SAINT-PETERSBURG STATE UNIVERSITY

**Proceeding of the**

# ‘PAST GATEWAYS’ FIRST INTERNATIONAL CONFERENCE AND WORKSHOP

**St. Petersburg, May 13-17, 2013**

Saint-Petersburg, 2013

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## Introduction

'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.

PAST-Gateways Steering Committee

H. Alexanderson, C. Andresen, L. Bjarnadottir, J. Briner, A. de Vernal, G. Fedorov, M. Henriksen, N. Kirchner, R. Lucchi, H. Meyer, C. O’Cofaigh (Chairman), R. Noormets, K. Strand, and R. Urgeles.

Website: http://www.geol.lu.se/pastgateways/

## ‘PAST Gateways’ First International Conference and Workshop, St. Petersburg, 2013

## Scientific Programme

**Monday 13 May**

Arrival in St. Petersburg. Guests arrange their own transportation and hotel stay at St. Petersburg before departure to the “Gelios” Hotel in Zelenogorsk. We recommend that you use the hotel below.

"Rossiya" hotel

Russia, Saint Petersburg, sq. Chernyshevsky, 11

Phone: 7-812-329-39-01

http://rossiya-hotel.ru/

**Tuesday 14 May**

9:00 - Pickup at "Rossiya" hotel

9:00-19.00 - Field Excursion: **Duderhof Heights, Sablino and Nevsky Pyatochok (Neva River head)**

19:00 - Arrival to the “Gelios” Hotel in Zelenogorsk (www.gelios-otel.ru/) and the ice breaker party

**Wednesday 15 May**

9:00 – Welcome address by **Joern Thiede**, Saint Petersburg State University

9:05 – Welcome address by PAST Gateways chair **Colm O’Cofaigh**

9:10 – Practical info local organizers: **Grigory Fedorov**

9:20-9:40 – **Joern Thiede, A. I. Zhirov, V. J. Kuznetsov, D. V. Lopatin, L. A. Savelieva and G. Fedorov**. Mysteries and History of the Siberian Drainage to the Arctic Ocean.

9:40-10:00 – **Helena Alexanderson, Mona Henriksen, Ólafur Ingólfsson & Jon Y. Landvik**. A revised glacial history of Svalbard.

10:00-10:20 – **Andrei Andreev, Volker Wennrich, Pavel Tarasov, Elena Raschke (Morozova), Julie Brigham-Grette, Norbert Nowaczyk, Martin Melles**. Late Pliocene/Early Pleistocene environments inferred from Lake El'gygytgyn pollen record.

10:20-10:40 – **Valery Astakhov**. Subaerial processes in the postglacial Pleistocene of the Russian North.

10:40-11:00 – **Henning A. Bauch and Nalan Koç**. Cross-arctic contrasts in temperature regimes during interglacial MIS 11.

11:00-11:20 – **coffee break**

11:20-11:40 – **D. Bolshiyanov, A. Makarov**. Lena River Delta formation during the Holocene and the Late Pleistocene.

11:40-12:00 – **Lilja Rún Bjarnadóttir, Monica Winsborrow, Karin Andreassen**. Deglaciation of the central Barents Sea.

12:00-12:20 – **Colm Ó Cofaigh, Chris R. Stokes, Olav B. Lian, Chris D. Clark and Slawek Tulacyzk.** Formation of mega-scale glacial lineations: insights from sedimentological investigations on the Canadian Shield, Northern Canada.

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14:00-16:00 – **Discussion and concluding remarks**

16:00-16:30 – **coffee break**

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## Posters

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**D.E. Dorechkina**. Genesis of Late Pleistocene diamicton from the northernmost part of Novaya Zemlya shelf.

**Grigory Fedorov**. Large Siberian Arctic lakes level oscillations during Late Pleistocene and Holocene.

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**Zykov E.A.** Lithological peculiarities of the Chukchi sea inner shelf sediments.

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## Excursion Guide

## Geologic excursion through some places of interest in the Leningrad Region

*Bedrocks*

In the north of the Leningrad Region the boundary between Baltic crystal shield and Russian sedimentary platform is situated. Within the Baltic shield Archean and Proterozoic crystal rocks are only covered with thin and discrete layers of late-glacial and Holocene deposits. Starting from that area to the south direction, a cover of Ediacaran and Paleozoic sedimentary rocks is emerging and thickening – this is a wing of larger Moscow Syneclise. In the territory of St. Petersburg the thickness of sedimentary cover is growing to the south in the range of approximately 200 to 300 meters.

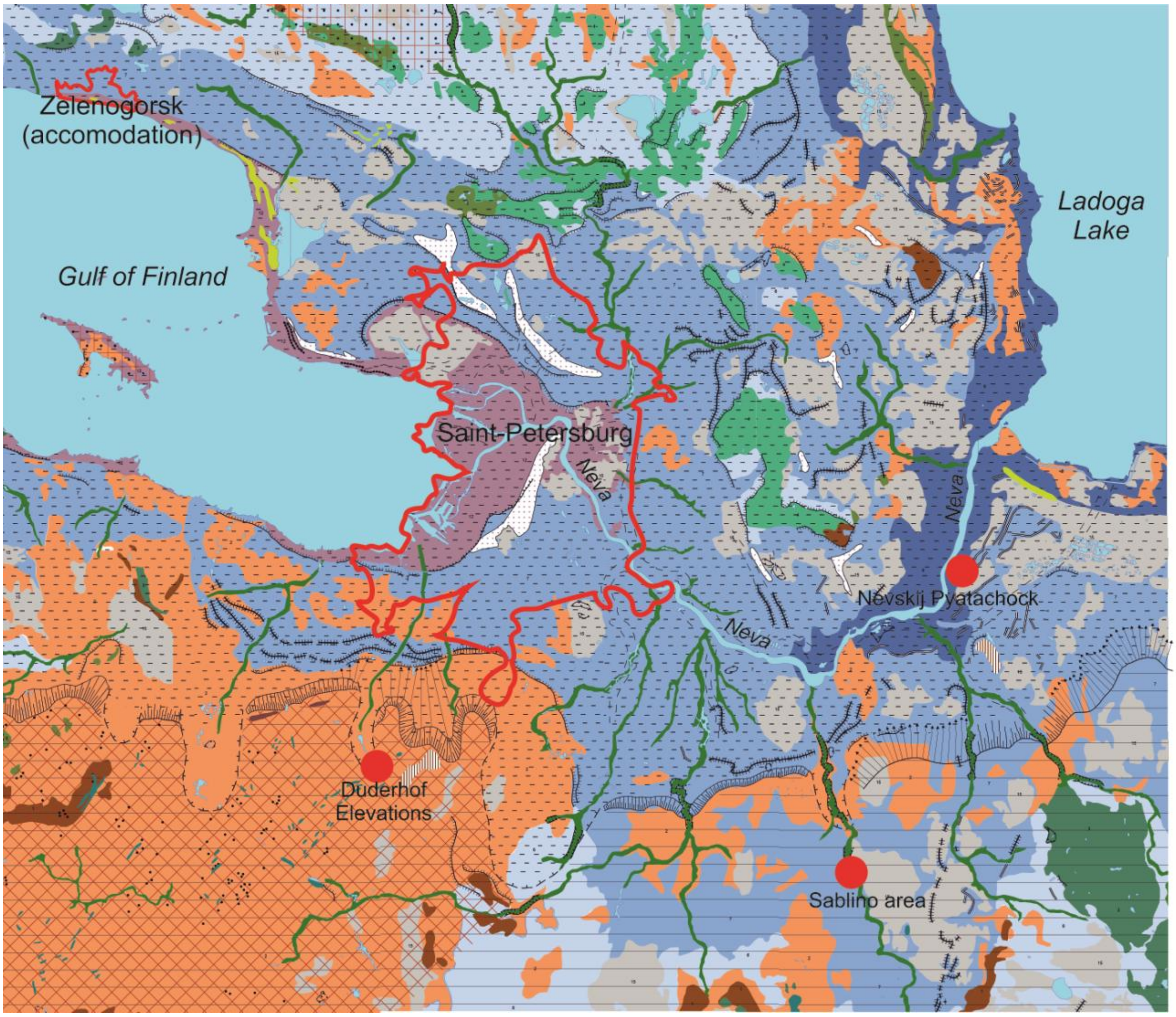
*Quaternary deposits*

Quaternary cover of the Leningrad Region is of a variable thickness: from several meters within elevations (Baltic shield area, plateaus armored by Ordovician and Carbon limestone) to tens of meters within bottom lands that surround largest river basins, Baltic Sea and the Ladoga. The biggest thicknesses of Quaternary deposits – up to 100 meters – take place within former ice-sheding elevations (for example, The Central Elevations of Karelian Isthmus) and some glaciodislocations (Duderhof Elevations).

Quaternary deposits are usually of late-glacial or Holocene age; inside the valleys, including buried ones, also older deposits can be found. Till, fluvioglacial, marine and lacustrine deposits are prevailing; various relief forms are made of them: moraine hills, ridges and plateaus, eskers, kames, sandrs, flat lake-bottom plains, etc.

*Places to visit*

Participants of the excursion will visit three places of interest, which are located along the south outskirts of the city of St. Petersburg: Duderhof Elevations, Sablino area and Nevskij Pyatachock. The first two are situated within the area of Klint – structural-denudation escarpment, which divides Neva low lands (the most of St. Petersburg lies within these low lands) from the plateau of Izhora. Nevskij Pyatachock (Neva’s land spot) is situated in the upper Neva riverside.



Fragment of the geomorphologic map of St. Petersburg area

### *Duderhof Elevations*

These are so called Leningrad Mountains: rather steep-sloped hills that exceed surrounding plateau by 70 meters which is anomalous for flattened landscapes of the Leningrad Region. There is a range of hypotheses of Duderhof Elevations' origin: glaciotectonic, clay-diapiric, plicate (folded), of impact origin, and cryptovolcanic. Today, the first hypothesis has the best fact base. It considers Duderhof Elevations as a large glaciodislocation, which is related to neighboring glacier-excavated valley named after Krasnoe Selo settlement. The valley was being cut into the Klint.

Excursionists will see specific topography of Duderhof Elevations and climb up to the top of Orekhovaja Hill. Field footwear and dress are advisable; in case of a rain short rubber boots will also be good. On the adjacent Kirchehof Elevations some sandpits will be surveyed. They partly strip the inner of these hills.

### *Sablino area*

Sablino area hosts summer field training camp for the students of St. Petersburg State University. This place is interesting due to its well-exposed geological structure and specific topography. Kettle-shaped part of the valley of Tosna River (left tributary of Neva) is supposed to be another glacier-excavated valley being cut into the Klint. Adits (so called Sablino caves) which were dug over a hundred years ago to mine quartz sand allow observing Early-Paleozoic sedimentary rocks from inside.

Excursionists will visit Sablino caves (some warmer clothes are advisable) and the most interesting parts of the Tosna river valley: small waterfalls and a canyon, picturesque “kettle” with erosion monadnocks, some of which are presumable glaciodislocations.

***Nevskij Pyatachock***

This land spot (1x4 km) situated on the left riverside of upper Neva was an area of a long severe battle during the World War II. Here in the natural exposures the sands left by the Ladoga transgression, which led to a water inrush from the Ladoga to Baltic Sea, can be seen. Radiocarbon dating of bedding and covering peat made it possible to evaluate the age of the river of Neva at approximately three thousand years.

Excursionists will see riverside exposures with abovementioned Holocene layers and get to know about the history of origination of Neva, in which mouth the city of St. Petersburg had been built.

# Abstracts

# A revised glacial history of Svalbard

Helena Alexanderson[1], Mona Henriksen[2], Ólafur Ingólfsson[3] & Jon Y. Landvik[2]

[1]*Lund University, Sweden*; [2]*Norwegian University of Life Sciences, Norway;* [3]*University of Iceland, Iceland & UNIS, Norway*

Svalbard terrestrial records of environmental change over the last 200 000 years consist mainly of coastal cliff sequences of raised marine and littoral deposits that are interbedded with thin tills. Most Late Quaternary records come from the west coast, and only few from the northern, central and eastern parts. This is mainly due to more open sections along the west coast because of ongoing transgression and coastal erosion, and partly due to access (better infrastructure and less sea-ice in the west making it easier to work there). Wave-eroded coastal cliffs, where sediments are exposed, are scarce in northern and eastern Svalbard, because of limited wave erosion along the predominantly regressional coastlines and extensive sea ice cover resulting in low-energy coastal settings.

Due to its location in the centre of Spitsbergen and its comprehensive record of four glacial advances and ice-free phases, the Kapp Ekholm stratigraphy (e.g. Mangerud & Svendsen 1992) is central to the glaciation curve for northern Barents Sea and Svalbard as reconstructed by Mangerud *et al.* (1998). However, re-investigations of previously described sites on western Svalbard have shown them to contain records of at least as many events as Kapp Ekholm, e.g. at Leinstranda (Alexanderson *et al.* 2011) and at Poolepynten (Alexanderson *et al.* 2012).

The Svalbard terrestrial stratigraphical sites have been correlated mainly on the basis of glacial event stratigraphy, amino acid ratios and absolute dating (Mangerud et al., 1998). The absolute chronology is based on radiocarbon, OSL, IRSL, TL and U/Th ages, in combination with relative age information from lithostratigraphy, amino acid ratios and biostratigraphy (molluscs, foraminifera) (Mangerud et al., 1998 and references therein). For sections older than the range of radiocarbon, the chronology is also based on correlation via IRD to marine records dated with oxygen isotope stratigraphy (Mangerud et al., 1998). However, the chronology is not entirely straightforward due to large uncertainties of absolute ages and correlations may be more complicated than previous stratigraphic schemes assumed (Alexanderson *et al.* submitted). In recent years re-investigations of several sites, new data on ice thickness and ice dynamics as well as improved chronologies (Alexanderson *et al.* 2011; 2012; Hormes *et al.* 2011; Landvik *et al.* 2013; submitted; Henriksen *et al.* submitted) have resulted in a partly new view on the complexity of the Svalbard-Barents Sea ice sheet dynamics (Ingólfsson & Landvik 2013), with large contrast in ice dynamics between ice-stream and inter ice-stream areas (Landvik et al., submitted). This shows that the previous 'glaciation curve' for Svalbard (Mangerud *et al.* 1998) gives a too simplified picture, which we now are able to refine.

## References

Alexanderson, H., Backman, J., Cronin, T. M., Funder, S., Ingólfsson, Ó., Jakobsson, M., Landvik, J. Y., Löwemark, L., Mangerud, J., März, C., Möller, P., O'Regan, M. & Spielhagen, R. F. submitted: An Arctic perspective on dating Pleistocene environmental history. Quaternary Science Reviews.

Alexanderson, H., Ingólfsson, Ó., Murray, A. S. & Dudek, J. 2012: An interglacial polar bear and an early Weichselian glaciation at Poolepynten, western Svalbard. Boreas.

Alexanderson, H., Landvik, J. Y. & Ryen, H. T. 2011: Chronology and styles of glaciation in an inter-fjord setting, northwestern Svalbard. Boreas 40, 175-197.

Henriksen, M., Alexanderson, H., Landvik, J. Y., Linge, H. & Peterson, G. submitted: Dynamics and retreat of the Late Weichselian Kongsfjorden ice stream, NW Svalbard. Quaternary Science Reviews.

Hormes, A., Akçar, N. & Kubik, P. W. 2011: Cosmogenic radionuclide dating indicates ice-sheet configuration during MIS 2 on Nordaustlandet, Svalbard. Boreas 40, 636-649.

Ingólfsson, Ó. & Landvik, J. Y. 2013: The Svalbard–Barents Sea ice-sheet – Historical, current and future perspectives. Quaternary Science Reviews 64, 33-60.

Landvik, J. Y., Alexanderson, H., Henriksen, M. & Ingólfsson, Ó. submitted: Landscape imprints of changing glacial regimes during ice sheet build-up and decay: a case study from Svalbard. Quaternary Science Reviews.

Landvik, J. Y., Brook, E. J., Gualtieri, L., Linge, H., Raisbeck, G., Salvigsen, O. & Yiou, F. 2013: $^{10}$Be exposure age constraints on the Late Weichselian ice-sheet geometry and dynamics in inter-ice-stream areas, western Svalbard. Boreas 42, 43-56.
Mangerud, J., Dokken, T., Hebbeln, D., Heggen, B., Ingólfsson, Ó., Landvik, J. Y., Mejdahl, V., Svendsen, J. I. & Vorren, T. O. 1998: Fluctuations of the Svalbard-Barents Sea ice sheet during the last 150 000 years. *Quaternary Science Reviews 17*, 11-42.
Mangerud, J. & Svendsen, J. I. 1992: The last interglacial-glacial period on Spitsbergen, Svalbard. *Quaternary Science Reviews 11*, 633-664.

## Late Pliocene/Early Pleistocene environments inferred from Lake El'gygytgyn pollen record

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The Arctic is known to play a crucial, but not yet completely understood, role within the global climate system. The Middle Pliocene (3-3.5 Ma) is considered to be the most probable scenario of the future climate changes. Therefore, the development of possible scenarios of future climate changes in the Arctic is a major scientific challenge. However, reliable climate and environmental projections are hampered by the complexity of the underlying natural variability and feedback mechanisms. An important prerequisite for the validation and improvement of the future projections is a better understanding of the long-term environmental history of the Arctic. Unfortunately, formation of continuous, non-interrupted paleoenvironmental records in the Arctic was widely restricted due to repeated glaciations, limiting information predominantly to the Holocene and in a few cases to the last glacial/interglacial cycles (e.g. Andreev et al., 2011 and references therein). Continuous sequences that penetrates the entire Quaternary and further into the Pliocene, with a temporal resolution at least as good as the marine record, are highly desired from the terrestrial Arctic and would enable to validate the absolute temperature rise during the mid-Pliocene that was proposed by former studies. Such a record has now become available from Lake El´gygytgyn (67º30'N, 172º05E') located in a meteorite impact crater in north-eastern Siberia (Melles et al., 2011).

The crater was created nearly 3.6 Ma ago in volcanic target rocks. The impact formed an 18 km wide hole in the ground that then filled with water. The modern lake is 170 m deep and has a roughly circular shape with a diameter of 12 km. The retrieved lake sediments are trapped pollen from a several thousand square-kilometer source area providing reliable insights into regional and over-regional millennial-scale vegetation and climate changes of the Arctic since the Pliocene (for details see Melles et al., 2011, 2012 and references therein).

The German-Russian-American ''El´gygytgyn Drilling Project" of ICDP has completed three holes in the center of the lake between October 2008 and May 2009, penetrating about 318 m thick lake sediments and about 200 m of the impact rocks below. Because of its unusual origin and high-latitude setting in western Beringia, scientific drilling at Lake El´gygytgyn offered unique opportunities for paleoclimate research, allowing the time-continuous reconstruction of the climatic and environmental history of the terrestrial Arctic back into the Pliocene for the first time (Melles et al., 2012; Brigham-Grette et al 2013). We received the first pollen record reflecting paleoenvironmental and paleoclimate changes during the Late Pliocene and transition to the Early Pleistocene inferred from the lower 200 m of Lake El'gygytgyn lacustrine sediments (Andreev et al., 2013).

Revealed pollen assemblages can be subdivided into 50 main pollen zones and a number of subzones, which reflect the main environmental fluctuations in the region during the Late Pliocene and Early Pleistocene, approximately 3.55-2.15 Ma BP. Pollen-based climate reconstructions show that conditions in the study area were the warmest about 3.55-3.4 Ma BP when spruce-pine-fir-hemlock-larch-*Pseudotsuga* forests dominated in nowadays treeless tundra area. After ca 3.4 Ma BP dark coniferous taxa gradually disappeared from the vegetation cover. Very pronounced environmental changes are revealed about ca 3.35-3.275 Ma BP when treeless tundra and steppe habitats dominated. Large amounts of coprophilous fungi spores point to a permanent presence of numerous grazing herds around the lake. It is interesting that this episode occurred at the so-called Mammoth subchron (M2).

Since ca 3.087 Myr BP (ca 163 m of the sediment core) extremely numerous, small (ca 12 µm), round and transparent cysts occur in many sampled intervals. The origin of these cysts is unclear. Most likely they are hypnozygote spores of algae from *Chlamydomonas* genus, which commonly produce such thick-walled cysts under environmental unsuitable conditions. Moreover, these cysts might be produced by the so-called snow-algae. The found cysts may belong to *Chlamydomonas* or *Chloromonas* representatives (Dr T. Leya from Fraunhofer IBMT, CryoCulture Collection of Cryophilic Algae personal communication). Dr R. Below (Institute of Geology and Mineralogy, University of Cologne) also suggests that the cysts likely hypnozygote spores of *Chlamydomonas* (personal communication).

Treeless and shrubby environments are also indicative for the beginning of the Pleistocene, ca 2.6 Ma. Dry and cold climate conditions were similar to those during the Late Pleistocene. The Early Pleistocene sediments contain pollen assemblages reflecting alternation of treeless intervals with cold and dry climate and warmer intervals when larch forests with stone pines, shrub alders and birches were also common in the region. Very dry environments are revealed after ca 2.175 Ma BP. High amounts of green algae colonies (*Botryococcus*) in the studied sediments point to a shallow water conditions ca 2.55, 2.45, and ca 2.175 Ma BP.

Our pollen studies show that lacustrine sediments accumulated in Lake El´gygytgyn are an excellent archive of vegetation and climate changes since ca 3.55 Myr BP (Andreev et al., 2013). The record well reflects main paleoenvironmental fluctuations in the region. The further high-resolution palynological study of the sediment core will reveal climate fluctuations inside the main glacial/interglacial intervals and will give the first continuous and detailed scheme of environmental changes for a whole Arctic.

## References

Andreev, A., Schirrmeister, L., Tarasov, P., Ganopolski, A., Brovkin, V., Siegert, C., Hubberten, H.-W. Vegetation and climate history in the Laptev Sea region (arctic Siberia) during Late Quaternary inferred from pollen records. *Quaternary Science Reviews* 30, 2011. 2182-2199.

Andreev, A.A., Wennrich, V., Tarasov, P.E., Brigham-Grette, J., Nowaczyk, N.R., Melles, M., El'gygytgyn Scientific Party. 2013. Late Pliocene/Early Pleistocene environments of the north-eastern Siberian Arctic inferred from Lake El'gygytgyn pollen record. *Climate of the Past*. (in preparation).

Melles, M., Brigham-Grette, J., Minyuk, P., Koeberl, C., Andreev, A., Cook, T., Gebhardt, C, Haltia-Hovi, E., Kukkonen, M., Nowaczyk, N., Schwamborn, G., Wennrich, V., El'gygytgyn Scientific Party. 2011. The Lake El'gygytgyn Scientific Drilling Project - Conquering Arctic Challenges in Continental Drilling. *Scientific Drilling* 11, 29-40.

Melles, M., Brigham-Grette, J., Minyuk, P.S., Nowaczyk, N.R., Wennrich, V., DeConto, R.M. Anderson, P.M., Andreev, A.A., Coletti, A., Cook, T.L., Haltia-Hovi, E., Kukkonen, M., Lozhkin, A.V., Rosén, P., Tarasov, P., Vogel, H., Wagner, B. 2.8 Million. 2012. Years of Arctic Climate Change from Lake El'gygytgyn, NE Russia. *Science* 337, 315-320.

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

## Ocean-cryosphere interactions by Helheim Glacier, Southeast Greenland, as evidenced from marine paleo-records

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Since major outlet glaciers on Greenland started to accelerate, thin and retreat in the early 2000s, the causes and significance of this change has been debated, however, it is widely believed now that changes in the ocean currents around Greenland play an important role. The understanding of the climatic influence on outlet glacier behaviour is hampered by the short time span for which satellite observations of glacier changes exist. The purpose of the SEDIMICE project (‘linking sediments with ice sheet retreat’) is to extend the glacier and ocean changes back in time by analysing sediment cores obtained from the fjords into which the outlet glaciers terminate and thus leave sedimentary traces from icebergs and melt water. Here we present data from Sermilik Fjord by Helheim Glacier in Southeast Greenland and discuss oceanographic conditions during and after the LIA and the concordant outlet glacier behaviour.

