heights of 20 m above sea level. It is thus important to understand the frequency of submarine landslides, especially large volume events that are more tsunamigenic. Previous work on the Storegga Slide concluded that another ice-stream advance to the shelf edge is needed to deposit sediment rapidly and cause another large landslide. Their recurrence interval was therefore thought to be > 100 ka in this location. This is a primary reason why such landslide-tsunamis do not currently feature on the UK National Risk Register. Here we show that multiple large (400 to > 3,000 km^3) volume landslides can occur from the same source area without another glacial cycle or ice-steam advance, although it appears that not all of these large-volume submarine landslides produced major tsunamis. We first show that an even larger submarine landslide occurred at 55-60 ka B.P. from the same source area as the Storegga Slide. These two very large events thus occurred during the same longer-term (110 ka) glacial cycle. We then study the Trænadjupet (~4.5 ka B.P.) and Nyk (19-21 ka B.P.) Slides located further along the Norwegian margin. We show that much of the Trænadjupet deposit is part of the underlying Nyk Slide, meaning that both had very large volumes (400-720 km^3), and implying that multiple large volume events can occur within < ~15ka. However, coastal lakes along the adjacent Norwegian coast provide no evidence of a major tsunami associated with the Trænadjupet Slide, even though they do contain a well-developed Storegga tsunami deposit. It appears that the Trænadjupet Slide was slow moving or multi-stage, disintegrated to a much lesser extent, and did not generate a widespread tsunami. While multiple large volume slides can occur from a single source area without another ice-stream advance, these landslides may not always produce a major tsunami.

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Benthic foraminifera for the study of the deglaciation post LGM in the south-western Svalbard slope (Arctic Ocean)

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The north-western continental margin of the Barents Sea represents the only gateway for deep-water masses moving between the North Atlantic and the Arctic Oceans. The transfer of heat and salt to the Arctic Ocean is mainly attributable to the relatively warm and saline water masses inflow of the West Spitsbergen Current (WSC), which strength varied considerably over time in association with climate changes. On this respect, the western Svalbard margin, located on the western side of the Fram straight, represents a key area to study the paleoceanographic variation of the North Atlantic/West Spitsbergen currents.
Contour currents along the south-western continental margin of the Svalbard area, generated expanded sedimentary sequences suitable for high-resolution paleoceanographic and paleoenvironmental reconstructions. The Storfjorden-Kveithola glacial sedimentary system (south of Svalbard) was investigated during the EGLACOM and CORIBAR projects (Fig. 1) with the aim of reconstructing the deep-water paleoceanographic evolution after Last Glacial Maximum.

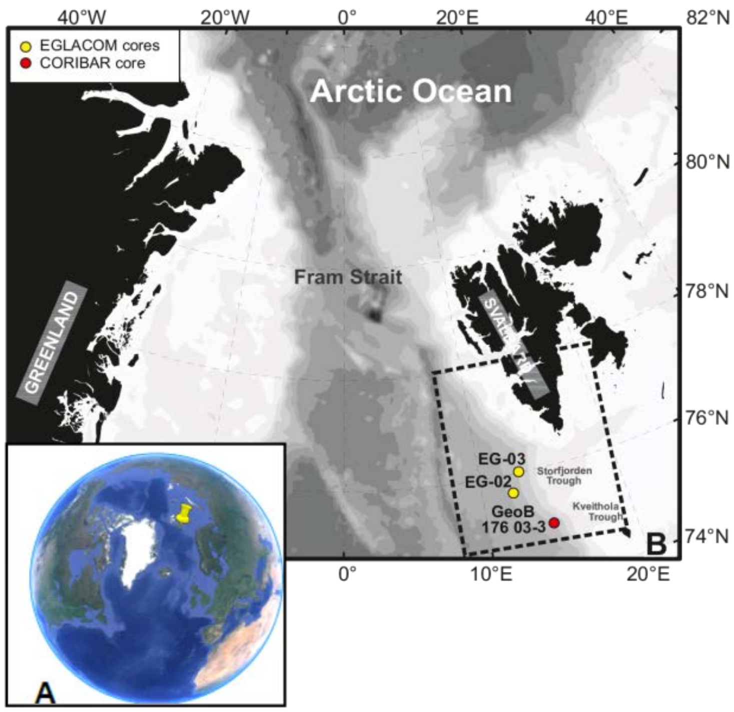

Figure 1. A) Location of the study area. B) The box indicates the study area in detail. Yellow dots indicate EGLACOM core location, red dot indicates CORIBAR core location.

Here we present the preliminary results concerning the benthic foraminifera of a multidisciplinary study carried out on a 9 m long core collected from the middle slope of the Kveithola Trough Mouth Fan and two cores collected from the middle slope off Storfjorden glacial system. Sediment samples were analysed for textural, compositional and micropaleontological aspects (using benthic and planktonic foraminifera, diatoms and calcareous nannofossils). A preliminary age model has been built on the basis of magnetic susceptibility correlations with previously studied cores for which the age model was based on the palaeomagnetic record and radiocarbon dating.