## Subaerial processes in the postglacial Pleistocene of the Russian North

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The last glaciation of the Russian mainland east of the White Sea terminated 50-60 ka BP (Svendsen et al., 2004) leaving for discussions the pre-Holocene history some 40-50 ka long. The nature and timing of pre-Holocene postglacial events has been a matter of considerable controversy for several decades. The models heavily depend on conventional radiocarbon dates. Those who believe that `old finite` (~35-50 ka) dates are impeccable maintain that the Weichselian formations (apart of glacial deposits) are mostly waterlain, i.e. marine, lacustrine and fluvial. However, hundreds of new AMS and luminescence dates of the same order obtained from much younger formations indicate that the conventional $^{14}C$ dates from interglacial waterlain sediments are often too young (Mangerud et al., 2002; Astakhov, Nazarov, 2010). Sediments related by modern geochronometric techniques to the postglacial Pleistocene are of quite different nature and appearance as compared to the `Mid-Valdaian` and Karginsky formations predating the last regional glaciation. In European Russia waterlain facies occur locally as terrace alluvium or lacustrine muds in topographic depressions. However, the prevailing mass of the surficial deposits is represented by dune sands, niveo-aeolian coversands, loess-like silts, soliflucted diamicts, slopewash, coarse sands left by ephemeral creeks, fine sands and peaty silts deposited by shallow thermokarst ponds. This generally fine-grained complex drapes all topographic elements except floodlains and lacustrine hollows and is basically of subaerial origin meaning all sedimentary processes without permanent water bodies (Astakhov, Svendsen, 2011). They are the essence of periglacial environments with meagre water supply which has been amply documented in Europe. If the dominant subaerial processes are ignored the postglacial history would appear as a collection of riddles.

The ubiquitous processes of the subaerial system are weathering, wind action and frost-cracking with ice wedges increasing in size and number eastwards. In East Siberia ice wedges, which cannot grow under water, often volumetrically exceed the silty matrix of the Yedoma Formation, also called the `Ice Complex`. The geocryologists have traditionally believed in alluvial origin of the Yedoma silts although the draping occurrence, grain size, mineralogical composition and organic remains strongly support the subaerial genesis for the Yedoma. Especially important is wind transportation inevitably accompanying all periglacial processes. The bulk of evidence was assembled long ago by Tomirdiaro and Chornyenky (1982) who, for example, found in the arctic Yedoma silts abundant fragments of volcanic rocks, including ash, which were alien to local provenances and best explained by long-distance aerial transportation. The basically aeolian source of the Yedoma silts was also stressed by Péwé and Journaux (1983) who compared them with the Alaskan loess. However, several permafrost investigators still believe in widespread aqueous sedimentation even for the Late Weichselian despite the overwhelming sedimentological and palaeonthological evidence of extremely arid climates in Siberia within this timeframe.

The extreme continental environments of periglacial type acknowledged for the arctic postglacial Weichselian in the final QUEEN report were strongly supported by data from the Taimyr Peninsula and Lena delta implying not only low precipitation levels but also warmer than now summers concurrent with very cold winters (Hubberten et al., 2004). The studies within the APEX framework have confirmed this conclusion providing more palaeonthological and sedimentological evidence. The domineering presence of xeric tundra-steppe species with insignificant share of hydrophiles is recorded by different proxies: pollen spectra (Andreev, Tarasov, 2007), plant macrofossils, fossil insects and testate amoebae (Sher et al., 2005). A good signature of subaerial environments are bones of large mammals scattered all over the postglacial Pleistocene together with tundra-steppe plant remains. Numerous mammoth carcasses with $^{14}C$ dates from >53 to 10 ka BP are characteristic of habitats with very cold winters, dry soils and tall grass. Important evidence of principally subaerial conditions is provided by numerous cryoxeric paleosols in the East Siberian Yedoma. During the interstadials the paleosols formed in semi-arid conditions with a reduced influx of aeolian dust and wind-blown plant detritus (Gubin et al., 2008).

Humidization with aqueous processes and mesic plant communities is noticeable only for the Mid-Weichselian interstadial from 50 to 24 ka BP and the final Weichselian since 15 ka BP. These interstadials, marked by fluvial activity which produced two alluvial terraces with abundant megafauna and Palaeolithic artifacts, still remained in the periglacial realm of generally treeless permafrost environments. The bulk of the sedimentary mantle was formed in the time span of 24 to 15 ka BP in frozen steppe with reduced biota in Siberia and in almost sterile polar semi-desert leeward of the Barents Ice Sheet (Astakhov, Svendsen, 2011). The extra-dry landscapes of northeastern Europe changed beyond the Urals to more hospitable tundra-steppe where frozen grasses and herbs provided forage for mammoths even in the Late Weichselian (Sher et al., 2005).

A novel accent imparted by the recent studies of northern Siberia is the stability of the grass/herb-dominated environments with progressing aridity and decreasing temperature through the Middle and Late Weichselian. \`Within this new paradigm, the LGM environment was just an impoverished variant of the MIS 3 tundra-steppe\` (Sher et al., 2005, p. 564). The absence of considerable climate changes in postglacial arctic Siberia has lately been confirmed by integrated studies of sedimentary DNA, pollen and macrofossil data indicating that \`the vegetation cover in the interior of the Taimyr Peninsula has remained fairly stable during the Late Pleistocene from c. 46 to 12.5 cal kyr BP\` (Jørgensen et al., 2012, p. 2000). Appreciable fluctuations of post-glacial climates are recorded only west of the Urals.

The new palaeonthological and pedological results are in harmony with the geological evidence of predominantly subaerial processes caused by the low sea level. The multitude of radiocarbon dates confidently correlates the arctic postglacial Pleistocene with the Middle-Late Pleniglacial of north-western Europe (50–13 ka BP) which was also dominated by subaerial sedimentation and growing permafrost without major temperate events. The European environments, though, were not that harsh: the January-July temperature difference was 28-33°C (Huijzer, Vandenberghe, 1998) against 55-60°C on the Laptev Sea shores (Sher et al., 2005).


**References**

Andreev, A. A., Tarasov, P. E. 2007. Postglacial pollen records of Northern Asia. Encyclopedia of Quaternary Science, Elsevier, 2720–2729.

Astakhov, V., Nazarov, D. 2010. Correlation of Upper Pleistocene sediments in northern West Siberia. Quaternary Science Reviews 29, 3615–3629.

Astakhov, V.I., Svendsen, J.I. 2011. The cover sediments of the final Pleistocene in the extreme northeast of European Russia. Regionalnaya Geologia i Metallogenia 47, 12–27 (in Russian).

Gubin, S.V., Zanina, O., Maksimovich, S.V. 2008. Pleistocene vegetation and soil cover of the plains of northeastern Eurasia. Put na sever: okruzhayuschaya sreda i samye ranniye obitateli Arktiki I Subarktiki. Institute of Geography RAS, Moscow, 238–242 (in Russian).

Hubberten, H. W., Andreev, A. Astakhov, V.I. et al. 2004. The periglacial climate and environment in northern Eurasia during the last glaciation. Quaternary Science Reviews 23(11-13), 1333–1357.

Huijzer, B., Vandenberghe, J. 1998. Climatic reconstruction of the Weichselian Pleniglacial in northwestern and central Europe. Journal of Quaternary Science 13(5), 391–417.

Jørgensen, T., Haile, J., Möller, P. et al. 2012. A comparative study of ancient sedimentary DNA, pollen and macrofossils from permafrost sediments of northern Siberia reveals long-term vegetational stability. Molecular Ecology 21(8), 1989–2003.

Mangerud, J., Astakhov, V., Svendsen, J-I. 2002. The extent of the Barents-Kara Ice Sheet during the Last Glacial Maximum. Quaternary Science Reviews 21(1-3), 111–119.

Péwé, T., Journaux, A. 1983. Origin and character of loess-like silt in unglaciated south-central Yakutia, Siberia. US Geol. Survey Professional Papers, № 1262, 46 p.

Tomirdiaro, S.V., Chornyenky, B.I. 1987. Kriogenno-eolovye otlozheniya Vostochnoi Arktiki i Subarktiki. Nauka, Moscow, 197 p. (in Russian).

Sher, A.V., Kuzmina, S.A., Kuznetsova, T.V., Sulerzhitsky, L.D. 2005. New insights into the Weichselian environment and climate of the East Siberian Arctic derived from fossil insects, plants and mammals. Quaternary Science Reviews 24, 553–569.

Svendsen, J. I., Alexanderson, H., Astakhov, V. I. et al. 2004. Late Quaternary ice sheet history of Northern Eurasia. Quaternary Science Reviews 23(11-13), 1229–1271.


## Cross-arctic contrasts in temperature regimes during interglacial MIS 11


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A number of recent observations and interpretations from various climate archives would imply varying impacts on the arctic environment during some older interglacials. Among several past warm periods, marine isotope stage 11 (MIS 11) is often named as a particularly severe interglacial phase with a tight global-scale climate connection. For the polar north it is suggested that the Greenland ice sheet was so strongly reduced in size that trees were able to thrive. And as noted in records from Lake El'gygytgyn in NE Siberia, average temperatures and precipitations exceeded those of the Holocene by far. Indeed, this interpretation of a rather moist and warm climate over Siberia seems to be in line with previous assumptions based on diatom productivity records from Lake Baikal as well as a new study using speleothem growth data.

In terms of low-to-high latitude transfer of ocean-atmosphere heat across the North Atlantic the Nordic Seas comprise the major gateway into the Arctic Ocean. By investigating in detail the oceanic surface ocean warmth during MIS 11 we cannot identify overly enhanced heat flow from the North Atlantic into the Arctic during this interglacial interval. As further deduced from our data, subsequent warm periods (MIS 5e and MIS 1) appear to have had significantly warmer surface ocean conditions than MIS 11. Moreover, sediment records from close to Greenland would imply a very active East Greenland ice sheet margin throughout MIS11 with regard to iceberg release rates and occurrence of sea ice. It is therefore proposed that the rather cold surface conditions in the Nordic Seas but comparatively warm temperature regime over the

Pacific side of the Arctic either resulted in or caused a distinct cross-arctic climate contrast which significantly affected arctic albedo and associated feedback factors, such as seasonal sea ice extent as well as circum-arctic vegetation and snow cover.

## Deglaciation of the central Barents Sea

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The pattern and dynamics of deglaciation in the central Barents Sea, which includes the formerly disputed zone between Norway and Russia are poorly constrained. Here we present new marine geophysical datasets from the area, including regional bathymetry, detailed multi-beam swath bathymetry, high resolution single-channel seismic and chirp sub-bottom profiles. The data provide valuable information about seafloor geomorphology and the thickness and acoustic character of seabed sediments, which was compiled in geomorphic maps. Based on the nature and distribution of glacial bedforms and grounding zone sediment accumulations, we have identified several new ice margin positions related to prolonged still-stands and/or readvances during times of overall ice-sheet retreat. The reconstructed relative age of these ice margin positions indicates a far more dynamic pattern of ice retreat in the troughs than on the shallower banks.

Ice streams are identified to have occupied the troughs of the central Barents Sea, and during overall episodic retreat these appear to have experienced cycles of fast and slower flow. In some cases, the periods of slow flow included ice stream stagnation and possibly ice shelf formation through floating-off. The distribution of landforms indicates considerable variation in the location of ice divides and domes, with ice flow becoming increasingly topographically constrained during the course of deglaciation.

## MAREANO - an integrated national seabed mapping programme

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The oceans are a major source of wealth, but their resources are not infinite and require sustainable, ecosystem-based management. This calls for a sound understanding of geographic distribution of benthic habitats and their role within the ecosystems. Detailed knowledge on bathymetry, geology, geomorphology and oceanographic conditions is essential, providing important information for characterisation and spatial delineation of benthic habitats. For example, in areas of high geodiversity, e.g. at cold seeps and where gas flares occur, rich biodiversity may be expected. This highlights the necessity of a thorough understanding of geological controls/influence on ecosystems for effective ecosystem-based management.

MAREANO is a Norwegian seabed mapping program funded by the Norwegian government, receiving 12.6 million Euros in 2013. MAREANO’s work is conducted by the Geological Survey of Norway (marine geology), the Norwegian Mapping Authority (hydrography) and the Institute of Marine Research (marine biology). The main data types acquired are multibeam bathymetry, backscatter and water column data, video data, physical samples including sediment samples and high resolution bottom penetrating sonar data. Since the programme started in 2005, a total of 107 000 $km^2$ of the continental shelf and slope, as well as deeper parts of Norwegian waters have been covered.

The programme has mapped bathymetry, seabed sediments, landscapes and landforms, biotopes, biodiversity and environmental conditions. Environments such as shelf-edge canyons have been mapped, as well as some of the world´s largest cold water coral complexes. Geological features mapped include both large-scale landscape features and smaller landforms. Examples of the former are marine valleys and canyons, and of the latter moraines and glacial lineations. The results from the MAREANO programme are available as maps and reports informing governmental decisions All MAREANO products are available to the public on www.mareano.no. Main results are also published in international scientific journals.

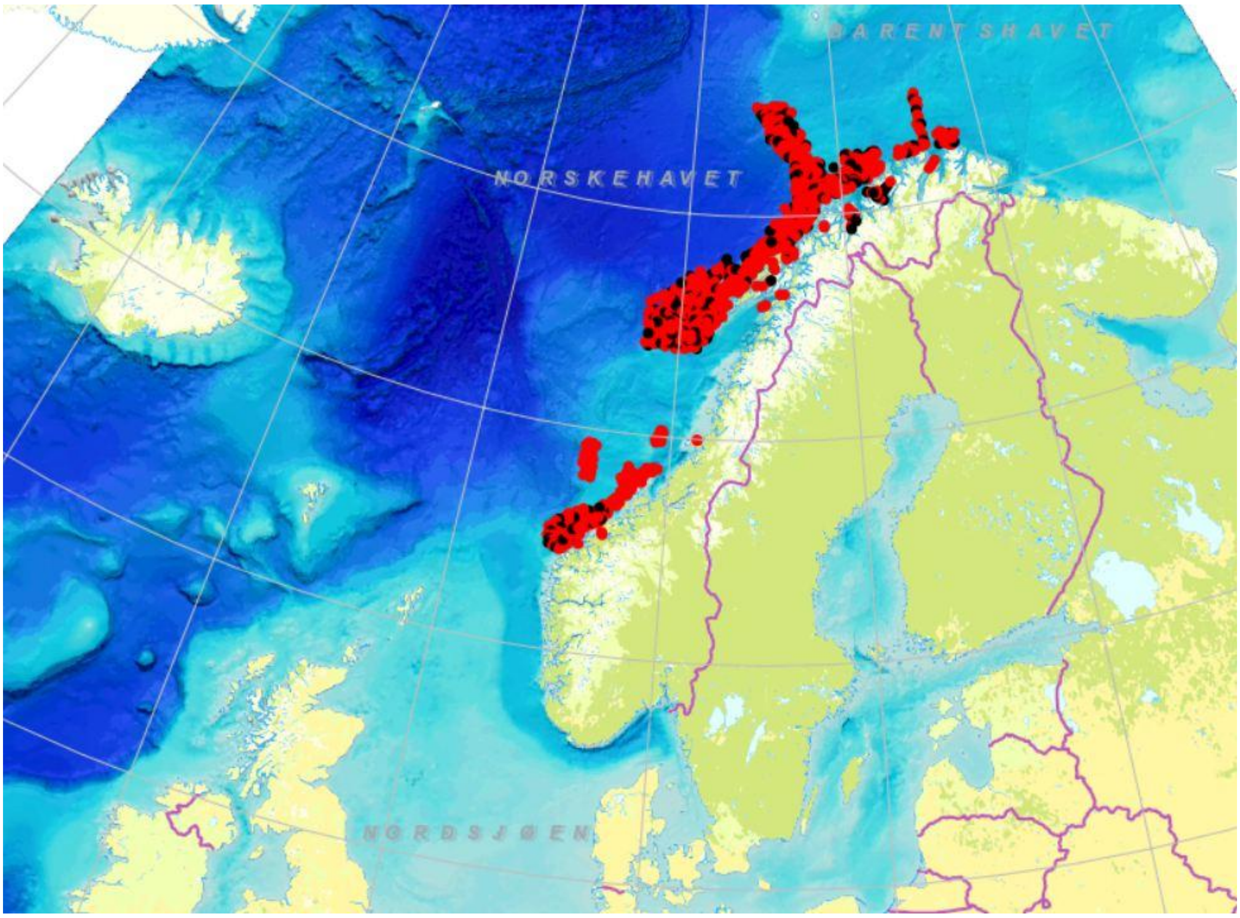


Fig. 1. Overview map of MAREANO stations, 2005-2012.

## Lena River Delta formation during the Holocene and the Late Pleistocene

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The Lena River Delta, the largest delta of the Arctic Ocean, differs from other deltas because it consists mainly of organomineral sediments, commonly called peat, that contain a huge organic carbon reservoir. In the Lena River Delta, organomineral sediments are extremely widespread and comprise the first alluvial-marine terrace. Results of radiocarbon dating, lithological description, and analysis of spores, pollen, and plant macroremains indicate that these deposits could not have accumulated in floodplain swamps. A layered sediment is a specific sediment type that accumulates under stagnant estuarine conditions at stages when sea level rising. Since layered sediments accumulated under conditions of high sea level, their dating can show when transgressive phases of Delta evolution occurred. Geomorphological analysis and compilation of the geomorphological map of the Lena River Delta showed that the Delta did not form by a simple protrusion into the Laptev Sea. Rather, it evolved by stages under estuarine conditions when it was essentially cut off from the sea; Delta formation progressed from west to east during the Holocene. Against this background, sea transgressions occurred during which the organomineral masses accumulated, creating the first terrace. During stages of regression these sediments were partly washed out, as were more ancient islands. Transgressive stages occured during 8-6 Ka, 4.5-4 Ka, 2.5-1.5 Ka, and 0.4-0.2 Ka, and periods of sea regression took place at 5.3 Ka and 0.5 Ka (Fig.1). The regressive periods were shorter than the stages of sea level rise. Currently, the southeastern part of the Delta (Bykovskaya Channel) has developed as an estuary under conditions of rising sea level, and the southwestern part (Olenekskaya Channel) as a meandering arm under conditions of falling sea level.

Studying of organomineral sediments of Ice Complex in Lena Delta Region and on Taimyr Peninsula show that these unique deposits have been formed under conditions of high sea level standing during Karginskaya transgression 60-25 thousand years ago (Bolshiyanov et al., 2013).

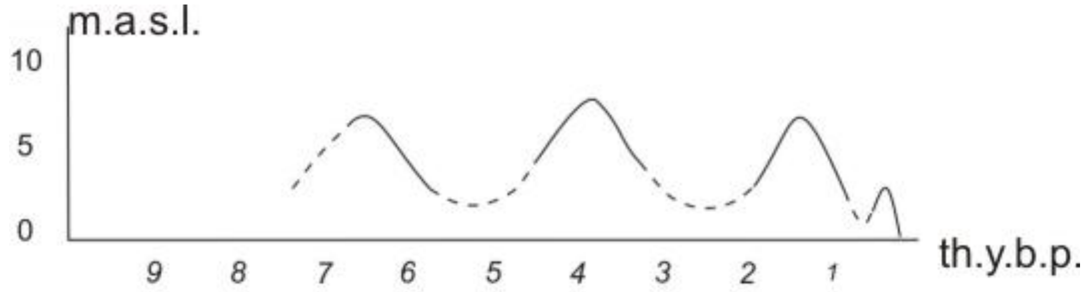


Fig. 1. Holocene sea level changes in Lena River Delta.

**References**

Bolshiyanov D., Makarov A, Schneider W., Stof G. 2013. Origination and development of the Lena River Delta. AARI. St.Petersburg. 268 p.p. *(In Russian)*

## Glacial history and paleoceanography of the southern Yermak Plateau since 132 ka BP

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The southern Yermak Plateau northwest of Svalbard is situated at the entrance to the Arctic Ocean in the narrow marginal ice zone (MIZ) between the Polar and Arctic fronts. We have studied the gravity core JM10-02GC from this strategic location to reconstruct paleoceanography and movement of the sea ice edge and the Svalbard-Barents Sea Ice Sheet margin during the last interglacial-glacial cycle. Our investigation is based on the distribution patterns of planktic and benthic foraminifera, planktic and benthic oxygen and carbon isotopes and variations in the ice rafted debris (IRD).The sediment core covers the time interval from the Marine Isotope Stage (MIS) 6-5 transition (Termination II,c.132 ka BP) to the Holocene period. During Termination II, the Svalbard Barents Sea Ice Sheet (SBIS) retreated and during MIS 5 to MIS 4, the sea-ice edge was close to the core site. The glacial high productivity (HP) zones during MIS 4 and MIS 2 were associated with open water conditions and advection of Atlantic surface water and retreat of the sea ice margin.The barren zones during MIS 3 and MIS 1 represented periods with the sea ice edge in vicinity of the core site, while the barren zone during MIS 2 represents enhanced supply of IRD from ice bergs/sea ice due to advance of the SBIS.

**References**

Dowdeswell, J., Jakobsson, M., Hogan, K., O'Regan, M., Backman, J., Evans, J., Hell, B., Löwemark, L., Marcussen, C., Noormets, R., 2010. High-resolution geophysical observations of the Yermak Plateau and northern Svalbard margin: implications for ice-sheet grounding and deep-keeled icebergs. Quaternary Science Reviews 29, 3518-3531.

Hebbeln, D., Dokken, T., Andersen, E.S., Hald, M., Elverhoi, A., 1994. Moisture supply for northern ice-sheet growth during the Last Glacial Maximum. Nature 370, 357-360.

Jakobsson, M., Nilsson, J., O'Regan, M., Backman, J., Löwemark, L., Dowdeswell, J.A., Mayer, L., Polyak, L., Colleoni, F., Anderson, L.G., Björk, G., Darby, D., Eriksson, B., Hanslik, D., Hell, B., Marcussen, C., Sellén, E., Wallin, Å., 2010. An Arctic Ocean ice shelf during MIS 6 constrained by new geophysical and geological data. Quaternary Science Reviews 29, 3505-3517.

Noormets, R., Dowdeswell, J.A., Jakobsson, M., O'Cofaigh, C., 2010. New evidence on past ice flow and iceberg activity on the southern Yermak Plateau, 2010 Fall Meeting, AGU, San Francisco, Calif.

Nowaczyk, N.R., Frederichs, T.W., Eisenhauer, A., Gard, G., 1994. Magnetostratigraphic data from late Quaternary sediments from the Yermak Plateau, Arctic Ocean: evidence for four geomagnetic polarity events within the last 170 Ka of the Brunhes Chron. Geophysical Journal International 117, 453-471

Rasmussen, T.L., Thomsen, E., Ślubowska, M.A., Jessen, S., Solheim, A., Koç, N., 2007. Paleoceanographic evolution of the SW Svalbard margin (76°N) since 20,000 $^{14}C$ yr BP. Quaternary Research 67, 100-114.

Vogt, C., Knies, J., Spielhagen, R.F., Stein, R., 2001. Detailed mineralogical evidence for two nearly identical glacial/deglacial cycles and Atlantic water advection to the Arctic Ocean during the last 90,000 years. Global and Planetary Change 31, 23-44.

Zamelczyk, K., Rasmussen, T.L., Husum, K., Hald, M., 2013. Marine calcium carbonate preservation vs. climate change over the last two millennia in the Fram Strait: Implications for planktic foraminiferal paleostudies. Marine Micropaleontology.

## Sea ice cover variations in the Arctic Seas and the subpolar northern North Atlantic Ocean during the Holocene based on dinocyst data

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Sea ice cover extent expressed in terms of mean annual concentration was reconstructed from the application of the modern analogue technique to dinocyst assemblages. The useof an updated database, which now includes 1492 sites and 64 taxa, yields sea ice concentration estimates with an accuracy of ±1.1/10. Holocene reconstructions of sea ice cover were made from dinocyst counts in more than 30 cores of the northern North Atlantic and Arctic seas. In the Canadian Arctic, the results show high sea ice concentration (>8/10) with little variations throughout the interval. In contrast, in Arctic areas such as the Chukchi Sea and the Barents Sea, the reconstructions show large amplitude variations of sea ice cover suggesting millennial type oscillations with a pacing almost opposite in western vs eastern Arctic. Other records show tenuous changes with some regionalism either in trends or sea ice cover variability. During the mid-Holocene, and notably at 6 ± 0.5 ka, minimum sea ice concentration is recorded in the eastern Fram Strait, northern Baffin Bay and Labrador Sea. However, this minimum cannot be extrapolated at the scale of the Arctic and circum-Arctic. The comparison of recent observations and reconstructions suggest larger variations in the sea ice cover during the last decades than throughout the Holocene, notably in the western Arctic, off southeast Greenland and in the Fram Strait.