The benthic foraminifers are scarce in the lithological units that represent the deglaciation after LGM, and became abundant in the Holocene sequences, as generally observed for other microfossils taxa. The preservation state of the benthic foraminifera, indicated as percentage of fragmentation, is generally low in the glaciomarine sediments and decreases upcore towards the recent sediments, where open marine conditions prevail. Here the benthic foraminifera assemblage contains *Cassidulina reniforme*, *Cassisulina teretis*, *Islandiella helenae/norcrossi*, *Melonis barleeanum* and *Cibicidoides wuellerstorfi*. The assemblage is indicative of non-permanently ice-covered conditions since about 16 ka. The significant occurrence of small taxa, such as *Stetsonia horvati*, during the medium-late Holocene suggests a condition of low productivity and consequently low content of organic matter to the sea floor. Some peaks of agglutinated species, corresponding to high percentage of fragmentation/dissolution, along the core CORIBAR GeoB17603-3 core, could suggest the influence of cold, salty and dense waters (brines) coming from the shelf area, that are very aggressive to the calcareous tests.

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Reconstructing Weichselian ice sheet dynamics and extent in the eastern Barents Sea based on marine geophysical data

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The former Barents Sea Ice Sheet represents the only true glaciological and geological analogue for a full understanding of contemporary polar marine-based ice sheet retreat and long-term deglaciation. There is considerable scientific focus on using numerical and geological models of the Barents Sea Ice Sheet to improve our understanding of the processes, sensitivity and rate of marine-ice sheet response to atmospheric and oceanic forcing. These efforts are currently hampered by a lack of definitive constraints on both the timing and style of deglaciation in the Kara Sea and eastern Barents Sea.

Here we present a new compilation of analogue and digital geophysical data, covering the entire eastern Barents Sea and a large part of the Kara Sea. When used to constrain a state-of-the-art 3D numerical ice sheet model, this dataset provides an unprecedented opportunity to investigate the former ice sheet footprint, dynamics and rate of change in this little studied area.

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Buried iceberg-keel scouring features in the southern Spitsbergenbanken, NW Barents Sea

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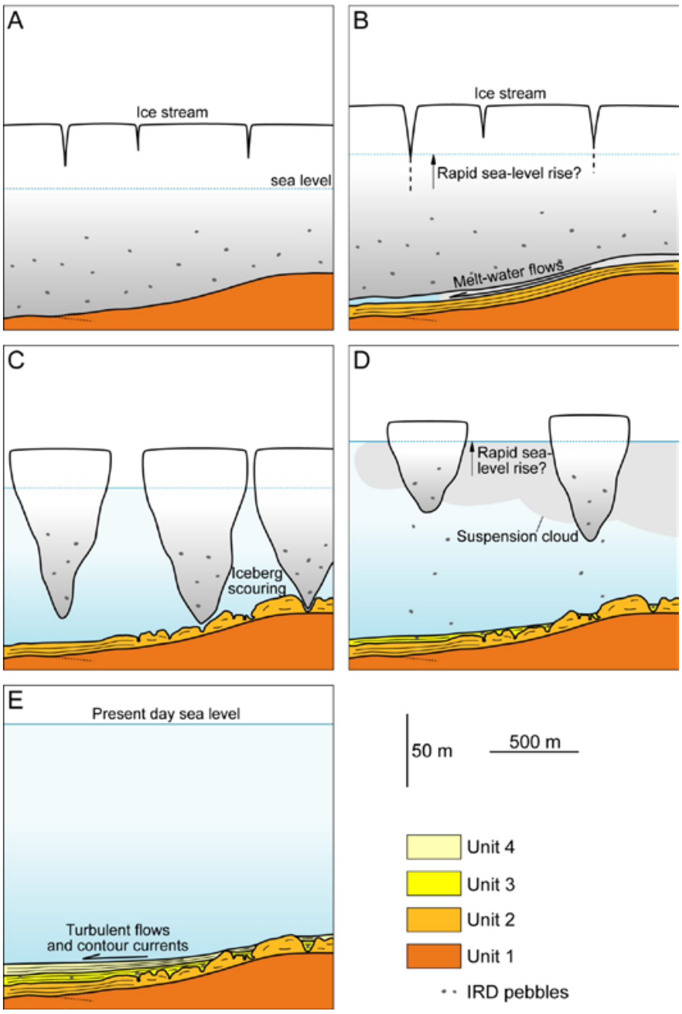
The analysis of PARASOUND profiles acquired in the southern Spitsbergenbanken, NW Barents Sea, has allowed the recognition of iceberg-keel scouring features buried by sediments accumulated during the post-glacial sea-level rise. Four seismic units (Units 1 to 4 from the base to the top), defined on the basis of their seismic facies and bounding surfaces, were recognized: Unit 1 is interpreted as a glacial till, whereas Units 2 to 4 have accumulated from suspension clouds, turbulent flows and contour currents, during the deglaciation phase. The top of Unit 2 was scoured by iceberg keels, resulting in relatively deep ploughmarks then buried by Units 3 and 4. On the basis of present data, three main events are thought to have characterized the evolution of the studied succession: (1) the change from till sedimentation (Unit 1) below grounded ice to the accumulation of laminated sediments (Unit 2), inferred to reflect ice lifting and meltwater release; (2) iceberg-keel scouring after sedimentation of Unit 2; (3) the apparent abrupt termination of iceberg-keel scouring possibly related to glacio-eustatic rise. A linkage between these events and rapid phases of post-glacial sea-level rise, such as meltwater pulses, is inferred, although further studies are needed to better understand the relationships between the sedimentary events recognized in the Barents Sea and climate changes.



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