# Genesis of Late Pleistocene diamicton from the northernmost part of Novaya Zemlya shelf

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Determination of genetic types for quaternary deposits on the northernmost part of Novaya Zemlya shelf is problem during last decades. This is due to deficiency of geological samples and seismic data. Lately big seismic database was composed, which allows us to make amended map of Late Pleistocene diamicton distribution.

The diamicton consist of grey silty-claied deposits mixed with sand, pebble and gravel. Graded layering typical for deposits on the slope of St.Anna ridge [1]. According to R. Krapivner [2] diamicton was formed by three periodically changing factors: depositing clay and silt from suspended matter under sea ice cover in the winter, accumulating medium and fine sand with silt in wave conditions and debris from melting sea ice cap during spring-summer-autumn period.

Using sediments characteristics [1, 2 et.al.], information from island and new amended diamicton distribution map [3] we conclude that this deposits was formed as result melting ice sheets from near land. Their accumulation was occurred according R. Krapivner by three periodically changing factors. We assume that the Late Pleistocene diamicton on the northernmost part of Novaya Zemlya shelf is of glacial-marine genesis.

**References**

Krapivner R.B. 2009. Origin of diamictons on the Barents Sea Shelf // Lithology and Mineral Resources. Vol. 44. № 2. P. 120-134.

Krapivner R.B. 2008. Nature of a shelf and archipelagoes of the European Arctic regions. Vol. 8. Materials of the international scientific conference (Murmansk, on November, 9-11th, 2008). Murmansk. P. 193-197

Dorechkina D., Rekant P., Korshunov D., Portnov A. 2012. The distribution of late Quaternary glacial-marine deposite on the northernmost part of Novaya Zemlya shelf // The Proceedings of the Mining Institute, Vol. 195. P. 28-32

# Large Siberian Arctic lakes level oscillations during Late Pleistocene and Holocene

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Three large Siberian arctic lakes (Pyasino, Taymyr and Elgygytgyn) level oscillations during late Pleistocene and Holocene have been investigated. We conclude the climate-driven concurrent character of level changes for all three lakes. During the late OIS 3 and early OIS 2 (about 42-17 kyr BP) lake levels were much higher than modern. The deep regression is reconstructed for the late OIS 2. Abrupt and very high rising of lake levels happened in the beginning of Holocene (about 12 kyr BP). The lake levels lowering down to modern positions happened only after warm Boreal period (about 8 kyr BP).

## Dynamics of surging tidewater glaciers in Tempelfjorden, Spitsbergen

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Terrestrial glacial geomorphology has long been used to evaluate the extent, chronology and dynamics of former glaciers and ice sheets. New marine geophysical methods provide an opportunity to study the glacial submarine morphology of modern continental shelves and fjord systems. This makes it possible to study landform assemblages in the submarine settings that are often better preserved than their terrestrial counterparts (Ottesen et al 2008).

This study focuses on the recent surge history of the tidewater glacier Tunabreen, which calves into Tempelfjorden in Western Spitsbergen. Tunabreen is a small outlet glacier of the Lomonosovfonna ice cap that has experienced three recorded surges during the last hundred years. Together with the Little Ice Age surge of the adjacent von Postbreen, four surges have been recorded in Tempelfjorden since 1870 (Plassen et al 2004, Forwick et al. 2010), which distinguishes the study area from earlier studied Svalbard tidewater surge glacier settigs, where the glaciers have been known to surge only once or twice (Ottesen et al. 2008, Ottesen and Dowdeswell 2006).

This study presents a detailed analysis of submarine landforms and the glacier margin positions in the innermost Tempelfjorden. Based on this analysis, a recent dynamics of Tunabreen has been reconstructed. Tunabreen has left a specific morphological imprint on the sea floor, consisting of ice flow-parallel lineations and generally flow-transverse retreat moraines. The multiple surge events have removed or reworked landform assemblages created by earlier surges, resulting in a complex geomorphological imprint on the bed of Tempelfjorden. Comparison of retreat moraines mapped from high resolution multibeam bathymetric data and glacier terminal positions, established using remote sensing imagery suggest that the moraines in the inner part of Tempelfjorden are annually formed recessional moraines, formed during winter still stands of the glacier margin or during its minor re-advances. Although detailed reconstruction of glacier surge dynamics based solely on the landform distribution is challenging, it is evident that Tunabreen has experienced fast flow during surges and semi-annual retreat of the margin after the surges.

Further investigations are needed to better understand the complexity of surge triggering mechanisms and their role in controlling the dynamics of the calving tidewater glaciers in Svalbard.

### References

Forwick. M. Vorren. T. O. Hald. M. Korsun. S. Roh. Y. Vogt. C. Yoo. K-C. 2010: Spatial and temporal influence of glaciers and rivers on: the sedimentary environment in Sassenfjorden and Tempelfjorden, Spitsbergen. Geological society of London, Special publications. Vol. 344. p. 163-183

Ottesen, D., Dowdeswell, J.A., 2006, Assemblages of submarine landforms produced by tidewater glaciers in Svalbard: Journal of Geophysical Research, Earth Surface, Vol. 111. p. 1-16.

Ottesen. D. Dowdeswell, J. A. Benn. D. I. Kristensen. L. Christiansen. H. H., Christensen, O. Hansen. L. Lebesbye. E., Forwick, M., and Vorren, T. O. 2008: Submarine landforms characteristic of glacier surges in two Spitsbergen fjords: Quaternary Science Reviews, Vol. 27, no. 15-16, p. 1583-1599.

Plassen. L. Vorren. T. O. Forwick. M. 2004: Integrated acoustic and coring investigation of glacigenic deposits in Spitsbergen fjords. Polar Research. Vol. 23. p. 89-110

## When did the Greenland ice sheet begin to aestivate?

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A peculiar characteristic of Greenland's Inland Ice is its ability to endure interglacials. Recent results indicate that the ice sheet apparently has survived interglacials that were both warmer and longer than the present has been so far….why? The answer to this question may brighten our view of the future where the threat of a rapid demise of the ice sheet ranks among the most dire consequences of Global warming. Using DNA in ice cores and an array of sophisticated dating methods we try to establish when the aestivation began.

Glacier ice in Greenland has a history that goes back into the Eocene, c. 45 ma ago, and the first contiguous ice sheets probably appeared in late Miocene or early Pliocene times, 7-10 ma ago, but the ice sheets were – like their neighbours in America and Eurasia – transient. Evidence of a Greenland that was forested and extensively ice free during the Quaternary comes from the Kap København Formation in North Greenland, The DYE3 ice core in southern Greenland, the ODP 646 core off southern Greenland, and, finally, new DNA results from the Camp Century ice core, which show that deciduous forests have grown at this high northern latitude in the Quaternary. However, the fitting together of these four puzzle-bricks into a coherent picture is complicated – still, an informed guess of the answer to the question above may be in the offing.

## Rapid Early Holocene ice retreat in west Greenland

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From 47 10Be cosmogenic exposure ages, 15 new plus 28 previously published radiocarbon ages, and 26 OSL ages (which all were too high), we have mapped the Early Holocene ice margin retreat in Central West Greenland between c. 65º and 63ºN. With a width of up to 125 km this is one of Greenland's larger ice free chunks of land. Ice margin retreat from the outer coast to the present margin-location was accomplished within less than 1000 years, but began earlier, at c. 11.4 ka, in the well-drained Godthåbfjord complex than in the landlocked Buksefjord and Sermilik areas, where the retreat only began at c. 10.5 ka or later. This indicates that the deep fjords triggered the land-based deglaciation by dynamic ice loss leading to a rapid Early Holocene ice retreat and drawdown of the west Greenland ice sheet. However, the huge piles of deglacial sediment that accumulated up in coastal and fluvial basins at this time show that also melting and runoff played a role. Our results demonstrate that even if there is topographic control on the onset of deglaciation, fast ice retreat is not restricted to deep fjord systems but may occur independently of the topography. Contrary to earlier researchers we have not seen evidence of significant, climatically induced stillstand or readvance – the so-called "Fjord Stage" or "Kapisgdlit Stade" - of the ice margin during its retreat.

## Collapse of the Viscount Melville Sound Iceshelf: instability at the NW margin of the Late Wisconsinan Laurentide Ice Sheet

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Recent work in the western Canadian Arctic Archipelago has seen a dramatic re-evaluation of the timing and extent of Late Wisconsinan glaciation by a primarily cold-based Laurentide Ice sheet. This has included the passage of ice across purportedly ice-free terrain as well as the extension of grounded ice throughout the central channels of the Northwest Passage, westwards onto the polar continental shelf. Although the pattern of ice extent and initial retreat is now better constrained in the terrestrial environment, significant questions remain regarding the ice retreat southeastwards from the marine channels onto mainland Canada in response to ameliorating climate and sea-level change.

Earlier research along the coasts of Victoria and Melville islands facing Viscount Melville Sound have demonstrated the retreat of grounded glacial ice from this > 105 000 km2 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 ~10.9 cal ka BP. Molluscan chronologies suggest the establishment of the iceshelf was extremely rapid, persisting for some 800 years, and subsequently undergoing an equally rapid collapse.

These terrestrial observations are now complemented by a series of Geological Survey of Canada / ArcticNet piston cores from the central part of Viscount Melville Sound, to test for the evidence of the short-lived ice shelf, especially to elaborate on the potential mechanisms and dynamics of iceshelf formation and collapse. Analyses of ice-rafted debris (IRD), coupled with micropalaeontological and chronostratigraphic investigation; data, suggest a rapid ice advance into Viscount Melville Sound consistent with terrestrial interpretations. The presence of loanstones (interpreted as “rain-out till”) as well as IRD indicative of a Victoria Island / M’Clintock Channel provenance is considered a result of deposition from a debris-rich tongue of floating glacial ice associated with streaming ice exiting M’Clintock Channel, permitting the on-shore rafting of ice and emplacement of coastal till sequences and iceshelf moraines. The rapid transition from sub-iceshelf sediments to ice proximal to distal sediments is also consistent with terrestrial evidence for the rapid retreat of the Viscount Melville Sound Iceshelf. AMS 14C-dated benthic foraminifera from above the iceshelf-marine transition provide a minimum age on iceshelf collapse of ~9.0 cal ka BP. Age-depth model projections indicate an approximate iceshelf collapse date similar to that indicated by terrestrial sequences.

This ongoing study contributes towards an improved understanding of the glaciological constraints placed on the streaming of ice from M’Clintock Channel into the Sound and the resulting draw-down and destabilization of the NW sector of the Laurentide Ice Sheet. Furthermore, emerging foraminiferal, diatom, and biogeochemical data provide valuable insights into the deglacial and postglacial history of the western sector of the Northwest Passage.

## Stratigraphy of bottom sediments from Mendeleev Rise (Arctic Ocean)

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The use of $^{230}$Th - dating method for the bottom sediment cores retrieved from the Mendeleev Rise slopes shows low sediment rates during the past 300 kyr (Fig. 1). Sediment rates vary in the range 0,11-0,437 cm / 1000 yr. The results of microfaunal study suggest that the upper 20-50 cm of cores were accumulated during the Late Pleistocene-Holocene. The cores from the northern part of the Mendeleev Rise reached, as we believe, Pliocene deposits as evidenced by the presence of agglutinated foraminifera including genus Cyclammina. The core located 400 km south of the northern ones did not reach Pliocene deposits as follows from the absence of genus Cyclammina in the samples. This fact correlates with the results of sedimentation rates obtained by radiochemical dating. Sedimentation rates in the Southern Mendeleev Rise exceed 2–3 times the rates calculated for the northern cores. Various rates of sedimentation are defined by different distances from the continental margin which means different source areas of the material.

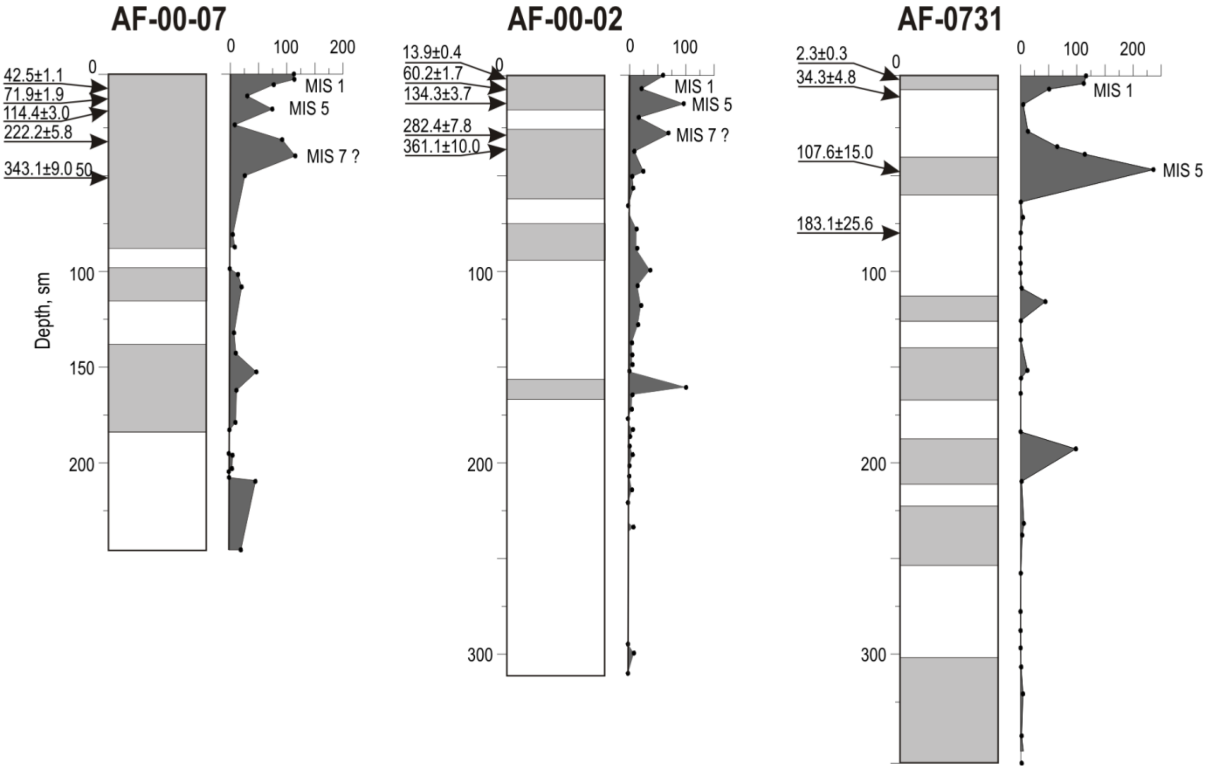


Fig. 1. Correlation of three cores sampled from Mendeleev Rise. Grey color marked brown sediments intervals. $^{230}$Th (KYR) derived age model shown leftward. Also shown are existing biostratigraphic constraints (foraminifera) (sp/g).

## Palaeoceanography of the Arctic -Water masses, Sea ice, and Sediments (PAWS) and LOMROGIII

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How and why has Arctic sea ice cover, an important player in the global climate and ecosystems, varied in the recent geologic past? The Arctic sea ice cover has been declining at an increasing rate since at least 1979, and September sea ice extent in 2012 was at a new record low. An assessment of past changes in sea ice coverage and water masses is needed to get a better understanding of the causes, processes and consequences of the modern decline. Here, we present the project Palaeoceanography of the Arctic -Water masses, Sea ice, and Sediments (PAWS), where we utilise the new sea ice proxy IP25, a biomarker from ice algae, together with grain size and other proxy data to study the variability in sea ice cover with time. Neodymium isotopes will be used to reconstruct past variations in water masses, especially inflow of warm Atlantic water, to investigate its influence on sea ice cover in the past. The analyses will be performed on 10 new sediment cores retrieved from the central-western Lomonosov Ridge during the 3rd Lomonosov Ridge off Greenland (LOMROGIII) expedition in Aug-Sept 2012 with I/B Oden, along with previous cores from our repository at Stockholm University.

The sediment cores recovered during LOMROGIII come from an under-sampled region of the Lomonosov Ridge. Together with the existing cores in our repository at Stockholm University, this will allow us to study sediment material representing a 1000 km transect of the Lomonosov Ridge, to better constrain spatial changes in sea ice cover, drift patterns and water mass changes. Effects of a suggested catastrophic drainage of an ice-dammed lake into the Arctic Ocean 50,000 years ago will also be assessed using Nd isotopes as a sediment source tracer. Analyses of the cores are now underway at Stockholm University and the first samples for IP25 will be analysed during spring 2013.

## The Late Weichselian Kongsfjorden ice stream, NW Svalbard: surface exposure age constraints on ice dynamics and retreat

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Terrestrial cosmogenic nuclide dating in combination with detailed landform mapping in the Kongsfjordhallet area, NW Svalbard, have provided new insight on configuration, dynamics, and deglaciation of the Late Weichselian ice stream in Kongsfjorden (Henriksen et al., submitted). The minimum Late Weichselian ice surface elevation in Kongsfjorden was >440 m a.s.l. yielding considerably thicker ice and steeper surface gradient than earlier suggested by Landvik et al. (2005). For the adjacent inter-ice stream area an even steeper surface slopes is reconstructed based on the TCN dates by Landvik et al. (2013), indicating feeding areas for the Kongsfjorden ice-stream. The landform succession, as well as the surface exposure ages of erratic boulders at different elevations, suggests a gradual lowering of the ice-stream surface. Deglaciation of the higher elevations was underway as early as 20.0 ka. At ca. 16.6 ka the ice stream terminus had retreated to the mouth of Kongsfjorden where it stayed until 14.3 ka, and a large moraine complex (‘the Kongsfjorden moraine’), first described by Lehman & Forman (1992), was deposited. The shape of the moraines, the steep ice surface gradient, as well as the correlation to laminated clay in the Kongsfjordrenna trough (Landvik et al., 2005) suggest that ice dynamics switched from ice-stream behaviour to a slower flowing outlet (tidewater) glacier. This is concordant with the generalized succession of ice flow in western Svalbard proposed by Landvik et al. (submitted). In the fjord/trough areas the maximum flow style with ice streams are followed by transitional flow style in the form of constrained fjord glaciers. A Younger Dryas or Early Holocene advance of local valley glaciers is shown by moraine lobes cross-cutting the Late Weichselian lateral moraines. The agreement between $^{10}$Be ages and $^{14}$C ages from the area suggests that the in situ $^{10}$Be production rate from northern Norway (Fenton et al., 2011) also is applicable in Svalbard.

**References**
Fenton, C.R., Hermanns, R.L., Blikra, L.H., Kubik, P.W., Bryant, C., Niedermann, S., Meixner, A. & Goethals, M.M. 2011: Regional $^{10}$Be production rate calibration for the past 12 ka deduced from the radiocarbon-dated Grøtlandsura and Russenes rock avalances at 69° N, Norway. Quaternary Geochronology 6, 437-452.
Henriksen, M., Alexanderson, H., Landvik, J.Y., Linge, H. & Peterson, G. submitted: Dynamic and retreat of the Late Weichselian Kongsfjorden ice stream, NW Svalbard. Quaternary Science Reviews.
Landvik, J.Y., Ingólfsson, Ó., Mienert, J., Lehman, S.J., Solheim, A., Elverhøi, A. & Ottesen, D. 2005: Rethinking Late Weichselian ice sheet dynamics in coastal NW Svalbard. Boreas 34, 7-24.
Landvik, J.Y., Brook, E.J., Gualtieri, L., Linge, H., Raisbeck, G, Salvigsen, O. & Yiou, F. 2013: $^{10}$Be exposure age constraints on the Late Weichselian ice-sheet geometry and dynamics in inter-ice-stream areas, western Svalbard. Boreas 42, 43-56.
Landvik, J.Y., Alexanderson, H., Henriksen, M. & Ingólfsson, Ó., submitted: Landscape imprints of changes in glacial regime during ice sheet build-up and decay: a case study from Svalbard. Quaternary Science Reviews.
Lehman, S.J. & Forman, S.L. 1992: Late Weichselian glacier retreat in Kongsfjorden, West Spitsbergen, Svalbard. Quaternary Research 37, 139-154.

## Changes in the Arctic sea-ice sources and export rate through Fram Strait since the Last Glacial Maximum

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Elemental (Ca, Zr, Th), U-series and radiogenic isotope (Pb, Nd, Sr) measurements in terrigenous sediments, cored the central Fram Strait and Lomonosov Ridge and spanning the Last Glacial Maximum-Present interval, were used to document the sources and pathways of the outflowing carrier sea-ice. At Lomonosov, a sedimentary hiatus spanning the Last Glacial Maximum - Bølling-Allerød indicates significantly reduced ice-rafting deposition (IRD) if any, throughout the interval, thus the presence of multi-year, low mobility ice in the Central Arctic. Meanwhile, some sea-ice was still exported through Fram Strait towards the GIN seas. At ~13 ka, IRD resumed over the Lomonosov Ridge and intensified at Fram Strait, with a rate about 5 times higher than those of the Holocene, persisting throughout the whole Younger Dryas (YD) interval at both sites. We have broadly identified the isotopic signatures of the three major source areas of IRD, the Russian, Canadian and Greenland margins, based on isotopic measurements in surface sediments from the circum-Arctic. The elemental and isotopic analysis in the Fram Strait core display distinct trends prior to and after the YD. The pre-YD interval, with $\varepsilon_{Nd}$ values between -10.1 and -13.2, and $^{87}$Sr/$^{86}$Sr ratios from 0.715 to 0721, reflects a mixture of IRD from the Russian and Canadian margins. The YD episode stands out with sediments originating mostly from the Canadian end-member, displaying the lowest $\varepsilon_{Nd}$ values and highest $^{87}$Sr/$^{86}$Sr ratios. This suggests enhanced sea-ice production and/or drifting along the Beaufort Gyre at that time which we link to a major meltwater event of the northwestern Laurentide Ice Sheet, through the Mackenzie River corridor. The post-YD interval, i.e. the Holocene, is characterized by a less variable mixture of IRD material, with $\varepsilon_{Nd}$ values and $^{87}$Sr/$^{86}$Sr ratios centered at -12.2 and 0.718 respectively. This material was derived from several sources including the Beaufort Sea area, the western Arctic, the East Siberian/Chukchi Seas, and the more proximal Greenland margin. The isotopic compositions of exchangeable fractions of radiogenic isotopes, recovered using standard sediment leaching protocols, are mostly linked to boundary exchange processes between deep-water masses and particulate fractions from major meltwater/freshwater source areas. Due to its longer residence time relative to Pb, the exchangeable-Nd preserves an isotopic signature from more distal areas where such high-density particulate fluxes have occurred. In the Fram Strait core, Nd-isotope leachate data illustrate the influence of the western Russian margins prior to the YD event and that of the East Siberian and Chukchi Sea margins following this event. This study illustrates that complementary information on IRD sources and water-mass histories can be obtained from isotopic analyses of inherited (residual) and exchangeable (leachable) fractions in deep Arctic Ocean sediments, despite their low overall sedimentation rates, thus the poor time resolution achieved.

## Postglacial climatic and environmental changes in the Barents Sea: response to variations in sea-ice extent and Atlantic water inflow

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The Barents Sea represents one of the two gateways for the warm and saline Atlantic water inflow into the Arctic Ocean and for polar water outflow. At present, the subsurface Atlantic water penetrates the Barents Sea from the north via three deep-water troughs where the surface waters are commonly covered by sea ice during most of the year. At the surface, Atlantic water enters into Barents Sea from the south-west which is generally ice free. In this study, we compare the paleoceanographic changes from the northern and southwestern parts of the basin over the last ~ 16 kyrs, i.e. the time span encompassing the decay and melting of the Barents Ice Sheet and the present interglacial, the Holocene.

In the northern part of the Barents Sea, our paleoceanographic reconstructions are based on the new high resolution benthic and planktic oxygen and carbon isotope, foraminiferal and IRD time series from the AMS-$^{14}$C dated sediment cores. The cores were collected in the Kvitøya-Erik Eriksen and Franz Victoria troughs during the cruises by Russian RV *Professor Shtokman* (cruise 63), *Akademik Nikolaj Strakhov* (cruise 25) and *Akademik Aleksandr Karpinsky* (cruise 28). We infer changes in water column, Atlantic water input, surface and bottom water conditions. In the core S 2528 from the Kvitøya Trough, dinocyst assemblages were used to make inference about sea-surface temperature, salinity and sea ice records.

Pronounced peaks of IRD (>100 microns) and rock fragments (>2 mm) indicate iceberg calving likely from East Spitsbergen at about 17 ka. These peaks mark the upper contact of glaciomarine diamicton (Murdmaa et al., 2006) corresponding to the end of early deglaciation stage. Our data also suggest subsurface Atlantic water penetration into the Franz Victoria and Kvitøya troughs as early as 16 ka, which corresponds to the end of Oldest Dryas. Such an early advection of the Atlantic water was previously documented by Rasmussen et al. (2007) from the Storfjorden, Western Barents Sea, although dense sea ice cover characterized the area according to our dinocyst record. A much stronger Atlantic water inflow into the Barents Sea occurred at the end of Bølling-Allerød, likely earlier in the south-west (Chistyakova et al., 2010) than in the northern troughs. In the north, remarkable sea surface warming and sea ice retreat were documented by ~ 13 ka. Surface warming and strong Atlantic water inflow were followed by intense iceberg calving in the Erik Eriksen Trough as indicated by the high IRD content of core S 2519. Significant increase of Atlantic water inflow was inferred to occur at the end of Younger Dryas, from ca 12 ka, in the northern troughs as follows from our data and from (Lubinski et al., 2001), and during the early Holocene, at 11-9 ka, in the western part of the Barents Sea (Risebrobakken et al., 2011; Chistyakova et al., 2010). However, sea ice cover extended to the north and as far as the Ingøydjupet Depression in the south-west, at least during winter (Risebrobakken et al., 2010), and summer surface temperatures also decreased. Therefore, the water column was well stratified with the mild Atlantic water flowing below cold and low saline surface Arctic water.

The proxy records from different locations indicate that the middle Holocene from about 6 ka was represented by relatively stable conditions with rather subtle environmental changes. The late Holocene was characterized by a considerable spatiotemporal variability in the water column structure, sea surface temperature and sea ice extent.

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**References**

Chistyakova, N., Ivanova, E., Risebrobakken, B., Ovsepyan, E., Ovsepyan Ya., 2010. Reconstruction of Postglacial environments in teh south - western Barents Sea. Oceanology, 50(4), 573–581.
Lubinski, D.J., Polyak, L., Forman, S.L., 2001. Freshwater and Atlantic water inflows to the deep northern Barents and Kara seas since ca 13 $^{14}C$ ka: foraminifera and stable isotopes. Quaternary Science Review, 20, 1851-1879.
Murdmaa, I.O., Ivanova, E.V., Duplessy, J.C., et al., 2006. Facies System of the Central and Eastern Barents Sea since the Last Glaciation to Recent. Mar. Geology, 230 (3-4), 273-303.
Rasmussen, T.L., Thomsen, E., Ślubowska, M.A., Jessen, S., Solheim, A., Koç, N., 2007. Paleoceanographic evolution of the SW Svalbard margin (76°N) since 20,000 14C yr BP. Quaternary Research, 67, 100–114.
Risebrobakken, B., Moros, M., Ivanova, E., Chistyakova, N., Rosenberg, R., 2010. Climate and oceanographic variability in the SW Barents Sea during the Holocene. The Holocene, 20(4), 609–621.
Risebrobakken, B., Dokken, T., Smedsrud, L.H., Andersson, C., Jansen, E., Moros, M., Ivanova, E.V., 2011. Early Holocene temperature variability in the Nordic Seas: The role of oceanic heat advection versus changes in orbital forcing. Paleoceanography, 26, PA4206.

## Eurasian Arctic ice sheets in transition during MIS4 to MIS3 - indications from the central Arctic Ocean sediment provenance changes and transport mechanisms

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The present research is carried out in the project Rapid environmental changes in the Eurasian Arctic - Lessons from the past to the future (REAL) at the Thule Institute, University of Oulu.

The main aim of this project is to produce land-marine integrated information on rate of natural environmental changes and their mechanisms on the transitions between extremes events within past 130 ka.  Particular aim is to study distinct transitions in decay of the Eurasian Arctic ice sheets that caused hydrological changes including changes in sea level, glacial ice extent and volume, drainage basins and ocean currents during that period of time. Major past environmental changes are registered in marine and terrestrial sediments. The detailed study of sediments via proxies provides information for paleoenvironmental reconstruction. Data that will be stored into the database include sedimentological, mineralogical, biostratigraphical, geochronological and geomorphological data from published literature including the data generated during the project.

Then GIS-based reconstructions for the environmental and provenance change in certain time slices will be displayed.

This presentation will focus on the one distinct transition in decay of Eurasian Arctic ice sheet by investigating the central Arctic Ocean marine record during MIS 4-3 for their provenance and transport processes. The lithological, mineralogical and geochemical data previously generated from core (AO96-12pc1) from the Lomonosov Rigde make it possible to reconstruct the ice sheet development and to make an assumption about probable sediment provenance changes. The core contains the distinct sediment layer the deposition of which was dated as the time of transition from MIS 4 to MIS 3. These sediments consist of a 48 cm thick homogenous layer of grayish silty clay that may give an evidence for suggestion about dynamic event, nature of which is not yet clearly identified. The detailed study of sediments from 40 cm down to 180 cm below sea floor via heavy minerals proxy can allow implementation of the above mentioned aims. For heavy mineral content in each sediment sample, approximately 40-50 randomly selected grains in 0.125–0.250 mm fraction were analyzed with Electron Probe Microanalyzer (EPMA) on the basis of the University of Oulu and frequencies counted.

The heavy mineral composition of the gray layer shows for example that the most abundant heavy minerals in this layer are garnet, epidote, ilmenite and hematite/goethite with amphiboles and zircon. The mineral composition varies from stage to stage, showing the increase of presence of amphiboles, pyroxenes, garnets and decrease of amount of epidote, zircone, titanite, apatite and Fe-oxides during the early MIS 4. This composition completely changes to the end of this stage – the sediments of late MIS 4 consist the increase amount of ilmenite, zircon, Fe-oxides and decrease amount of amphiboles, pyroxenes, garnet, epidote, titanite. Thus, the mineralogical composition of sediments is reflected the changes of depositional conditions which, in their turn, depends from the provenance and transport mechanism changes.

We are planning to make more exact comparison these data with previous published data generated from the study of rocks of the prospective provenance areas. Correlation of the data will allow assume the exact source areas and pathways of the central Arctic Ocean sediments which have a nature of terrigenous origin. The prominent provenance area for almandine-pyrope garnet, for instance and epidote are the granulitic and lower grade metamorphic rocks of the Anabar Shield (Condie et al., 1991) and the Taymyr Fold Belt (Pease & Vernikovsky, 1998). Taymyr  Peninsula and the archipelago of Severnaya Zemlya are well known as an area where ancient crystalline and metamorphic rocks e.g. gneisses, phyllitic schists, siliceous schists, two-mica quarzites are developed (Nalivkin, 1960). These kinds of rocks may well provide the source for amphiboles and almandine-pyrope garnet associated with metamorphic rocks. The rocks of the Taymyr Peninsula, especially carbonatites are suggestive sources for apatite, amphiboles, grossularite garnets, titanite, epidote (Petrov & Proskurnin, 2010). Some of the Fe-oxides presented in our sediments are the product of weathering of the ore minerals such as pyrite, magnetite, hematite, pyrrhotite. Pyroxenes which are abundant in the lower part of the gray layer as well as ilmenite and hematite are referring to their origin from the Siberian flood basalt province of the Putorana Plateau (Reichow et al., 2002) with the prominent pathway being along the Khatanga or Yenissei river valleys. Chemical weathering of basalts in the Putorana Plateau has generated soils consisting of smectite with goethite saturated bore waters (Pokrovsky et al., 2005), which both minerals are also represented in the mineral composition of the gray layer. Clay mineral kaolinite also presented in the sediments may be transported via icebergs from the Franz Josef Land rocks (Wahsner et al., 1999). In this way, taking into consideration our mineralogical data and data generated through the study of source rocks we could receive proved picture of about the provenances and their changes for the central Arctic Ocean marine sediments during the considered period of time. This will help to understand continental ice sheet extent and volume changes as well as drainage basin evolution on land. In this presentation a special emphasis will be attended to demonstrating a manner of collapse of the shelf-based Barents-Kara Ice Sheet after MIS 4.

**References**

Condie, K.C., Wilks, M., Rosen D.M., & Zlobin, V.L. 1991. Geochemistry of metasediments from the Precambrian Hapschan Series, eastern Anabar Shield, Siberia. Precambrian Research 50, 37-47.

Nalivkin, D. V., 1960. The Geology of the U.S.S.R. Pergamon Press, 1-170.

Pease, V., & Vernikovsky, V., 1998. The Tectono-Magmatic Evolution of the Taimyr Peninsula: Further Constraints from New Ion-Microprobe Data. Polarforschung 68, 171-178.

Petrov, O. V., & Proskurnin, V. F., 2010. The Early Mesozoic carbonatites in the Taymyr Fold Belts. Reports of Russian Academy of Sciences, vol. 435, 776-779, (in Russian).

Pokrovsky, O.S., Schott, J., Kudryavtzev, D.I., & Dupre, B., 2005. Basalt weathering in the Central Siberia under permafrost conditions. Geochimica et Cosmochimica Acta 69, 5659-5680.

Reichow, M. K., Saunders, A.D., White, R.V., Pringle, M.S., l'Mukhamedov, A.I., Medvedev, A.I., & Kirda, N.P., 2002.  40Ar/39Ar dates from the West Siberian Basin: Siberian Flood Basalt Province doubled.  Science 296, 1846–1849.

Wahsner, M., Müller, C., Ivanov, G., Nürnberg, D., Shelekhova, E. S., Stein, R., & Tarasov, G., 1999. Clay mineral distributions in surface sediments from Eurasian Arctic Ocean and the Eurasian continental margin as indicator for source areas and transport pathways of sediments: A synthesis. Boreas 28, 215-233.

## Sources of the large-sized (>1 cm) dropstones and Late Quaternary history of the ice\iceberg regime in the Central Arctic Ocean

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523 large-sized stones (> 1 cm) were collected during description and sampling of the sediments cored at 23 sites during two expeditions in the Central Arctic onboard IB Polarstern (ARK-XXIII/3 in 2008, Mendeleev Ridge, and ARK-XXVI/3 in 2011, Alpha Ridge). The samples were retrieved with Gravity Corer, Kastenlot, Multicorer and Box Corer. A list of the stones sampled in ARK-XXIII/3, their sizes and preliminary identifications are shown in the Krylov et al. (2009).

Stones are mainly composed of carbonates (dolomite 44.9% and limestones 21.6%) and to a lesser degree of sandstones (22.4%). Igneous rocks (granites, diorites, and basalts – 5.4%), chert (2.7%) and schist (1.5%) are infrequent. Concentration of carbonates decrease to the Lomonosov Ridge. In order to reconstruct the source areas more accurately, thin sections were made from selected stones for petrographic analysis. In addition, the following analyses of dropstones were carried out: morphological (shape&surface), XRD, isotopes (C&O, Sr), XRF.

The dolomites are often contain a traces of fossil. The main organic components observed in all samples are algae. Fragments of ostracods, corals (?), gastropods, trilobites, bryozoans, brahiopods were also observed. Foraminifers were not identified. Poor preservation of fossils do not allow to determine their exact age. However, set of indirect characteristics allows to assume the Early Paleozoic age for dolomites as well as their origin in platform environments. Ten different lithological types have been distinguished among the dropstones: two types of sedimentological dolomites; stromatolitic dolomites; dolomites&limestones containing fauna; silicified dolomites; sandy&silty dolomites; quartzitic sandstones; sandstones&siltstones with a basal cement; flints; phosphates.

Absence of outcrops and the considerable thickness of Quaternary sediments in the certain places of stones sampling (Jokat, 2009) suggest delivering the most part of stones with ice/icebergs. The possible source area for studied carbonates are Victoria\Banks Islands (Canadian Arctic Archipelago) and Eastern Mackenzie Platform. However, partly samples could be transported by ice from Siberian sources.

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### References

Jokat, W., 2009. The Expedition of the Research Vessel "Polarstern" to the Arctic in 2008 (ARK-XXIII/3). Reports on Polar and Marine Research, v. 597, 222 p.

Krylov, A. Occurrence of dropstones. In: The Expedition of the Research Vessel "Polarstern" to the Arctic in 2008 (ARK-XXIII/3). Ed. W. Jokat. Reports on Polar and Marine Research, v. 597, 2009, p. 59-60.

## Reconstructing the nature of Pliocene–Pleistocene landscape dynamics in the Canadian Arctic from the age and architecture of the Iperk Fm. in the Beaufort Sea

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In the Canadian Beaufort Sea, Pliocene to Pleistocene strata constitute the Iperk Fm., an expansive progradational wedge deposited on a regional unconformity of probable Pliocene age (Blasco et al., 1990; McNeil, et al., 2001). The Iperk Fm. comprises basal turbidite fills overlain by basinal strata that grade upward and landward into slope facies overlain by delta and shelf deposits. This sequence achieves a maximum thickness of >4000 m and is characterized by complex sigmoid-oblique clinoform patterns indicative of high-energy, coarse-clastic, deltaic sedimentation (Dixon et al., 1992; Dixon, 1996; McNeil et al., 2001). Initial deposition of the Iperk Fm. was coincident with a transgression over the basal unconformity and a 15–20 km landward shift of the shelf edge (McNeil et al., 2001). Subsequent progradation of the shelf edge by ~120 km represents a dramatic increase in sedimentation rates, which are presently irresolvable because of a lack of geochronological data (Dixon, 1996; McNeil et al., 2001).

Current research is aimed at characterizing patterns and rates of shelf progradation and the age of the sub-Iperk unconformity using reflection seismic data, biostratigraphy, and terrestrial cosmogenic nuclide (TCN) burial dating. This knowledge will allow multiple hypotheses regarding Pliocene–Pleistocene landscape dynamics to be refined. For example, new TCN-derived estimates of erosion rates and TCN burial ages will allow causal linkages between Iperk strata and past changes in climate, sea level, tectonics, dynamic topography, and ice sheets to be investigated. Further, a new chronostratigraphic framework of Pliocene–Pleistocene deposits in the Beaufort Sea will permit revised correlations to stratigraphic records in the circum-Arctic, including the Beaufort Fm. (Fyles, 1990, 1994), and to other Pliocene progradational wedges and unconformities (Dahlgren et al., 2005). This study will also help refine the history of Pliocene–Pleistocene marine connectivity between the North Atlantic and Arctic oceans by constraining the age of cross-shelf troughs on the Beaufort Sea Shelf (i.e. Amundsen Gulf, M'Clure Strait), which are eroded into Iperk strata and comprise a fundamental physiographic component of the modern Canadian Arctic Archipelago.

### References

Blasco, S.M., Fortin, G., Hill, P.R., O'Connor. M.J., Brigham-Grette, J.K. 1990. The late Neogene and Quaternary stratigraphy of the Canadian Beaufort continental shelf. In: A. Grantz, L. Johnson, J.F. Sweeney (Eds.), The Geology of North America, Vol. L, pp. 491–502.

Dahlgren, K.I.T., Vorren, T.O., Stoker, M.S., Nielsen, T., Nygard, A., Sejrup, H.P. 2005. Late Cenozoic prograding wedges on the NW European continental margin: their formation and relationship to tectonics and climate. Marine and Petroleum Geology 22, 1089–1110.

Dixon, J. 1996. Depositional Facies. In: J. Dixon (Ed.), Geological atlas of the Beaufort–Mackenzie area. Geological Survey of Canada, Miscellaneous Report 59, pp. 90–98.

Dixon, J., Dietrich, J.R., McNeil, D.H. 1992. Upper Cretaceous to Pleistocene sequence stratigraphy of the Beaufort–Mackenzie and Banks Island areas, northwest Canada. Geological Survey of Canada, Bulletin 407.

Fyles, J.G. 1990. Beaufort Formation (Late Tertiary) as seen from Prince Patrick Island, Arctic Canada. Arctic 43, 393–403.

Fyles, J.G. 1994. Ballast Brook and Beaufort Formations (Late Tertiary) on northern Banks Island, Arctic Canada. Quaternary International 22/23, 141–171.

McNeil, D.H., Duk-Rodkin, A., Dixon, J., Dietrich, J.R., White, J.M., Miller, K.G., Issler, D.R. 2001. Sequence stratigraphy, biotic change, $^{87}Sr/^{86}Sr$ record, paleoclimatic history, and sedimentation rate change across a regional late Cenozoic unconformity in Arctic Canada. Canadian Journal of Earth Sciences 38, 309–331.

## Late Wisconsinan dynamics of the marine-based sectors of the northwest Laurentide ice sheet, Arctic Canada

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During Late Wisconsinan glaciation the northwest Laurentide ice sheet (LIS) converged over the western Canadian Arctic and terminated in the Beaufort Sea (Dyke, 2004; Stokes et al., 2006, 2009; England et al., 2009; Lakeman and England, 2012, *in press*; Nixon and England, *submitted*). This study clarifies the extent and dynamics of the northwest LIS on the Beaufort Sea Shelf, including Amundsen Gulf and M'Clure Strait, which were occupied by two of the largest ice streams to discharge into the Beaufort Sea during the last glaciation (Stokes et al., 2006, 2009; England et al., 2009; Lakeman and England, 2012, *in press*; MacLean et al., 2012; Nixon and England, *submitted*). As such, they constituted major dynamical components of the LIS, as well as primary source areas for widespread ice-rafted debris in the Arctic Ocean basin and for thick icebergs that scoured the seafloor to depths of ~450 m (Polyak et al., 2007).

Recent fieldwork on western Banks Island and a revision of existing, widespread geological and geophysical data from the Beaufort Shelf between Mackenzie Trough and Amundsen Gulf (Blasco et al., 1990), indicate that the northwest LIS advanced onto the shelf during Late Wisconinan glaciation (Murton et al., 2007; Lakeman and England, *in press*). Deglaciation of the shelf was characterized by the withdrawal of thin and likely cold-based glacier lobes, and was complete by ~16 cal ka BP (Murton et al., 2007; Lakeman and England, *in press*). In Amundsen Gulf, widespread mega-scale glacial lineations, developed primarily on subglacial sediments, confirm the former presence of an ice stream. Multibeam bathymetric mapping and terrestrial observations indicate that streaming ice followed the axis of Amundsen Gulf and was at least 700 m thick in the central part of the channel. At its maximum extent, likely achieved after ~22 cal ka BP (Murton et al., 2007), the grounding line was situated at the margin of the inner shelf. Mapped glacial landforms and available deglacial radiocarbon ages indicate two phases of ice stream recession which were characterized by pervasive calving of the terminus, as inferred from widespread seabed erosion to depths of ~400 m by iceberg keels and observations of thin and spatially discontinuous deglacial glaciomarine sediment. Newly acquired multibeam bathymetric and subbottom sonar data indicate that the M'Clure Strait ice stream extended at least as far west as ~127º W, where mega-scale glacial lineations are identified. Terrestrial observations indicate an ice stream thickness of at least ~635 m south of western Melville Island (England et al., 2009). No chronological data are available to constrain the onset of ice stream retreat, however, recent mapping indicates that ice stream withdrawal from north-central Banks Island to northwest Victoria Island (~350 km) may have been achieved in less than 400 calibrated years, circa 13.75 cal ka BP (England et al., 2009; Lakeman and England, 2012).

The deglacial history of the Beaufort Shelf, including Amundsen Gulf and M'Clure Strait, provides important constraints on the variables that occasioned the demise of the LIS. Understanding the complex interplay among these variables during the last deglaciation will bear on current model projections of the dynamics of the Greenland and Antarctic ice sheets. In addition, quantifying past iceberg fluxes to the Arctic Ocean has implications for assessing past climate, and the origin of ice-rafted sediment and deep iceberg scours in the Arctic Ocean basin.

**References**
Blasco, S.M., Fortin, G., Hill, P.R., O'Connor. M.J., Brigham-Grette, J.K. 1990. The late Neogene and Quaternary stratigraphy of the Canadian Beaufort continental shelf. In: A. Grantz, L. Johnson, J.F. Sweeney (Eds.), The Geology of North America, Vol. L, pp. 491–502.
Dyke, A.S. 2004. An outline of North American deglaciation with emphasis on central and northern Canada. In: Ehlers, J. (Ed.), Extent and Chronology of Quaternary Glaciation. Elsevier.
England, J.H., Furze, M.F.A, Doupé, J.P. 2009. Revision of the NW Laurentide Ice Sheet: implications for paleoclimate, the northeast extremity of Beringia, and Arctic Ocean sedimentation. Quaternary Science Reviews 28, 1573–1596.
Lakeman, T.R., England, J.H. 2012. Paleoglaciological insights from the age and morphology of the Jesse moraine belt, western Canadian Arctic. Quaternary Science Reviews 47, 82–100.
Lakeman, T.R., England, J.H. Late Wisconsinan glaciation and postglacial relative sea level change on western Banks Island, Canadian Arctic Archipelago. Quaternary Research, *in press*.
MacLean, B., Blasco, S., Bennett, R., Lakeman, T., Hughes-Clarke, J. 2012. Geological history of Amundsen Gulf over the last ~19,000 years: ameliorating climate transition from glacial to interglacial conditions. Abstract #650. International Polar Year 2012 Conference, Montreal, PQ, April 22–27, 2012.
Murton, J.B., Frechen, M., Maddy, D. 2007. Luminescence dating of mid- to Late Wisconsinan aeolian sand as a constraint on the last advance of the Laurentide Ice Sheet across the Tuktoyaktuk Coastlands, western Arctic Canada. Canadian Journal of Earth Sciences 44, 857–869.
Nixon, F.C., England, J.H. Expanded Late Wisconsinan ice cap and ice sheet margins in the western Queen Elizabeth Islands, Arctic Canada. *Submitted*.
Polyak, L., Darby, D., Bischof, J., Jakobsson, M. 2007. Stratigraphic constraints on late Pleistocene glacial erosion and deglaciation of the Chukchi margin, Arctic Ocean. Quaternary Research 67, 234–245.
Stokes, C.R., Clark, C.D., Winsborrow, M.C.M., 2006. Subglacial bedform evidence for a major palaeo-ice stream and its retreat phases in Amundsen Gulf, Canadian Arctic Archipelago. Journal of Quaternary Science 21, 399–412.
Stokes, C.R., Clark, C.D., Storrar, R. 2009. Major changes in ice stream dynamics during deglaciation of the north-western margin of the Laurentide Ice Sheet. Quaternary Science Reviews 28, 721–738.

## Pore water geochemistry of Arctic sediments and its implication for the interpretation of paleoenvironmental conditions

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Geochemical studies of the pore water composition in sediment cores provide information about the diagenetic remobilization of redox sensitive compounds, e.g., Mn- and Fe-(hydr)oxides. These processes may alter the chemical composition of sediments and have to be considered for the interpretation of the sedimentary record. Li et al. (1969) studied the pore water composition of a sediment core from the Alpha-Mendeleev Ridge and found elevated $Mn_S$ (solid Mn) concentrations at the top of the core and an increase of dissolved Mn in the pore water ($Mn_{PW}$) down to one meter depth. This indicates the dissolution/remobilization of primary solid Mn phases after deposition under (microbially induced) reducing conditions, and their reprecipitation at oxic conditions close to the sediment/seawater boundary. Other systematic pore water studies on diagenetic element mobilization and its impact on the sedimentary record in the Arctic Ocean are rare (e.g., Backman et al., 2006; Dickens et al., 2007; März et al., 2011). Recently, dark brown sediment layers rich in $Mn_S$ have been used for core correlation in the Arctic Ocean (e.g., Jakobsson et al., 2000), as they seem to be formed primarily within the water column during warmer periods. In an attempt to increase our understanding of the formation mechanism of these layers for paleoenvironmental interpretation, pore water profiles of five Arctic sediment cores obtained during *RV Polarstern* cruise ARK-XXVI/3 (Schauer, 2012) were analyzed for $NO_3^-$, and dissolved $Mn_{PW}$, $Fe_{PW}$, $Co_{PW}$ and $Mo_{PW}$.

In a sediment core from the Lomonosov Ridge, a decrease of $NO_3^-$ is seen down to 5 m sediment depth. At ~4.5 m, $Mn_{PW}$, $Co_{PW}$ and $Mo_{PW}$ start to increase towards the base of the core (~6 m). In all samples $Fe_{PW}$ is very low and close to the detection limit indicating only weak suboxic conditions. Our results indicate that reduction of $Mn_S$ currently takes place in the sediment and may potentially alter the $Mn_S$ content. Under oxic conditions, $Mn_S$ is predominantly present as (oxihydr)oxide and may adsorb trace metals like Co and Mo. The synchronous increase in $Mn_{PW}$, $Co_{PW}$ and $Mo_{PW}$ indicates that the dissolution of solid Mn phases liberates the trace metals Co and Mo. In a sediment core from the northern Lomonosov Ridge $NO_3^-$ reduction is completed at ~1.2 m sediment depth. A broad peak of $Mn_{PW}$ is present in the interval from ~1 m to ~4 m, indicating an active Mn reduction zone extending about 3 m. Again, $Co_{PW}$ and $Mo_{PW}$ are elevated within this interval whereas $Fe_{PW}$ cannot be detected.

The pore water composition of two other sediment cores from the Alpha Ridge differs from the above findings. Concentrations of $NO_3^-$ do not decrease and $Mn_{PW}$, $Fe_{PW}$, $Co_{PW}$ and $Mo_{PW}$ are consistently low and show no significant increases or decreases. At these sites, obviously no remobilization processes take place in the cored interval (~6 m) indicating fully aerobic conditions.

Our study reveals that the chemical composition of pore waters in Arctic Ocean sediments is highly variable. The zone of nitrate reduction, if present, differs from 1 m to 5 m depth. This may be explained by the varying activity of nitrate and Mn-reducing microorganisms. Some cores are presently undergoing Mn diagenesis, which may alter the sediment composition and therefore impede using dark brown layers for core correlation and as stratigraphic markers. After dissolution of available Mn-(hydr)oxides, reduction of Fe-(hydr)oxides is the next step for microorganisms to gain energy from metal (hydr)oxides. As no significant enrichment in $Fe_{PW}$ can be observed in our cores, the zone of Fe reduction must be located deeper in the sediment. Therefore $Fe_S$ records are currently not biased by diagenetic processes. It is important to note that pore water composition represents a snapshot of the current environmental conditions, and past overprints of the sedimentary Fe signal cannot be excluded. Factors controlling the different redox regimes include the quality and export rate of organic matter to the sea floor, which in turn are also a function of sea ice cover and water depth. Remobilization processes do not only alter the chemical composition of sediments but also affect physical parameters like magnetic susceptibility, porosity and sediment color. Combined pore water and sediment analyses are therefore required to identify processes, which may significantly affect the interpretation of sediment geochemistry. In a subsequent step, the corresponding solid phase of the cores will be studied for major and trace elements to compare pore water and sediment results. Pore water modeling will reveal whether diagenetic Mn enrichments in the sediment are compatible with the present $Mn_{PW}$ flux (as demonstrated by März et al., 2011).

**References**

Backman J., Moran K., McInroy D. B., Mayer L. A. and Expedition 302 Scientists, 2006. Proc. IODP, 302, Integrated Ocean Drilling Program Management International, Inc., Edinburgh.

Dickens, G. R., Kölling, M., Smith, D. C., Schnieders, L. and IODP Expedition 302 Scientists, 2007. Rhizon sampling of pore waters on Scientific Drilling Expeditions: an example from the IODP Expedition 302, Arctic Coring Expedition (ACEX). Sci. Drill. 4.

Jakobsson M., Løvlie R., Al-Hanbali H., Arnold E. M., Backman J. and Mörth M., 2000. Manganese and color cycles in Arctic Ocean sediments constrain Pleistocene chronology. Geology 28, 23–26.

Li, Y.-H., Bischoff, J.,Mathieu, G., 1969. Migration of manganese in Arctic Basin sediments. Earth Planet. Sci. Lett. 7, 265–270.

März, C., Stratmann, A., Matthiessen, J., Meinhardt, A.-K., Eckert, S., Schnetger, B., Vogt, C., Brumsack, H.-J., 2011. Manganese-rich brown layers in Arctic Ocean sediments: Composition, formation mechanism, and diagenetic overprint. Geochim. Cosmochim. Acta 75, 7668-7687.

Schauer, U. (Ed.), 2012. The Expedition of the Research Vessel "Polarstern" to the Arctic in 2011 (ARK-XXVI/3 - TransArc). Reports on Polar and Marine Research, 649, 1-203.

# The oxygen isotope record from diatoms at Lake El'gygytgyn, Far East Russian Arctic – comparing interglacials back to MIS 11

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In the Arctic, continuous terrestrial paleoclimate records dating back to the Eemian and beyond are rare. Here, we present a lacustrine diatom isotope record from Lake El'gygytgyn dating back to 250 kyrs from core Lz1024. This study is complemented by a longer sediment core (ICDP 5011-1) taken during scientific deep drilling in winter 2008/2009 in the El'gygytgyn Crater lake, far eastern Russia. Within these two cores, biogenic silica (diatom) samples were used for a combined oxygen isotope ($\delta^{18}O$) record since no carbonates were preserved. The usefulness of $\delta^{18}O_{diatom}$ as a proxy for reconstructing climatic changes i.e. air temperature and the isotope composition of precipitation has been underlined in several studies. Two diatom species prevail in Lake El'gygytgyn: *Cyclotella ocellata* which is present throughout the whole core and *Pliocaenicus costatus* mainly existing in the Holocene. The different species were separated as they occur in different size fractions. No species-effect on the oxygen isotope composition has been detected.

Downcore variations in $\delta^{18}O$ values of core Lz1024 show that glacial-interglacial cycles are present throughout the core and $\delta^{18}O_{diatom}$ values are mainly controlled by $\delta^{18}O_{precipitation}$. Changes in the $\delta^{18}O$ record include the Holocene Thermal Maximum (HTM), the Last Glacial Maximum (LGM) and the interglacial periods corresponding to MIS 3, MIS 5 and MIS 7 with a peak-to-peak amplitude of $\delta^{18}O$=5.3 ‰. The Lz1024 dataset is the first continuous $\delta^{18}O_{diatom}$ record from an Arctic lake sediment core directly responding to precipitation and dating back to more than 250 ka. The record correlates well with the stacked marine $\delta^{18}O$ LR04 (r =0.58) and□ $\delta D$ EPICA Dome-C record (r =0.69). These results indicate strong linkage of our data to both marine and ice-core records and strong interhemispheric climate control. Therefore, records from Lake El'gygytgyn can be used to further investigate the past natural climate variability and sensitivity of the Arctic climate to past global climate changes.

Recent studies on the upper 135.2 m of core 5011-1 dating back to about 2.8 Ma show evidence for extremely warm "super interglacial" conditions during the Quaternary (e.g. MIS 11 and MIS 31). Therefore, and to expand the Lz1024 $\delta^{18}O$ diatom record to the past, we focused on MIS 11 to find out about the warmest phase in the past 450 kyrs. Comparing the warm stages, similar reconstructed mean annual air temperatures (MAAT) occurred in the time of the HTM and MIS 7, whereas MIS 5.5 and MIS 11 were significantly warmer than the HTM. Average MAAT reconstructed for MIS 11 from our diatom $\delta^{18}O$ record correspond to about 4-5°C warmer conditions being the warmest interglacial of this record. This is in line with results of palynological analyses. In a next step, more samples back to 1.5 Ma will be analysed to gain further insight into the applicability of $\delta^{18}O$ from diatoms for deep drilling records and to provide information about potential diagenetic impact on the oxygen isotope composition of biogenic silica for this time span.

## Linking the Atlantic Multidecadal Oscillation to Greenland Sea Ice in the Holocene

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The arctic sea ice–climate system appears to be in rapid transformation, with implications for ice–ocean–atmosphere interactions, including changes in the Greenland Sea region, which is a major spatial gateway for arctic–subarctic exchanges. However, the long-term natural modes of variability such as multidecadal variability are relatively poorly known. Recent advances in developing long sea-ice time series from historical and high-resolution paleo proxy reconstructions provide an opportunity to: (a) Robustly identify and track multidecadal sea-ice variability, and (b) Establish linkages to known climate system fluctuations on multidecadal time scales. Here we present observational and paleo evidence for pervasive and persistent multidecadal sea-ice variability, based on time-frequency analysis of a comprehensive set of several long historical and paleo proxy sea-ice records from multiple regions. Moreover, through explicit comparisons with instrumental and paleo proxy records, we demonstrate covariability with the Atlantic Multidecadal Oscillation (AMO). We establish a signal of pervasive and persistent multidecadal (about 60–90 year) fluctuations that is most pronounced in the Greenland Sea region. Covariability between sea ice and the AMO is evident during the instrumental record, including an abrupt change at the onset of the early 20th century warming. Similar covariability through previous centuries is evident from comparison of the longest historical sea ice records and paleo proxy reconstructions of sea ice and the AMO.

A relevant question is whether the AMO-related variability evident in the sea-ice series from the Greenland Sea over several centuries may be evident in longer sea-ice records. Holocene sea-ice proxies are based on marine sediments, and as such there are few records whose temporal resolution is high enough to resolve multidecadal variability. Here we analyse a high-resolution sea-ice proxy from marine core MD-2269 from the North Icelandic shelf. The existence of multidecadal fluctuations is tested using wavelet filtering and spectral analysis applied to those parts of the record with sufficient resolution. A distinct multidecadal signal is apparent through several millennia, albeit weaker in some intervals. This quasi-persistence is similar the modulation of possible AMO-related signals found in other paleo records from the region, notably $\delta$18O from the Renland ice cap in eastern Greenland and reconstructed SSTs from core MD-2275 north of Iceland, in proximity to the MD-2269 sea-ice record. The presence of persistent multidecadal variability in the full Holocene sea-ice proxy offers independent support for the robustness of the signal seen in the shorter records from the Greenland Sea region.

This observational evidence supports recent modelling studies that have suggested that arctic sea ice is intrinsically linked to Atlantic multidecadal variability. This has implications for understanding the recent negative trend in sea ice extent, and its future trajectory. Further, AMO-related variability of ice–ocean conditions in the Greenland Sea region has implications for ocean regulation of marine-terminating Greenland Ice Sheet outlet glaciers; the last-mentioned aspect is being considered as part of the SEALEV project at the Centre for Climate Dynamics at the Bjerknes Centre for Climate Research, Bergen, Norway.

## Rapid changes in advance–retreat (co)variability of Sermilik fjord glaciers, southeast Greenland

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

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

The possible reasons for the sometimes coherent and sometimes incoherent behavior of the three glaciers, and the connection with climatic forcing are discussed. We also compare and extend our results with recently published results for the Sermilik fjord glaciers in the past, based on longer historical observations, a marine sediment-based proxy for calving, as well as Holocene fluctuations from paleo reconstructions.

## Whether the very fine-grained glaciomarine diamicton matrix in the Barents Sea consists of the remote aeolian dust?

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The Late Weichselian ice sheet covered the entire Barents Sea continental shelf and surrounding archipelagoes during the LGM. High latitude insolation and rising sea level caused ice stream flow regime, iceberg calving and melting. We distinguish four following lithostratigraphic units in the Late Quaternary (LGM to present) sediment cover unconformably overlying the Mesozoic bedrocks (Murdmaa et al., 2006):

Unit 1 – Holocene marine sediments

Unit 2 – late deglaciation glaciomarine sediments

Unit 3 – early deglaciation glaciomarine diamicton

Unit 4 – non-marine moraine deposits.

This study is focused on the Unit 3 matrix. The glaciomarine diamicton was deposited directly over the bottom moraine of the last (late Weichselian) ice sheet during the early deglaciation phase (ca. 16 – 13 $^{14}$C ka). According to more than 100 combined pipette / decantation granulometric analyses, it consists of a disordered mixture of iceberg rafted coarse fractions (sand to boulders) and the fine-grained matrix dominated by <0.001 mm size fraction that precipitated from the glacier melt-water suspension (so-called “glacier milk”). We present here our hypothesis about a major contribution of the remote aeolian dust to the fine-grained sediment load of the Barents Sea ice sheet that produced the “glacier milk” during its melting, thus serving as a material source for the glaciomarine sediments.

The glaciomarine diamicton is characterized by bimodal grain-size distribution. Unsorted coarse fractions, from sand to pebbles and boulders, mainly represent iceberg-rafted debris (IRD). Their concentration and grain size does not depend neither on water depth, nor on distance from the coast. The fine-grained matrix mode falls into <0.001 mm fraction which content varies from 26% to 57% in the studied diamicton sections. Relationship between three fractions within the matrix (<0.01 mm fraction) is rather uniform irrespective of coarse fractions content, thus suggesting an independent fine-grained material source common for all core locations.

XRD analyses of the <0.001 mm fraction (proportions of four clay minerals calculated by Biscaye method) from the diamicton matrix, as well as from units 2 and 1 demonstrate dominating illite content throughout and an unusually high kaolinite proportion, up to 36% of total clay minerals, in the diamicton from most studied cores, except for core 902 near the Novaya Zemlya, where low kaolinite, but high chlorite occur. The uniform kaolinite-illite association of the clay matrix with high quartz and low smectite does not correlate with variations in heavy minerals composition in the fine sand fraction and was likely derived from another (initially aeolian?) source.

The very fine-grained diamicton matrix dominated by <0.001 mm fraction that mainly consist of illite-kaolinite clay mineral association with rather high finely dispersed quartz content was derived from the ice sheet meltwater load that flowed into the initial marine basin as the “glacier milk”. We hypothesize that remote aeolian dust accumulated in the ice during the ice sheet growth and released with the meltwater during its rapid decay. The increased kaolinite content, not characteristic for high-latitude clay provenances, suggests the dust source somewhere in the arid zone. Similar clay mineral assemblages with abundant quartz, illite, and kaolinite are described in present aerosols, e.g. over Mediterranean (Guerzoni et al., 1977) and tropical North Atlantic (Glaccum and Prospero, 1980). The “yellow snow” event in March 2008, when the aeolian dust from semi-arid southern Russia, dominated by quartz (45-52%) and kaolinite-illite clay mineral association (25-35%), covered a wide area of the northern European Russia just to the south of the Barents Sea (Shevchenko et al., 2010), supports the hypothesis. The aeolian dust fluxes are known to increase during glacials, thus deriving more terrigenous material to glaciers ice than today.

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**References**

Glacum, R.A., and Prospero, J.M., 1980. Saharan aerosols over the tropical North Atlantic: mineralogy. Marine Geology, 37, 295-321.

Guerzoni, S., Molinaroli, E., Chester, R., 1997. Saharan dust inputs to the western Mediterranean Sea: depositional patterns, geochemistry, and sedimentological implications. Deep-Sea Res. II (3-4), 611-654.
Murdmaa, I., Ivanova, E., Duplessy, J.-C., Levitan, M., Khusid, T., Bourtman, M., Alekhina, G., Alekseeva, T., Belousov, M., Serova, V., 2006. Facies system of the Eastern Barents Sea since the last glaciation to present. Marine Geology, 230, 275-303.
Shevchenko, V.P., Korobov, V.B., Lisitsyn, A.P., Aleshinskaya, A.S., Bogdanova, O.Yu., Goryunova, N.V., Gritsenko, I.V., Dara, O.M., Zavernina, N.N., Kurteeva, E.I., Novichkova, E.A., Pokrovskii, O.S., Sapozhnikov, F.V., 2010. First data on the composition of atmospheric dust responsible for yellow snow in Northern European Russia in March 2008. Doklady Akademii Nauk, 431(5), 675–679.

## New marine geological evidence on the past ice sheet activity from the northern Svalbard Barents Sea shelf and fjords

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The configuration and dynamics, and the chronology of growth and decay of the Late Weichselian Svalbard-Barents Sea Ice Sheet (SBIS) is considerably better established along the western and southern Svalbard margins than in its northern and eastern parts. The reasons are the historically more favourable sea ice conditions and the proximity of major settlements on the west coast of Spitsbergen. The scarce geological data along the northern and eastern Svalbard margins is hindering reliable reconstructions of the past glacials-interglacials and the evolution of the Late Weichselian ice sheet in the northern Barents Sea.

UNIS has targeted the poorly studied areas in the northern Barents Sea on its annual marine geological-geophysical cruises on the R/V Helmer Hanssen (formerly Jan Mayen) since 2010. New high-resolution multibeam and chirp subbottom profiling data as well as sediment cores and CTD data have been acquired in several key areas on the shelf and in the fjords of northern Spitsbergen and in Nordaustlandet.

The continental shelf north of Nordaustlandet features a variety of landforms revealing its glacial history. Streamlined landforms, such as drumlins, crag-and-tails and glacial lineations of varying dimensions suggest that a previously unknown, NNE to NE flowing ice streams existed in the cross-shelf trough off Albertinibukta, and on the inner shelf off Duvefjorden and Rijpfjorden. Large grounding zone wedges and till lobes as well as smaller ice-marginal moraine ridges on the outer and mid-shelf indicate that temporary standstills or readvances during the retreat of a grounded ice stream occurred in the Albertini Trough. Ice-marginal transverse ridges suggest retreat of a grounded ice margin also in the eastern part of Erik Eriksen Strait south of Kvitøya after the Last Glacial Maximum.

The observed submarine landform assemblages suggest that ice streams existed on the continental shelf NE and E of Nordaustlandet and that ice sheet was grounded during the deglaciation in these areas. Scarce marine geophysical data from the continental shelf north of Nordaustlandet, between the Hinlopen Trough in the west and Kvitøya Trough in the east suggest that a relatively large ice stream existed in the Albertini Trough and potentially also in the somewhat less well-expressed cross-shelf trough connected to Duvefjorden. Gradually less well-expressed troughs from the east to west on the inner shelf suggest westwards decreasing ice stream activity on the northern shelf of Nordaustlandet. Integrating the high-resolution geological records in the fjords with the cross-shelf ice dynamics can lead to development of provenance tracers for the northern Svalbard continental margin.

## Formation of mega-scale glacial lineations: insights from sedimentological investigations on the Canadian Shield, Northern Canada

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Mega-scale glacial lineations (MSGLs) are highly elongate, subglacial landforms produced beneath zones of fast-flowing ice. While qualitative data on their morphology have existed for several decades, studies of their composition and sedimentology are comparatively rare. Sediment exposures along the course of the Finnie River in Nunavut, northern Canada, provide a window into the internal stratigraphy and sedimentology of MSGLs formed by the Dubawnt Lake palaeo-ice stream during regional deglaciation of the Laurentide Ice Sheet. Stratigraphic sections record evidence for an initial advance of ice into the study area followed by ice sheet recession and deposition of glacifluvial and glacilacustrine outwash. Subsequently, the Dubawnt Lake palaeo-ice stream overrode and reworked this outwash subglacially forming an'MSGL till'. This till comprises a sandy, red diamicton facies, forming the core of the MSGL ridges and containing variably deformed lenses, stringers and rafts of outwash. The sedimentology of this diamicton is consistent with an origin as a glacitectonite and hybrid till formed by a combination of subglacial sediment deformation and lodgement. Facies variations from stratified to massive diamicton, in turn, variations in strain and subglacial transport distance. The occurrence of stratified glacifluvial sediments within these ridges and the well preserved nature of many of the sandy inclusions within the diamicton imply relatively short transport distances and incomplete mixing. MSGLs under the Dubawnt Lake Palaeo-Ice Stream formed through a combination of subglacial erosion and deposition. This included non-pervasive, subglacial sediment deformation and the reworking of pre-existing sediment depocentres during streaming flow. These results emphasise the importance of sediment supply to MSGL formation with the presence of abundant pre-existing deglacial sediments which were subsequently overridden being critical to lineation formation.

## Paleoclimatic Signals from Ice-Wedge Stable-Water Isotopes at the Oyogos Yar Coast, Dmitry Laptev Strait, Northeast Siberian Arctic

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Ice wedges are the most abundant type of ground ice in the ice-rich permafrost deposits of the Northeast Siberian Arctic. They are formed by the periodic repetition of frost cracking in winter and subsequent crack filling in spring, mostly by melt water of winter snow. Ice wedges can be studied by means of stable-water isotopes. Their isotopic composition is directly linked to atmospheric precipitation (i.e. winter snow) and, therefore, indicative of past winter climate conditions even though also genetic aspects, such as sublimation, melting and refreezing in the snowpack and the frost crack, have to be taken into account. Paleoclimate information from ice wedges can be deduced from Glacial-Interglacial up to centennial timescales.

Here we present stable-water isotope data of ice wedges at the Oyogos Yar coast of the Dmitry Laptev Strait (72.7°N, 143.5°E) in the Northeast Siberian Arctic. The ice wedges from different stratigraphic units comprising pre-Eemian, Eemian, Middle Weichselian Ice Complex (Yedoma) and Holocene themokarst (Alas) sediments were studied and sampled in 2002 and 2007. Stable-

water isotopes were measured in the stable-isotope lab of the Alfred Wegener Institute in Potsdam, Germany. Organic material of selected ice-wedge samples was radiocarbon-dated using the AMS facilities at the Leibniz Laboratory for Radiometric Dating and Stable Isotope Research (Kiel University) as well as at the University of Cologne (both in Germany).

Our Oyogos Yar ice-wedge stable-water isotope data indicate substantial variations in Northeast Siberian Arctic winter climate conditions ($\delta^{18}O$) as well as shifts in the moisture generation and transport patterns (d excess) during the Late Quaternary, in particular between Glacial and Interglacial but also during the last decades to centuries.

The oldest ice wedges at the Oyogos Yar coast originate from the pre-Eemian Kuchchugui Suite. They are characterized by high sediment content (ice-sand wedges) and give hints for cold conditions ($\delta^{18}O$ and d excess values of about -30‰ and 3‰, respectively) and rapid sedimentation. Younger but still pre-Eemian ice wedges of the Bychchagy Suite exhibit mean $\delta^{18}O$ (d excess) values of about -34‰ (6‰), representing the coldest conditions found in Oyogos Yar ice wedges.

Small ice wedges in Eemian sediments show distinctly warmer mean $\delta^{18}O$ values of about -24‰ and mean d-excess values of about 4‰. However, probably they represent younger epigenetically grown ice wedges with an isotopic composition altered by sediment-ice interaction.

Huge syngenetically grown ice wedges build the high and steep walls of the Ice Complex outcrops and belong to the Middle Weichselian Yedoma Suite. They are characterized by mean $\delta^{18}O$ values of about -28‰ to -33‰ and mean d-excess values between 5 and 7‰ in different altitude levels, reflecting the Middle Weichselian climate variability with moderate cold to very cold winter temperatures. The ice wedges on top of the Ice Complex with mean $\delta^{18}O$ values of about -26‰ (d excess: 7‰) give evidence for Holocene ice wedge activity and a distinct warming associated with the transition from Pleistocene to Holocene.

A thermokarst depression, formed during the Late Glacial, is characterized by Holocene ice wedges. They have been grown syngenetically in the Middle and Late Holocene and exhibit mean $\delta^{18}O$ values of about -25‰ and mean d-excess values of 8‰, mirroring the distinctly warmer winter climate during the Holocene. However, the youngest parts of these Holocene ice wedges and recent ice wedges grown in the last years to decades are characterized by mean $\delta^{18}O$ values of about -22‰ and mean d-excess values of 8‰ and testify the recent winter warming in the Northeast Siberian Arctic.

## Millennial-scale variability of paleoceanographic conditions in the western Bering Sea during the last 180 kyr

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Variability of surface water bioproductivity, intermediate water ventilation and sea ice cover were reconstructed using benthic (BF) and planktonic (PF) foraminiferal assemblages and sedimentary record in the Core SO201-2-85KL from the Shirshov Ridge (the western Bering Sea). The 18m-long core covers the last ~180 kyr (Max et al., 2012, Riethdorf et al., 2012). The highest gravel accumulation rates (GAR) are estimated at the middle MIS 6, i.e. ~163-157 kyr BP (fig. 1). This finding implies that the most extensive although mobile particle-supplying sea-ice cover over the Shirshov Ridge is characteristic of the middle MIS 6. High proportions of *Epistominella arctica* that can survive under extremely low organic matter flux to the sea floor correspond to GAR maxima and support the idea about the development of seasonal to perennial sea-ice cover in the western Bering Sea. The IRD maxima are followed by a series of enhanced surface water productivity events inferred from the dominance of high-productivity species

*Bulimina tenuata*, *Fursenkoina* spp. and high total BF abundance between ~159 and ~147 kyr BP. High values of dysoxic BF group during these events indicate oxygen-depleted bottom water conditions. We assume that the increase in productivity is related to the sufficient nutrient availability in the mixed layer resulted from episodic meltwater inputs. The latter was likely caused by a retreat of glaciers in East Siberia and Alaska areas regarding the precessional forcing which increased the Northern Hemisphere summer insolation (fig. 1; Berger, Loutre, 1991).

The onset of Termination II is marked by two pronounced spikes of BF and PF abundance and point to short-term high productivity events resulted from a reorganization of circulation in the Bering Sea and the Northern Pacific. The late part of the Termination II, as well as MIS 5.5-5.1, is characterized by scarce occurrence of calcareous microfossils and by high abundance of siliceous ones. Rare BF tests are etched that points to a dissolution during the time span. Increase in Northern Hemisphere summer insolation at the end of Termination II caused a substantial melting of surrounding glaciers and meltwater input to the Bering Sea. According to Waelbroeck and co-authors (2002; fig. 1), opening of the Bering Strait at ~133 kyr BP is found to occur roughly simultaneous with a strong dissolution of benthic and planktonic foraminifers. Opening of the Bering Strait might lead to a massive freshwater input from the Arctic to the Bering Sea or, alternatively, the sharpened halocline might also result from a strong metlwater spike only. Anyway, significant fresh-water amounts resulted in a more stable stratification of the upper ocean that prevented a deep convection (Hu et al., 2012) and a release of $CO_2$ to the atmosphere. Excess carbon dioxide in the water column induced calcium carbonate dissolution.

MIS 4 – early Termination I is characterized by a dominance of glacial benthic foraminiferal assemblages with high values of *Alabaminella weddelensis* and *Islandiella norcrossi* (Ovsepyan et al., 2013). This implies low bioproductivity conditions. Dominance of suboxic BF group suggests well-oxygenated bottom water. Development of sea ice cover over the Shirshov Ridge and ice rafting during spring melting through MIS4 – early Termination I are inferred from moderate values of GAR with maxima at ~63 kyr BP and LGM. The increase in the PF abundance which is >100 times higher than those during the MIS 3 – LGM and the synchronous low-amplitude spike of BF abundance reflect the enhanced bioproductivity at the onset of the deglaciation, i.e. 20--19 kyr BP (fig. 1). The bioproductivity rise in the Shirshov Ridge area might be related to the longer ice-free summer seasons at the site location due to northward migration of the sea-ice margin regarding an increase in Northern Hemisphere summer insolation or more vigorous vertical mixing which stimulated upwelling of nutrient-rich deep water. Well-known Bølling/Allerød and Early Holocene productivity spikes and corresponding weakening in the bottom water ventilation are well-pronounced in the Core SO201-2-85KL as well. We argue that the peaks of PF and BF abundance reflecting an increase in bioproductivity during mid-Bølling/Allerød and Early Holocene were mainly related to the intensified advection of nutrients by the surface currents from the gradually flooded northeastern shelf of the sea during the glacioeustatic sea level rise. Alternatively, nutrients supply to the euphotic layer might be associated with events of the vigorous vertical mixing as it is suggested by some authors (Okazaki et al., 2012).

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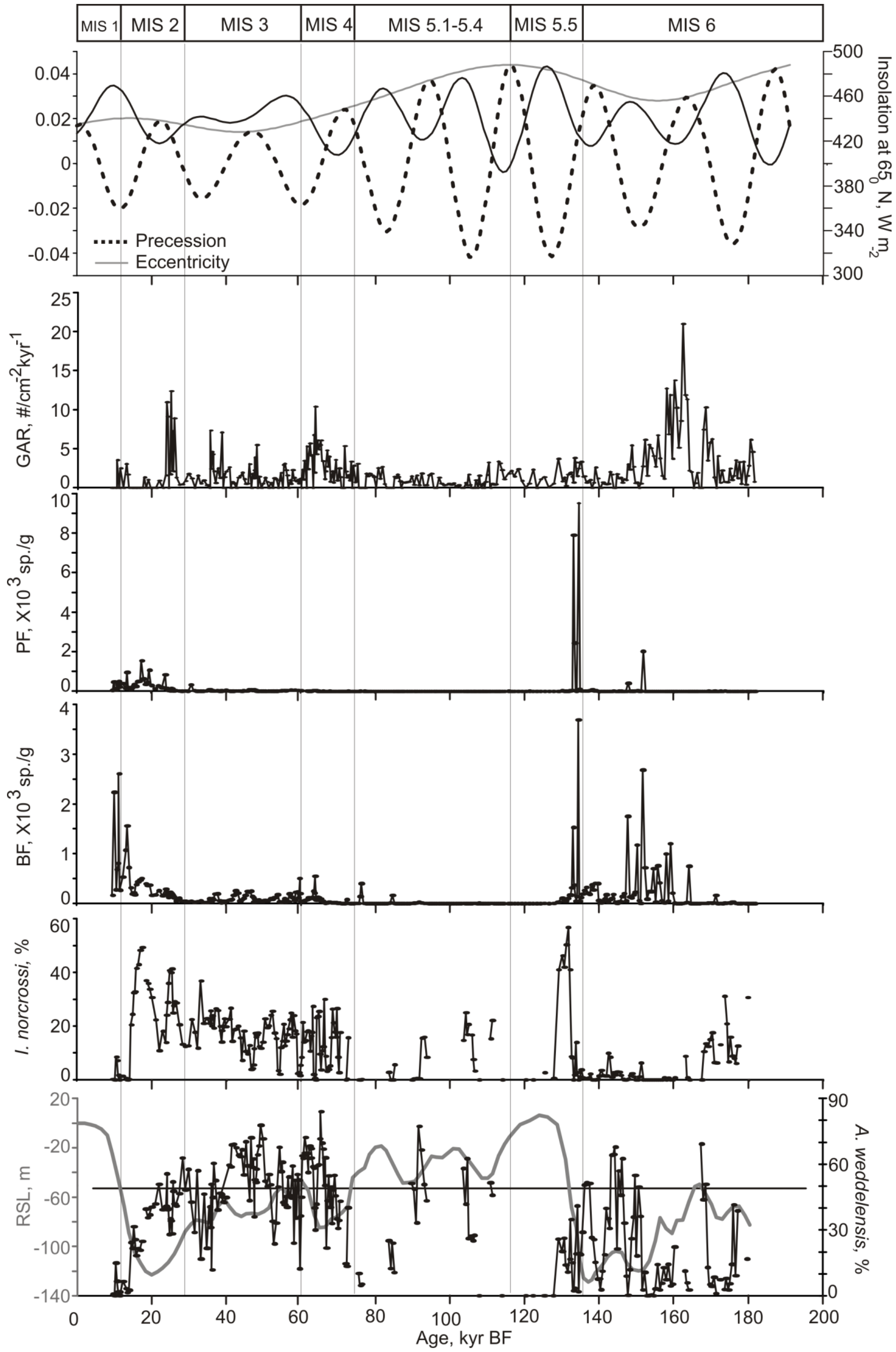


Fig. 1. Multi-proxy record from the Core SO201-2-85KL for the last 180 kyr. Precession, eccentricity and insolation at 65°N after (Berger, Loutre, 1991). Relative sea level (RSL) record after (Waelbroeck et al., 2002). Horizontal line indicates present-day depth of the Bering Strait. BF – benthic foraminifers, PF – planktonic foraminifers, GAR – gravel accumulation rates, MIS – marine isotopic stages.

## References

Berger A. and Loutre M.F., 1991. Insolation values for the climate of the last 10 million years. Quaternary Science Reviews, 10 (4), pp. 297-317.

Hu A., Meehl G.A., Han W., et al., 2012. The Pacific-Atlantic seesaw and the Bering Strait. Geophysical Research Letters, 39, L03702, doi:10.1029/11GL050567.

Max L., Riethdorf, J.4R., Tiedemann R. et al., 2012. Sea surface temperature variability and sea ice extend in the subarctic Northwest Pacific during the past 15.000 years. Paleoceanography, 27. PA3213. doi:10.1029/2012PA002292.
Okazaki Y.,Timmermann A., Menviel L. et al., 2010. Deepwater formation in the North Pacific during the last glacial termination. Science, 329, 200–204.
Ovsepyan E.A., Ivanova E.V., Max L. et al., 2013. Late Quaternary oceanographic conditions in the Western Bering Sea. Oceanology, 53(2), in press.
Riethdorf J.-R., Nürnberg D., Max L. et al., 2012. Millennial-scale variability of marine productivity and terrigenous matter supply in the western Bering Sea over the past 180 kyr. Clim. Past Discuss., 8, 6135–6198.
Waelbroeck C., Labeyrie L., Michel E., et al., 2002. Sea-level and deep water temperature changes derived from benthic foraminifera isotopic records. Quaternary Science Reviews, 21, 295-305.

## Benthic foraminifers in the Laptev Sea surface sediments: implication for paleoenvironmental reconstructions

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Benthic foraminifers are sensitive environmental indicators. However, environmental control on their distribution in the Arctic is still poorly understood. This investigation enlarges the scarce data available so far on recent foraminifers from the Laptev Sea in order to improve previous microfossil-based paleoenvironmental reconstructions for this region (Taldenkova et al., 2005, 2008, 2009, 2012). In marine sediment cores from marginal seas benthic foraminifers represent the most abundant group of microfossils; they attract special attention also because of the poor representation of planktonic foraminifers.

Laptev Sea foraminifers were studied in 42 surface sediment samples from water depth range 16-270 m that were obtained during Russian-German expeditions TRANSDRIFT V, XII, XIV-XVI. The research includes analysis of the species composition of live and dead foraminifers and relative abundance of different ecological groups from > 63 μm sediment fraction. We also include the previously obtained data on recent foraminifers from TRANSDRIFT I expedition, that were published by S.-O. Bude (1997).

Most benthic foraminifers in surface samples are represented by live forms, maximum up to 90% with average values of 60%. Live foraminifers are especially abundant in front of the Lena delta in the area of high terrigenous sediment fluxes and nutrient supply. High abundance of riverine organic matter causes favorable conditions for certain species of live microfauna, but it might also produce carbonate dissolution environments. Benthic foraminifers are largely represented by agglutinated forms on the whole shelf. Their abundance can reach up to 87% in the surface sediments. But if we compare these data with the downcore distribution of foraminifers we will see the significant decrease of agglutinated species below 10 cm likely due to post-depositional destruction of agglutinated tests. When calcareous frequencies from the modern assemblages are calculated without the addition of agglutinated taxa to the sample sum, then closer faunal affinities to the fossil assemblages are obtained (Austin, Sejrup, 1994). Altogether the dominance of live foraminifers and agglutinated taxa (Dittert et al., 1999; Murray et al., 1989) evidence poor preservation of foraminifers in the modern Laptev Sea sediment and possible dissolution.

Planktonic foraminifers *Neogloboquadrina pachyderma* sin. were found in a single sample from the outer shelf. This indicates unfavorable conditions for this group of microfossils because of surface water freshening.

In general, our data on the Laptev Sea foraminiferal distribution correspond to the main trend in the distribution of species and ecological groups in the Arctic marginal seas previously established in the river-affected Kara Sea by L. Polyak and co-authors (Polyak et al., 2002). Nearshore regions are largely inhabited by the typical river-proximal species: *Hyanesina* *orbiculare, Elphidium incertum, E. bartletti, Elphidiella groenlandica, Buccella frigida* and opportunistic species *Elphidium clavatum*. The widely spread shallow-water marine species (river intermediate group) occur throughout the studied area with maximum abundance in the mid-shelf region: *Pyrgo williamsoni, Nonion labradoricum, Stainforthia loeblichi, Elphidium subarcticum, Quinqueloculina* spp. River-distal foraminifers represented by *Islandiella norcrossi/helenae, Cibicides lobatulis, Astrononion gallowayi* and *Melonis barleeanus* are extremely rare on the shelf.

Application of cluster analysis allowed distinguishing four major regions with specific composition of benthic foraminifers: upper continental slope; outer shelf with > 40 m water depth; inner shelf with < 40 m water depth; freshened shallow area close to the Lena, Anabar, Olenek deltas. Following this modern trend a similar transgression-induced succession of fossil assemblages from nearshore to river-distal ones is recorded in sediment cores from the outer shelf.

Taxonomic diversity of benthic foraminifers tends to increase in offshore direction, primarily due to the fact that different ecological groups occur on the outer shelf and upper continental slope including those from the nearshore regions that are largely ice-rafted to the outer shelf and upper continental slope as was also recorded for modern ostracods (Stepanova et al., 2003, 2007). In sediment cores from the outer shelf and continental slope an increase in ice-rafted nearshore foraminifers and ostracods is characteristic for mid-late Holocene units otherwise containing modern-like relatively deep-water assemblages. Contrary, the deep-water species are absent in surface sediments from the nearshore regions. However, in mid-late Holocene sediments of the core from the inner shelf periodical occurrence of river-intermediate benthic foraminifers and even planktonic foraminifers likely evidences enhancement of reversed bottom currents.

## References


Austin, W., Sejrup, H. 1994. Recent shallow water benthic foraminifera from western Norway: Ecology and paleoecological significance. Cushman Foundation Special Publication No. 32, pp. 103-125.

Bude S.-O. (1997) Artengemeinschaften bentischer Foraminiferen in der Laptev-See, sibirische Arktis: Rezent Verteilungsmuster und Okologie. Unpubl. M.Sc. Thesis, Kiel University.

Dittert, N., Baumann, K., Bickert, T., Henrich, R., Hubert, R., Kinkel, H., Meggers, H., 1999. Carbonate dissolution in the deep-Sea: methods, quantification and paleoceanographic application. In: Fisher, G., Wefer, G., (eds), Use of proxies in paleoceanography: examples from the South Atlanthic. Springer-Verlag, Berlin Heidelberg, pp. 255-284.

Murray, J., 1989. Sindepositional dissolution of calcareous foraminifera in modern shallow-water sediments. Mar. Micropal., 15, pp. 17-27.

Polyak, L., Korsun, S., Febo, L., Stanovoy, V., Khusid, T., Hald, M., Paulsen, B.E., Lubinski, D.A., 2002. Benthic foraminiferal assemblages from the southern Kara Sea, a river-influenced arctic marine environment. J. of Foram. Res., 32, 3, 252-273.

Stepanova A., Taldenkova E., Bauch H.A., 2003. Recent Ostracoda of the Laptev Sea (Arctic Siberia): taxonomic composition and some environmental implications. Mar. Micropal., 48 (1-2), 23-48.

Stepanova A., Taldenkova E., Simstich J., Bauch H.A., 2007. Comparison study of the modern ostracod associations in the Kara and Laptev seas: Ecological aspects. Mar. Micropal., 63, 111-142.

Taldenkova, E., Bauch, H.A., Stepanova, A., Dem'yankov, S., Ovsepyan, A., 2005. Last postglacial environmental evolution of the Laptev Sea shelf as reflected in molluscan, ostracodal and foraminiferal faunas. Glob.Planet. Change, 48 (1-3), 223-251.

Taldenkova, E., Bauch, H.A., Stepanova, A., Strezh, A., Dem'yankov, S., Ovsepyan, Ya., 2008. Postglacial to Holocene benthic assemblages from the Laptev Sea: paleoenvironmental implications. Quat. Int., 183, 40-60.

Taldenkova, E.E., Bauch, H.A., Stepanova, A.Yu., Pogodina, I.A., Ovsepyan, Ya.S., Simstich, J., 2009. Paleoenvironmental changes of the Laptev and Kara sea shelves during the Postglacial transgression (inferred from fossil ostracods and foraminifers). In: Kassens, H., Lisitzin, A.P., Thiede, J., Polyakova, Ye.I., Timokhov, L.A., Frolov, I.E. (Eds.), Sistema Morya Laptevykh i Prilegayushchikh Morei Arktiki: Sovremennoe Sostoyanie i Istoriya Razvitiya (System of the Laptev Sea and the Adjacent Arctic Seas: Modern and Past Environments). Moscow Univ. Press, Moscow, pp. 384-409. (in Russian with English Abstr.).

Taldenkova E., Bauch H.A., Stepanova A., Ovsepyan Ya., Pogodina I., Klyuvitkina T., Nikolaev S.D., 2012. Benthic community changes at the North Siberian margin in response to Atlantic water mass variability since last deglacial times. Mar. Micropal., 96-97, 13-28.

## Ocean circulation driving the termination of the Younger Dryas

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The coastal waters of southeastern Newfoundland represent an ideal location to study past variability in the Atlantic Meridional Overturning Circulation (AMOC). Influenced by water masses from the cold Labrador Current and the warmer and more saline Gulf Stream waters, the area is currently situated at the boundary between the North Atlantic Subpolar Gyre and the Subtropical Gyre. Although in this region several records of the Younger Dryas – Holocene transition are available from the terrestrial realm, marine records spanning this interval at high resolution are so far rare. In this study we present results from a multi-proxy reconstruction of oceanic conditions and sea ice variability at the onset of the Holocene (Pearce et al. 2013).

Marine sediment core AI07-14G was taken from 239 m water depth in Placentia Bay off the south coast of Newfoundland. Based on 6 radiocarbon dates, the 510 cm core spans the age interval from 12.9 to 9.9 cal. kyrs. BP. With an average accumulation rate of 5.7 years/cm, the core provides a high resolution record of the Younger Dryas – Holocene transition. After X-ray fluorescence (XRF) core scanning, the core was subsampled and analyzed for diatoms, benthic foraminifera, grain size distribution, calcium carbonate content, total organic carbon content, and the geochemical diatom sea ice proxy IP25.

The Younger Dryas termination is clearly reflected in the record as a stepwise succession of events, with changes in ocean circulation preceding the main transition into the Holocene. In our record, the transition is first characterized by a gradual decrease of the Labrador Current intensity, followed by an intensification of Gulf Stream – North Atlantic Current water transport accompanied by a rapid decline of sea-ice cover. Although relatively large uncertainties may exist regarding the local marine reservoir age for this time period, the identification of a detrital carbonate layer associated with Heinrich Event 0, indicates that the observed changes in ocean circulation took place well before the Younger Dryas termination, defined as the shift in atmospheric circulation seen in Greenland ice cores. This thus infers that the ocean circulation changed prior to the shift in atmosphere, with a change in ocean circulation being a main driver of this major climate change.

**References**

Pearce, C., Seidenkrantz, M.-S., G., Antoon Kuijpers, Reynisson, N. F., Kristiansen, S. M., 2013. Ocean lead at the termination of the Younger Dryas cold spell. Nature Communications, in press.

## Late Quaternary deglacial to postglacial environments of marine Arctic Canada: synopses, challenges, and pressing issues

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The Canadian Arctic Archipelago (CAA), characterised by an extensive network of marine channels ("the Northwest Passage"; 1.1 million km$^2$), represents a fundamental link in the global climate system via large-scale oceanic and atmospheric circulation, heat transport, and freshwater budgets. Nonetheless, our knowledge of late Quaternary environments in this region is principally based on radiocarbon-dated materials (molluscs, marine mammal remains, driftwood) from coastal sediments now isostatically uplifted above modern sea-level.

Here we present direct marine data from five marine (piston and trigger weight) cores from the Parry Channel, the main east-west axis of the Northwest Passage. These records were investigated for sedimentological characteristics, micropalaeontology (dinocysts, non-pollen palynomorphs, benthic and planktonic foraminifera, ostracods), and stable isotope ratios. All cores extend to the end of the last regional glaciation, bottoming out on diamicton. Our data suggest grounded glacial ice in Barrow Strait, followed by rapid deglaciation, with a progression from ice-proximal to ice-distal conditions interrupted by an interval of pervasive landfast sea-ice. Although the timing of deglaciation is difficult to determine due to the absence of dateable materials at the diamicton/glaciomarine transition and chronological complexities such as the Portlandia Effect, age model extrapolations suggest deglaciation at ~11.0-10.8 cal ka BP (region-dependent). Noticeable biological activity commences in the early Holocene, a prominent signal of planktonic foraminifera (*Neogloboquadrina pachyderma*) appearing at ~10.0 cal ka BP. This marks the penetration of deeper (Atlantic-derived) Arctic Intermediate Water (AIW) into the archipelago following deglaciation, likely facilitated by higher sea-levels permitting increased flow across inter-channel sills. Postglacial amelioration (open-water season greater than at present) is subsequently recorded at ~10.0-7.0 cal ka BP, corresponding to a possible regional "Holocene Thermal Optimum". The exclusion of AIW due to glacioisostatic shallowing, coupled with generally cooling climate, eventually leads to increased sea-ice and modern microfossil assemblages. Analogous conditions similar to modern commence at ~6 cal ka BP. Our data indicate that although climate ultimately forces long-term environmental shifts, regional dynamics, especially sea-level changes, exert a significant control on marine conditions throughout the CAA.

Although these marine records show remarkable similarities, complications remain. Such challenges include: micropalaeontological issues (low diversity assemblages; generalist taxa; dissolution/destruction; cryptic palaeoenvironmental preferences), non-analogous early to mid-Holocene environmental conditions which limiting the utility of modern analogue based transfer functions, and non-standardized chronostratigraphic approaches (different ΔR values, dating and calibration protocols, radiocarbon dating materials selection). A multiproxy approach, coupling micropalaeontological, sedimentological and biogeochemical data, may best overcome such challenges in the CAA. Additionally, emerging marine records should be assessed in tandem with the wealth of geomorphological and geological terrestrial data, given the exceptional linkage between marine and terrestrial environments in this archipelago. Collectively, such approach would lead to an integrated understanding of long-term environmental and climatic histories in this climatically-sensitive region.

## Evolution of glaciations and sea ice in the western Arctic in the Early to Middle Pleistocene

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New sediment-core data as well as re-investigated older collections from the western Arctic Ocean (Northwind and Mendeleev Ridges) show considerable changes in Quaternary sedimentation patterns and paleobiological records, especially pronounced around the Mid-Pleistocene Transition (MPT). Where calcareous microfauna is preserved (mostly benthic foraminifers and ostracodes), it provides evidence of step-wise assemblage changes interpreted as an overall shift from seasonally ice free to permanently ice covered ocean conditions. This shift is generally consistent with climatic cooling and ice-sheet growth in the Northern Hemisphere, but the actual control(s) on sea-ice expansion in the western Arctic are yet to be understood. A major benthic turnover near the Early–Middle Pleistocene boundary (ca. 0.75 Ma) is marked by replacement of the “old” species (some known since the Oligocene) by fauna that appears to be related to food-deprived environments under permanent sea ice. Further increase in ice coverage can be inferred notably from an almost complete disappearance of species indicative of the ice-margin proximity and an appearance of the ostracode directly associated with perennial ice.

Glaciarization of the Arctic Ocean margins generally increased in parallel with the expansion of sea ice, as indicated by enhanced glacigenic sedimentary inputs starting from estimated Marine Isotope Stage (MIS) 20 (ca. 0.8 Ma). A conspicuous rise in the content of detrital carbonates in glacial sediment, indicative of the Canadian Arctic provenance, is recorded since MIS 16. This pattern likely signifies a growing role of the Laurentide ice sheet in the Middle Pleistocene, while early glacial inputs may have originated largely from the Chukchi–East Siberian margin. New data from this area indicate much more widespread glaciations than previously believed, although their chronology is poorly constrained thus far.

The relationships between the development of ice sheets and sea ice in the Arctic are yet to be investigated. Sea-ice spread may have accelerated glacier growth through increased albedo; on the other hand, elevated meltwater inputs may have facilitated stable perennial ice cover, while glacial debris had a negative impact on benthic fauna. Sorting out these relationships will enhance our understanding of the current changes in Northern Hemisphere sea ice and stability of modern ice caps including the Greenland ice sheet. Knowledge stemming from paleobiological proxies is especially important for projecting the reaction of the marine biota to present decrease in sea-ice extent and seasonal duration.

## Late and postglacial fluctuations of the oceanographic conditions in the southern margin of the Svalbard Archipelago (Arctic Ocean)

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SV-04 piston core recovered from the middle slope of the western Svalbard continental margin during the BIO Hespérides SVAIS cruise (29 July-17 August 2007) was analyzed for its sedimentological, paleontological (dinocysts, diatoms and coccoliths) and biomarker content in order to reconstruct the changes in the oceanographic conditions occurred during last glacial-interglacial period. The high-resolution age model based on 8 radiocarbon dating and rock magnetic parameters (magnetic susceptibility and anhysteretic remanent magnetization, Sagnotti et al., 2010) indicate sediment record spanning last 25,000 years. Microfossil abundances show marked shifts along the record that were associated to different climate/environmental conditions. Low concentrations of coccoliths, diatoms, planktic foraminifers and cysts of organic-walled dinoflagellates (dinocysts), characterize the lower part of the sequence (Late Pleistocene, IRD-rich, coarse-grained sediments), and increase up the sequence (Holocene, fine-grained, bioturbated sediments). Transfer functions based on dinocyst assemblages were used to quantitatively reconstruct the sea-surface conditions of the studied area, including salinity, temperature of warmest and coldest months and the seasonal extent of sea-ice cover (expressed in number of months per year with >50% sea-ice coverage). The biomarker profiles (alkenone derived mean annual temperature, amount of tetraunsaturated alkenone, alkanes, etc) trace the final retreat of the Barents ice sheet at the end of the deglaciation period and a transition from an early Holocene hypsithermal to a neoglaciation in the late Holocene, as observed in other paleoarchives from this region (Dahl-Jensen et al., 1998; Martrat et al., 2003). All these tools have proved to be very useful in explaining the main climatic features at North-Eastern Atlantic latitudes, which were closely linked to the Barents ice sheet history during the last deglaciation and the Holocene.

**References**

Dahl-Jensen, D. et al. Past Temperatures Directly from the Greenland Ice Sheet. Science 282, 268-271, doi:10.1126/science.282.5387.268 (1998).

Martrat, B., Grimalt, J. O., Villanueva, J., van Kreveld, S. & Sarnthein, M. Climatic dependence of the organic matter contributions in the north eastern Norwegian Sea over the last 15,000 years. Organic Geochemistry 34, 1057-1070 (2003).

Sagnotti, L., Macrì, P., Lucchi, R.G., Rebesco, M., Camerlenghi, A., 2010. A Holocene paleosecular variation record from the northwestern Barents Sea continental margin. Geochemistry, Geophysics, Geosystems, 12 (11), art. no. Q11Z33.

## West Greenland ice stream instability during the LGM deglaciation

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The continental shelf of West Greenland harbours the imprint of a series of large, cross-shelf ice streams that reached the shelf edge at the LGM controlling ice and sediment flux to the ocean. Little is known of the offshore deglacial history of most of them, but newly developed onshore and offshore chronologies from the Uummannaq Trough enable assessment of the importance of both climate and topography in influencing ice stream retreat.

Deglaciation of the Uummannaq ice stream system (UISS) began on the outer shelf at ~14.8 ka, with Ubekendt becoming ice free at ~12.4 ka. This period of retreat of appears to be an initial response to increasing JJA solar radiation and sea-level rise, with an additional rapid rise in air temperature between 16 – 14.5 ka in the run up to the Bølling Interstadial. It is also possible ocean forcing played a part in early deglaciation. The wide mid-shelf trough (> 30km) with no constrictions also facilitated calving. The UISS then underwent 80 - 100 km of retreat by ~11.4 - 11.0 ka as the northern and southern feeder zones unzipped. This coincided with an increase in insolation, peak sea-level, topographic over-deepening and fjord widening. This occurred despite Younger Dryas cooling. Along the southern arm of the UISS the grounding line retreated towards Store Gletscher becoming topographically pinned due to fjord narrowing at ~11.4 – 11.0 ka. From 9.3 ka onwards retreat rates increased again with the ice margin reaching the present Store Gletscher margin by 8.7 ka. The northern arm of the UISS deglaciated quickly from Ubekendt, calving northward through Igdlorsuit Sund. At ~11.3 ka the ice front in Karrat/Rinks Isfjord became topographically pinned and remained stable for the next 5000 yrs (until ~6.9 – 6.5 ka), being insensitive to both atmospheric and oceanic forcing. Hence, the northern and southern feeder outlet glaciers of the UISS behaved asynchronously during the LGM/Holocene transition.

Asynchronous responses between adjacent ice stream drainage basins is also evident on a regional scale, with Jakobshavn Isbrae (JI) deglaciating from the mid to inner shelf much later than the UISS and being present on the outer shelf during the Younger Dryas (12.8 – 11.7 ka). It only reached the present coast between 10.3 to 10.0 ka – over 1000 years later than the UISS. As both drainage systems were subjected to similar climatic and sea-level forcing mechanisms between 15.0 and 10.0 ka outlet dynamics therefore appear to be controlled by contrasts in trough geometry. There is no evidence of a strong influence of the warm West Greenland Current on either the UISS or JI as they crossed the mid/inner shelf until after 9.2 ka, possibly precluding a significant oceanic forcing mechanism for deglaciation.

## First pollen records from Is-fiord, Western Spitsbergen

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Bottom sediments from three 1,4 to 2,1-m thick cores recovered in Is-fiord, Western Spitsbergen have been studied for pollen and spores. Fiord sediments are represented by over-watered in the topmost 20-cm grayish-green silty pelites with gruss and pebble inclusions.

In spite of extremely low concentration and predominance of reworked microfossils, marine pollen spectra are quite similar to those known from radiocarbon-dated lake sediments and peat exposures on the coasts of neighboring fiords – Bulle (Dorozhkina, 2005), Van Meien (Zelikson, 1971; Serebryanny et al., 1974), Hornsunn (Srodon, 1960) and Kongs (Knaap, 1988). Provided that long-distant originated pollen of conifers and spores of ferns are eliminated from the spectra composition they enable understanding of the features of the coastal vegetation and tracking the phases of evolution of local vegetation as well.

The oldest pollen spectra of the studied bottom sediment sections are provisionally dated to Subboreal period. They document that open grass-sedge associations, heather-bogs and other habitats with cereals, Bryales and *Sphagnum* predominated in Is-fiord vicinities since the beginning of the late Holocene whereas osier-bed occupied elevated areas.

Increase of Cyperaceae and Poaceae pollen reflects active coastal bogging produced by Subatlantic humidification.

Extremely low pollen concentration in silty pelites possibly reflects very high accumulation rate during the time of sedimentation.

### References

Dorozhkina, M, 2005. Pollen study of Holocene lake and peatbog sediments in the area of Nurdamen Lake, Western Spitsbergen. Kompleksnye issledovaniya prirody Shpitzbergena. Proceedings of the V International Conference, Murmansk, Russia, pp. 167-173 (in Russian).

Knaap W., 1988. A pollen diagram from Brøggerhalvøya, Spitsbergen: changes in vegetation and environment from ca. 4400 to ca. 800 BP. Arctic and Alpine Res., 20, pp. 106-116.

Serebryanny, L., Tishkov, A., Malyasova, Ye., 1984. Reconstruction of the vegetational evolution in the high-Arctic. Proceedings of the Academy of Sciences of the USSR, 6, pp. 75-84 (in Russian).

Srodon A., 1960. Pollen spectra from Spitsbergen. Folia Quaternaria, 3, p. 112-118.

Zelikson, E., 1971. Palynologic investigation of Holocene peatbog from Spitsbergen. In: Palinologiya golotsena, Moscow, pp.199-212 (in Russian).

## Sea ice cover retreat in the eastern Barents Sea during the last 500 years

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Sea ice is an active component of Arctic climate, and its variability is mainly driven by the advection of warm Atlantic water to the Arctic (Vinje, 2001). The Barents Sea is one of the main gateways of warm and salty Atlantic water to the Arctic Ocean, and thus the region is key to track the variability in heat balance between low and high latitudes.

We have undertaken a reconstruction of sea ice, sea surface temperature (SST), freshwater extent and export productivity variations in the eastern Barents Sea that spans the last 4.400 years and is located in a site influenced by the North Atlantic Current inflow (73º 37.5' N, 50º 43.0' E; 270m water depth) (Voronina et al. 2001). To achieve this goal, we have used a combination of biomarker proxies, based on highly branched isoprenoid lipid (IP25) synthesized by sea ice diatoms (Belt et al. 2007) to infer variations in past sea ice cover, together with the concentration of alkenones - algae synthesized lipids - from which we also estimated past SST ($U^{K}_{37}$' index) and fresh water mass variation (%$C_{37:4}$).

The interpretation of IP25 is open to some debate. In here we follow the model by Müller et al. (2011) which requires the combination of various biomarker signals. From this we propose that there was a progressive cooling from 4400 BP towards 1700 BP, with important polar water mass influence and extended sea ice cover, probably due to a lower influence of Atlantic water mass reaching the Barents Sea. A progressive transition towards greater inflow of Atlantic water took place after 1700 BP, with an increase in summer export productivity and less extended sea ice cover. From 500 BP towards present, there was a progressive increase in Atlantic Water inflow and a retreat of the sea ice cover limit.

However, our interpretation may appear somewhat at odds with the reconstruction of summer sea ice extent based on a circum-Arctic compilation of high-resolution terrestrial proxies that indicated that the duration and magnitude of the current and recent reduction in sea ice cover is unprecedented during the last 1.450 years (Kinnard et al., 2011). It seems that in the eastern Barents Sea a progressive retreat in sea ice and environmental warming started some centuries before - around 500 years BP.

### References

Belt, S.T. et al., 2007. A novel chemical fossil of palaeo sea ice: IP25. Organic Geochemistry, 38(1), pp.16-27.
Kinnard C, Zdanowicz CM, Fisher DA, Isaksson E, Vernal A de and Thompson LG (2011) Reconstructed changes in Arctic sea ice over the past 1,450 years. Nature 479(7374): 509–512: doi:10.1038/nature10581.
Müller, J. et al., 2011. Towards quantitative sea ice reconstructions in the northern North Atlantic: A combined biomarker and numerical modelling approach. Earth and Planetary Science Letters, 306(3-4), pp.137-148.
Voronina, E. et al., 2001. Holocene variations of sea-surface conditions in the southeastern Barents Sea, reconstructed from dinoflagellate cyst assemblages. Journal of Quaternary Science, 16(7), pp.717-726.
Vinje, T., 2001. Anomalies and trends of sea-ice extent and atmospheric circulation in the Nordic Seas during the period 1864-1998. Journal of Climate 14 (3), pp, 255–267.

## Deglaciation of the White Sea, as part of the problem completion of the Ostashkov glaciation in water basins along the periphery of the Scandinavian Ice Sheet

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The problem of glaciation of North-West Russia is still a subject for discussion. Main disputed issues: borders glaciations, the genesis of glacial-marine sediments, the nature of the ice sheet and the presence of the Late Valdai glacier in North-Eastern of the Russian Plain. Recent studies of glacial and postglacial formations in the White Sea and its surroundings have allowed to definitely solving these problems.

The White Sea is an inland marine basin, the formation of which is largely determined by the nature of the last glaciation. The depression of White Sea is a tectonic structure associated with the Riphean age orogeny. The main in the formation of the White Sea is its location on the periphery of the Baltic Shield, where contact hard crystalline rocks and soft sediments of the Russian Platform. The White Sea basin located under the ice cover in Late Valday time. The southern part of the coastline has distinct traces of activity exaration by glacial streams. Deglaciation began about 13-14 thousand years ago, when the glacier retreated from the boundary of the Luga glacier formation. At this time in the southern part of the Onega Bay emerged glacial lakes. It is crucial that in other water basins on the periphery of the Baltic shield is also having similar lakes (Ladoga and Onega, the Gulf of Finland). Landscape zoning at this time wore submeridional character and determined by the boundary gradually containing ice shield. Data of palynological analysis of bottom sediments cores confirm this assumption. Deglaciation in all basins was fast, but was accompanied by oscillator stage-thrusts. As a result, the complexes of marginal glacial formations was formed in all seas and lakes of North-Eastern Europe. The till thickness in these ridges is up to 100 meters and more. The field work in 2011-2012 has shown that glacier in the Late Valday comes not only from Scandinavia, but also from the North-East ( from Czechskaja bay). It is different from the common opinion about the absence in the northeast of the Russian plate of glacier in Late Pleistocene.

Connection with the open sea in the White Sea in the Late Allerod happened, and in the Baltic Sea - at the end of the Late Drias. In the first case, it happened gradually as a result of increasing of level of the Barents Sea. In the Baltic Sea was due to the connection of a catastrophic release of water from the glacial lakes in the Skagerrak. In this case, the penetration of water from the Arctic Ocean indicates the absence, at least in Allrod, Barents Sea Ice Sheet (Spiridonov and other.1992). Early Holocene (Boreal, Preboreal ) is the period when installed in these seas marine conditions. At this time, the great European lakes were practically separated from marine basins. Their development occurred gradually, against raising the coast, most clearly evident in the White Sea. The bottom sediments in transition have accumulated in this time. The concentration of biogenic components (Corg., $SiO_2$ aut, $CaCo_3$) increased. The high content of organic has led to authigenic sulfide mineralization.

Postglacial development of the Baltic Sea occurred by cyclic change of transgressions and regressions. For example, final connection of the Baltic with ocean came as a result Litorina transgression in the Atlantic time. Predominant type of development of the coastal zone of the White Sea was regression. Thus, the level of the sea in Preboreal - Boreal (about 9000 years ago) fell to 50-60m and was fixed under the modern sea level. Sea-level rise in the Atlantic time has led once again to the flooding of the drained bottom and to the emergence of a modern bathymetric level. Lake Ladoga from Ladoga caused by the melting of the glacier and tectonic movement. The water reached the modern Southern bays of the Ladoga Lake as result of the Ladoga transgression. Large areas of limno-glacial sediments were under water were on the water. Sea-level rise in the Atlantic time has led once again to the flooding of the drained bottom and to the emergence of a modern level of bathymetric. Erosion were major sedimentological factors from the Atlantic period. Thus, development of a separate water basins along the periphery of the Baltic Shield there has been. Since that time. A persistent landscape zoning has been sublatitudinal character and become similar to the modern one.

Thus, studying of the bottom sediments of the White Sea, had obtained information about the nature of glaciation in the Barents Sea, especially the degradation of the ice sheet, including the early development of postglacial transgressions. The change of regime periglacial lake sedimentation occurred for over 3000 years, resulting in the White Sea to the Baltic became the inner shelf seas. From early Holocene Lake Ladoga and Onega revivals own as large lakes.

**References**

Spiridonov M.A, Rybalko A.E. and Poljak L.V. 1992, Stratigraphy of upper quaternary deposits of Novaja Zemlja shelf and paleogeography of the Eastern Barents Sea in the Late Pleistocene – Holocene / The sedimentary cover of glacial shelf of northwest seas of Russia. Saints-Petersburg, VSEGEI, p.p. 47-68

## Holocene palaeoenvironmental changes on the North Kola Peninsula: formation of modern landscapes.

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Palaeoclimatic changes, tectonic and coastline movement during Middle – Late Holocene caused vegetation changes on the North Kola Peninsula. We studied different types of sediment cores in the area between 69° N - 70° N and 31°12’ E - 35° E by pollen analysis and the modern vegetation in this region by geobotanic analysis.

At Subboreal period pollen record from all sites indicates forest tundra vegetation with *Betula* dominance. Pollen data suggest relatively warm and moist conditions. Subatlantic period is indicated by decrease of forest vegetation. It’s suggested the climate was getting colder.

Nowadays all sites are located at tundra zone about 10 km beyond the modern northern conifer treeline. The northern *Pinus* limit passes tens kilometers to the south of studying region (Gervais & MacDonald., 2001) and where the southern type of tundra pass to forest tundra. Modern vegetation is presented by *Betula* dominance, while *Betula nana* and *Empetrum nigrum* form a dense cover of ground with mosses and lichens. Bogs are extended in this area. According geobotanic data we made landscape maps of Teriberka area (69°10’ N; 35°11’ E) and Sredniy Peninsula (69°39' N; 31°58' E). Surface sediments from Sredniy Peninsula near Norwegian border were analyzed by pollen analysis too. The results correlate with previous data, received from surface sediments.

**References**

Gervais B.R., MacDonald G. M. 2001. Tree-ring and summer-temperature response to volcanic aerosol forcing at the northern tree-line, Kola Peninsula, Russia // The Holocene 11,4, pp. 499–505

## Paleogeographical situation on the Nordaustlandet (Spitsbergen Archipelago) at the boundary of the Late Pleistocene-Holocene

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The 98 radiocarbon dates (Blake, 1961; 2006; Olsson, 1969; Salvigsen, 1978; Sharin, Arslanov, 2011) of wood, shells and bone remains of mammals from the Nordaustlandet (Spitsbergen Archipelago) were analyzed. Reconstruction of Palaeogeographic situation for the Late Pleistocene-Holocene was fulfilled on the basis of analysis of these dates, geomorphologic features, results of study of Quaternary sediments of marine, glacial, glacial-marine and fluvial-glacial origin as well as the field work results obtained in 2007 and published geophysical data (Dowdesvell et al., 1986). It is established that the Upper Holocene sea level in the Svartknausflya Plain was located at ~75 m height; in the Murchison fjord – at ~82 m height, in the Prince Oscar Land – at 22-25 m height; in the Invikbukta – at 20-25 m height.

In the period of 12 000-10 000 B. P. a third part of the Nordaustlandet was covered by marine transgression. During this period, the maximum uplift rate was obtained, the trend of which increased from the north to the south. These data contribute the new information about the formation and age of coastlines in extent of postglacial transgression as well as about the origin of recent tectonic movements.

**References**

Blake W., Jr. 1961. Radiocarbon dating of raised beaches in Nordaustlandet, Spitsbergen // Geology of Arctic. Toronto, 133–145.
Blake W. Jr. 2006. Occurence of the Mytilys edulis complex on Nordauslandet, Svalbard: radiocarbon ages and climatic implications // Polar Research. 25 (2), 123–137.
Dowdesvell, J.A., Drewry D.J., Cooper, A.P.R., Gorman, M.R. 1986. Digital mapping of the Nordauslandet ice caps from airborne geophysical invistigations // Annals of Glaciology 8, 51-58.
Olsson I. U., El-Gammal S., Goksu Y. 1969. Uppsala natural radiocarbon measurements IX // Radiocarbon 11, 515–544.
Salvigsen O. 1978. Holocene emergence and finds of pumice, walebones and drift wood at Svartknausflya, Nordauslandet // Norsk Polarinst. Arbok, 217-228.
Sharin V.V., Arslanov Kh.A. 2011. New radiocarbon dates of sea terraces of Nordauslandet (archipelago Spitsbergen) // Bulletin of the St.-Petersburg University. Series 7, 2, 129-134.

## Morphometrical and hydrochemical studies of thermokarst lakes of Indigirka and Kolyma lowlands during 2011-2012 field campaigns

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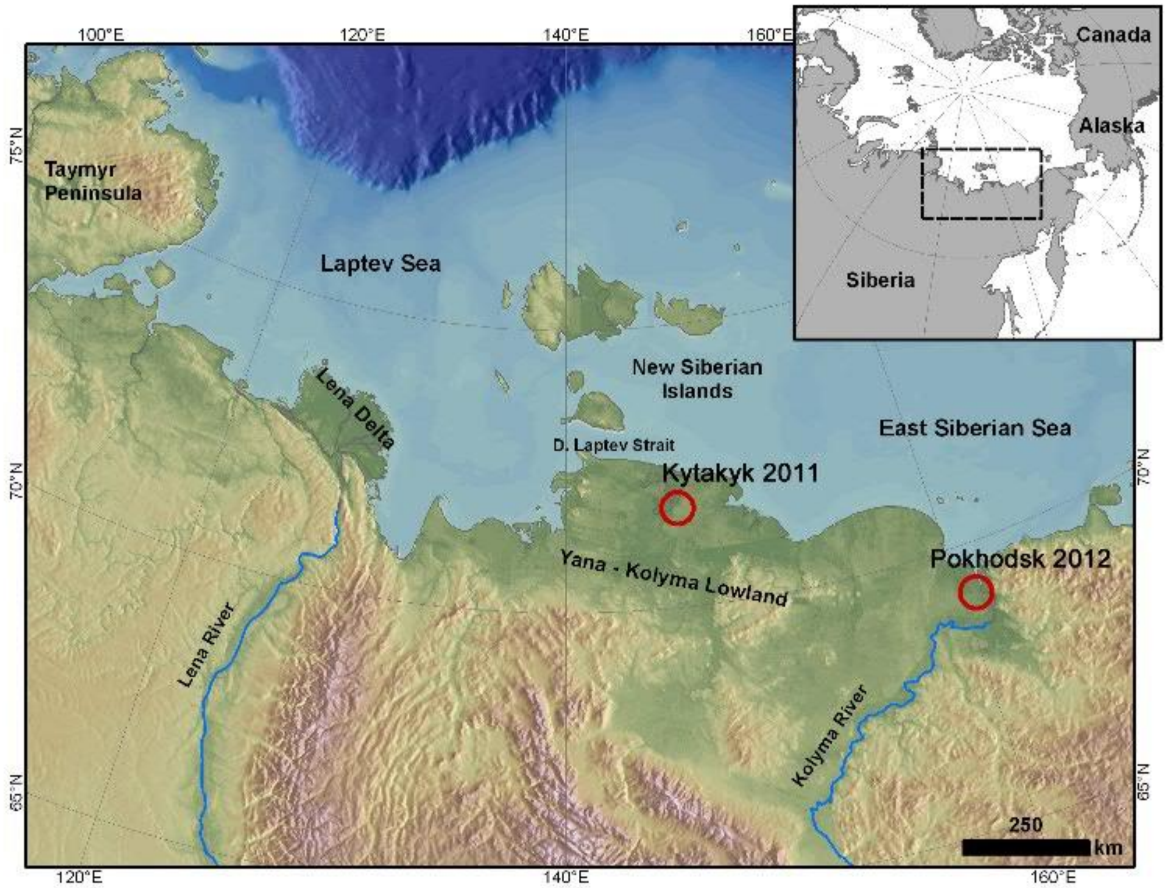
The state and dynamics of tundra wetlands under climate variability in Siberian Polar Regions is the topic of a joint German-Russian research project that started in 2010. Two expeditions focusing, among other topics, on limnological and paleographic characteristics of thermokarst lakes were carried out in the Indigirka River floodplain (Kytalyk, 70°N 147°E) and in the Kolyma Delta (Pokhodsk, 68°N, 161°E) in 2011 and 2012 (app.1). A major objective was to explore the ages and geneses of periglacial landscapes by studying the origin, location, and shapes of eleven different thermokarst lakes. Pursuing these objectives, scientists carried out coring of ground deposits. Collected sediment cores will be analyzed for TOC, TIC, TN, TS contents, grain size composition and stable isotope ratios ($\delta D$, $\delta^{18}O$, $\delta^{13}C$) and geochronology in order reconstruct lake dynamics and to establish sedimentation rates in the different stages of lakes evolution.

To distinguish different types of thermokarst lakes, hydrochemical dat~~a~~ (e.g. pH, oxygen concentration, acidity, alkalinity, main ions) as well as temperature and electrical conductivity were measured. Based on morphometric (lake size, lake area, shoreline shape, lake orientation) and bathymetric data, different lake types were classified with respect to their form e.g. round, triangular) and orientation. Thermokarst lakes in thermokarst depressions, on the higher plain of the Khalerchinskaya Tundra (Kolyma Lowland) and lakes of floodplain genesis were classified. In the Yedoma ice complex landscape of the Indigirka River region (Kytalyk), the border of modern thermokarst lakes seems to be parallel to the border of old dry lakes basins (alas depressions). The shape of modern lakes remains round and has an average depth of 1.3 to 1.5 m. The surrounding territory is dominated by polygonal structures, including numerous small polygonal ponds. Lakes in the Kolyma Lowland are deeper (in average 2.2 to 2.5 m) and have a triangular shape and a north-eastern orientation. The Kolyma Lowland lake density is significantly higher than in the Indigirka Lowland. Bathymetric measurements allow the constrcuction of 3D-models of lakes useful for differentiation. Physico-chemical characteristics of the studied lakes together with climatic ~~data~~ obtained from weather stations (e.g. air temperature, precipitation and solar radiation) helps to elucidate the modern condition of thermokarst lake formation. The project was implemented with financial support from German Science Foundation (DFG), the Russian Foundation for Basic Research (RFBR 11-04-91332) and the German Academic Exchange Service (DAAD).




## References

Morgenstern A., Grosse G., Schirrmeister L., 2008. Genetic, Morphological, and Statistical Characterization of Lakes in the Permafrost-Dominated Lena Delta. NICOP

Kienast, F., Tarasov, P., Schirrmeister, L., Grosse, G., Andreev, A.A., 2008. Continental climate in the East Siberian Arctic during the last interglacial: Implications from palaeobotanical records. Global and Planetary Change 60 (3-4) , pp. 535-562

Grosse, G., Schirrmeister, L., Siegert, C., Kunitsky, V.V., Slagoda, E.A., Andreev, A.A., Dereviagyn, A.Y., 2007. Geological and geomorphological evolution of a sedimentary periglacial landscape in Northeast Siberia during the Late Quaternary. Geomorphology 86 (1-2) , pp. 25-51

Ilyashuk, B.P., Andreev, A.A., Bobrov, A.A., Tumskoy, V.E., Ilyashuk, E.A., 2006. Interglacial history of a palaeo-lake and regional environment: A multi-proxy study of a permafrost deposit from Bol'shoy Lyakhovsky Island, Arctic Siberia. Journal of Paleolimnology 35 (4) , pp. 855-872

Kienast, F., Wetterich, S., Kuzmina, S., Schirrmeister, L., Andreev, A.A., Tarasov, P., Nazarova, L., (...), Kunitsky, V.V., 2011. Paleontological records indicate the occurrence of open woodlands in a dry inland climate at the present-day Arctic coast in western Beringia during the Last Interglacial. Quaternary Science Reviews 30 (17-18) , pp. 2134-2159

Wetterich S., Schirrmeister L., Meyer H., Siegert C., 2008. Thermokarst Lakes in Central Yakutia (Siberia) as Habitats of Freshwater Ostracods and Archives of Palaeoclimate. NICOP.

## Early Holocene Atlantic Water advection to the Arctic Ocean

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The Arctic is among the the areas which are responding most rapidly to global warming. In search of an analog for the Arctic under future warm and possibly ice-free conditions, the Early Holocene is often considered as a candidate. There is evidence from marine archives that Atlantic Water advection to the Arctic Ocean was particularly strong after ca. 10 ka, although maximum sea surface temperatures were reached only after 9 ka (Risebrobakken et al., 2011). We present preliminary foraminiferal and isotope data from four sediment cores along a transect from 79°N in the eastern Fram Strait along the western Yermak Plateau to 83°N on the westernmost Gakkel Ridge (Arctic Ocean) which allow to trace the subsurface advection of Atlantic Water to the interior Arctic on decadal to multicentennial timescales during the so-called "Holocene Thermal Maximum" (HTM). While the planktic foraminiferal associations in the eastern Fram Strait are strongly dominated by subpolar specimens over the entire HTM interval (ca. 10.5 – 8.5 ka), the more northerly sites tend to show only short intervals with abundant supolar specimens within the HTM. The Gakkel Ridge core record (with lower temporal resolution) eventually has only one sample in the Early Holocene with significant numbers of subpolar foraminifers (15%). Planktic foraminifer contents (specimens/g) and calculated fluxes are highly variable for the Early Holocene in the four cores. Peak-to-peak correlation is not always possible and has to be improved by further radiocarbon datings. The oxygen isotope data from polar planktic foraminifers Neogloboquadrina pachyderma are low (ca. 3 permille) both in the eastern Fram Strait and on the Gakkel Ridge, but relatively high on the western Yermak Plateau. Considering also the change from low carbon isotope values in the south and high values on the Gakkel Ridge, we conclude on variable habitats of planktic foraminifers along the transect in the HTM. Our preliminary results suggest that the advection of Atlantic Water to the interior Arctic during the Early Holocene was rather variable on centennial timescales, similar to what is known for the last two millennia.

### References

Risebrobakken, B., Dokken, T., Smedsrud, L.H., Andersson, C., Jansen, E., Moros, M. and Ivanova, E.V., 2011. Early Holocene temperature variability in the Nordic Seas: The role of oceanic heat advection versus changes in orbital forcing. Paleoceanography, 26, PA4206, doi:10.1029/2011PA002117.

## Dynamics of the North American Ice Sheet Complex during its inception and build-up to the last Glacial Maximum

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The North American Ice Sheet Complex played a major role in global sea level fluctuations during the Late Quaternary but our knowledge of its dynamics is based mostly on its demise from the Last Glacial Maximum (LGM), a period characterised by non-linear behaviour in the form of punctuated ice margin recession, episodic ice streaming and major shifts in the location of ice divides. In comparison, knowledge of the pre-LGM ice complex is poorly constrained, largely because of the fragmentary nature of the evidence relating to ice sheet build-up. In this paper, we explore the inception and growth of ice (120-20 ka) using a glacial systems model which has been calibrated against a large and diverse set of data relating to the deglacial interval. We make use of calibration data prior to the LGM but its scarcity introduces greater uncertainty, which is partly alleviated by our large ensemble analysis. Results suggest that, following the last interglaciation (Oxygen Isotope Stage: OIS 5e), the ice complex initiated over the north-eastern Canadian Arctic and in the Cordillera within a few thousand years. It then underwent rapid growth to an OIS 5 maximum at ~110 ka (5d) and covered ~70% of the area occupied by the LGM ice cover (although only 30% by volume). An OIS 5 minimum is modelled at ~80 ka (5a), before a second phase of rapid growth at the start of OIS 4, which culminated in a large ice complex at ~65 ka (almost as large as at the LGM). Subsequent deglaciation was rapid (maximum modelled sea level contribution of >16 cm per century) and resulted in an OIS 3 minimum between ca. 55-60 ka. Thereafter, the ice complex grew towards its LGM configuration, interrupted by several phases of successively less significant mass loss. Our results support and extend previous inferences based on geological evidence and reinforce the notion of a highly dynamic pre-LGM ice complex (e.g. with episodes of ± 10s m of eustatic sea level equivalent in <5 ka). Consistent with previous modelling, the fraction of warm-based ice increases towards the LGM from <20 to >50%, but even the thin OIS 5 ice sheets exhibit fast flow features (several 1000 m $a^{-1}$) in major topographic troughs. Notwithstanding the severe limitations imposed by the use of the 'shallow-ice approximation', we note that most fast flow-features generated prior to the LGM correspond to the location of 'known' ice streams during deglaciation, i.e. in major topographic troughs and over soft sediments at the southern and western margins. Moreover, the modelled flux of these 'ice streams' (*sensu lato*), appears to be non-linearly scaled to ice sheet volume, i.e. there is no evidence that decay phases were associated with significantly increased ice stream activity. This hypothesis requires testing using a model with higher-order physics and future modelling would also benefit from additional pre-LGM constraints (e.g. dated ice free/margin positions) to help reduce and quantify uncertainties.

## Mysteries and History of the Siberian Drainage to the Arctic Ocean

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As demonstrated by the ACEX 2004 drill cores from Lomonosov Ridge a clear sedimentary impact of an Arctic sea ice cover started to appear in Eocene sediments, approx.. 48 Ma, much earlier than known hitherto. The onset of IRD sedimention was preceded by the *Azolla*-fresh water event (Backman & Moran 2009) which seems to mark the onset of the drainage of large quantities of fresh water to the Arctic Ocean leading to the formation of the Arctic sea ice cover and a general cooling of the climate over the Northern Hemisphere. The unresolved question remains how this development was triggered.

Looking at the geography of Eastern Siberia one has to realize that the modern rivers of the entire Siberian platform virtually all drain to the North into the Arctic (Fig. 1, from Aleksev & Drouchits 2004), but the history and evolution of this drainage pattern is only poorly unknown. From Arctic Ocean sediment cores we know that a sea ice cover existed for the past 48 Mio. yrs.. It is an unresolved question if it existed the entire time span because the stratigraphic record is interrupted by 2 long lasting hiatusses. We believe that Eocene fresh water event in the central Arctic may be linked to the plate tectonic collision of the Indian plate with with the southern Eurasian continental margin (Fig.2), resulting in the initial built-up of mountain chains to the South of the Siberian platform and the generation of a drainage pattern of the Siberian rivers to the North. The large amounts of fresh water entering the Arctic Ocean then generated an environment conducive for the initiation of a sea ice cover in the Arctic much earlier than the formation of the Antarctic ice cover. The later part of the Tertiary history of the Siberian river run-off is still shrouded in mystery.

During the Neogene and Quaternary the Arctic Ocean sediment record formed frequently under the influence of intensive melt water events from the glacial ice sheets. The events of the past 200 000 years are known in considerable detail (Spielhagen et al. 2004), but it is difficult to link them to the history of the large rivers draining the Siberian hinterland. As part of a major study of the paleomorphology of  Northernmost Eurasia we have therefor initiated a project aiming at resolving the history of the Lena River from its upper to the lowermost reaches. During 2 expeditions in 2011 and 2012 we have sampled a substantial number of sections from a large variety of sedimentary environments.

The late Quaternary history of the upper Lena is complicated by the hypothesis (supported by the distribution of sedimentary facies) that a river transport across Lake Baikal was possible. This hypothesis is in contradiction to most stratigraphic data of Lake Baikal sediments and of our understanding of age and nature of origin of lake Baikal itself.

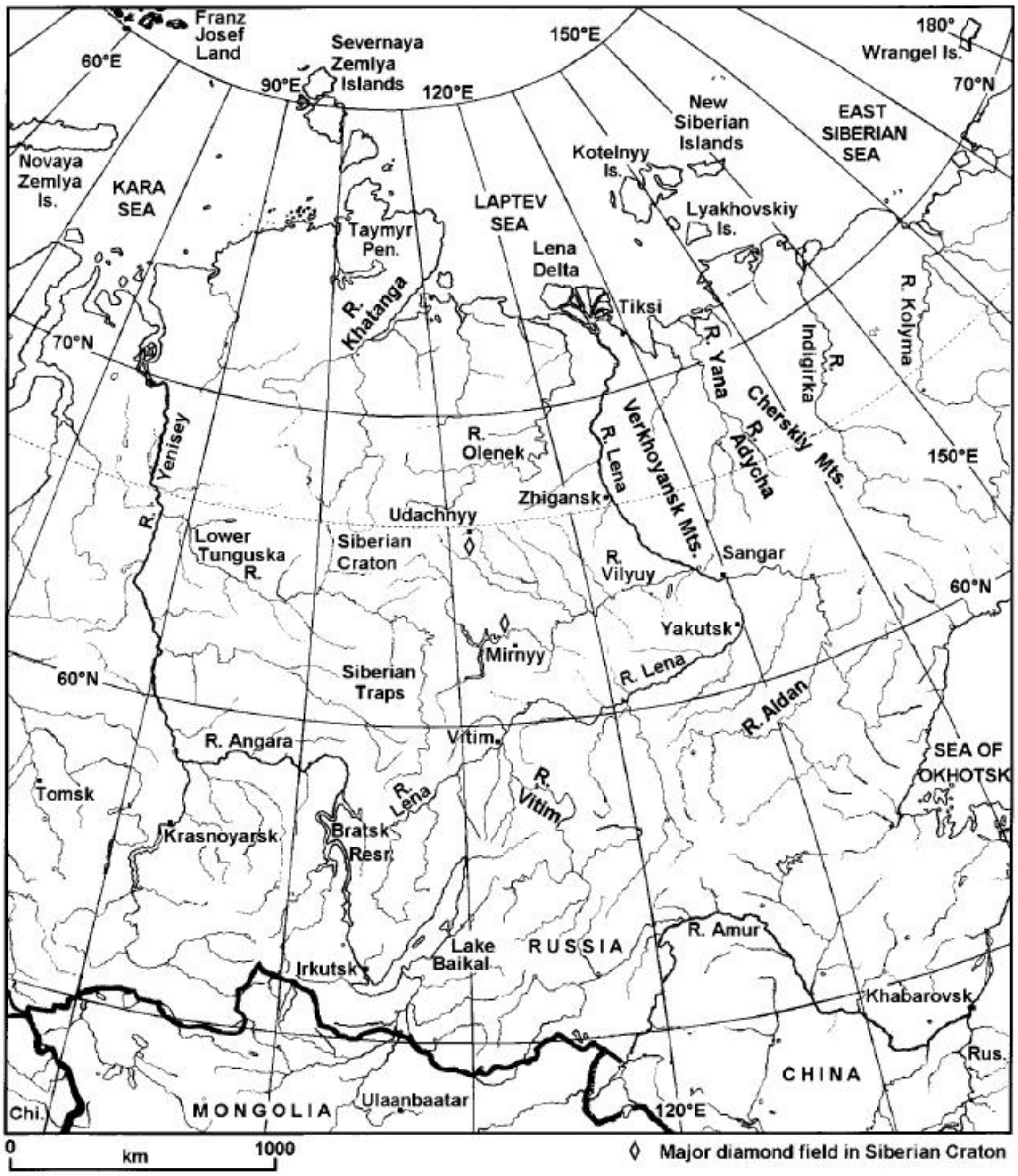


Fig. 1. Modern drainage pattern of the Siberian platform with most of the rivers flowing northward into the Arctic Ocean (from Alekseev and Drouchits, 2004).

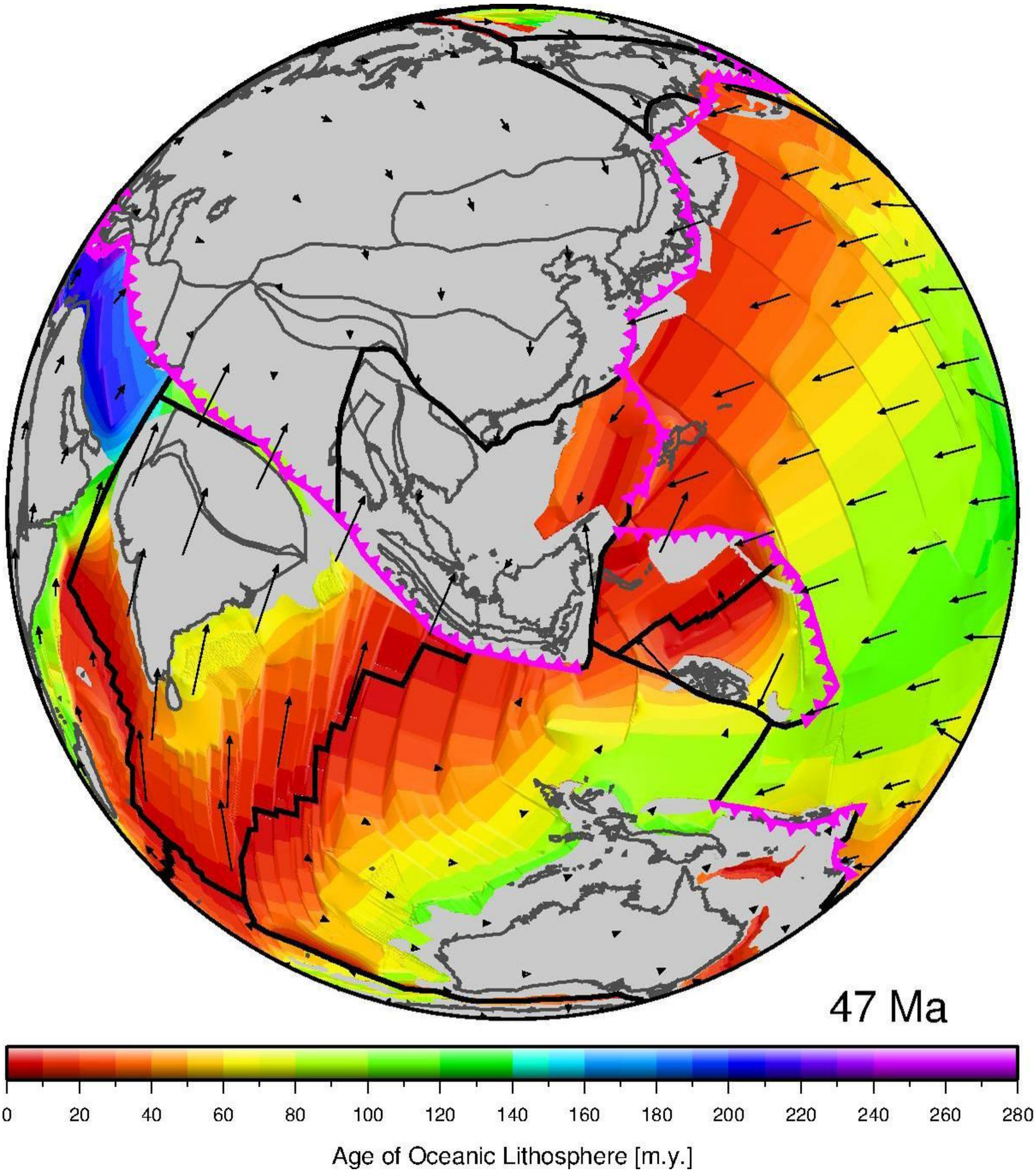


Fig. 2. Plate tectonic reconstruction for the Early Eocene (pers. comm. D. Müller, Sydney 2006).

## References


Alekseev, M. N. & V. A. Drouchits 2004 Quaternary fluvial sediments in the Russian Arctic and Subarctic: Late Cenozoic development of the Lena River system, northeastern Siberia.- Proc. Geol. Assoc., 115 (4): 339-346

Backman, J. & K. Moran 200ß: Expanding the Cenozoic paleoceanographic record in the Central Arctic Ocean: IODP Expedition 302 Synthesis.-Cent. Europ. J. Geosci., 1(2): 157-175.

Müller, D. 2006 (Prof. Geophys. U Sydney, pers. comm.): ftp://ftp.geosci.usyd.edu.au/pub/permanent/earthbyte/palaeobath/Antarctic/ant_paleodepth_grids.tgz

Spielhagen, R. F., K.-H. Baumann, H. Erlenkeuser,N. R. Nowaxzyk, N. Noegaard-Pedersen, N. vogt & D. Weiel 2004: Arctic Ocean deep-sea record of Northern Eurasian ice sheet history.- Quat. Sci. Rev., 23: 1455-1483.

## The palaeogeographical researches of Polar Regions within St. Petersburg State University`s megagrant

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Staff members of the department of geomorphology under the scientific guidance of the German scientist of world-wide reputation Joern Thiede took direct participation in a creation of "Palaeogeography and Geomorphology of Polar Countries and the World Ocean" laboratory in St. Petersburg State University in 2010-12 within a grant of the Government of the Russian Federation. In a final form the laboratory was created in March, 2013.

Research works were conducted in four directions which included geomorphological mapping of the polar countries and particular sections of the Mid-Atlantic Ridge (MAR), palaeogeographical and geochronological researches of the Middle and Upper Neopleistocene and Holocene of the Arctic and the Subarctic regions.

Results of the research works are expounded in “The geomorphological atlas of the Antarctic” (Senior Editor – A. N. Lastochkin), in monographs “Origin and development of the Lena River delta” by D. Yu. Bolshiyanov, A. S. Makarov, etc, “Quaternary geochronometry methods in palaeogeography and marine geology” by V. Yu. Kuznetsov and F. E. Maksimov, in more than 50 articles in domestic and foreign academic periodicals. Furthermore, a creation of “The geomorphological atlas of the Arctic” has begun.

Geochronological researches under guidance of V. Yu. Kuznetsov with the participation of H. A. Arslanov, L. A. Savelieva, F. E. Maksimov, etc. had made it possible to deduce inference about forming time and climate conditions of different types of deposits such as the deposits of buried oyster reef lying on a sea cliff in eastern part of Tanfilyev island (unique find near the Kuril Islands), the mollusc shells from transgressive deposits of Svalbard (Western Spitsbergen and Northeastern Land), the marine sediments from Mendeleev Rise, the diluvium, glaciofluvial, fluvial and lacustrine deposits of Tolokonka section beside a high coast of Northern Dvina 100 km downstream from Kotlas.

In virtue of palaeogeographical researches of lacustrine deposits, coasts and deltas as well as other geological and geomorphological evidences of fluctuation of climate and ocean level in the Arctic in the Holocene D. Yu. Bolshiyanov, A.S. Makarov, etc. offered a new technique of an identification of fluctuations of a sea level. This technique is based on studies of organo-mineral deposits that had been sedimented under the influence of sea level rising. The main stages of formation of the Lena River delta and sea level changes of Laptev Sea in the Holocene were established using this technique. Climate fluctuations of the Holocene and the last millennium were studied with the analysis of lacustrine deposits, buried trees, sporo-pollen spectrums and exuviaes of bugs (L. A. Savelieva, etc.). A studying of warm climatic phases in the geological past represents a great interest from the point in the context of obtaining information that is necessary for an assessment of environmental development in the conditions of climatic changes of the recent decades

A composition of "The atlas of photos of plants and pollen of the delta of the Lena River" (L. A. Savelieva, E. A. Rashke, D. V. Titova) had become a separate area of focus, which allowed to simplify a reconstruction of paleoflora growth conditions. A knowledge of modern conditions of habitats of the plants determined by pollen is needed for the reconstruction which stresses the importance of the Atlas creation. It is for this reason that the Atlas includes both photos of modern pollen and plants and information about habitats of different species so that it is the main difference from other publications of this sort. Besides that all information in the Atlas is given not only in Russian, but also in English.

In 2012 the group under the guidance of J. Thiede and G. B. Fedorov with the assistance of F. E. Maksimov, L. A. Savelieva, etc. explored the Upper Lena River. Results of this research are being analyzed at the present time. Next thing to research is the middle reaches of the Lena in 2013. The goal of research is not less important: "A reconstruction of changes of environment and climate in the territory of Siberia and the Russian North in the Late Pleistocene and the Holocene (on the example of Lena river basin)". Considering uniqueness of a river basin of Lena that is what it was never blocked by an inland ice, and a river drain wasn't interrupted, it is possible to count on obtaining the extremely important scientific information.

## Lithological peculiarities of the Chukchi sea inner shelf sediments

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The study area covers largely underexplored waters of the Chukchi Sea inner shelf. The purpose of the study was to identify lithological and mineralogical characteristics of sediments of the Central Chukotka Plain which was formed under the predominant influence of the non-wave accumulation. The area is characterized by avalanche sedimentation rates in the Holocene – up to 100 cm in 1000 years [2, 3, 4]. The deposits, which are determinant in their turn, are composed of pure lutaceous and lutaceous and aleurite fraction particles (up to 80%) with sand, scattered gravel and pebbles (as a result of ice drift). Dark grey and greyish-green colours are predominant (early diagenetic changes [1]). Aleurites are typical of the plain border areas. Sandy silts can be found along the coastal area and on the elevations of islands and banks, which reflect the structural uplift in the relief and are characterized by sediments of various grain composition determined by wave separation and ice drift. The current wave impact is primarily observed in the summit parts of the banks and causes a gradual increase in the sediment grade. Near Gerald Trench ferromanganese nodules up to 7 cm in diameter are detected. The Central Chukotka Plain is characterized by quite a high content of iron ore minerals. As for mineralogical characteristics, minerals of the heavy residue of amphibole-epidote-pyroxene group prevail. It should be noted that the Bering Current is one of the main sources bringing sediment in the Chukchi Sea.

### References

Astakhov A.S., Bosin A.A., Kolesnik A.N., et al. 2010. Geological studies in the Chukchi Sea of the Arctic Ocean Expedition Rusalca-2009 // Pacific Geology. Vol. 6. P. 110-116.

Gusev E.A., Andreeva I.A., Anikina N.Y., Bondarenko S.A., Derevyanko L.G., Iosifidi A.G., Klyuvitkina T.S., Litvinenko I.V., Petrova V.I., Polyakova E.I., Popov V.V., Stepanova A.Y. 2009. Stratigraphy of Late Cenozoic sediments of the western Chukchi Sea: New results from shallow drilling and seismic-reflection profiling // Global and Planetary Change. Vol. 68. Is. 1-2. P. 115-131.

Hill J.C., Driscoll N.W., Brigham-Grette J. et al. 2007. New evidence for high discharge to the Chukchi shelf since the Last Glacial Maximum // Quaternary Research. Vol. 68. P. 271-279.

Hill J.C., Driscoll N.W. 2010. Iceberg discharge to the Chukchi shelf during the Younger Dryas // Quaternary Research.. Vol. 74. P. 57-62.